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WATERSHED WORK PLAN

WILLIAMS-CHANDLER WATERSHED

MARICOPA AND PINAL COUNTIES, ARIZONA

Vineyard Rd. + Rittenhouse Floodwater Retarding Structures

OUR SOIL ★ OUR STRENGTH

January 1963

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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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
Board of Supervisors of Pinal County
Queen Creek Soil Conservation District
East Maricopa Soil Conservation District

With assistance by:

U. S. Department of Agriculture
Soil Conservation Service

January 1963

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WATERSHED WORK PLAN
WILLIAMS-CHANDLER WATERSHED
Maricopa and Pinal Counties, Arizona
January 1963

SUMMARY OF PLAN

Size and Location

The watershed is located in eastern Maricopa and northwestern Pinal Counties, Arizona. The Williams-Chandler Watershed heads in the Superstition Mountains and drains onto a wide alluvial fan on which valuable improvements have been established. Lying east of Chandler and about 25 miles east of Phoenix, the flood plain includes a large acreage of cultivated irrigated land which is some of the most highly productive farm land in the state. Also within the watershed are the Williams Air Force Base, the Town of Higley, part of the City of Chandler, the Roosevelt Water Conservation District Canal, the Eastern and Consolidated East Branch Canal system of the Salt River Project, and the Southern Pacific Railroad.

The total watershed area contains 154,976 acres of which 36 per cent is cultivated farm land, three per cent is non-agricultural and the remaining 61 per cent is in range land. Forty-six per cent of the watershed is in private ownership, 44 per cent is state owned, eight per cent is Federal (one per cent National Land Reserve, four per cent Tonto National Forest, and three per cent is Air Force installation), and two per cent is Indian land.

This watershed is one of three for which the sponsoring local organizations have requested concurrent planning because part of the flood problem area is affected by all three watersheds. The northernmost watershed is "Buckhorn-Mesa", the central watershed is "Apache Junction-Gilbert", and the southern watershed is "Williams-Chandler." The relationship of the three watersheds is shown in Figure 1 - Watershed Location Map.

Sponsoring Organizations

This work plan was prepared by the Flood Control District of Maricopa County, the Board of Supervisors of Pinal County, the Queen Creek Soil Conservation District and the East Maricopa Soil Conservation District, with technical assistance furnished by the United States Soil Conservation Service.

Watershed Problems

High intensity "cloudburst" storms during July, August, and September, and long gentle rains in the winter months, result in destructive floods. Floodwaters resulting from these storms inundate the rich irrigated farm irrigated farm land above the Roosevelt Water Conservation District Canal. These floodwaters back up behind the Roosevelt Water Conservation District Canal and overflow into the canal in such volume as to cause breaks in the canal banks. Floodwaters then pour over high valued farm land and into the Salt River Project's canal system where further damage occurs. Historically, the area has been affected by floodwaters on the average of once every two and one-half years.

Flood flows throughout the area are complex in that runoff from the Apache Junction-Gilbert Watershed to the north enter and combine with flood flows from the Williams-Chandler Watershed. Floodwaters originating in the Queen Creek drainage area that exceed the capacity of the channel overflow and intermingle with floodwaters in this watershed.

Works of Improvement to be Installed

The project includes both land treatment and structural works of improvement. The land treatment measures reduce runoff and erosion and increase infiltration rates and the waterholding capacities of the soil. Measures to be installed on the cultivated land include crop residue use, conservation cropping systems, irrigation water management, cover and green manure crops, "rough tillage," land leveling, irrigation pipelines, field ditches, and ditch lining.

To reduce floodwater and sediment damages two floodwater retarding structures and 9.2 miles of floodway will be installed. Provisions will be made to divert floodwaters from the floodway into a main irrigation canal for irrigation use. (See Figure 5)

A 57 per cent reduction in floodwater and sediment damages will be afforded the flood plain as a result of installing this project. It will eliminate all damages from floodwaters originating above the structures up to and including the one per cent event (the 100-year flood) and reduce damages from floods greater than the one per cent event. Additional irrigation water will be made available by the installation of agricultural water management features. The project will be installed during a four-year period.

Project costs of $6,156,070 will be borne by P.L. 566 and other funds as follows:

	P.L. 566 Funds	Other Funds	Total
Land Treatment Measures	23,610 1/	1,557,560	1,581,170
Structural Measures -			
Flood Prevention	3,733,400	831,400	4,564,800
Irrigation	6,150	3,950	10,100
TOTAL	3,763,160	2,392,910	6,156,070

1/ Technical assistance only.

Average Annual Benefits Compared to Average Annual Costs

Total average annual benefits attributable to the structural measures, as proposed in this work plan are $326,050. Average annual cost of structural measures is estimated at $197,300. The ratio of average annual benefits to average annual costs is 1.6 to 1.0.

Arrangements for Installation, Operation and Maintenance

Land treatment measures will be applied and maintained by farmers cooperating with the Queen Creek and East Maricopa Soil Conservation Districts.

All structural measures will be installed, operated, and maintained by the Flood Control District of Maricopa County. Average annual cost of operation and maintenance is estimated at $23,700. The Flood Control District of Maricopa County has authority under State law to construct, operate, and maintain works of improvement.

Operation and maintenance agreements will be executed between the Flood Control District of Maricopa County and the Soil Conservation Service prior to issuing invitations to bid for each construction unit.

DESCRIPTION OF THE WATERSHED

Physical Data

Location

The watershed is located in eastern Maricopa and northern Pinal Counties, Arizona, about 25 miles east of Phoenix. Heading in the Superstition Mountains, it drains onto a wide alluvial fan on which valuable agricultural and non-agricultural properties have been established and are developing. Located on the flood plain area are the Williams Air Force Base, the Town of Higley and part of the Town of Chandler.

Land Use and Status

The total watershed area contains 154,976 acres of which 55,791 acres are cultivated farm land, 4,649 acres are non-agricultural and the remaining 94,536 acres are range land. Seventy-one thousand four hundred eight acres in the watershed are privately owned, 68,303 acres are state owned, 11,662 acres are Federal (1,550 acres National Land Reserve, 6,662 acres Tonto National Forest, and 3,840 acres are Air Force installation), and 3,603 acres are Indian land (Land use and status are shown in Figure 4).

Land Resource Units

Land resource units have been used to describe the soil, cover, topography, geology, and erosion. Resource units delineated in the watershed include the following:

Resource Unit	Acres	% of Area
Mountains	22,810	15
Valley Slopes	31,040	20
Valley	101,126	65
TOTAL	154,976	100

Topography

The elevation ranges from 1220 feet at the western watershed boundary to 5100 feet in the Superstition Mountains in the northeastern portion of the watershed. The general slope is to the southwest. The following is a tabulation of average slope variations in the resource units:

Resource Unit	Per Cent Slope
Mountains	15 - vertical
Valley Slopes	1 - 3
Valley	less than 1

Geology

Physiographically, the area is part of the Sonoran Desert section of the Basin and Range province. The Superstition Mountains are composed of igneous and metamorphic rocks, the most common being Tertiary dacite. Other rocks present in minor amounts are Pre-Cambrian granite, schist, quartzite, and a small amount of Tertiary andesite. Gentle alluvial slopes extend basinward from the mountains. The upper slopes in places are underlain at shallow depth by rock surfaces.

Soils

Soil conditions differ considerably in the watershed. A general description of the soils by land resource units follows:

Mountains - Soils are generally very shallow to shallow stony gravelly loams and sandy loams. Up to 40 per cent of the area is rock outcrop.

Valley Slopes - Soils are moderately deep on alluvium derived from a variety of rocks. The top soils usually have a loam or gravelly loam texture. Subsoils are sandy clay loam and underlain by a strongly cemented lime layer at 14 to 30 inches.

Valley - Soils are deep, medium textured, weak to strongly developed from alluvium derived from a variety of rocks.

Vegetation and Range Condition

Mountains - The vegetation is mainly shrubs with a light overstory of trees. During wet years there is a fair growth of annual grass and weed species. Perennial grasses are lacking. The shrub species are burr sage, cacti, creosote, and shrubby buckwheat with an overstory of paloverde. Range condition is poor.

Valley Slopes - Vegetation consists of shrubs with a light overstory of trees. In wet years there is a fairly dense cover of annual grass and weed species. Perennial grasses and forbs are lacking. The shrub species are chiefly burr sage, creosote, and cacti. The overstory is composed of paloverde and ironwood. Range condition is poor.

Valley - Most of this area is under cultivation. Crops grown are cotton, alfalfa, grain sorghums, small grains, and truck crops. Vegetation on the uncultivated area is shrubs with a light overstory of trees. In wet years there is a heavy cover of annual weed and grass species. Perennial grasses are lacking. The shrub species are creosote bush and burr sage with an overstory of mesquite. Range condition is poor.

Stream Channels

There are no perennial streams in the watershed. Channels in the mountains are well defined but most of them meander and disappear when they reach the valley slopes. Those which are well defined through the valley slopes spread out on the valley floor. Where floodwaters are concentrated on the valley floor, gullies with active head cuts are formed.

Climate

The climate of the watershed varies from arid on the irrigated land in the western portion of the watershed to semi-arid in the mountainous country in the eastern portion of the watershed.

The Weather Bureau station data from Mesa and Superior is typical of the western and eastern portions of the watershed. The mean annual precipitation varies from eight inches at Mesa to 17 inches at Superior. The summer months of July, August, and September account for 35 per cent of the average annual precipitation and the winter months in December, January, and February account for 33 per cent of the annual precipitation.

Following are mean monthly precipitation values for the Mesa and Superior stations:

Month	Precipitation (inches) Western (Mesa Station)	Eastern (Superior Station)
January	.93	1.87
February	.82	1.85
March	.77	1.83
April	.38	.94
May	.14	.32
June	.12	.29
July	.96	2.14
August	1.19	2.55
September	.77	1.41
October	.39	1.02
November	.66	1.31
December	.93	1.96

During the summer months, short duration thunderstorms may occur in late afternoon or early evening. These storms are associated with moist tropical air that originates in the Gulf of Mexico. The largest daily precipitation occurred at Superior in March 1954 and amounted to 3.66 inches.

The severe thunderstorms are associated with tropical disturbances originating in the Pacific Ocean off the west coast of Mexico, causing precipitation that would normally fall in an average year to fall within a period of six hours to two days.

Temperature Data - Degrees Fahrenheit

	Mesa Station	Superior Station
Mean annual	68	69
Mean January	50	53
Mean July	88	86
Highest recorded	119 (July 1907)	111 (July 1958)
Lowest recorded	15 (January 1950)	25 (Feb. 1955)

Daytime Humidity Data - Per Cent

	Mesa Station	Superior Station
Mean annual	30	39
Mean June	17	25
Mean December	44	49

In the late spring and early summer the temperature normally varies about 20° F. between daybreak and early afternoon. Snow has occurred only once in Mesa's 59 years of record and this was in January 1937. There are on the average 332 frost-free days per year with temperatures reaching 26° F. or lower only five days a year.

A second season of moderately heavy precipitation occurs during the winter months. This precipitation originates from the Pacific Ocean causing widespread gentle showers, which may continue intermittently for several days.

Water Resources

Water resources originate from three sources: (1) impounded water from the Salt River system of dams located outside the watershed boundaries, (2) underground water which is pumped only when surface supplies are deficient, and (3) runoff from precipitation within the watershed. The total amount of water used each year on the irrigated land remains approximately the same; however, the amount of water used from each source may vary year to year depending on the availability of water from the other sources.

Runoff water from precipitation within the watershed supplies a small fraction of the amount of water needed for the irrigated area. This is obtained by the installation of flood gates in the Roosevelt Water Conservation District Canal banks; however, because of the nature of the uncontrolled flow, most of this floodwater has to be diverted south to Queen Creek above and adjacent to the banks of the Roosevelt Water Conservation District Canal in a floodway constructed for this purpose.

Surface water is brought to the irrigated lands from reservoirs located on the Salt River, north and east of the watershed. The Salt River system of dams has an impoundment capacity of 2,000,000 acre-feet of water. Surface water for the irrigated area is delivered by three canals, the Roosevelt Water Conservation District, Eastern, and Consolidated East Branch, which traverse the watershed in a north-south direction. Surface water from the Salt River system of dams is augmented by pump water on the irrigated farm land below the Roosevelt Water Conservation District Canal.

Underground supplies are available at depths ranging from 160 to 400 feet. However, the underground water level is dropping approximately eight feet a year as pumpage exceeds replenishment from surface sources. The irrigated farm land above the Roosevelt Water Conservation District Canal is irrigated entirely by pump water from underground supplies.

There are no reservoirs in the watershed where surface waters are impounded for irrigation use. There are a few small stockwater ponds which have a negligible effect on surface runoff.

Queen Creek, an intermittent desert stream, is the southernmost boundary of the watershed. The surface runoff from the Queen Creek drainage basin at times overflows the channel banks and intermingles with floodwaters from the watershed.

Economic Data

The estimated population of the Williams-Chandler Watershed is 10,300. This does not include the many military and civilian personnel working at the Williams Air Force Base located nine miles east of the Town of Chandler. Two other towns, Higley, located seven miles east of Chandler, and Queen Creek, located three miles southeast of Williams Air Force Base, are located within the watershed. Migratory workers increase the area's population during the peak harvest seasons.

Population growth is and has been expanding over the past years as additional land areas become available for subdivision purposes.

The economy of the watershed is based primarily on the agricultural-services trade enterprise. Agriculture is well established and highly developed. Farmers obtain water through the Salt River Project, Roosevelt Water Conservation District and by private wells to irrigate the 55,790 acres of cultivated land in the watershed. The value of this farm land is estimated to be $74,200,000. Two high valued crops, cotton and vegetables, are grown on 30,130 acres. Alfalfa, grain sorghum and barley comprise the remaining 25,660 acres. These crops are grown on approximately 195 farms having an average size of 285 acres. The composite weighted gross income per acre realized from these crops is estimated to be $360.

There are a number of cotton gin companies providing ginning services to the cotton growers. A number of good size livestock feed lots supplement the crop-pasture segment of the agricultural economy.

The Superstition Mountain area attracts many winter tourists, adding considerably to the economy of the watershed.

Transportation facilities are considered adequate at this time. Arizona Highway 87-93 traverses the extreme western edge of the watershed through the Town of Chandler to the City of Mesa. Numerous other state and county roads serve the area's population. The main line of the Southern Pacific Railroad between Tucson and Phoenix parallels the west boundary of the watershed. A branch line of the Southern Pacific Railroad runs through the eastern segment of the cultivated area through Gilbert, by the Town of Queen Creek, and within close proximity of Williams Air Force Base.

WATERSHED PROBLEMS

Floodwater Damages

Historical records indicate that from 1910 to 1960, 33 floods have, in varying degrees, damaged agricultural lands, residences, retail-commercial property, roads, highways, irrigation canals, the Southern Pacific

Railroad, Williams Air Force Base, and other physical features of the watershed. During this period 21 floods have occurred in the summer months and 12 during the winter months. Runoff from heavy rains in the years 1926, 1930, 1941, 1943, 1946, 1954, and 1959 caused particularly serious damage.

Land owners, both agricultural and non-agricultural, have over the past years attempted to reduce the frequency of floodwater damages by constructing flood dikes. Some ten miles of on-farm dikes to divert floodwaters have been constructed in the farm area east of the Roosevelt Water Conservation District Canal. The farm dikes have to a very limited degree protected the cultivated lands of the area. Flood flows of any magnitude breach these dikes and flow in a south-southwest direction. Williams Air Force Base was subject to floodwater inundations prior to the construction of four miles of a channel and dike around the perimeter of the base and other flood features in 1957-58. The approximate cost of these works was $275,000. While they provide for complete protection up to the one per cent event, inundation of the access roads to the base results in losses of upwards to $50,000 per day due to the inability of the many civilian and military personnel to enter the base. Of more importance is the possible threat to the nation's and area's security.

Flood flows in this area east of the Roosevelt Water Conservation District Canal during the August 18 and 19, 1954 flood inundated 4,490 acres of cultivated land, breached the Southern Pacific Railroad and points along the track and built up behind the Roosevelt Water Conservation District Canal and eventually broke through the canal at its confluence with the railroad track. This storm is of the magnitude of one occurring once every 17 years. The canal was damaged for a length of six miles to the south of the canal and the railroad. The flood situation in the areas east of the canal and west of the canal was further aggravated by flood flows from the Apache Junction-Gilbert Watershed. The two flows continued in a south-southwest direction and inundated an additional 11,580 acres of cultivated land. Floodwaters from greater events than this 1954 flood have reached as far west as the City of Chandler and have inundated 20,330 acres of cultivated land within the watershed.

Floodwater damages, as a result of the 1954 flood, seriously affected the economy of the watershed. Damage to the cultivated areas valued at $21,373,000 was extensive. Loss of cotton on the 7,715 acres of cotton land inundated amounted to 5,400 bales, or a gross loss of $675,000. The cotton seed rendered unusable from this cotton amounted to 1,750,000 pounds, or a gross loss of $56,000. Cotton farmers in this area are still feeling the effects of this loss. Not only did this represent a considerable loss to the farmers themselves, it represented a serious loss to the ginning companies and other agricultural service-trade facilities in the area. Cotton quality as a result of this flood was lowered. Ginning costs were higher as a result of flood debris on the bolls.

The estimated gross loss to alfalfa hay as a result of this flood, amounted to $313,150. The tonnage of alfalfa lost amounted to an estimated 14,000 tons. This was a critical loss of feed to the number of large dry lot livestock operators within the watershed. This loss in alfalfa tonnage was equivalent to the production of 408,000 to 580,000 pounds of live weight beef based on a roughage feed.

Flood damages to the 580 acres of vegetable crops in the watershed amounted to a gross loss of $435,000. This loss consisted of damages suffered mainly to the melon and fall lettuce crops. The majority of these crops were plowed under.

The total evaluated floodwater damage to crops and pasture as a result of this 1954 flood is estimated to be $1,038,000.

Residential and retail-commercial property experienced flood flows of from six inches to three feet as a result of runoff from the 1954 event. These properties are well scattered throughout the flood plain and for the most part are residences of farmers. Damages to the residences and stores include loss of furnishings, repair of tile and wood floors, and repair of landscaping. Thirty-seven miles of county and state maintained roads were heavily scoured and washed. Transportation on these roads was practically nil for two to three days after the flood. Many watershed residents were stranded in their homes while repairs were being made. The total damages to residences, retail-commercial stores and roads within the watershed, as a result of the 1954 storm, amounted to $36,000.

The flood plain area is experiencing a substantial development process. This development is taking place for the most part in the desert land east of the Roosevelt Water Conservation District Canal quite close to the Williams Air Force Base. Floodwater damages to these potential developments some 15 to 20 years hence, if a storm of the magnitude of the 1954 event were to recur, would amount to an estimated $314,000. This includes the damages that would be sustained to roads as they increase with increased development.

Total floodwater damages estimated for the watershed as a result of the 1954 storm amounted to $1,074,000. Potentially these damages could amount to $1,350,000 as urbanization takes place on the flood plain.

The potential floodwater and sediment damage in the watershed in the case of a one per cent event (an event which would occur once in 100 years) could amount to an estimated $2,000,000. Similarly a storm of the magnitude of occurring once every ten years could cause an estimated $990,000 damage under present flood plain conditions. The watershed economy could be set back an estimated $462,000 gross from damage to cotton alone from a storm of this magnitude.

In addition to direct losses within the watershed, there are considerable indirect effects suffered as a result of flood flows. Rail traffic along the Southern Pacific Railroad is delayed as waters threaten to breach the tracks. Considerable loss of time is experienced to laborers involved in harvesting the variety of crops grown in the flood plain. This is especially true in the case of vegetables which are almost entirely harvested by hand. Cotton gins serving the area suffer loss of income and disruption of scheduling as a result of floods.

Flood damages to this intensive agricultural producing area are a continual drain on the economy of the watershed. They have hindered land treatment application within the watershed and have indirectly affected all agricultural connected services and trades inside and outside of the watershed.

Sediment Damages

Deposition of sediment on the cultivated fields within the flood plain from the 1954 storm was estimated at $296,000. Farmers were faced with the task of releveling fields covered by heavy depositions of sediment. Clean-out of on-farm irrigation ditches and private wells serving both agricultural and non-agricultural interests was necessary. These type damages had a serious effect on the efficiency of applying irrigation water. Alfalfa fields were "smothered out" as a result of sediment deposition. These sediment damages increased in magnitude as the flood flows broke on-farm dikes and breached the floodway of the Roosevelt Water Conservation District Canal.

Clean-out of silt deposits in homes and stores presented a formidable task. Carpets were ruined. Normal sanitation conditions were disrupted. Scraping of roads for easy access was another type of sediment damage encountered. These conditions will steadily become worse as urbanization of the flood plain area takes place.

Erosion Damages

After the 1954 event, farmers were required to haul in fill material to replace soil which was scoured out. This damage occurred most frequently where flows broke through on farm dikes and floodways. Again the need to maintain proper irrigation grades on cultivated fields was the prime concern in immediate restoration. This scour damage amounted to an estimated $13,500 in 1954.

Problems Relating to Water Management

Irrigation water to supply the cultivated farm land west of the Roosevelt Water Conservation District Canal is supplied through the facilities of the Roosevelt Water Conservation District and Salt River Project. The source of this supply is from surface water as diverted from the Salt River system and a series of wells along the main irrigation canals. A third but very undependable source is from the capturing of flood flows as they occur and enter the canals through gates installed in the canals. This source is presently used to augment the surface supply and reduce the overdraft of the underground supply. This method has a number of undesirable features. The flood flows upon entering the canals contain sediment and at present no measures are constructed to desilt this water. Capacity of the canals are then lowered and higher maintenance costs are encountered. These flows usually scour and damage the canals at the gates upon entrance into the canals.

Since surface supplies are short, the wells along the Roosevelt Water Conservation District Canal supply the majority of irrigation water. The problem of augmenting these well supplies through the use of clean, controlled flood flows when available is of concern to the local sponsoring organization for a sustained agricultural production.

The Queen Creek and East Maricopa Soil Conservation Districts have assisted farmers in the flood plain in constructing, operating and maintaining measures considered essential in the efficient use of irrigation water.

PROJECTS OF OTHER AGENCIES

Three major canal systems cross the watershed from north to south. Two of these systems are operated and maintained by the Salt River Project. The other system is operated and maintained by the Roosevelt Water Conservation District. All three of the canal systems will be benefited as a result of the structural measures proposed herein.

The Bureau of Reclamation has developed preliminary plans for the proposed Central Arizona Project. The proposed Salt-Gila Aqueduct of the Central Arizona Project will traverse the watershed in a north-south direction approximately seven miles east of the Roosevelt Water Conservation District Canal and will be complemented by the structural works of improvement proposed in this plan. Considerable savings will be afforded the aqueduct in providing flood protection and drainage. The local office of the Bureau of Reclamation has concurred in the formulation of structural measures outlined in this work plan.

The Whitlow Dam, located on Queen Creek five miles east of the watershed, was constructed in 1960 by the U. S. Army Corps of Engineers. This structure will reduce flood peaks that could flood the watershed adjacent to Queen Creek.

Four miles of channel and dike have been constructed by the U. S. Army Corps of Engineers around the perimeter of Williams Air Force Base to protect the base from flood damages. These existing works and the Whitlow Dam will eliminate serious floodwater damages to the Air Base proper up to and including the one per cent event.

BASIS FOR PROJECT FORMULATION

The project objectives of the local people are to: (1) eliminate or reduce floodwater and sediment damages to the highly productive irrigated lands, farm property, roads, and utilities; (2) protect the existing Salt River Project and Roosevelt Water Conservation District's Canals and on-farm irrigation facilities; (3) reduce flood plain scour and erosion; (4) afford protection to urban and industrial areas and land suitable for future development to such use, and (5) make use of flood flows for agricultural purposes.

The land treatment measures, as proposed in this plan, will meet a portion of the above objectives by reducing runoff and erosion and increasing the infiltration rates and waterholding capacities of the soils. In determining the magnitude of 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 flood plain.

Because of the complex and inter-related conditions that exist within the three watershed areas, the formulation of floodwater retarding structures placed in series with one common outlet to a safe disposal point was more economical than other formulations considered and afforded a high level of protection to the overall watershed areas. Works of improvement proposed on the Roosevelt Water Conservation District floodway provided sufficient incremental benefits over incremental costs for the one per cent event for inclusion in this plan. (See Figure 5)

The planned measures will provide for the retardation of runoff up to and including the 100-year storm.

Consideration was given to release of floodwaters to Queen Creek immediately south of the Rittenhouse floodwater retarding structure. This not only included the volume of water from the Vineyard Road and Rittenhouse structures, but also the detention volume of the Powerline structure in the Apache Junction-Gilbert Watershed. It was determined that serious channel stability problems in Queen Creek would occur as a result of the release of these floodwaters. The cost of stabilizing Queen Creek would be in excess of the cost of the floodway proposed. Further details concerning this alternate study are discussed in the Investigations and Analyses section of this plan.

An alternate study included a longer release time (30 days) from the Powerline, Vineyard Road, and Rittenhouse floodwater retarding structures. This study proved that additional embankment costs exceeded the floodway costs. Another alternate study which would dispose of floodwaters into a groundwater recharge system showed that the total cost exceeded those of the planned floodway.

Consideration was given to storage of surface runoff for irrigation use. This was determined to be unfeasible for two reasons: (1) the lack of suitable storage sites because of foundation and topographic conditions, and (2) the erratic occurrence of surface runoff which could be stored.

A substantial portion of the irrigation water supply in the watershed is pumped from deep wells, so this part of the water supply is subject to rapid control. At such times as surface water from floods is available, even though highly erratic in occurrence, it can be beneficially used on the agricultural land by manipulation of the pumped supply. This will, in turn, help to reduce the overdraft on the underground supply.

In the selection of sites for floodwater retarding structures, a primary consideration was given to locations that would give the maximum degree of protection to flood plain developments in place or to be installed. This dictated a location higher on the watershed than the upper edge of the developed area. After determination of the approximate size of the area needed for future expansion, structure locations were made from a study of topographic and geologic conditions, comparative costs, and other related factors.

Formulation of the project has been based on the principle of accomplishing the sponsoring groups' flood prevention and irrigation objectives in such a manner as to achieve maximum net project benefits within the limitation of Soil Conservation Service standards and policies. Alternate plans have been compared, involving kinds of structures and degrees of protection. The selections have been made that gave the maximum net benefits without regard to relative Federal and non-Federal costs. Floodway construction on the Eastern and Consolidated East Branch Canals of the Salt River Project proved unfeasible.

The proposed measures will provide to local residents an acceptable degree of protection. Watershed residents will be able to make better use of their available resources without fear of seriously damaging floods. Urbanized growth will be sustained. Property values will increase through reduction in floodwater problems. Use of flood flows for irrigation purposes will be made possible.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Land treatment measures prescribed within this plan include only those measures and practices which contribute to program objectives, by reducing runoff and erosion and increasing the infiltration rates and waterholding capacities of the soils and contribute to better agricultural water management. All of these measures are considered essential to the successful functioning of the watershed project. The measures provide for the use of the land within its capabilities and treatment in accordance with its needs for sustained agricultural production. Table 1 shows the quantity to be installed within the project installation period and the estimated costs. The practices recommended for inclusion in this plan are conservation cropping systems, cover and green manure crops, crop residue use, irrigation water management, "rough tillage", land leveling, field ditches, irrigation pipelines, and ditch lining. The total cost of installing these measures, including the cost of technical assistance, is estimated to be $1,581,170.

Conservation cropping systems is the growing of crops in combination with needed cultural and management measures.

Cover and green manure crops is the use of grasses, legumes, or small grains in a cropping system primarily for summer or winter protection and/or the working into the soil these grasses and legumes while green or soon after maturity for soil improvement.

Crop residue use is the utilization of plant residues left in the 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 water management is the use and management of irrigation water according to a planned farm-irrigation system where all necessary control structures have been installed; where the quantity of water used for each irrigation is determined by the need of the crop and the water-holding capacity of the soil; where the water is applied at a rate and in such manner that the crops are able to use it efficiently; and where significant erosion does not occur.

"Rough tillage" is the practice of leaving the soil in a rough or cloddy condition for a period of 30 to 90 days to increase aeration, water penetration, micro-organism activity, and to prevent further soil structure breakdown.

Land leveling is the reshaping of the land surface to a planned grade to permit uniform distribution of irrigation water without erosion, or to provide necessary surface drainage.

Field ditch installation is the construction of permanent irrigation ditches leading from the source of supply to a field or fields within the farm distribution system.

Irrigation pipelines is the installation of pipe and other conduits in supply and distribution systems, including tile and perforated pipe used for subsurface irrigation.

Ditch lining is the installation of fixed linings of impervious materials in existing or newly constructed field irrigation ditches or canals.

No accelerated land treatment measures in the upland drainage areas of the watershed are proposed in this plan. The major portion of the land above the structures is state or Federally owned and restricted in grazing rights to years where sufficient rainfall has provided an adequate vegetative cover. Under this condition, it is felt by the various agencies concerned that the conservation objectives for this type land is at the present satisfactory.

Structural Measures

Structural measures to be installed are those needed to reduce damages caused by flooding and those needed for agricultural water management. Two floodwater retarding structures controlling 45 per cent of the watershed area, 9.2 miles of floodway construction, and one irrigation water turnout structure with gates are included in this plan. The total estimated cost of installing these measures is $4,574,900 and is shown in Table 2.

Floodwater retarding structural data are shown in Table 3 and floodway structural data are shown in Table 3A. Location of project works are shown in project map, Figure 5. Typical structural details are shown in Figures 2 and 3.

Rittenhouse Dam and Floodway

The Rittenhouse floodwater retarding structure will be constructed east of the Rittenhouse Auxiliary Air Field in Pinal County at an estimated installation cost of $1,365,400. This structure will provide floodwater protection from the one per cent event. It will have a total storage capacity of 3,770 acre-feet with 3,590 acre-feet allocated to floodwater storage and 180 acre-feet allocated to a 50-year accumulated sediment storage. The dam will be four miles long and have a maximum height of 22 feet. The maximum release rate from the 54-inch diameter reinforced concrete pipe principal spillway will be 313 c.f.s. (cubic feet per second) and will drain the runoff from the one per cent event in about ten days. The emergency spillway will be of earth construction and will be located around the south end of the embankment. Additional structural data are shown in Table 3.

A floodway 1.2 miles long will convey floodwater from the principal spillway in the Rittenhouse dam to the Vineyard Road dam. The capacity of this floodway is 313 c.f.s. The floodway will be lined with reinforced concrete with a stilling basin at the lower end. The estimated installation cost of this floodway is $408,400. Additional structural data are shown in Table 3A.

Vineyard Road Dam and Floodway

The Vineyard Road floodwater retarding structure will be constructed immediately east of Vineyard Road in Pinal County at an estimated installation cost of $1,673,600. The structure will provide floodwater protection from the one per cent event. It will have a total storage capacity of 4,310 acre-feet, with 4,110 acre-feet allocated to floodwater storage and 200 acre-feet allocated to a 50-year accumulated sediment storage. The dam will be five miles long and have a maximum height of 21 feet. The maximum release rate from the 6'x6' reinforced concrete culvert principal spillway will be 705 c.f.s. and will drain the runoff from the one per cent event in about ten days. The emergency spillway will be of earth construction and will be located around the south end of the embankment. Additional structural data are shown in Table 3.

A floodway 0.8 miles long will convey floodwaters from the 6'x6' reinforced concrete culvert principal spillway in the Vineyard Road dam to a reinforced concrete junction structure in the Powerline floodway in the Apache Junction-Gilbert Watershed. The capacity of this floodway is 705 c.f.s. The installation cost of this floodway is estimated to be $301,400. Additional structural data are shown in Table 3A.

Roosevelt Water Conservation District Floodway

The existing 7.2 miles of floodway within this watershed above the Roosevelt Water Conservation District Canal will be enlarged to collect and discharge floodwaters from the Powerline floodway plus the floodwaters from the uncontrolled area below the dams. This 7.2 miles of improvement of the floodway represents a portion of the total 14.6 miles of floodway improvement proposed in the two watersheds. The remaining 7.4 miles of floodway improvement is proposed within the Apache Junction-Gilbert Watershed. The estimated installation cost of constructing the 7.2 miles of floodway is $816,000. The floodway capacity varies from 4,133 c.f.s. to 4,633 c.f.s. These floodway improvements are designed to convey the one per cent event.

Measures for Irrigation

A reinforced concrete structure with gates is planned in the levee between the Roosevelt Water Conservation District floodway and canal below the junction with the Powerline floodway. This structure will permit floodwaters to be entered into the canal, when desired, and utilized for irrigation purposes. This structure will have a capacity of about 500 c.f.s. The total installation cost of the irrigation structure is estimated at $10,100. Additional structural data are shown in Table 3A.

EXPLANATION OF INSTALLATION COSTS

Land Treatment Measures

The total cost of land treatment measures were determined by unit costs of the various practices. These unit costs were derived from average costs for the state and adjusted to meet farming conditions as found in the watershed area. The land owners will bear the cost of applying land treatment measures on their own land.

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. Cost of technical assistance was likewise derived on the basis of what is being accomplished from regular appropriations of the Soil Conservation Service and what is needed under the accelerated program. Cost of technical assistance for accelerating the rate of installation of the land treatment measures will be met by P.L. 566 funds.

Structural Measures

The total installation cost of structural measures includes: (1) construction cost, (2) installation services, (3) the cost of land, easements, and rights-of-way, and (4) the cost of administering contracts.

Cost estimates for construction items shown in the engineer's estimate have been based on data found in the most recent Abstract of Contract data for flood prevention projects in Arizona. Cost data from recent pipe and irrigation catalogues have also been used for computing estimates. Contingency costs are based on additional costs that may be incurred as a result of detailed studies and reflect additional costs needed at the time of construction. These costs are estimated at 20 to 25 per cent. These two cost items, engineer's estimate and contingencies, make up the construction cost for each item as shown on Table 2 of this plan.

Installation service costs reflect time required to complete detailed engineering surveys, intensive geologic investigations, design, contracturl items, layout, supervision of construction and other services. Twenty per cent of the construction cost was used in determining engineering services, and other services were figured at ten per cent of the construction cost.

Land, easements and rights-of-way cost figures were furnished by the sponsors after reviewing available data with the Maricopa County Planning and Zoning Department and the State Land Department. Land on and surrounding the floodwater retarding structure locations is state-owned land. After a review of recent state sales in the area by the sponsors and the State Land Department, an average cost was determined. Private land along the Vineyard Road floodway was computed on the basis of going prices as estimated by the local sponsors. Value of agricultural land needed along the Roosevelt Water Conservation District floodway area was estimated and recognizes going price coupled with type and value of crops grown. Bridges, road relocations, telephone line relocation, land, easements, and rights-of-way costs outlined in this work plan have been determined by the sponsors and the Service and are mutually understood.

Administration of contracts is estimated at one per cent of the construction cost. They include legal, administrative, and clerical services incurred by the contracting local organization carrying out contracts.

Total cost of the project is estimated at $6,156,070 and will be shared as follows:

P.L. 566 funds	$3,763,160	61%
Other funds	2,392,910	39%

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 $23,610)

2. The construction cost of the Vineyard Road and Rittenhouse floodwater retarding structures and their floodways, and the Roosevelt Water Conservation District floodway. (Estimated $2,871,800)

3. The Federal share of the construction cost of the features for agricultural water management. (Estimated $3,850)

4. The cost of installation services for all structural measures. (Estimated $863,900)

The following costs will be borne by other funds:

1. The cost of installing land treatment measures on non-Federal land (Estimated $1,461,880). Such cost-sharing assistance as will be available under other programs will be utilized.

2. The cost of technical assistance for existing land treatment programs on non-Federal land. (Estimated $95,680)

3. The non-Federal share of the construction cost of the features for agricultural water management. (Estimated $3,850)

4. The cost of land, easements, and rights-of-way for structural measures. This item includes cost of bridges, and relocation of utilities. (Estimated $802,700)

5. The cost of administration of contracts. (Estimated $28,800)

Sharing of costs allocated to agricultural water management is based on P.L. 566 funds bearing 50 per cent of the construction cost and all costs of installation services.

The total P.L. 566 cost of this project is estimated to be $3,763,160, and other obligations estimated to be $2,392,910. Installation costs for each fiscal year during the installation period are shown as follows:

Fiscal Year	P.L. 566 Land Treatment Measures (Dollars)	P.L. 566 Structural Measures (Dollars)	Other Land Treatment Measures (Dollars)	Other Structural Measures (Dollars)	Total
1st Year	5,900	50,000	389,390	300,000	745,290
2nd Year	5,900	1,665,600	389,390	515,200	2,576,090
3rd Year	5,900	1,465,150	389,390	10,050	1,870,490
4th Year	5,910	558,800	389,390	10,100	964,200
TOTAL	23,610	3,739,550	1,557,560	835,350	6,156,070

EFFECTS OF WORKS OF IMPROVEMENT

The works of improvement proposed in this plan will substantially reduce floodwater damages and associated problems. Some 195 farmers cultivating approximately 55,790 acres valued at $74,230,000 will directly or indirectly be benefited through reduction of floodwater and sediment damages. Of the 16,070 acres of agricultural land inundated by the August 18 and 19, 1954 flood, approximately 13,120 acres will be flood free if this storm or one of a similar magnitude were to recur. Of the 4,490 acres of cultivated land flooded by the 1954 storm east of the Roosevelt Water Conservation District Canal, approximately 2,920 acres will receive no floodwater inundation after installation of project works. The cultivated lands west of the Roosevelt Water Conservation District Canal were inundated to the extent of 11,580 acres in 1954. After program works are installed an estimated 10,200 acres will be flood free considering a storm the size of 1954 or one of similar magnitude. Floodwater and sediment damages sustained to crop and pasture and associated agricultural aspects under present conditions will be reduced some 80 per cent under project conditions. The cost of cleaning out and repairing irrigation facilities will be reduced by approximately 76 per cent. This reduction, coupled with the protection afforded to the Salt River Project's and Roosevelt Water Conservation District's Canals, will have a meaningful effect on the efficient use of irrigation water which in the past have been disrupted for critical periods of time after flood flows have breached these canals. The need by farmers to relevel irrigated lands scoured by flood flows will also be greatly reduced.

Floodwater and sediment damages to existing roads, highways and other properties will be reduced an estimated 71 per cent. The program will also afford a high degree of protection to an estimated 790 homes expected to be built in the flood plain. Investors will be able to make better use of their available resources without fear of serious flood threats.

One significant effect of the proposed project will be the reduction of flood flows over the main access routes to Williams Air Force Base. This will reduce substantially the period of delays encountered on the access roads to the base.

Structural facilities to provide use of flood flows for irrigation purposes, as proposed in this plan, will make available 75 per cent of the estimated average annual yield of 3,220 acre-feet from the controlled area behind the floodwater retarding structures. This 2,415 acre-feet of water will help reduce overdraft of the underground supplies and is sufficient water to irrigate 520 acres of cultivated lands. The quality of this water will be improved by removal of most of the sediment.

PROJECT BENEFITS

Project benefits to accrue within this watershed, as a result of installing the proposed structural programs in both the Williams-Chandler and Apache Junction-Gilbert Watersheds, are estimated at $382,180. Those benefits which will accrue as a result of the installation of works of improvement in the Apache Junction-Gilbert Watershed are estimated at $50,930. Net project benefits attributable to structural measures, as proposed in the Williams-Chandler Watershed, is estimated at $326,050. Benefits from application of the land treatment measures on the cultivated land are estimated to be $5,200 annually.

Flood damage reduction benefits are estimated to be $285,050. Floodwater benefits are estimated to be $213,790 of this amount. Sediment benefits and reduction in flood plain scour is estimated to be $45,610. Reduction of indirect damages is estimated to be $25,650. Of the $213,790 floodwater benefits an estimated $164,620 will accrue to crops and pasture and other agricultural aspects.

In addition to the flood damage reduction benefits, the installation of irrigation facilities will accrue benefits estimated to be $41,000.

Benefits of a non-monetary nature are also expected to accrue. The proposed program will have a far reaching effect on the 195 farmers in the area. These farmers will be able to make more efficient use of irrigation water. Reduced delays in harvesting and transporting goods to market are expected benefits of this program. Developments of this nature should increase the demand for both semi-skilled and unskilled labor on the farm.

Some 10,300 people will realize greater ease of travel from their residences and places of business through reduced flooding of roads and highways. The significance of this type benefit is brought to light when examining the potential loss due to the inability of civilian and military personnel to travel to the Williams Air Force Base. Losses estimated at $50,000 per day will be greatly reduced through reduction in flood flows over access routes to the base. Perhaps a more significant effect is the reduced flood hazard to the country's defense system.

Property values will increase as a result of reducing the frequency of flooding. As a consequence, the area's tax base will increase and provide a more sound foundation for investment in the economy of the watershed.

COMPARISON OF BENEFITS AND COSTS

The amortized installation cost of planned works of improvement for this proposed project is $173,600. The estimated average annual cost of operating and maintaining these works of improvement is $23,700. The total average annual costs are $197,300, and the estimated average annual primary benefits are $326,050. The ratio of average annual benefits to the average annual costs is 1.6 to 1.0. Table 6 shows a comparison of benefits and costs for the structural measures proposed. Secondary benefits were not evaluated and hence not used in project justification.

PROJECT INSTALLATION

To assure the installation of measures outlined in this plan, groups of private, local, state, and Federal interests will be involved. These groups include farmers and ranchers, residents, the Flood Control District of Maricopa County, the Pinal County Supervisors, the East Maricopa Soil Conservation District, the Queen Creek Soil Conservation District, City of Chandler, Williams Air Force Base, State Land Department, Salt River Valley Water Users' Association, Roosevelt Water Conservation District, United States Bureau of Land Management, United States Forest Service, United States Bureau of Reclamation, and the United States Soil Conservation Service.

The local field office of the Bureau of Land Management, United States Department of the Interior, has concurred in the features of this plan relating to watershed lands under their jurisdiction. The Forest Service, United States Department of Agriculture, has assisted in the preparation of the phases of the work plan for all lands under their jurisdiction.

Responsibilities for carrying out the provisions of this work plan are assigned as follows:

Land Treatment Measures

Queen Creek Soil Conservation District and East Maricopa Soil Conservation District will:

1. Provide assistance to land owners and operators to assure the application of land treatment measures shown in Table 1.

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

Bureau of Land Management will:

1. Continue its existing management program which it administers.

Forest Service will:

1. Continue its program of controlled use adhering to accepted conservation practices for utilization of natural resources.

Soil Conservation Service will:

1. Furnish technical assistance through the Queen Creek and the East Maricopa Soil Conservation Districts to private land owners for the application of land treatment measures outlined in this work plan.

Agricultural Conservation Program Service will:

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

Structural Measures

The local responsibilities for installing, operating, and maintaining structural works of improvement will be assumed by the Flood Control District of Maricopa County.

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 land owners or water users have acquired the necessary water rights.

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, and specifications of structural works of improvement for flood prevention and agricultural water management, 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 to the end that united effort and coordinated action will produce effective results.

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. It is planned to complete construction in four years. Land treatment measures shown in Table 1 will be applied concurrently with the installation of structural measures.

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 investigations, and engineering design will be made for the Vineyard Road and Rittenhouse dams and floodways. Work will be started to acquire the necessary land, easements, and rights-of-way.

Second year--the application of land treatment measures will be continued. The Vineyard Road dam and floodway will be built under contract after all land, easements, and rights-of-way have been acquired for the construction unit.

Third year--engineering field surveys, geologic foundation investigations, and engineering design will be made for the Roosevelt Water Conservation District floodway with its agricultural water management features. Application of land treatment measures will continue. The Rittenhouse floodway and floodwater retarding structure will be constructed.

Fourth year--the application of land treatment measures will be completed. The Roosevelt Water Conservation District floodway will be built.

FINANCING PROJECT INSTALLATION

The Maricopa Flood Control District 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 power to acquire property by eminent domain or otherwise and issue bonds.

The boundaries of the District are contiguous with those of the county. However, facilities may be acquired, constructed, and maintained outside the boundaries of the county for the benefit of the District.

The District has analyzed its financial needs in consideration of the scheduled installation of works of improvement so that funds will be available when needed through cash resources or tax and assessment levies. Taxes are 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 sponsor's 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, 83rd Congress, 68 Stat. 666), as amended.

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 under the Agricultural Conservation Program.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Farmers cooperating with the Queen Creek Soil Conservation District and the East Maricopa Soil Conservation District will be responsible for maintenance of land treatment measures.

Structural Measures

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

A joint inspection of structural measures will be made by a representative(s) designated by the sponsors and by representatives of the Soil Conservation Service annually (about October 1) or after each major flood, to determine if and what maintenance work is necessary to insure their proper functioning.

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

Total annual operation and maintenance cost of structural measures is estimated to be $23,700.

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 and will begin to release water as soon as the floodwaters reach them.

2. The gates in the turnout structure, when closed, will keep floodwaters flowing down the Roosevelt Water Conservation District floodway to Queen Creek. By opening the gate, floodwaters will flow into the canal and will be utilized for irrigation purposes.

Maintenance--

1. Keep gate in good mechanical condition and free from debris and sediment accumulation.

2. Regrade faces of earth embankment.

3. Repair damage to emergency spillways.

4. Remove trash and debris from principal spillway inlets.

5. Repair damage to floodways and stilling basins.

6. Maintain drainage gradient through reservoir basins.

TABLE 1 - ESTIMATED INSTALLATION COST

Williams-Chandler Watershed, Arizona

Installation Cost Item	Unit	Number	Estimated Costs (Dollars) 1/		
				Non-Federal Land	
			P.L. 566	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cons. Cropping Systems	Acres	38,588		38,600	38,600
Cover & Green Manure Crops	Acres	6,532		130,640	130,640
Crop Residue Use	Acres	50,000		86,480	86,480
Irrig. Water Management	Acres	15,568		15,560	15,560
Rough Tillage	Acres	12,160		48,640	48,640
Land Leveling	Acres	9,120		638,400	638,400
Ditch Lining	Miles	55.6		333,600	333,600
Field Ditches	Miles	9.2		520	520
Irrig. Pipelines	L.F.	24,204		169,440	169,440
Technical Assistance			23,610	95,680	119,290
TOTAL LAND TREATMENT			23,610	1,557,560	1,581,170
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	Ea.	2	1,880,900	0	1,880,900
Irrigation Features	No.	1	3,850	3,850	7,700
Floodway Construction	Miles	9.2	990,900	0	990,900
Subtotal-Construction			2,875,650	3,850	2,879,500
Installation Services					
Soil Conservation Service					
Engineering Services			575,900	0	575,900
Other			288,000	0	288,000
Subtotal - Installation Services			863,900	0	863,900
Other Costs					
Land, Easements, R/W			0	802,700	802,700
Administration of Contracts			0	28,800	28,800
Subtotal - Other			0	831,500	831,500
TOTAL STRUCTURAL MEASURES			3,739,550	835,350	4,574,900
TOTAL PROJECT			3,763,160	2,392,910	6,156,070

1/ Price Base - 1962 prices.

January 1963

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

(at time of Work Plan preparation)

Williams-Chandler Watershed, Arizona

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
NON-FEDERAL			
Cons. Cropping System	Acres	9,454	9,450
Cover & Green Manure Crops	Acres	2,388	47,760
Crop Residue Use	Acres	17,549	26,320
Irrigation Water Mgmt.	Acres	5,483	5,480
Rough Tillage	Acres	2,765	11,060
Land Leveling	Acres	36,627	2,563,890
Field Ditches	Miles	34	1,900
Irrig. Pipelines	L.F.	102,854	719,980
Ditch Lining	Miles	217	1,302,000
Technical Assistance	Dollars		257,240
FEDERAL (Tonto National Forest)			
Fences	Miles	7	8,400
Spring Development		3	900
Technical Assistance			920
TOTAL	xxx	xxx	4,955,300

1/ Price Base - 1962 prices.

January 1963

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Williams-Chandler Watershed, Arizona
(Dollars) 1/

Structure Name	Installation Cost--P.L. 566 Funds				Installation Cost - Other Funds				Total Inst. Cost
	Construction	Instal. Services Engineering	Instal. Services Other	Total PL 566 Costs	Constr.	Adm. of Contract	Ease. R/W	Total Other	
FLOODWATER RETARDING STRUCTURES									
Rittenhouse	853,200	170,700	85,300	1,109,200	0	8,500	247,700	256,200	1,365,400
Vineyard Road	1,027,700	205,500	102,800	1,336,000	0	10,300	327,300	337,600	1,673,600
FLOODWAYS									
Rittenhouse	310,400	62,100	31,000	403,500	0	3,100	1,800	4,900	408,400
Vineyard Road	224,000	44,800	22,400	291,200	0	2,200	8,000	10,200	301,400
Roosevelt Water Conservation District	456,500	91,300	45,700	593,500	0	4,600	217,900	222,500	816,000
IRRIGATION FEATURES	3,850	1,500	800	6,150	3,850	100	0	3,950	10,100
GRAND TOTAL	2,875,650	575,900	288,000	3,739,550	3,850	28,800	802,700	835,350	4,574,900

1/ Price Base - 1962 prices

January 1963

TABLE 2A - COST ALLOCATION AND COST-SHARING SUMMARY

Williams-Chandler Watershed, Arizona

(Dollars)1/

Item	PURPOSE Flood Prevention	Irrigation	Total
	COST ALLOCATION		
Single Purpose	4,564,800	10,100	4,574,900
TOTAL	4,564,800	10,100	4,574,900
	COST SHARING		
P.L. 566	3,733,400	6,150	3,739,550
Other	831,400	3,950	835,350
TOTALS	4,564,800	10,100	4,574,900

1/ Price Base - 1962 Prices.

January 1963

TABLE 3 - STRUCTURE DATA

FLOODWATER RETARDING STRUCTURES

Williams-Chandler Watershed, Arizona

ITEM	UNIT	STRUCTURE Rittenhouse	Vineyard Road	TOTAL
Drainage Area	Sq. Mi.	51.3	57.8	109.1
Storage Capacity				
Sediment	Ac. Ft.	180	200	380
Floodwater	Ac. Ft.	3590	4110	7700
Total	Ac. Ft.	3770	4310	8080
Surface Area				
Sediment Pool	Acre	80	110	190
Floodwater Pool	Acre	600	730	1330
Volume of Fill	Cu.Yds.	883,000	1,035,000	1,918,000
Elevation Top of Dam	Ft.	1586.0	1542.0	xxx
Maximum Height of Dam	Ft.	22.0	21.0	xxx
Emergency Spillway				
Crest Elevation	Ft.	1580.0	1536.0	xxx
Bottom Width 1/	Ft.	700	600	xxx
Type		earth	earth	xxx
Percent Chance of Use		1	1	xxx
Av. Curve No. - Condition II		81.9	82.2	xxx
Emergency Spillway Hydrograph				
Storm Rainfall (6 Hr.)	In.	3.5	3.5	xxx
Storm Runoff	In.	0.68	0.62	xxx
Velocity of Flow (Vc) 2/	Ft/Sec.	--	--	xxx
Discharge Rate 2/	C.F.S.	--	--	xxx
Max. w.s. elevation 2/	Ft.	1576.3	1532.4	xxx
Freeboard Hydrograph				
Storm Rainfall (6 Hr.)	In.	7.0	7.0	xxx
Storm Runoff	In.	2.27	2.12	xxx
Velocity of Flow (Vc) 2/	Ft/Sec.	4.3	4.5	xxx
Discharge Rate 2/	c.f.s.	1670	1720	xxx
Max. w.s. elevation 2/	Ft.	1582.0	1538.2	xxx
Principal Spillway				
Capacity at Emergency Spillway	c.f.s.	313	705	xxx
Time to Release	Days	10	10	xxx
Capacity Equivalents				
Sediment Volume	In.	0.07	0.07	xxx
Detention Volume	In.	1.31	1.33	xxx
Spillway Storage	In.	1.66	1.87	xxx
Class of Structure 3/		B	B	xxx

1/ Greater than minimum criteria.
2/ Maximum during passage of hydrograph.
3/ Storm rainfalls selected for emergency spillway design data are between the B and C criteria established for class of structure, as stated in Engineering Memo 27.

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TABLE 3A - STRUCTURE DATA
FLOODWAY STABILIZATION
Williams-Chandler Watershed, Arizona

Channel Designation	Sta. Numbering for Reach: Sta. Ft.	Sta. Ft.	Type Channel	R/W Width Feet	Design Storm Frequency %	Required Channel Capacity c.f.s.	Av. Bottom Width Feet	Av. Side Slope Hor.--Vert.1/	Av. Depth Channel Feet	Av. Fall Ft/Ft.	Av. Vel. in Channel Ft/Sec.	Vol. of Excavation Cu. Yd.	Vol. of Concrete Cu. Yds.
Rittenhouse	0+70	63+70	R/C	50	1	313	7.5	Vert.	5.25	0.0060	11.5	20,000	2,650
Floodway	63+70	63+90	Stilling Basin			313	7.5	Vert.					40
Vineyard	11+00	55+30	R/C	60	1	705	6.0	1½:1	5.25	0.0060	13.9	13,000	2,040
Road	55+30		R/C structure at junction with Powerline Floodway										60
Roosevelt	634+00	845+00	earth	150	1	4133	100	3:1	8.5	0.0005	4.0	464,000	
Water							(Embankment 66,700 cu.yds.)						
Conserva-	(Maximum structure release rates					1033	100	3:1	3.8	0.0005	2.5)		
tion	634+00	634+12	R/C	Turnout structure with gates installed in levee for agr. water mgmt.									
District	845+00	1014+00	earth	150	1	4633	110	3:1	8.5	0.0005	4.0	368,000	
Floodway	1014+00	Floodway enters Queen Creek channel					(Embankment 53,300 cu. yds.)						

1/ Shape of floodway may be altered during detailed design phase if found advantageous to the Service.

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TABLE 4 - ANNUAL COST

Williams-Chandler Watershed, Arizona
(Dollars)1/

Evaluation Unit	Amortization of Installation Cost 2/	Operation and Maintenance Cost	Total
Floodwater Retarding Structures and Floodways	173,600	23,700	197,300

1/ Price Base - 1962 prices

2/ Amortized at 2 7/8% for 50 years.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Williams-Chandler Watershed, Arizona

(Dollars) 1/

ITEM	ESTIMATED AVERAGE ANNUAL DAMAGE Without Project	With Project	DAMAGE REDUCTION BENEFIT
FLOODWATER			
Crop and Pasture	193,850	37,170	156,680
Other Agriculture	54,160	13,040	41,120
Non-Agricultural (residential, retail-commercial, roads, etc.)	82,900	24,040	58,860
Subtotal	330,910	74,250	256,660
SEDIMENT			
Crop and Pasture	35,200	8,470	26,730
Other Agriculture	24,370	5,870	18,500
Non-Agricultural	10,240	2,970	7,270
Subtotal	69,810	17,310	52,500
EROSION			
Flood Plain Scour	2,710	650	2,060
Subtotal	2,710	650	2,060
INDIRECT	41,050	11,090	29,960
TOTAL	444,480	103,300	341,180
Benefits allocated to structural measures in Apache Junction-Gilbert Watershed 2/	xxx	xxx	50,930
TOTAL NET FLOOD PREVENTION BENEFITS	xxx	xxx	290,250

1/ Price Base - 1962 prices

2/ Benefits accruing in the Williams-Chandler flood plain but attributable to structural measures in Apache Junction-Gilbert Watershed.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Williams-Chandler Watershed, Arizona

(Dollars) 1/

Evaluation Unit	Average Annual Benefits: Flood Prevention Damage Reduction	Average Annual Benefits: Ag. Water Management Irrigation	Total	Average Annual Cost	Benefit Cost Ratio
Floodwater Retarding Structures and Floodways	285,050 2/	41,000	326,050	197,300	1.6:1.0

1/ Price Base - 1962 prices

2/ In addition, it is estimated that Land Treatment Measures will provide flood damage reduction benefits of $5,200 annually.

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TABLE 7 - CONSTRUCTION UNITS

Williams-Chandler Watershed, Arizona
(Dollars)1/

Measures in Construction Unit	Annual Benefits	Annual Costs
Vineyard Road and Rittenhouse Structures and Corresponding Floodways	281,370	152,500
Roosevelt Water Conservation District Floodway	44,680	44,800

1/ Price Base - 1962 prices

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WATERSHED WORK PLAN

Williams-Chandler Watershed

INVESTIGATIONS AND ANALYSES

INVESTIGATIONS & ANALYSES

LAND USE AND TREATMENT

Land treatment measures to be applied during the installation period of the project were based on soil surveys, technical guide data, needs, and past accomplishments of the going program in and around the flood plain area. Cost of technical assistance was based on average work performance time for each of the particular measures to be applied. The cost of accelerated technical assistance to be borne by P.L. 566 funds was determined by subtracting the cost of the technical assistance available within the watershed under the going programs from the estimated total cost of technical assistance.

Farm operators in cooperation with the Queen Creek and East Maricopa Soil Conservation Districts are at the present time carrying out a substantial land treatment program under the present adverse conditions. They have expressed, however, a desire to intensify this program in line with the proposed flood control features.

HYDROLOGIC INVESTIGATIONS

Basic Data

There are no stream gaging stations within the watershed, however, there are ten years of runoff records available for the Whitlow Dam site on Queen Creek, five miles southeast of the watershed. These records on Queen Creek cover a period from 1949 through 1958, which is the time the Whitlow Dam project construction began.

Due to the absence of runoff data, the ten years of Queen Creek runoff records were used in computing the flood volumes for this watershed.

Weather Bureau precipitation data was recorded from the following daily recording stations:

Name	Years of Record	Location from Watershed
Phoenix	45	25 miles west
Ashurst-Hayden	5	20 miles southeast
Chandler	11	West boundary
Chandler-Heights	16	4 miles south
Pinal Ranch	66	25 miles east
Sacaton	52	15 miles south
Stewart Mountain	21	10 miles north
Superior	40	20 miles east
Superstition Mountain	13	Near north boundary
Falcon Field	16	10 miles north
Florence	48	15 miles southeast
Granite Reef Dam	63	15 miles north
Mesa	63	7 miles north of west boundary
Mormon Flat	36	15 miles northeast

Hourly recording stations located at Superstition Mountain and Phoenix have ten years and 39 years of record, respectively.

Soil groupings and on-site range conditions were determined for various areas on the watershed.

Flood Volume Determinations

A determination was made of frequencies of the 24-hour, and monthly point precipitation values for each of the stations. Frequencies of the two-hour and six-hour precipitation values were determined from the Phoenix and Superstition Mountain hourly recording stations.

Isohyets were drawn of six known events and an average ratio of area to point rainfall was computed for each storm event. This average was used to determine a curve for the area to point rainfall ratio which was compared to figure 3.21-4 in the National Engineering Handbook, Sec. 4, Supplement A (Hydrology Guide).

Design point rainfall values at various frequencies were computed using the average rainfall of the Mesa, Superstition Mountain, Granite Reef, Florence, and Superior Stations as the areal rainfall and thence using the curve for ratios of area to point rainfall in computing the design point rainfall values. These values were compared to Weather Bureau technical papers #28 and #25 values, which agreed reasonably well. These values were also compared to John H. Dorroh, Jr's. "Southwest Runoff Determinations" and to maximum known point rainfall events in Arizona and compared favorably. For purposes of this study, because of the noticeable difference in precipitation characteristics between the Superstition Mountains and the irrigated area, the watershed was divided into two zones. Different daily design rainfall values for the two zones were determined.

A rainfall distribution curve was prepared showing the ratios to the six-hour event of durations from zero to 24 hours. These curves were used in subsequent studies in volume duration as shown in Soil Conservation Service Technical Release #10, dated March 30, 1959. Volumes of runoff were computed using the methodology from Secs. 3.7 to 3.10 in the Hydrology Guide.

Composite curve numbers for the Queen Creek drainage area above Whitlow Dam site were computed for eleven known runoff events. Areal rainfall for these events was determined by correlating the Pinal Ranch weather station data with the runoff data at Whitlow Dam site. On the basis of this computation, a 34 per cent transmission loss was determined for volume computations. This value was less than that shown in figure 3.19-1 of the Hydrology Guide and was used in this study.

After making volume corrections for transmission losses up to the 24-hour duration, volumes were determined for durations from one day to 90 days using George Watt's determinations for Queen Creek outlined in his paper entitled, "Development for Runoff Duration Curves". The resultant volumes were compared with the results of a similar study made by the Central Technical Unit in Washington. Volumes determined from George Watt's paper were, therefore, used in preparing volume-duration curves. Storage detention requirements were computed on the basis of methodology shown in Technical Release #10. Comparisons of storage detention volumes were made to those computed for Florence, Magma, and Frye Creek Watersheds and compared favorably.

The 24-hour duration design rainfall data was used in determining a frequency-volume relationship to present areas flooded. Volumes were computed by procedures shown in Secs. 3.7 to 3.10 of the Hydrology Guide with appropriate allowances made for the transmission losses. These volumes were divided by the acres of flooded cultivated area to obtain an average depth of flooding. These depths were compared to the 1954 and 1959 flood depths obtained by interviews and were found to compare favorably.

Volumes for two reaches, one above the Roosevelt Water Conservation District Canal and the other reach between the Roosevelt Water Conservation District and Eastern Canals, were computed on a frequency basis, taking into account the capacity of the existing floodway above the Roosevelt Water Conservation District Canal to divert floodwater south out of this watershed. Also taken into account was the capacity of county road ditches to contain part of the flood flows before flood damages begin.

The volumes in the reach above the Roosevelt Water Conservation District Canal were computed as follows:

1. Seven cross-sections were taken of road ditches in the reach above the Roosevelt Water Conservation District Canal and the capacities in c.f.s. determined.

2. The capacities were averaged and a point rainfall computed using the methodology in Sec. 3.16 of the Hydrology Guide.

3. The frequency where flood damages began in this reach was taken at the frequency of this point rainfall.

4. Volumes for the reach were determined by subtracting the volumes generated at the frequency determined in the previous step from the total volume generated for the reach.

Volumes for the reach below the Roosevelt Water Conservation District Canal were computed as follows:

1. Cross-sections were taken of the existing Roosevelt Water Conservation District floodway at 0.2 mile intervals and the capacities in c.f.s. were determined at each cross-section and plotted on graph paper.

2. Various frequency events of point rainfall were used in computing a family of curves of frequencies of peak discharges along the Roosevelt Water Conservation District floodway and these curves were then plotted on the graph prepared in step (1).

3. Frequency of protection of the existing Roosevelt Water Conservation District floodway was determined by noting which frequency-discharge curve came closest to representing the minimum capacity of the floodway.

4. Twenty cross-sections were taken of road ditches in this reach between the Roosevelt Water Conservation District Canal and the Eastern Canal and capacities in c.f.s. were determined.

5. Frequency of protection of road ditches was determined by the same method as shown in steps (2) and (3) for the first reach. The point where damages began in this reach was taken at this frequency.

6. Volumes for this reach were determined by subtracting the volumes generated at the frequencies determined in steps (3) and (5) for road ditches and the existing floodway from the total volumes generated for both reaches, plus the volumes diverted into this watershed from the Apache Junction-Gilbert Watershed.

Volumes of runoff for the emergency spillway and freeboard hydrographs were determined by the procedure shown in Sec. 3.21 of the Hydrology Guide and by the criteria shown in Soil Conservation Service Memorandum #27, dated March 14, 1958.

Hydrograph Development

Field surveys were made to determine 15 channel cross-sections and channel slopes. Seven channel cross-sections were obtained of a wash originating in the Superstition Mountains in the headwaters of the proposed Vineyard Road floodwater retarding structure. Eight channel cross-sections were taken of a wash originating in the Superstition Mountains above the proposed Rittenhouse floodwater retarding structure. Four of these cross-sections were taken on the alluvial fan where many poorly defined channels exist. A 1000-foot wide sample cross-section was taken of this area and applied to the entire width of the fan area in order to obtain a composite cross-section for the drainage area under consideration. Times of concentration were determined by the following steps:

1. Computation of a stage-discharge curve for each cross-section.

2. By successive trials, a time of concentration for each reach was determined so that the velocity used in finding the time of concentration coincided with the velocity for the peak discharge on the stage-discharge curve.

3. For several reaches of channel, the times of concentration were summated from reach to reach so that a total time of concentration was arrived at for the point in question.

The principal spillway hydrograph was determined by computing the c.f.s. inflow at one-hour intervals from zero to 24 hours; at one-day intervals from one day to ten days, and ten-day intervals from ten to 90 days. The inflow was computed by converting the inches of runoff from zero to 90 days to c.f.s. from the previously computed volumes of floodwater.

After determining the times of concentration, the emergency spillway and freeboard hydrographs were developed by: (1) referring to figure 3.21-2 of the Hydrology Guide for the point six-hour rainfall and modifying this by the criteria in Soil Conservation Service Memorandum #27 to the class structure required, (2) this rainfall was modified by the area-depth relationship curve labeled "Dorroh" in figure 3.21-4 of the Hydrology Guide. The hydrographs were derived by the method shown in Sec. 3.21-1 of the Hydrology Guide; also using tables 3.21-15 to 3.21-71 and figures 3.21-7 to 3.21-8.

WATER YIELD DETERMINATION FOR AGRICULTURAL WATER MANAGEMENT

Average annual yield was determined from map entitled "AVERAGE ANNUAL WATER YIELDS, ARIZONA" published July 1951. This compared favorably to the average annual yield for ten years of record at the Whitlow Ranch gaging station on Queen Creek.

Amount of yield available for irrigation purposes at the Southern and Roosevelt Water Conservation District Canals at various design discharges was determined by using a study of the Whitlow Ranch gaging station by the Central Technical Unit in Washington in relation to probability of volume-duration flows. The discharge at various frequencies was determined by using this study in preparation of an inflow hydrograph and routing this hydrograph through the floodwater retarding structures involved. The subsequent yield available at these outflow discharges was computed by determining the amount of yield that exceeds these assumed various design discharges of the outflow structure. The various design discharges were related to per cent of yield available for irrigation purposes.

SEDIMENT INVESTIGATIONS

Sedimentation Surveys

Investigations included sedimentation surveys of five stock ponds, three of which are outside, but close to this watershed. The other two ponds are located in the central portion of the watershed. Stock ponds were selected to represent varied topographic and soil conditions. The vegetative cover on the drainage area of these stock ponds is poor as is the general condition for the entire watershed. Sedimentation rates for these ponds ranged from 0.04 to 0.32 acre-feet per square mile per year.

The three ponds located outside of the watershed are in terrain characteristic of the Mountains Unit in the upper part of the watershed. Sedimentation rates for these ponds ranged from 0.08 to 0.32 acre-feet per square mile per year.

The other two stock ponds are located within the Valley Slopes Unit. Sedimentation rates for these ponds ranged from 0.04 to 0.05 acre-feet per square mile per year.

Sediment Source Areas

Investigation shows that the major source of sediment is from all areas above the proposed dam sites. The principal soil loss is through sheet erosion with gully erosion being of minor importance. Other sources of sediment are erosion of canal banks and farm and county roads.

Sediment Storage Requirements

Sediment storage requirements for the floodwater retarding structures are based on stock pond surveys, study of sediment sources, and factors that influence sediment yield. The most important factor is the difference between watershed size of the stock ponds sampled and the proposed structures. The larger watershed affords a greater opportunity for sediment deposition before it reaches the reservoir basin. This deposition occurs in the channels and at the mouths of the discontinuous drainageways that are characteristic of the alluvial slopes above the proposed reservoir basins. Based on these considerations, it is estimated that sediment will accumulate at the rate of 0.07 acre-feet per square mile per year in the Rittenhouse and Vineyard Road structures. Sediment storage requirements for the 50-year period are estimated to be 180 acre-feet for Rittenhouse and 200 acre-feet for Vineyard Road structure.

GEOLOGIC INVESTIGATIONS

Foundation and Borrow

To evaluate the general feasibility of the two dam sites, a preliminary investigation was made to determine foundation conditions and nature of available borrow material. The investigation included analysis of test pit and drill hole logs and surface studies of watershed slopes, channel banks, and rock outcrops. Sixteen holes were drilled along the centerline of the proposed Rittenhouse floodwater retarding structure to depths of ten to 16 feet and 18 test pits were dug to depths of ten to 12 feet. Nineteen holes were drilled along the centerline of the proposed Vineyard Road floodwater retarding structure to depths of 17 to 25 feet and 13 test pits were dug to a depth of ten feet.

The investigation shows that both dam sites are underlain by somewhat compressible sands and silts a few feet in thickness over a more compact silty sand or a hard siltstone. In some cases a compact sandy gravel is present which becomes more prevalent toward the southern end of the Rittenhouse floodwater retarding structure.

The soils available for construction range from silty sand (SM) to sandy silt (ML). Poorly graded sand (SP) was found in each of the numerous washes and small quantities of sandy clay (CL) and sandy gravel (GP) were also found.

Both structures will have emergency spillways cut into erosive sandy silt and silty sand.

Groundwater levels reported in the few wells in the vicinity of the structures range from 180 to 265 feet deep. No groundwater was encountered during the investigation and at these depths will not be a problem.

Conclusions

The dam sites are geologically feasible. Results of the investigation show that geologic problems at the site can be overcome with proper design and construction.

The foundations of the dams, in places, are not competent to support the loads to be imposed without excessive settlement and the foundation materials to depths of a few feet will need to be remolded.

Borrow materials are available within the reservoir areas in sufficient quantities for construction of the proposed dams.

Additional geologic investigations must be made prior to the preparation of final structural design. These investigations will include in-place testing of foundations and additional borings to adequately outline the borrow areas and correlate foundation materials. Undisturbed samples of materials will be tested to provide information for design criteria.

FLOODWAY STABILITY

A soils study of floodways from the proposed dams and the floodway behind the Roosevelt Water Conservation District Canal shows that stability problems will exist. Nineteen backhoe pits were dug along the centerline of the Roosevelt Water Conservation District floodway. The investigation of the Rittenhouse floodway was by examination of channel banks and surface indications.

Soils in the Vineyard Road floodway vary from loose sandy silts to compact sandy clay. The average fall is 0.006 ft/ft. With this grade and type of soil it was determined that erosive velocities would exist.

Soils in the Rittenhouse floodway were moderately compact sandy silt and sandy clay with an average grade of 0.006 ft/ft. Because of the steep grade and the type of soil it was determined that erosive velocities would exist.

The use of vegetative cover to control erosion in the Vineyard Road and Rittenhouse floodways would be ineffective. Vegetation could not be established and maintained due to insufficient amounts of water when the floodway is not in use. Even with good cover conditions in the floodways erosive velocities would still exist. Stabilization of the floodways by structural means would allow the flood flows to meander in the channels and cause erosion of the floodway banks. This would require protection of the side slopes of the floodways by riprap or some other means and also require a considerable amount of maintenance. After considering the alternatives it was determined that the Vineyard Road floodway and the Rittenhouse floodway should be lined.

Soils in the Roosevelt Water Conservation District floodway range from loose silty sand to compact sandy clay. The average fall is 0.0005 ft/ft.

Although the flood peak velocities will be moderately high they will be of such short duration that reshaping and compaction of the floodway banks combined with a vegetative cover supported by supplemental irrigation from the adjacent canal will be sufficient and the floodway will remain unlined.

ENGINEERING INVESTIGATIONS

Maps

Most of the watershed area is covered by 7½-minute United States Geological Survey maps with contour intervals of ten to 20 feet. These maps were most helpful during the planning of the watershed. Stage highway planning maps of the area were obtained and used.

Surveys

Topographic maps were prepared with four-foot contour intervals and horizontal scale of one-inch = 400 feet of the floodwater retarding structure sites and reservoir areas. Centerline profiles were surveyed for each structure and used as a basis for computing volumes of embankment. Centerline profiles and cross-sections were surveyed on the floodways and used as a basis for design.

Design Criteria

The floodwater retarding structures were designed to contain the one per cent event. Additional capacity was provided to contain a 50-year accumulation of sediment. The principal spillways were designed to release the flood volume of the one per cent storm, flood-routed through the structures in series, without use of the emergency spillways.

Principal Spillways--ungated reinforced concrete conduits through the dams with inlet and outlet structures will release the impounded floodwaters from the dams into the floodway channels in about ten days.

Emergency Spillways--design is in accordance with Soil Conservation Service standards for floodwater retarding structures in moderately hazardous situations. The widths of the emergency spillways were determined by routing the design storm hydrographs through the spillways at a safe velocity. Depths of freeboard were determined by routing the design hydrographs through the emergency spillways without overtopping the dams. (See Table 3)

Earth Embankment--preliminary 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 of the dam sites. Final design will be based on the results of detailed subsurface investigations to be accomplished during early construction planning.

Floodways--these are designed to carry the maximum outflows from the principal spillways of the Rittenhouse and Vineyard Road floodwater retarding structures and will be lined with reinforced concrete throughout their lengths.

The floodway above the Roosevelt Water Conservation District's Canal will be designed for the capacity of a one per cent event on the uncontrolled area below the floodwater retarding structures plus the maximum release rate from the structures. This design criteria was selected after analysis of the ratio of incremental benefits over incremental costs. This floodway will be enlarged, constructed on a uniform grade, and the downstream levee reshaped to a three-horizontal to one-vertical side slope and faced with a compacted lining of selected borrow material, and sprigged to Coastal bermuda grass. Irrigation water to establish and maintain this grass is available from the adjacent irrigation canal.

Alternate Studies

The disposal of floodwaters from the Rittenhouse and Vineyard Road floodwater retarding structures, as well as the floodwater from the Powerline floodwater retarding structure in the Apache Junction-Gilbert Watershed, was considered as a part of a flood control system to discharge water into Queen Creek.

Consideration was given to designing the floodwater retarding structures with a 30-day average release rate. This would increase the height of the dams to provide for additional storage and thus reduce the size of the floodways. A comparison of costs showed that embankment costs increased more than the floodway costs were reduced; consequently, this alternate plan was eliminated from further consideration.

Queen Creek, which forms the south boundary of Williams-Chandler Watershed, is a sandy wash on the high part of the alluvial fan. Much of the channel is a man-made channel and conveys infrequent flood flows. This channel is not considered suitable from a stability standpoint to be used as an outlet for relatively clear water without extensive stabilization measures. The cost of stabilizing the Queen Creek channel with rock riprap and bottom stabilizers was more than the cost of the floodway that is now included in the project and was given no further consideration.

A study was made of a plan for the safe disposal of floodwater by artificial groundwater recharge utilizing open pits dug into the underlying gravel aquifer in sections 20 and 21 near Queen Creek. Water from the floodwater retarding structures would be conveyed in an earth channel and distributed by reinforced concrete drop structures and control pipes into a system of eight open pits. The maximum release rate from the structures was used for a design inflow into the recharge system. The total cost of this artificial groundwater recharge system exceeded the cost of the Powerline floodway and, therefore, is not included in this plan.

Cost Estimates

Costs are estimated on quantities of each item involved and unit costs are based on prevailing construction costs in the area. Some of the factors considered in estimating quantities and costs are outlined below.

Clearing and grubbing--the dam site, borrow and emergency spillway area will be cleared of scattered desert trees and shrubs. A unit price per acre was used to determine the total clearing and grubbing costs.

Foundation preparation--most of the vegetation is shallow rooted and very little or no organic matter is present in the soil. Volume of excavation for foundation preparation gave consideration to reworking foundation materials as needed and this cost is included.

Earth embankment--fill materials are available upstream from the proposed structures and can be acquired along the entire length of the dam. No overhaul costs were considered. Volume of embankment was computed by the average end area method, based on centerline height of the dam. Five per cent of the volume was included to allow for settlement of the dam and foundation.

Concrete--all concrete placed in risers, principal spillways, floodways and stilling basins will be steel reinforced and will require forming. Unit cost based on volume of concrete was used to determine the total cost of concrete structures. The cost of reinforcing steel, forming and placing of concrete was included in the unit price.

Irrigation features--the costs associated with irrigation water management are those costs required for the reinforced concrete turnout structure and gates needed to properly manage and utilize floodwater for irrigation purposes.

Land, easements, and rights-of-way--present land values were used for computing rights-of-way costs. Cost estimates for the relocation of utilities, road and bridge construction are included in this item.

Operation and maintenance--costs of operating and maintaining the structural measures, as proposed in this plan, are based on California Watershed Memo #6, dated August 15, 1958, and adjusted to meet local conditions.

ECONOMIC INVESTIGATIONS

Basic data relative to the evaluation of floodwater and sediment damages and potential benefits from works of improvement was obtained from land owners, agricultural technicians, and research bulletins published by the various Federal and State agencies. This information was supplemented with historical data pertaining to flood damages and the frequency of such damages from newspapers and other local sources. Long-term projected prices developed by the Agricultural Research Service and Agricultural Marketing Service were used in estimating monetary benefits.

Floodwater and sediment damages to the agricultural economy of the watershed were obtained through interviews with farmers, agricultural technicians and other local sources. The basis for establishing the magnitude of flood effects on this agricultural economy was a storm which occurred August 18 and 19, 1954. This storm was of a large magnitude and most vivid in the memory of farmers in the area. Damage evaluation through use of the historical method was deemed unfeasible. Sampling procedures were used and consisted of approximately a 50 per cent sample of the total cultivated acreage damaged by this 1954 flood.

Crop and pasture cost and return estimates for each of the crops grown were derived with the assistance of local farmers and other agricultural technicians. The reliability of these estimates was checked through the use of existing data as published for the various crops. Damageable values were determined for each crop on a monthly basis from the data collected in the field. A composite weighted monthly damageable value for all crops concerned was determined and further refined to represent a composite weighted damage per acre for any given year by the use of a monthly frequency analysis. Loss of yields, increased production costs, excessive maintenance, loss to real farm property and livestock--all of these factors were considered in developing a per acre damage to agriculture for any given flood. Total damages to agricultural lands for various storm events were calculated and subsequently used in evaluating damages on an average annual basis.

Appraisal of average annual damages to agriculture with and without proposed project improvements was made on the basis of a volume-damage relationship. Since the existing Roosevelt Water Conservation District Canal provides a certain degree of protection to irrigated lands west of the canal, the flood plain area was appraised on the basis of two separate evaluation units. Evaluation reach #1 covers land east of the Roosevelt Water Conservation District Canal and evaluation reach #2 represents the flood plain land west of the Roosevelt Water Conservation District Canal. Per cent-chance-volume relationships were derived along with volume-acres inundated to provide a basis for establishing the trend of the frequency-damage curves for the two evaluation units. Effects of proposed works of improvement were analyzed in like-manner as were the various alternate approaches.

Acres of cultivated land inundated by the 1954 flood were classified as to the source of the floodwaters. Since flood flows from Queen Creek have historically flooded acres below the Superstition Mountain drainage prior to the installation of the Whitlow Dam on Queen Creek in 1960, hydrologic studies supplemented with field investigations were made to clarify the acres of cultivated land in the watershed damaged by run-off from the Superstition Mountain area. Only that acreage as determined susceptible to flooding from the Superstition drainage was used in the program evaluation.

The following table shows the relationship between cultivated acres inundated and flood volumes for various size storm events for the two evaluation reaches. The data represents flood plain conditions as it exists at the present time. The table also indicates the ratio of acres inundated to total cultivated land in the watershed.

Per Cent Chance	Reach #1		Reach #2		Totals		Per Cent Ac. Inundated to Total Acres
	Volume Ac.Ft.	Acres Inundated	Volume Ac.Ft.	Acres Inundated	Volume Ac.Ft.	Acres Inundated	
1	15441	4529	10640	15798	26081	20327	36
6	9000	4493	3400	11579	12400	16072	28
10	7511	4456	1826	7387	9337	11843	21
20	5036	3357	0	0	5036	3357	6
50	1754	1169	0	0	1754	1169	2
80	261	174	0	0	261	174	1/

1/ Less than one per cent.

Damage evaluation to residential, retail-commercial stores, roads, highways and the main irrigation canals was made using the August 18 and 19, 1954 storm as a basis. Damages to roads, highways and the three main irrigation canals were estimated after collecting damages and other pertinent flood information from the agencies involved with maintenance of such features. Since the majority of the damage to the existing residential property of the watershed was to farmsteads and included in the agricultural field survey, no additional residential damage surveys were conducted for the relatively few remaining homes.

Residential growth within the watershed area, particularly in the desert area east of Williams Air Force Base, will be a factor in determining the full beneficial effect of the program. Large areas within this desert area have been purchased and are now in the process of being subdivided for future development.

The basis of estimating potential flood damages to this area was determined after basic information pertaining to the problem was gathered from investors, realtors and other local sources. Only those areas in the hands of private interests for subdivision purposes were used as a basis of the damage estimate. The number of potential homes to be built within a twenty-five year period was estimated. Values of these homes were calculated using average values per unit as derived from studies in similar areas. Damages were based on a per cent of market value as determined in previous flood studies and compared with data contained in Stanford Research Institute's Bulletin, "A Study of Procedure in Estimating Flood Damage to Residential, Commercial and Industrial Properties in California".

Average annual damages to future developed property were based on the per cent of average annual damages to total damage as calculated for similar type areas.

A study of what potential road damages might be as the miles of roads increase to accommodate the growth of the area was made by selecting an area which at the present is developed to the extent estimated for the future. The miles of roads within this area were determined and calculated on the basis of the number of properties per mile. Damage was calculated for present conditions on a per mile basis and applied to the estimated future road mileage to obtain potential road damage. Road damages were included with the residential damages for analysis on an average annual basis.

Indirect damages to agricultural and non-agricultural properties were estimated along with direct flood losses in the field and estimated to be ten to 15 per cent of direct. This relationship between indirect and direct losses was checked with information contained in Stanford Research Institute's Bulletin.

AGRICULTURAL WATER MANAGEMENT

The following information was derived in determining the magnitude of agricultural water management benefits:

1. Relationship between per cent chance of occurrence against peak routed outflow of the structures involved.

2. Relationship between these peak routed outflows and per cent volume of the annual equivalent yield of water available for irrigation purposes.

3. The value of an acre-foot of water calculated on the basis of composite weighted value.

4. Total annual equivalent water yield as calculated for the area controlled.

This information yielded sufficient data to construct a benefit frequency curve. Area under the curve was planimetered for the various per cent chances and outflows to derive the average annual benefits attainable in relation to the amount of water which can be diverted into the Roosevelt Water Conservation District Canal. The capacity of the Roosevelt Water Conservation District Canal at the point where floodwaters will be diverted into the canal is 250 c.f.s. Draw down of existing waters in the canal can be made in such time that practically the full capacity of the canal can be made available for floodwaters.

FISH AND WILDLIFE 1/

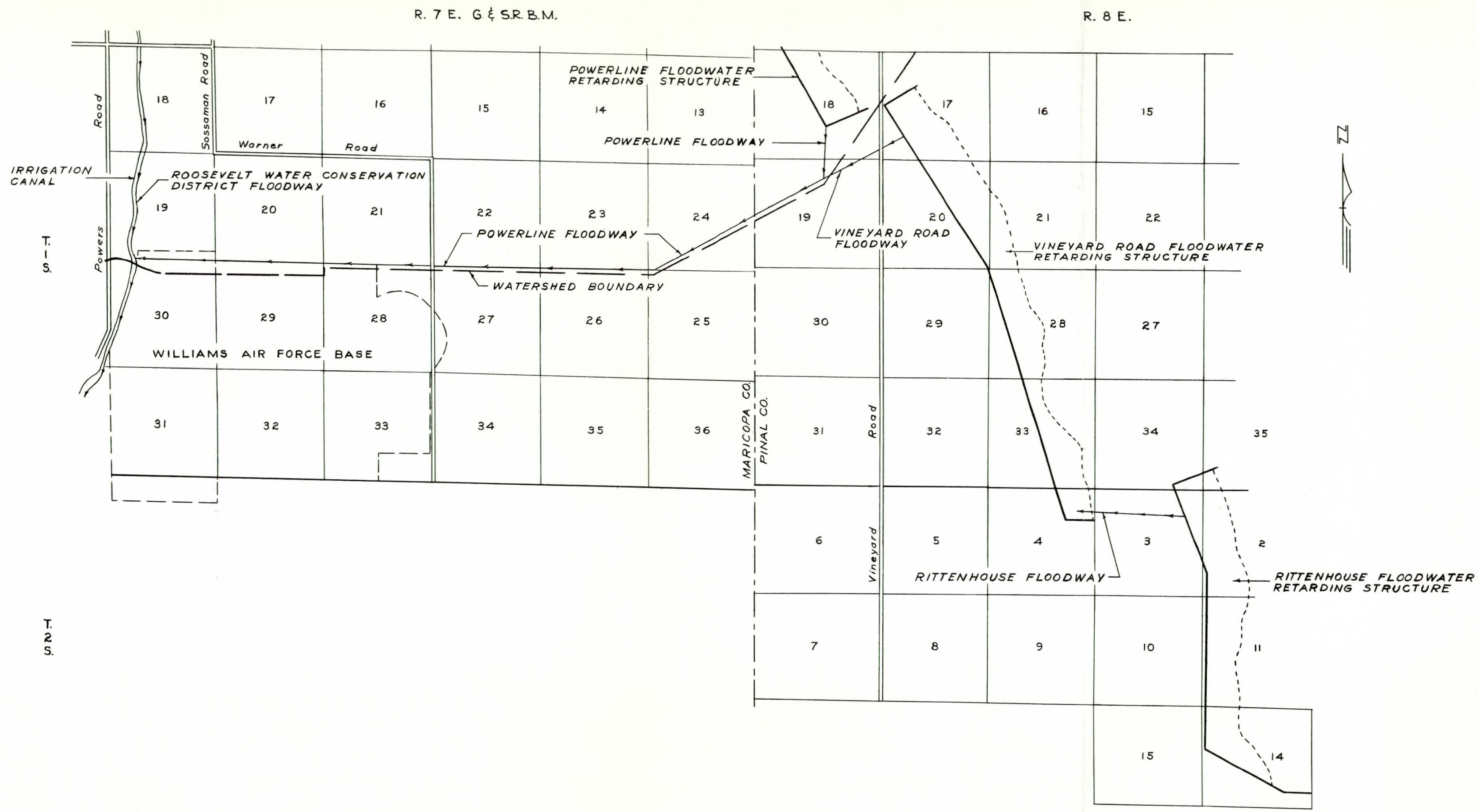
"The diversion of water from the watershed will produce only minor habitat changes to the resident wildlife in the area. Since floodwaters will not be impounded and will be completely diverted shortly after run-off, free water utilization by wildlife cannot be considered a

1/ Excerpt from the statement on the fish and wildlife of the project area, prepared by the Arizona Game and Fish Department, May 16, 1962.

beneficial change. It is true that the added moisture received by these periodic floodings behind the flood control structures will stimulate weed production and provide additional feed and cover for upland and other small game. This added moisture, over an extended period of time, may influence the growth of salt cedars, paloverde, mesquite and other perennial growth. This growth would eventually become beneficial to all game. However, the flooded areas adjacent to the flood control structures are too small to be of any significance to a large wildlife habitat area.

"An additional factor which makes habitat improvement unjustifiable, is the encroachment of Arizona's exploding population on the watershed area. The proposed flood control structures will further enhance all lands which were previously subject to flash flood inundation. This added protection from the flood control dams will further increase the population encroachment in these protected areas. Encouraging game to enter or remain in these areas will only lead to a serious depredation problem in the immediate future.

"We feel that the temporary benefits that the wildlife will receive from the flood control structures are desirable but that any long-range plans for developing wildlife habitat in the rapidly growing population area would not be wise. Therefore, we feel that the improvement of wildlife habitat in this watershed area cannot be justified".



LOCATION MAP

Scale in Miles

FIGURE 2 (1)

WORK PLAN

FLOODWATER RETARDING STRUCTURES

WILLIAMS-CHANDLER WATERSHED

PINAL COUNTY, ARIZONA

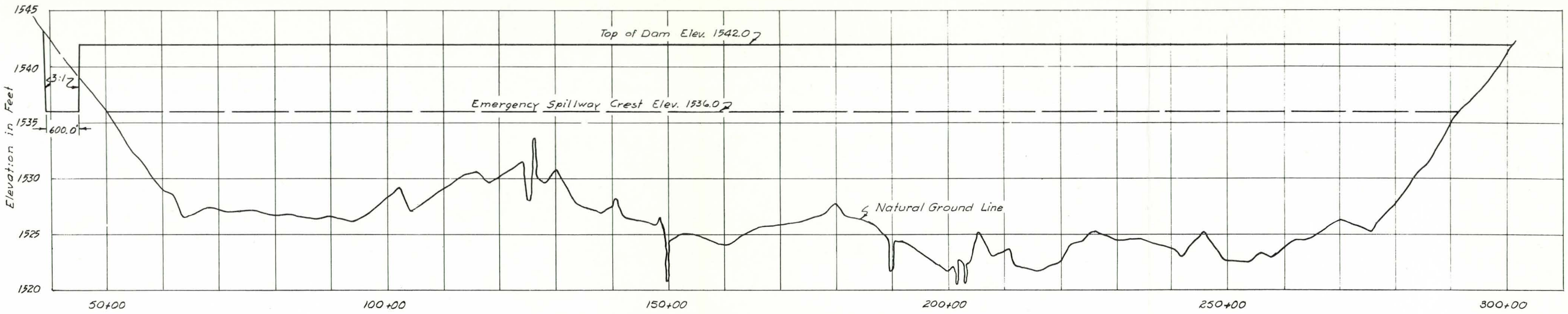
PRELIMINARY PLANS

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

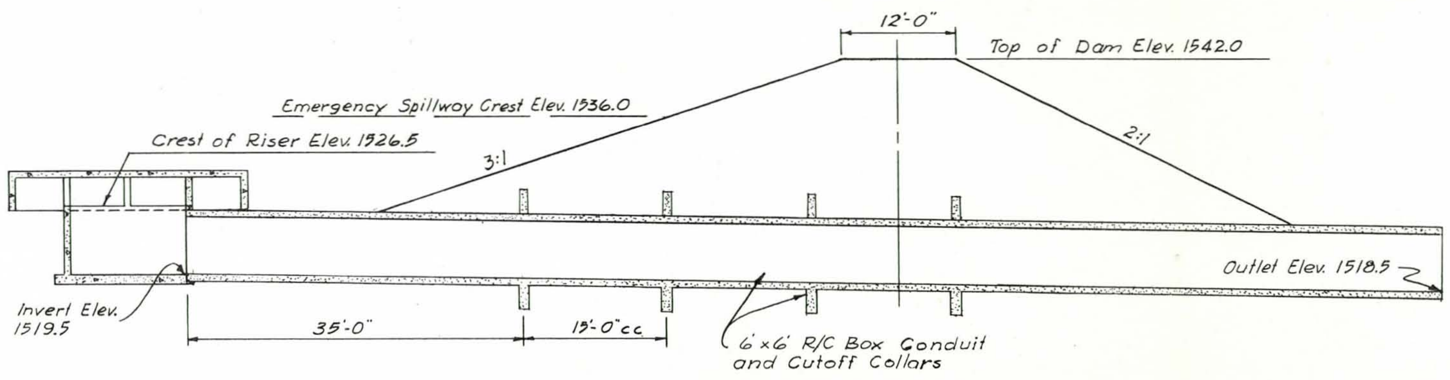
Prepared by R.K.M. Date 6-62 Drwg. No. 7-E-20397

Sheet 1 of 2 Sheets

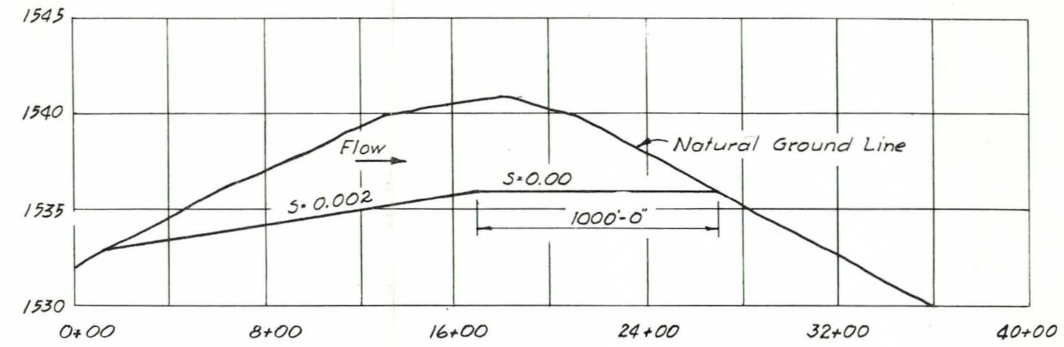
M 3732-1



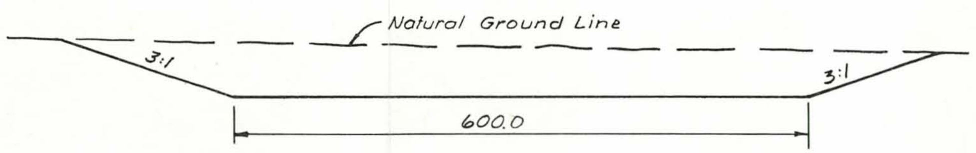
PROFILE ON ℄ OF DAM



CROSS SECTION THROUGH PRINCIPAL SPILLWAY



PROFILE ON ℄ EMERGENCY SPILLWAY



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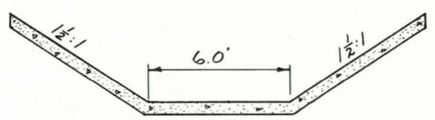
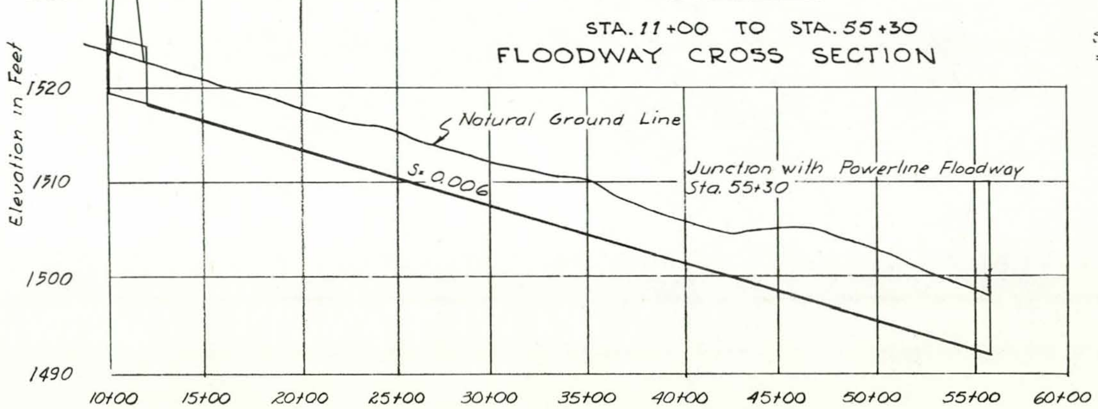


STA. 11+00 TO STA. 55+30
FLOODWAY CROSS SECTION



PROFILE ON ℄ OF VINEYARD FLOODWAY

STA. 55+30 VINEYARD ROAD FLOODWAY
=117+30 POWERLINE FLOODWAY

RESERVOIR STORAGE CHART

	Elevation	Area Acres	Storage Ac. feet	Total Storage Acre feet
	1521	0.0	0	0
	1524	19	29	29
Crest of Riser →	1526.5	110	171	200
	1528	175	218	418
	1532	436	1382	1,800
Crest of Emergency Spillway	1536	730	2,510	4,310
	1540	1,037	3,535	7,845
Top of Dam →	1542	1,193	2,235	10,080

FIGURE 2 (2)
WORK PLAN
VINEYARD ROAD RETARDING STRUCTURE
WILLIAMS-CHANDLER WATERSHED
PINAL COUNTY, ARIZONA
PRELIMINARY PLANS
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by M.H.K. Date 6-62 Drwg. No. 7-E-20397
Sheet 2 of 2 Sheets

USDA SCS PORTLAND ORE. 1962 M 3732-2

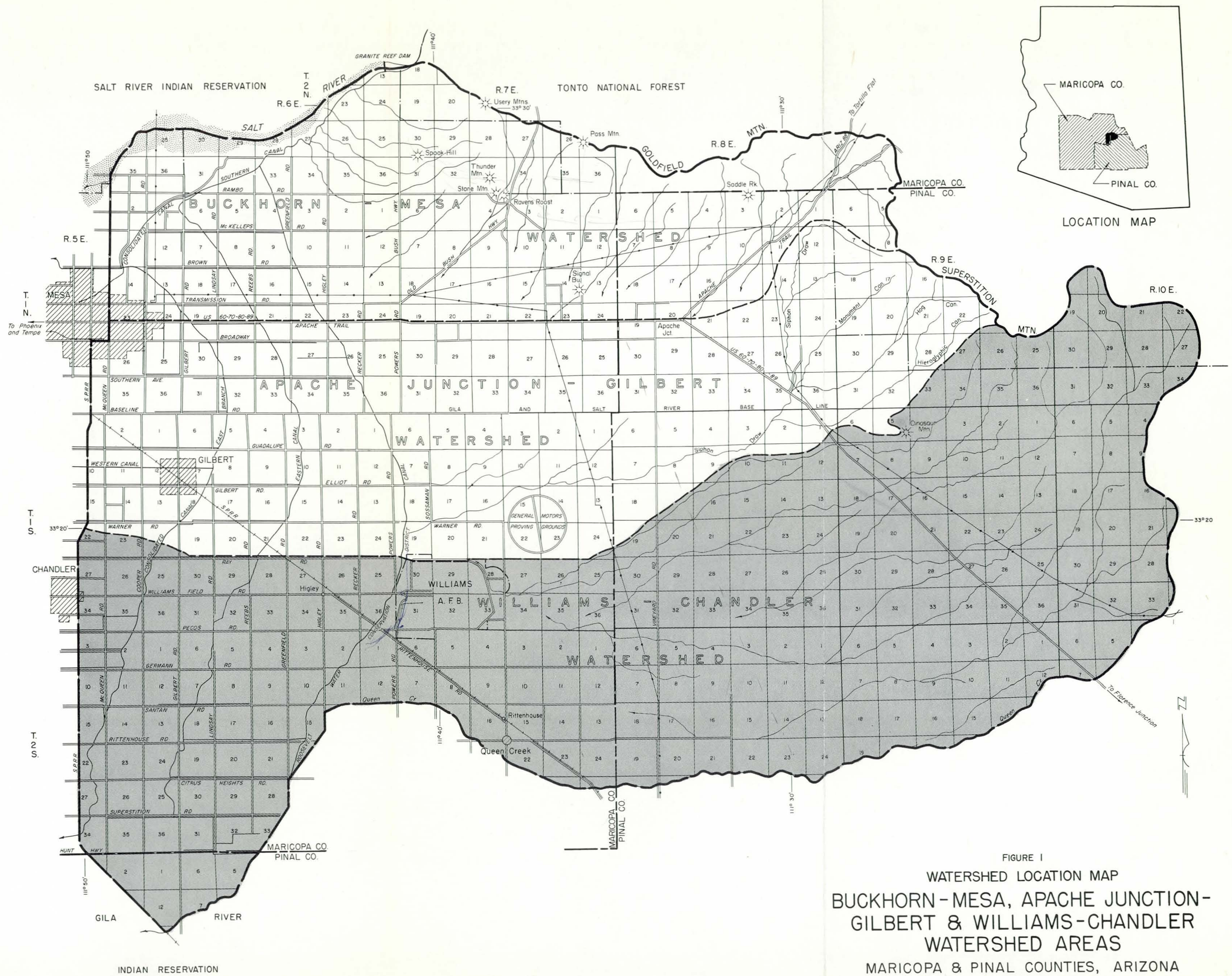


FIGURE I

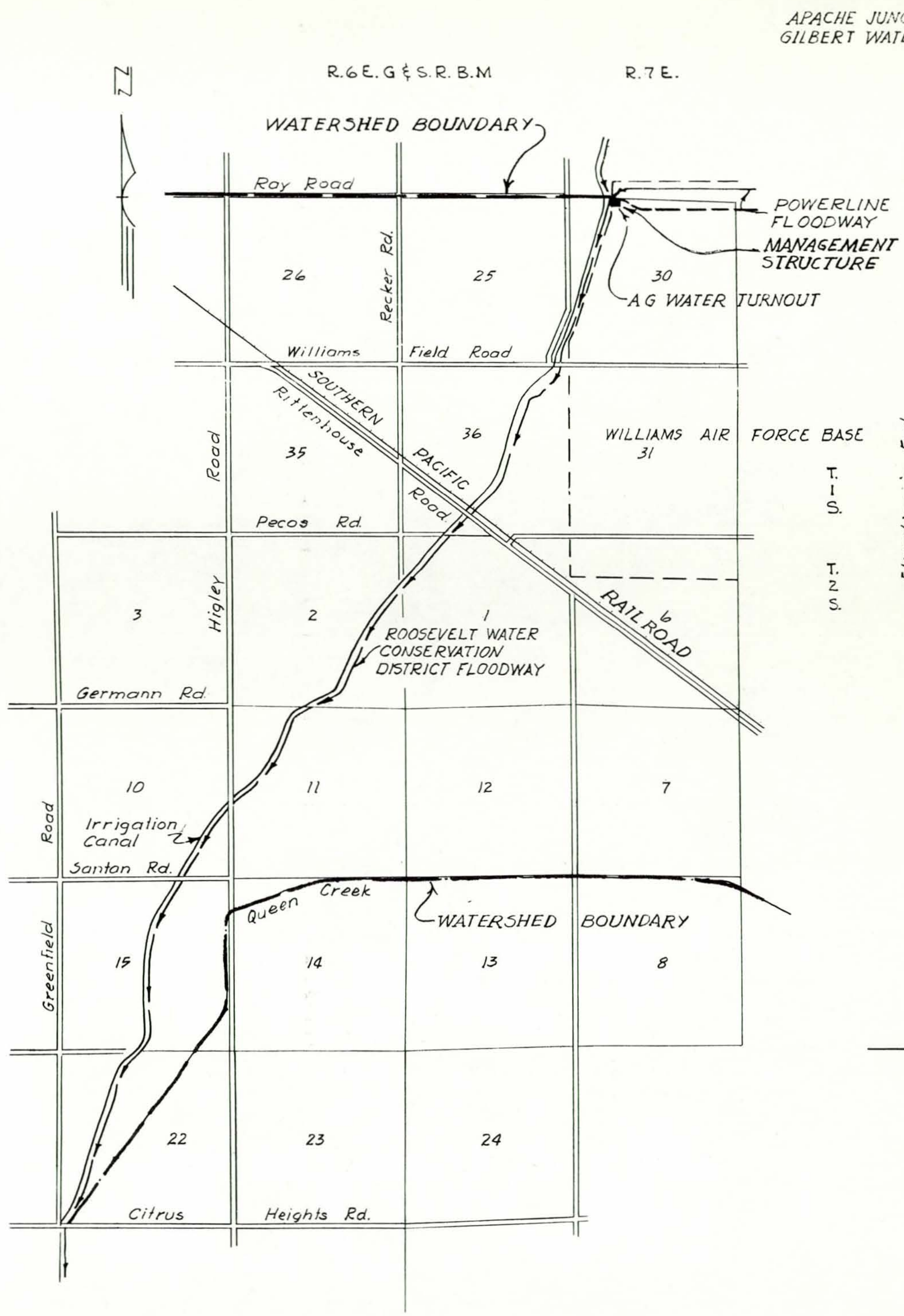
WATERSHED LOCATION MAP

BUCKHORN-MESA, APACHE JUNCTION-GILBERT & WILLIAMS-CHANDLER WATERSHED AREAS

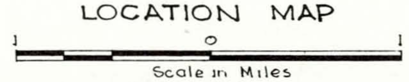
MARICOPA & PINAL COUNTIES, ARIZONA

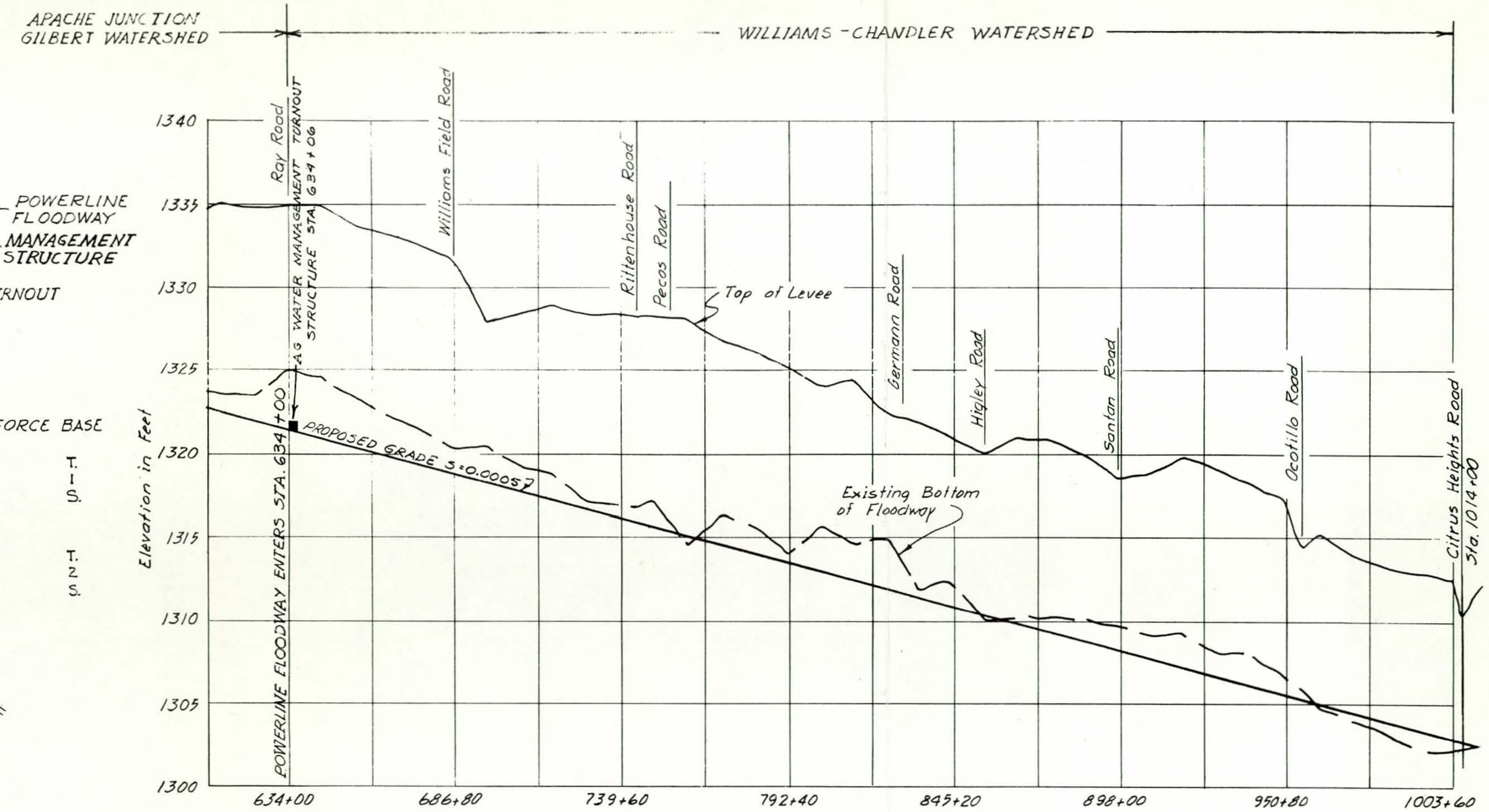
JUNE 1962

SCALE IN MILES

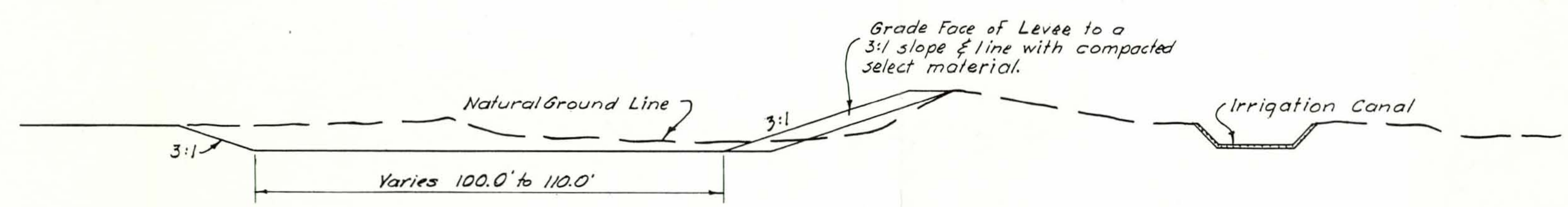


LOCATION MAP





PROFILE ON ℄ OF FLOODWAY



TYPICAL FLOODWAY CROSS SECTION

FIGURE 3 (1)
WORK PLAN

ROOSEVELT W. C. D. FLOODWAY

WILLIAMS-CHANDLER WATERSHED
PINAL COUNTY, ARIZONA
PRELIMINARY PLANS

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by M.H.K. Date 6-62 Drwg. No. 7-E-20398
Sheet 1 of 1 Sheet

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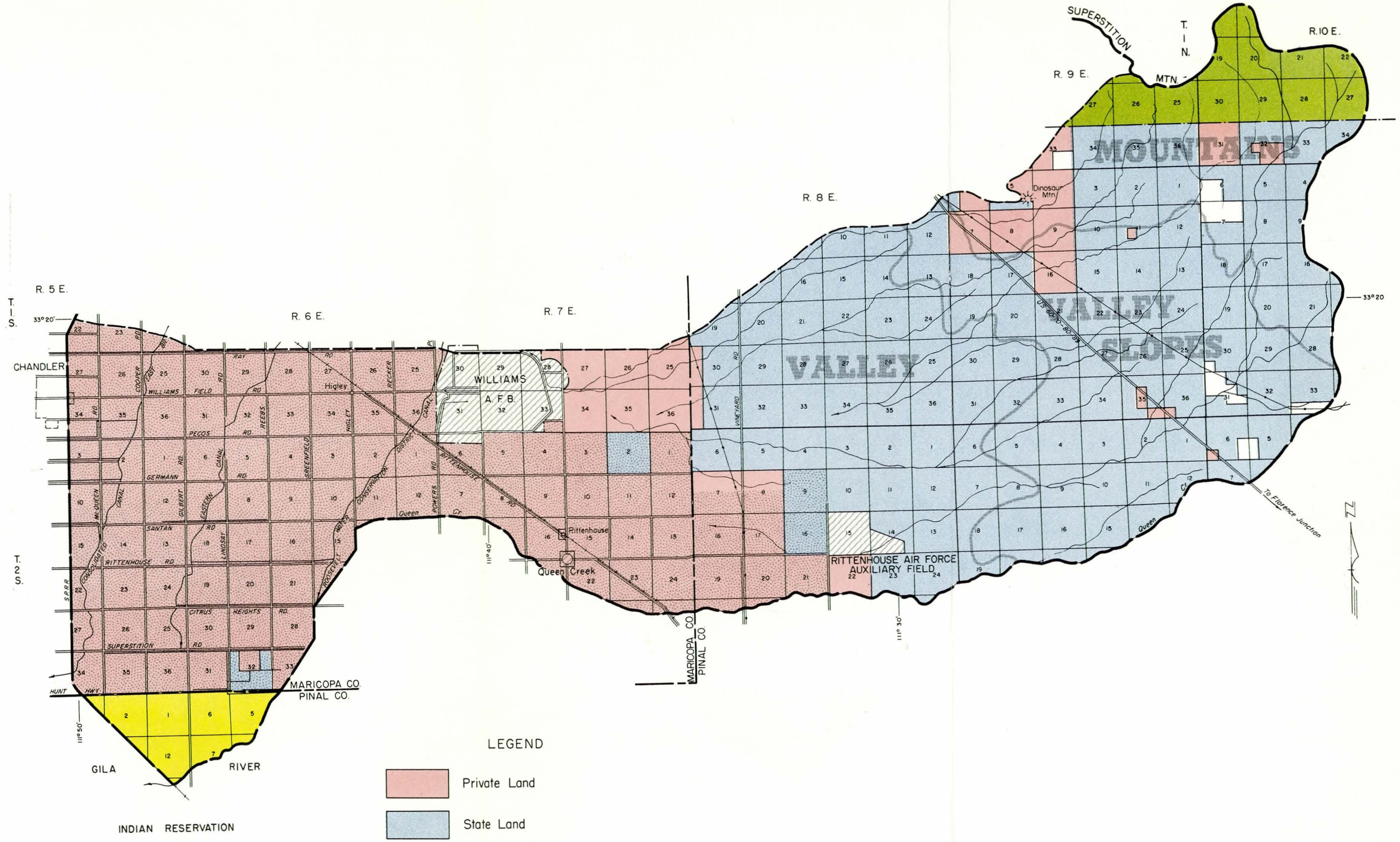


LEGEND

- Private Land
- State Land
- National Forest
- Federal B.L.M.
- Indian
- Farm Land
- Non-Agricultural
- Resource Unit Boundary and Name

FIGURE 4

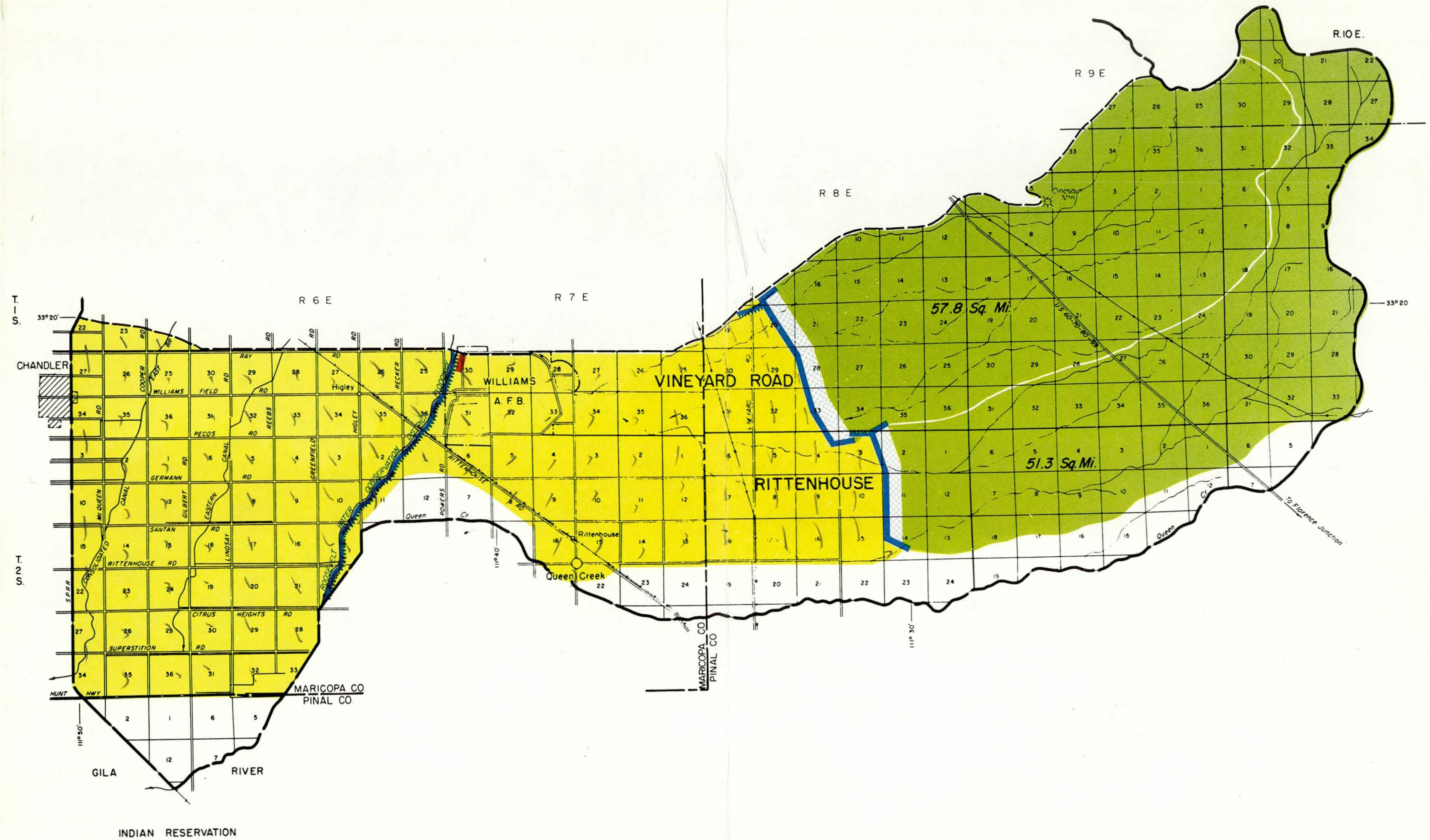
LAND STATUS, LAND USE & RESOURCE UNIT MAP

WILLIAMS - CHANDLER WATERSHED

MARICOPA & PINAL COUNTIES, ARIZONA

JUNE 1962

SCALE IN MILES



LEGEND

- Drainage Area Controlled by Structure
- Area Benefited
- Floodwater Retarding Structure
- Irrigation Facility
- Floodway

FIGURE 5

PROJECT MAP

WILLIAMS-CHANDLER WATERSHED

MARICOPA & PINAL COUNTIES, ARIZONA

JUNE 1962

SCALE IN MILES

U.S. DEPARTMENT OF AGRICULTURE. SOIL CONSERVATION SERVICE M-3732

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