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INTERIM REPORT

ON

SURVEY FOR FLOOD CONTROL

SANTA ROSA WASH, ARIZ.

(WITH APPENDIXES)

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CORPS OF ENGINEERS

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INTERIM REPORT OF THE DISTRICT ENGINEER ON SURVEY FOR FLOOD CONTROL

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ. AND N. MEX.

SYLLABUS

The district engineer finds that a serious flood problem exists in the Santa Rosa Wash basin downstream from the Tat Momolikot damsite. He finds that floods on Santa Rosa Wash and its tributaries (a) cause damage to all types of property in the overflow areas on both non-Indian and Indian lands, (b) constitute a menace to health, and (c) could cause loss of life. He also finds that studies by the U.S. Bureau of Indian Affairs indicate that the lack of an adequate supply of irrigation water in the reservation is adversely affecting the livelihood of the Papago Indians.

After investigation of various possible solutions to the flood problems, the district engineer finds that levee and channel improvements for the protection of areas downstream from Vaiva Vo are not economically justified at this time. However, he finds that economically feasible protection can be provided by the construction of a multiple-purpose dam and reservoir at the Tat Momolikot site on Santa Rosa Wash upstream from Vaiva Vo, Ariz. He finds that this dam and reservoir could be coordinated with the following improvements considered by the U.S. Bureau of Indian Affairs: (a) irrigation works for irrigable land, mostly upstream from Vaiva Vo; and (b) recreation, fish, and wildlife facilities in the reservoir area and immediately downstream from it. He also finds that area redevelopment benefits would accrue from operation of the recommended project.

The district engineer estimates the total Federal first cost of the recommended project at $6,430,000 (September 1962), including $1,256,000 for the Vaiva Vo irrigation project. He estimates the average annual charges at $272,000, including an average of $62,000 annually for maintenance and operation of the improvements. He estimates the average annual benefits at $905,000, comprising $527,000 in benefits that would accrue from the prevention of flood damage, $258,000 for water-conservation benefits, $60,000 for recreation benefits, $49,000 for fish and wildlife benefits, and $11,000 for area redevelopment benefits. He states that the ratio of average annual benefits to average annual charges would be 3.3 to 1. He concludes that the project would be justified on the basis of tangible benefits. Consideration of the intangible benefits would add weight to the justification.

The district engineer recommends:

(a) That the United States adopt the Santa Rosa Wash multiple-purpose project providing for (1) a dam and reservoir at the Tat Momolikot site on Santa Rosa Wash in the Papago Indian Reservation, Ariz.; (2) the Vaiva Vo irrigation project; (3) fish, wildlife, and recreational facilities, and (4) improvement of the economic standards of the Papago Tribe in the Papago Indian Reservation; all at an estimated total first cost of $6,430,000 (September 1962), and an estimated average annual cost of $62,000 for operation and maintenance.

(b) That the construction, operation, and maintenance of the recommended project, including necessary relocations and acquisition of rights-of-way, principally for flood control, be accomplished by the United States at Federal expense; and further that (1) the Corps of Engineers construct Tat Momolikot Dam, St. Clair Reservoir, wildlife, and recreational facilities in the reservoir area at an estimated Federal cost for construction of $5,375,000 (September 1962 prices) and a Federal annual cost for maintenance and operation of $13,000; (2) the Bureau of Indian Affairs construct the irrigation, recreation, fish, and wildlife improvements downstream from Tat Momolikot Dam at an estimated Federal cost for construction of $1,055,000 (September 1962 prices) and a Federal annual cost for maintenance and operation of $49,000.

(c) That 6 percent of the first cost of Tat Momolikot Dam, St. Clair Reservoir, and wildlife and recreational facilities in the reservoir area and 15 percent of the maintenance and operation costs of these facilities be allocated to water conservation; and that 89 percent of the first cost of irrigation, recreation, fish and wildlife improvements downstream from Tat Momolikot Dam and 68 percent of the maintenance and operation costs of these facilities be allocated to water conservation.

(d) That because water conservation benefits would accrue solely to the Papago Indians and, in accordance with laws applicable to the development of Indian lands, all costs allocated to water conservation be considered nonreimbursable so long as the lands remain in Indian ownership. Upon the transfer of title of any of the lands from Indian to non-Indian ownership, reimbursement of a suitable portion of the charges would be made in a manner to be determined by the Secretary of the Interior.

(e) That the remainder of the costs of the project be allocated to flood control, fish and wildlife, recreation, and area redevelopment purposes and be considered nonreimbursable.

(f) That construction of the recommended improvement be subject to the condition that local interests furnish assurances satisfactory to the Secretary of the Army that they will:

(1) establish and enforce floodway limits and regulations and perform necessary work on Santa Rosa Wash through non-Indian lands, from the north boundary of the Papago Indian Reservation to the Santa Cruz River, to maintain the hydraulic capacity of the existing channel; (2) hold and save the United States free from damages downstream from the Papago Indian Reservation as would arise from construction, maintenance, and operation of the works for flood control; and (3) hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the proposed project for flood control.

(g) That the Federal Government (Bureau of Indian Affairs) be responsible for adjustment of claims arising from construction and operation of the proposed project for other than flood-control purposes and for establishing and enforcing floodway limits and regulations for performing necessary work on Santa Rosa Wash through the Papago, Maricopa, and Gila River Indian Reservations downstream from Tat Momolikot damsite to maintain the hydraulic capacity of the existing channel.

(h) That the Papago Tribal Council make available to the Federal Government (1) appropriate rights to those lands required for construction of the dam and appurtenances, and (2) appropriate rights to those lands that would be required for construction of a water-conservation reservoir.

(i) That the Federal Government reimburse the Papago Tribe for a flowage easement on land required for flood control between elevations 1535 and 1547.

(j) That all monetary benefits (less maintenance, operation, and replacement costs) from operation of the project for uses other than flood control accrue to the Papago Indian Tribe.

(k) That the operation and maintenance of the entire project be under the administration of the Bureau of Indian Affairs, or a designated organization approved by the Secretary of the Interior and Secretary of the Army, subject to flood-control provisions prescribed by the Secretary of the Army.

(l) That the operation agency be responsible for requesting the annual nonreimbursable operation and maintenance funds for the Santa Rosa Wash, Ariz., multiple-purpose project.

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U. S. ARMY ENGINEER DISTRICT, LOS ANGELES,
CORPS OF ENGINEERS,
OFFICE OF THE DISTRICT ENGINEER,
Los Angeles, Calif., August 1, 1963.

Subject: Interim report on survey for flood control, Santa Rosa Wash, Ariz., Gila River basin, Ariz. and N. Mex.

Through: The Division Engineer, U.S. Army Engineer Division, South Pacific, San Francisco, Calif.

To: The Chief of Engineers, Department of the Army, Washington, D.C.

AUTHORITY

1. This interim report is submitted pursuant to act of Congress, Public Law 761, Seventy-fifth Congress, approved June 28, 1938, which reads in part as follows:

> SEC. 6. The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control including floods aggravated by or due to tidal effect at the following-named localities, * * *
>
> * * * * * * *
>
> Gila River and tributaries, Arizona and New Mexico
>
> * * * * * * *

2. The survey for the Gila River basin is being covered in 11 interim reports, 3 review reports, and a final comprehensive report. Seven of those interim reports have been submitted to Congress, as follows: (a) Tucson, Ariz., and vicinity, dated November 20, 1945; (b) Queen Creek, Ariz., dated February 2, 1946; (c) Gila River and tributaries below Gillespie Dam, Ariz., dated September 1, 1948; (d) Lower Agua Fria River and vicinity, Ariz., dated December 10, 1952; (e) Gila and Salt Rivers, Gillespie Dam to McDowell damsite, Ariz., dated December 4, 1957; (f) Gila River with particular reference to a dam at or near the Camelsback site, Ariz., dated May 1, 1960; and (g) Pinal Creek and tributaries, Ariz., dated September 15, 1961. All three review reports have also been submitted to Congress as follows: (a) Gila River, Camelsback Reservoir site to Salt River, Ariz., dated December 31, 1957; (b) Tucson, Ariz., and vicinity, dated January 26, 1959; and (c) Gila River and tributaries downstream from Painted Rock Reservoir, Ariz., dated April 1, 1961. (See plate 2.)

3. Three interim reports are now in preparation as follows: (a) Phoenix, Ariz., and vicinity, including the New River; (b) Indian Bend Wash, Ariz.; and (c) Willcox, Ariz., and vicinity.

4. This interim report considers Santa Rosa Wash. The final comprehensive report will include summaries of findings and conclusions in all interim and review reports, consideration of problems in areas not covered in any interim report, and analysis of the interrelation of problems and plans of improvement in all parts of the Gila River basin.

EXTENT OF INVESTIGATION

5. Geographical scope.--The Flood Control Act of June 28, 1938, authorized the preparation of a survey for flood control in the entire drainage area of the Gila River and tributaries, Arizona and New Mexico. On the basis of the authorization in that act, the Chief of Engineers, on November 20, 1958, authorized an interim survey of Santa Rosa Wash, Ariz. An inspection of the area showed that the major existing flood problems in the Santa Rosa Wash basin are along the wash and its tributaries from stream mile 31.5 (downstream from the Papago Indian Reservation) to stream mile 7.5 (downstream from Maricopa, Ariz.). Part of the developed area in the Santa Rosa Wash drainage basin is also subject to overflow from Santa Cruz River. However, examination of the records of these two streams indicates that floodflows of the Santa Rosa Wash would not coincide normally with floodflows of the Santa Cruz River. In addition, preliminary studies showed that, when coincidence would occur, the addition of Santa Cruz River flows to Santa Rosa Wash flows would increase flood damages by an amount approximately equal to the flood damages that would be caused by Santa Cruz River floodflows by themselves. Studies for this report were therefore limited to an analysis of flows from Santa Rosa Wash. There is very little economic development subject to flood damage in other parts of the Santa Rosa Wash basin. However, irrigation and recreation improvements considered by the U.S. Bureau of Indian Affairs for the area between Vaiva Vo (stream mile 37) and the Tat Momolikot damsite (stream mile 43.5) would also be subject to flood damage. Therefore, detailed consideration of the flood problem is limited to areas between the damsite and stream mile 7.5.

6. Functional scope.--The need for flood control and the solution of flood problems in urban and agricultural areas downstream from the damsite are considered in this report. Water conservation was considered because of the need to fully utilize the available water supply. Because the Papago Indian Reservation has been declared a depressed area, area redevelopment aspects were considered. The development of hydroelectric power was not considered feasible because the runoff from this relatively dry drainage area, which has a high evaporation rate, would be inadequate for the generation of power. Consideration was given to recreation development (including fish and wildlife) in the studies for this project.

7. Scope of topographic and aerial surveys.--Topographic maps of the Santa Rosa Wash basin were obtained from the U.S. Geological Survey, the U.S. Army Map Service, and the U.S. Bureau of Indian Affairs. Cross sections within the flood-problem area downstream from Vaiva Vo, Ariz., and at the site of the recommended Tat Momolikot Dam and St. Clair Reservoir were made by the U.S. Army Engineers. Topographic data pertinent to highway improvements affecting floodflows in the area under

detailed consideration were obtained from the State of Arizona Department of Highways and from local county engineers. Aerial photographs of the overflow area were obtained from the U.S. Department of Agriculture. Aerial photographs of the recommended dam and reservoir area were obtained from the U.S. Bureau of Indian Affairs.

PRIOR REPORTS

8. No prior survey report on flood control in the Santa Rosa Wash basin has been submitted to Congress by the U.S. Army Corps of Engineers.

DESCRIPTION

9. Location and extent.--The Santa Rosa Wash basin, which is a small part of the 58,200-square-mile drainage area of the Gila River, comprises about 2,400 square miles in south-central Arizona, about 70 miles south of Phoenix and about 70 miles northwest of Tucson. Santa Rosa Wash is tributary to the Santa Cruz River, which, in turn, is tributary to the Gila River upstream from the Salt River. The basin, which is almost entirely within Pima and Pinal Counties, is an elongated area with a maximum north-south length of about 80 miles and a maximum east-west width of about 50 miles (see index map, pl. 1, at end of the main report).

10. Streams.--Santa Rosa Wash, the main stream in the drainage area, rises on the northern slopes of the Comobabi Mountains and flows generally northward for about 90 miles to its confluence with the Santa Cruz River. Principal tributaries in the basin in downstream order are Kohatk Wash, Jack Rabbit Wash, and Greenes Wash. Surface flow in all streams in the Santa Rosa Wash basin is intermittent. In general, stream slopes are steep in the mountains and moderate in the valleys. Stream slopes range from about 150 feet per mile at the base of the mountains to about 10 feet per mile through the flood problem areas considered along Santa Rosa Wash. Downstream from the base of the mountains, the streams generally flow in poorly defined channels, the capacities of which are generally adequate for only small flows. Within the damage area, the channel capacity of Santa Rosa Wash is 5,000 cubic feet per second.

11. Topography.--Elevations in the drainage area range from 1,000 feet at the Santa Cruz River to about 6,800 feet in the mountains. The elevation at Vaiva Vo, near the site of the proposed damsite, is about 1,500 feet. About 20 percent of the area is mountainous, the remainder being a gently rolling desert plain.

12. Geology and soils.--In general, the mountains in the Santa Rosa Wash basin are of igneous and metamorphic rock - mostly granitic, schistose, or volcanic. The valleys along the main stream and its tributaries are alluvial fills of varying depths. The soil in the valleys is generally fertile. Where water is available for irrigation, the crop yields are high. The embankment foundation would be Recent alluvium. Suitable construction materials for the project are available partly from the sites of required excavation and partly from other sources within economically feasible hauling distances from the Tat Momolikot damsite. Although some mining claims are in the considered reservoir area, mining activities would rarely be affected by the general type of reservoir operation contemplated. More detailed information on geology and soils is given in Appendix 2: Bases for Design.

13. Vegetation.--In general, vegetation in the Santa Rosa Wash drainage area is sparse. Cactus, sagebrush, greasewood, and small trees such as mesquite and paloverde are the dominant desert plants. The vegetation tends to be thicker and denser along the stream courses. Perennial grasses grow at the higher elevations. Covers of annual grasses occur in much of the basin after winter rains. In the area downstream from Vaiva Vo, Ariz., where irrigation well water is available, the land loses its barren desert aspect. Nearly all parts of that area have been developed into productive farmland.

ECONOMIC DEVELOPMENT

14. Population.--The principal area that would be affected by improvements considered in this report extends for about 36 miles along both sides of Santa Rosa Wash downstream from Tat Momolikot damsite to a point about 2 miles downstream from the town of Maricopa. The area is essentially agricultural, but includes (a) the towns of Stanfield and Maricopa; and (b) parts of the Papago, Maricopa, and Gila Indian Reservations, including several small Indian villages. The populations of Stanfield and Maricopa increased from 115 to 127 in 1950 to 450 and 350 in 1960, respectively, representing a combined increase of about 230 percent in 10 years. The population of Pinal County, on the basis of the 1960 U.S. Census, was 62,673. The estimated 1960 population of the overflow area considered in this report was 2,000. Indian villages in the overflow area have a total population of about 300.

15. Available information indicates that most future development is expected to occur in the Phoenix and Tucson areas, north and southeast, respectively, of the Santa Rosa Wash basin. However, growth patterns indicate that some of the growth in the Phoenix and Tucson metropolitan areas will spread into the Santa Rosa Wash area.

16. The increasing number of tourists that pass through the Santa Rosa Wash drainage area on interstate and State highway systems creates a demand for services that add substantially to the growth potential. Local attractions include the colorful Indian villages and ceremonies, Kitt Peak's astronomical observatory, and baseball's San Francisco Giants training facilities, as well as much publicized natural attractions in the region, such as those at Casa Grande National Monument (20 miles northeast of Stanfield), Organ Pipe Cactus National Monument (70 miles southwest of Stanfield), and Saguaro National Monument (70 miles southeast of Stanfield).

17. Occupations and industries.--The principal industries in the flood-problem area downstream from the proposed damsite are farming, cotton ginning, and stockraising. Minor occupations in the area are manufacturing, operation of hotels and tourist motels, operation of retail-trade establishments, personal services, and operation of schools and utilities.

18. Cotton gins in the area process cotton for shipping and manufacture byproducts, such as cottonseed oil. Retail outlets for the sale of farming implements and machinery are in the area.

19. Land use and development.--Intensive agricultural development of the Santa Rosa Wash basin downstream from the damsite began subsequent to World War II. Although some grain, hay, and vegetables are grown, the main crop is cotton. Production of beef cattle utilizes some of the nonirrigated land. Urban development in the basin began with the establishment of the towns of Stanfield and Maricopa after World War I. The number of acres under cultivation in the Stanfield-Maricopa area increased from 10,000 in 1940 to 95,000 in 1958, an increase of 850 percent. Since 1958, the total acreage has remained practically constant. The growth of agriculture for the period 1940-1962 is shown by the following table:

Area in cultivation, Stanfield-Maricopa area (1940-1962)

Year	Area in cultivation
	Acres
1940	10,000
1945	35,000
1950	70,000
1958	95,000
1962	95,000

20. The agricultural economy of the Stanfield-Maricopa area has stabilized and the farmers are generally prosperous, although they experience serious losses because of floods. The availability of irrigation water by deep-well pumping from underground sources, coupled with the increased demand and higher prices generated by World War II and its aftermath, resulted in an increasing agricultural development in this area.

21. Facilitated by the mild winters and a long growing season, the area is adapted to a wide range of agricultural crops, including cotton, hay and grains, and truck crops. About one-half of the acreage is given to the raising of cotton, about one-third to hay and grains, and the remainder to truck crops. During 1958, the gross value of crops in the Stanfield-Maricopa area was about $30,100,000 for 95,000 acres, or about $317 per acre. Crop values per acre range from $540 for truck crops to $80 for hay and grains. The value of the cotton crop per acre is about $450.

22. Water supply.--Domestic water for the towns of Stanfield and Maricopa and the small Indian villages in the area is obtained by pumping from underground supplies. Irrigation facilities within the basin include many wells throughout the valley areas, several minor reservoirs, and pumping plants and pipelines for distributing the water. Overpumping in the agricultural section of the basin is creating a water-shortage problem that may affect

the future agricultural economy of the area. Plans of the U.S. Bureau of Reclamation make provision for supplying supplemental water to this area from the proposed Central Arizona project, but such waters will probably not be adequate to satisfy the demands. The present plan of development of that part of the Central Arizona project that would affect the Santa Rosa Wash multiple-purpose project considered in this report provides for the diversion of about 1,200,000 acre-feet of Colorado River water from Lake Havasu above Parker Dam by means of the Granite Reef and Salt-Gila aqueducts to existing San Carlos project facilities, south of Coolidge, Ariz. Turnout facilities would be constructed for systems serving lands such as the Stanfield-Maricopa area presently serviced by ground-water pumping only.

23. Nearly all water for irrigation in the Santa Rosa Wash basin is obtained by pumping from ground-water supplies. Pumpage of ground water in the Stanfield-Maricopa area for 1961 was about 470,000 acre-feet obtained from 520 wells.

24. In recent years, much more water has been pumped out of the basin than has been put back into it by rainfall and from other recharge sources. Consequently, the water table has fallen lower and lower, and pumping lifts generally have increased. In 1952, the average depth to ground water in the Stanfield-Maricopa area was about 145 feet. However, by 1962, the average depth had dropped approximately 100 feet.

25. The quantity of water applied annually to an acre of irrigated land varies with type of soil, kind of crop, efficiency of farm management, and amount of water available. The net duty of water in the basin varies from about 2.3 acre-feet per acre for truck crops to about 5.0 acre-feet per acre for alfalfa. The average net duty of water is estimated at about 4.0 acre-feet per acre, measured at the farmer's headgate. Cotton requires about 4.0 acre-feet per acre.

26. Water rights.--The principal non-Indian water users downstream from the site of the proposed Tat Momolikot Dam are about 200 farmers in the Stanfield-Maricopa area, the Buckeye Irrigation Company, the Arlington Canal Company, and the Gillespie Land and Irrigation Company. The three latter users take water from the Gila River below the mouth of the Santa Cruz River, to which Santa Rosa Wash is a tributary. The Buckeye Irrigation Company, the first and principal downstream user along the Gila River, has raised objections to the proposed upstream irrigation storage on the grounds that their use of floodflows from Santa Rosa Wash to dilute their high-saline-content ground water along the Gila River would be compromised. Studies were made by the Bureau of Indian Affairs to determine the effect of the proposed plan of improvement on the quantity of water diverted at the Buckeye heading. The Bureau indicates that the results of these studies

show that the quantity of water available for the Buckeye diversion would be reduced only slightly. In addition, the Bureau contends that the Papago Indians have prior right to the waters of Santa Rosa Wash. It is not known how long the Papago Indians have occupied the country in the vicinity of their present reservation. They were discovered by a Franciscan missionary who entered their country in 1539. A notice of water appropriation was filed and recorded in the Office of the Secretary of the State of Arizona on June 8, 1912, by John F. Armstrong, United States Allotting Agent, by direction of the Secretary of the Interior. Excerpts from the notice are as follows:

> Notice is hereby given that the United States of America hereby locates, claims, and appropriates perpetually the water of the Santa Cruz creek or river and its tributaries, torrential or otherwise, flowing in the channel or channels of the said Santa Cruz River and in the branches of the same, as to both the surface and underground flow, to the extent of 60,000 (sixty thousand) acre-feet for the purpose of irrigation and domestic use on lands in the county of Pinal, Arizona, which are reserved for, occupied by, or intended by the United States for allotment to its wards, the Papago and Pima Indians.
>
> * * * * * * *
>
> The United States intends to construct and maintain such other canals and irrigation works as shall be necessary to irrigate the lands now occupied by its wards the Papago and Pima Indians, and such other lands as may be allotted to the said Indians by the Government, in the county of Pinal, State of Arizona, along the course of the Santa Cruz river, and its branches and tributaries, said canals to commence at or near the reservoir site hereinbefore described, in the vicinity of the Jackrabbit mine, or such other suitable points of diversion as may be selected by engineers of the Government, and to extend to the cultivated fields and lands now occupied by the said Papago and Pima Indians in Pinal county and to such other lands as may be allotted to them by the United States Government. ***

27. The U.S. Bureau of Indian Affairs has indicated that, if, in the event of a controversy, the prior right of the Papago Indians to water arising on their reservation is not upheld, an adjustment would be reached with the Buckeye Irrigation Company.

28. Power.--Electric power is available from the Arizona Public Service Company over cooperative interstate

electrical transmission systems. Steam electric plants fired by natural gas provide relatively low-priced electric power. Low-priced power is also available by the direct use of natural gas in internal combustion engines. Availability of such low-priced power is one of the reasons for the economic feasibility of deep-well pumping.

29. Transportation facilities.--Arterial highways and railroads connect the Santa Rosa Wash drainage area with centers of manufacturing and commerce throughout the nation. Interstate Highway No. 8, connecting Tucson and Yuma, is under construction, crossing the area about 3 miles south of Stanfield in a generally east-west direction. State Highways 84, 93, and 87 connect the area with Phoenix and vicinity. Other State and county highways and roads supply connecting links, and many local roads complete a network that adequately serves present needs. One of the main lines of the Southern Pacific railroad crosses Santa Rosa Wash basin near the downstream end in a generally east-west direction. A branch line of the Atchison, Topeka and Santa Fe Railway connects Phoenix with the main line to the north. Small airports are at Stanfield and Maricopa. Large airports in Phoenix and Tucson provide local and transcontinental air service. Many transcontinental bus routes pass through the area.

CLIMATOLOGY

30. General.--The climate of the Santa Rosa Wash basin is subtropical and arid. Winters are mild with practically no snowfall, and the summers are hot. The average length of the growing season between frosts is about 250 days. Average wind velocities are low to moderate, except that high gusty winds may accompany thunderstorms usually occurring during July and August. U.S. Weather Bureau records for nearby stations indicate a long-term average temperature of about 71° Fahrenheit, with the temperatures ranging from 12° Fahrenheit in winter to 122° Fahrenheit in summer.

31. Precipitation records.--Precipitation records are available for 41 rainfall stations in and near the drainage area. Three of the seven stations in the area are active at present. The longest record for a single station is for Casa Grande, Ariz., which has 74 complete years of record for the period 1880-1960, inclusive. However, two stations at and near Tucson (Fort Lowell and University of Arizona) have a total almost continuous record of 90 years for the period 1866-1960, inclusive. Three recording gages are near the area, for which the longest period of record (beginning in 1934) is for Ajo, Ariz., located about 60 miles southwest of Stanfield.

32. The 90-year mean annual precipitation for the 24 stations with records for more than 5 complete years ranges from 5.51 inches at the Gila Bend Airport, about 35 miles west of the basin, to 13.02 inches at Silver Bell in the headwaters of the basin. The 90-year mean annual precipitation in the Santa Rosa Wash basin upstream from the proposed Tat Momolikot damsite, ranges from about 8.5 inches in the vicinity of the damsite to about 15.0 inches in the headwater area, with an average of 10.8 inches for this part of the basin.

33. Storms.--Three types of storms (general winter storms, general summer storms, and local thunderstorms) produce precipitation in the Santa Rosa Wash basin. Precipitation during the winter usually results from general storms associated with extratropical cyclones of North Pacific origin. Such storms reflect an orographic influence and, though low in intensity, may last several days and cover the entire basin. During the months from December to March, such storms move southward over the ocean and then inland to southern California, Arizona, and New Mexico and result in precipitation over areas of up to thousands of square miles. Precipitation during general winter storms may be more or less continuous for several days.

34. Precipitation during the summer usually results from general storms associated with an influx of tropical maritime air originating over the Gulf of Mexico or the South Pacific Ocean. These storms are subject to some orographic influence. During the months from July to September, such storms enter the area from a southeast to southwest direction and often result in heavy rainfall over large areas for periods of up to 24 hours. However, at the end of such storms, showers may continue intermittently for as long as 3 days.

35. Local thunderstorms, which are frequent summer phenomena, may occur separately or in conjunction with general storms. Such storms cover comparatively small areas and result in high-intensity rainfall of short duration, usually 3 hours or less. Detailed information on storms in the Santa Rosa Wash basin is given in appendix 1.

36. Floods may result from any of the three types of storms. The most destructive floods in the Santa Rosa Wash basin have been produced by the general summer storms in late summer or early fall. In general, local thunderstorms have not caused severe flood conditions because they are of short duration and the areas covered are small.

37. Snow.--Snow falls occasionally at the higher elevations in the basin, but usually melts within a few days. The effect of snowmelt on floodflows in the basin is negligible.

RUNOFF AND STREAMFLOW DATA

38. Streamflow records.--No long-term runoff records are available for the Santa Rosa Wash basin. Three recording stream-gaging stations were installed in the Santa Rosa Wash basin in October 1954. Only one (Santa Rosa Wash at Vaiva Vo) is still in operation. Pertinent data for these stations are given in the following table:

Pertinent data on stream-gaging stations in Santa Rosa Wash basin, Ariz.

Stream and location	Drainage area	Period of record	Peak discharge of record	
			Peak	Date
	Square miles		Cubic feet per second	
Santa Rosa Wash at Gu Komelik (stream mile 51.8).....	629	1954-59	14,000	Oct. 31, 1957
Santa Rosa Wash at Vaiva Vo (stream mile 37.0).....	1,782	1954-62	53,000	Sep. 25, 1962
Kohatk Wash at Chiapuk, about 17 miles upstream from the confluence with Santa Rosa Wash.....	185	1954-60	2,830	Jul. 20, 1955

39. Adequacy of streamflow for multiple-purpose uses.--Runoff data for Santa Rosa Wash at Vaiva Vo, Ariz., were estimated by the Bureau of Indian Affairs for the period 1954 to 1961, as given in the following table:

Estimated average annual runoff, Santa Rosa Wash at Vaiva Vo, Ariz., for the period 1954-1961

Water Year	Runoff
	Acre-feet
1954	(*)
1955	17,670
1956	1,600
1957	1,110
1958	27,600
1959	9,440
1960	5,910
1961	5,310
Total	68,640
Average	9,800

* Gaging station established in October 1954.

40. The U.S. Bureau of Indian Affairs made studies to determine the justification of developing (a) additional water supplies for use on irrigable Indian land, and (b) public-access facilities for recreation and fish and wildlife purposes in the proposed project.

41. The water-conservation studies made by the U.S. Bureau of Indian Affairs included (a) a study of reservoir operation to provide water conservation, (b) a safe-yield study, (c) a determination of the area of use of the conserved water, (d) an evaluation of water-conservation benefits from operation of the reservoir, and (e) a determination of the net effect of operation of the reservoir on the downstream water supply, both surface water and ground water. The Bureau concluded that the annual safe yield from a reservoir at the recommended site would, if supplemented by water pumped from the ground-water supply, make feasible the inclusion of water conservation as a purpose in the proposed project.

42. Studies by the Bureau, in cooperation with Federal and State fish and game agencies, indicated that streamflow would not be adequate to provide a permanent pool upstream from the dam for recreation or for fish and wildlife. However, the Bureau concluded that a pool of adequate size would be available for periods of sufficient length to warrant the installation of public-access facilities for hunting and boating. Studies show that a

reservoir area of over 100 acres would be available for recreational purposes about 40 percent of the time. The Bureau also concluded that the provision of public-access facilities for fishing, hunting, and recreation would be warranted in the recommended ponds downstream from the dam.

43. The development of hydroelectric power is not feasible because the intermittent runoff from this relatively dry drainage area, combined with a high evaporation rate, would not provide an adequate supply of water for the generation of power.

FLOODS

44. Floods of record.--Historical reference to floods along Santa Rosa Wash extends back to 1914, but stages and discharge measurements are available for only the period 1954 to date. Large floods during this period occurred in 1914, 1926, 1929, 1931, 1935, 1938, 1940, 1945, 1950, 1954, 1957, and 1962.

45. The largest flood of recent record occurred in September 1962. The peak discharge of this flood was estimated at 53,000 cubic feet per second on Santa Rosa Wash at Vaiva Vo, Ariz. (about 6-1/2 miles downstream from the proposed Tat Momolikot damsite) and 16,000 cubic feet per second on Santa Rosa Wash at Greenes Wash (approximately 14 miles downstream from the proposed damsite). The only other major flood of record for which an adequate estimate of peak discharge along Santa Rosa Wash is available occurred in October 1957. The peak discharge of that flood was estimated at 10,000 cubic feet per second at Vaiva Vo, Ariz., and 9,500 at Greenes Wash. Additional information on floods is given in appendixes 1 and 4.

46. Flood characteristics.--Many of the streams in the Santa Rosa Wash basin rise in steep mountain areas where the rate of runoff is relatively high. During major storms, the water concentrates quickly in the channels, producing violent and destructive floods. As the valleys widen and the gradients decrease, the channels increase in size and become more absorptive. Channel storage and losses substantially diminish the flood peaks when no additions are made by side drainage. Base flow, made up of contributions from ground water, melting snow, and surface runoff from antecedent rain of flood-producing intensities, is relatively small in comparison with the peak floodflows.

47. Flood frequencies.--The probable future frequencies of floods of various magnitudes were determined for the purpose of estimating the economic value of flood-control improvements. Because of the relatively short period of recorded stream measurements and because of only meager historical information about floods that occurred prior to those measured, frequency studies were made from the runoff records for the period 1905-1960 for two areas in the vicinity of Santa Rosa Wash basin subject to similar meteorological conditions. The areas considered are: (a) Santa Cruz River at Tucson, Ariz., and (b) San Pedro River at Charleston, Ariz. Correlation of these studies led to the discharge-frequency curves shown on plate 1, appendix 4. The estimated frequencies of uncontrolled floods of various magnitudes for Santa Rosa Wash are given in the following table and additional information regarding flood frequencies is given in appendix 4.

Estimated frequencies of uncontrolled floods of various magnitudes, Santa Rosa Wash at Greenes Wash*

Number of times that flood would be equaled or exceeded in 100 years	Uncontrolled peak discharge
	Cubic feet per second
0.5	**51,000
1.0	39,000
2.0	31,000
5.0	21,000
10.0	15,500
20.0	10,400
49.0	***5,000

* Discharges at this point are indicative of average discharges within damage area.
** Standard project flood at Greenes Wash.
*** Nondamaging.

48. On the basis of the frequency study indicated above, the September 1962 flood, with an average discharge within the damage area of 16,000 cubic feet per second, is estimated to have a frequency of occurrence of 10 times in 100 years, and the October 1957 flood, with an average discharge in the damage area of 9,500 cubic feet per second, is estimated to have a frequency of occurrence of 24 times in 100 years.

49. Standard project flood.--A standard project flood is an estimated or hypothetical flood that might be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical region involved, excluding extraordinarily rare combinations. Such a flood could occur in the area considered in this report if a storm equivalent in magnitude to that of the largest storm of record in the general region were to center critically over the drainage area when ground conditions were conducive to a high rate of runoff. The magnitude of such a flood constitutes a reasonable appraisal of the flood-producing potentialities of the wash and is considered a reasonable upper limit in determining the size of the flood for which flood-control improvements might be designed.

50. Estimates of the magnitude of the standard project flood along the Santa Rosa Wash upstream from the proposed Tat Momolikot Dam are based on calculations of runoff that would result if a storm having characteristics of the September 3-8, 1939, general summer storm that occurred near Needles, Calif. (located about 200

miles northwest of Stanfield, Ariz.), were centered over the area. Pertinent information on the standard project flood at the Tat Momolikot damsite (stream mile 43.4) is given in the following tabulation:

Drainage area	sq. mi.	1,750
Peak discharge	c.f.s.	*55,000
Volume	ac.-ft.	145,000
Duration	days	5

* The peak discharge of the standard project flood at Greenes Wash, which is representative of the average discharge over the damage area, is estimated at 51,000 cubic feet per second.

51. Maximum probable flood.--The maximum probable flood is defined as the flood that would result if the probable maximum precipitation for the drainage area were to occur at a time when ground conditions were conducive to maximum runoff. The peak discharge of the maximum probable flood for the Santa Rosa Wash at the Tat Momolikot damsite is estimated at 270,000 cubic feet per second. The 5-day volume of this flood is estimated at 484,500 acre-feet. This flood was used in determining the design of the spillway for the dam. More detailed information regarding the development of the maximum probable flood is given in appendix 1.

EXTENT AND CHARACTER OF OVERFLOW AREAS

52. Location and extent.--The overflow area affected by the improvements considered in this report consists of 56,000 acres along Santa Rosa Wash from Tat Momolikot damsite to the mouth. (See pl. 3.)

53. Type and value of property in the overflow area.--The 56,000-acre overflow area along Santa Rosa Wash ranges in width from less than a mile at the damsite to almost 6 miles in the Stanfield-Maricopa area. In that overflow area, the present value of agricultural property (including about 46,000 acres of cropped land), although occupying about 82 percent of the area, is estimated at only about 55 percent of the total value. About 380 residences, 90 businesses, 7 industrial facilities, 15 public facilities, and numerous utilities account for about 31 percent of the value and about 3 percent of the overflow area; while hundreds of miles of irrigation works, many miles of transportation facilities, and flood-control works account for about 13 percent of the value and about 2 percent of the overflow area. About 15 percent of the overflow area is presently undeveloped.

54. Population in the towns of Stanfield and Maricopa has increased about 230 percent during the period 1950-1960. Growth in these two towns should continue in the future. Average future values for most nonagricultural property were estimated principally by using population, residential, and business trends. The rapidly increasing population and business activity in the Phoenix and Tucson areas will be reflected to some extent in the Stanfield-Maricopa area. Highway facilities under construction (Interstate No. 8) and planned irrigation facilities in connection with the Central Arizona project would increase the value of such facilities. The space available for future expansion was considered.

55. Overpumping in the agricultural sections of the basin would affect the agricultural economy of the area. Although the Bureau of Reclamation is developing plans for the importation of Colorado River water to the area through the Central Arizona project, it is doubtful that such importation would fully meet the needs of the area. For the purposes of this report, it was assumed that the Central Arizona project would be constructed, but even with the importation of water, the agricultural acreage in the overflow area would be reduced about one-third. However, technical improvements; such as increased pumping efficiency, better soil moisture determination, improvements in irrigation layout and land leveling, improved application techniques such as sprinkling, and the growing of crops requiring less water would allow more efficient use of available water. In addition, increased productivity would increase the yields of crops and thereby increase the value of crops per acre. As a result of the above factors, it is estimated that agricultural values in

the overflow area, under average future conditions, would at least equal present agricultural values. The recent Supreme Court decision, although not final, appears to clear one of the major hurdles towards authorization of the project. However, conclusions and recommendations of this report would not be affected by failure to develop this outside source of water supply.

56. Assuming that no flood-control improvements would be constructed in addition to such improvements as have already been completed, estimated average property values for the next 100-year period (1962-2061) in the overflow area considered in detail in this report are shown in the table at the end of this paragraph. In order to reflect the time of development of future values, such future values were discounted by the application of present-worth factors. More detailed information on the effect of applying those factors, together with more detailed information on the present and estimated future development in the overflow area, is given in Appendix 4: Benefits from Flood Control.

Summary of estimated value of property subject to damage by uncontrolled standard project flood in the overflow area considered in detail, Santa Rosa Wash, Ariz.

Property	Present (1962) value of property	Average future value of property*
Residential	$4,350,000	$5,080,000
Business	4,620,000	6,930,000
Industrial	2,200,000	2,420,000
Agricultural	42,780,000	42,780,000
Irrigation works	6,500,000	8,600,000
Utilities	10,760,000	11,000,000
Railroads and railroad bridges	1,250,000	1,250,000
Highways, roads, and bridges	660,000	1,520,000
Public facilities	1,650,000	2,470,000
Flood-control works	400,000	400,000
Undeveloped land	900,000	900,000
Total	76,070,000	83,350,000
Say	76,100,000	83,400,000

* The value of average future development for period 1962-2061 without flood control was discounted by using present-worth factors.

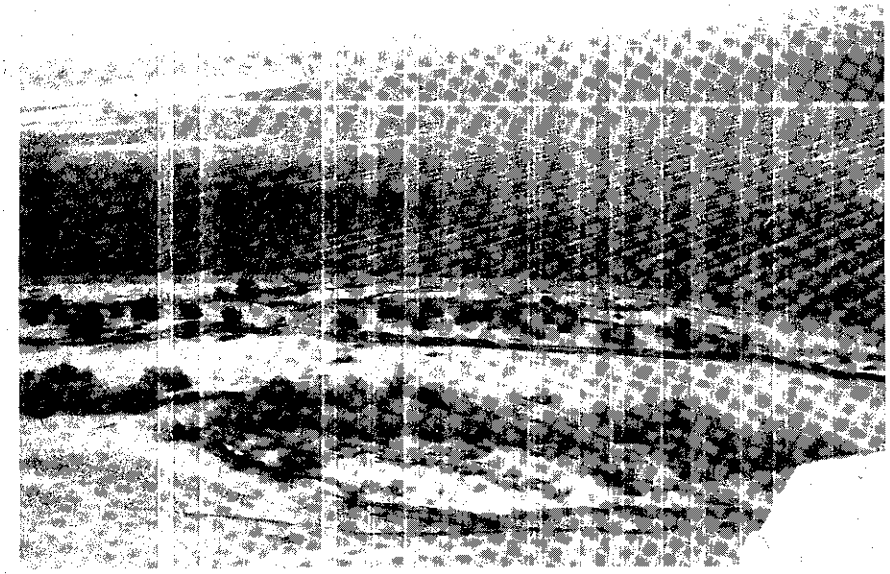
FLOOD DAMAGES

57. Damages from past floods.--Adequate estimates of damages resulting from past floods in the Santa Rosa Wash drainage area in the overflow area considered in detail are not available except for the October 1957 and September 1962 floods. Flood damage surveys were conducted by the U.S. Army Engineer District, Los Angeles, immediately after both of these floods. During the October 1957 flood, flows in the Santa Rosa Wash debouched into the Stanfield-Maricopa area and flooded 16,000 acres of cultivated land, mostly planted to cotton just ready for harvest (see photographs Nos. 1 and 2). Flood depths averaged 1 to 1-1/2 feet, but reached 3 feet in some areas. Mud, silt, and debris were spread over much of the flooded area. Erosion of land near the washes was considerable. The damage was greatest where water broke through weak spots of the small protective levees that local farmers had built along the washes. The October 1957 flood, with a peak discharge of 9,500 cubic feet per second at Greenes Wash, caused an estimated total damage of $625,000, of which about $540,000 would have been prevented if the recommended Tat Momolikot Dam had been in operation. A summary of the estimated damages caused by the flood of October 1957 is given in the following table:

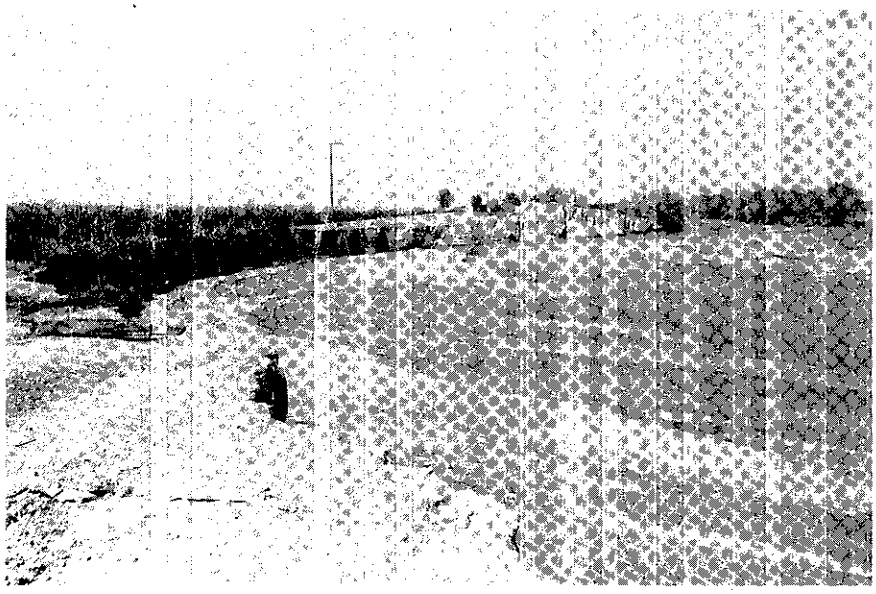
Summary of estimated damages, flood of October 1957, overflow area considered in detail, Santa Rosa Wash, Ariz.

Type of property	Damages		
	Physical damages	Emergency costs and business losses	Total
Residential	$7,000	$2,000	$9,000
Business and industrial	4,000	2,000	6,000
Agricultural*	321,000	120,000	441,000
Highways and bridges	116,000	7,000	123,000
Railroad and bridges	15,000	10,000	25,000
Utilities	3,000	2,000	5,000
Flood-control works	14,000	2,000	16,000
Total	480,000	145,000	625,000

* Including irrigation works.



NO. 1 Aerial view near confluence of Santa Rosa and Greenes Washes showing land erosion and flooded cotton fields near Stanfield, Ariz., Oct. 1957.

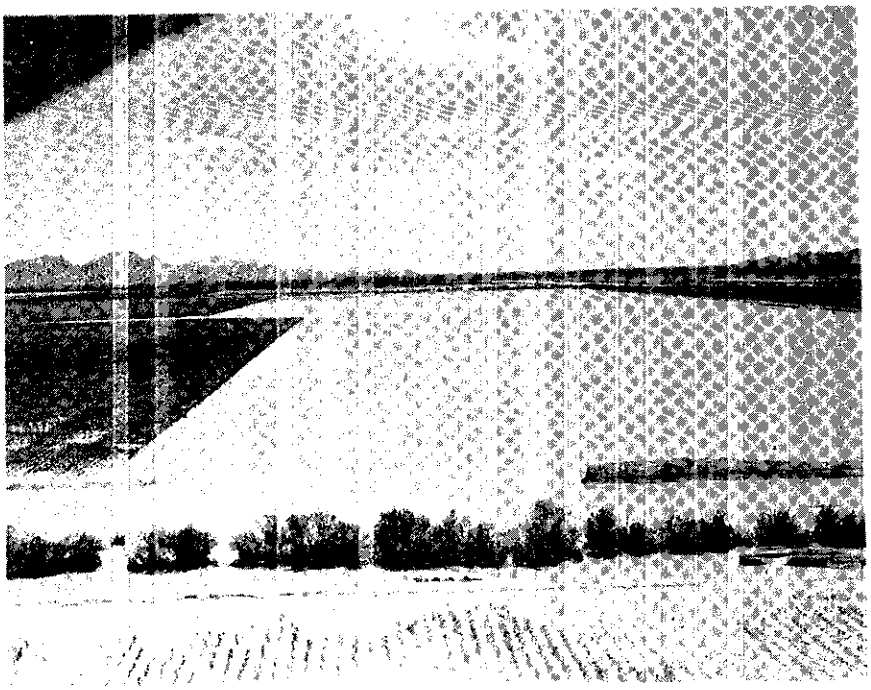


NO. 2 Road and crop damage along Santa Rosa Wash about 2 miles south of Stanfield, looking north (downstream). Flood of Oct. 1957.

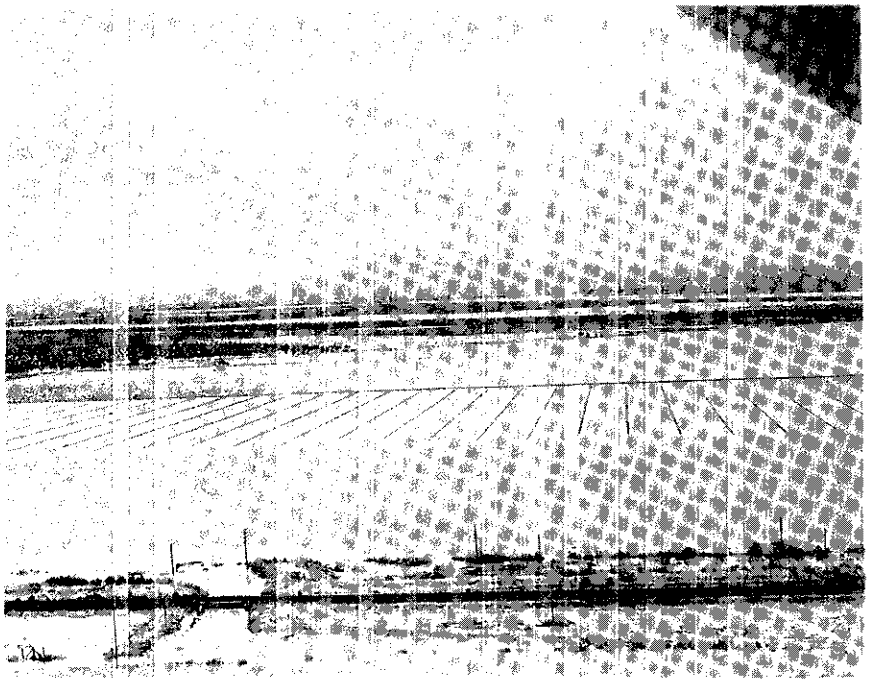
58. The September 1962 flood was widespread; floodflows occurred along the major streams on the lower Santa Cruz River basin and at Sells, Ariz., just south of the Santa Rosa Wash drainage area. In addition to flows along Santa Rosa Wash, floodflows occurred along (a) the Santa Cruz River, mostly north of Tucson, Ariz., (b) Brawley Wash, to the east of Santa Rosa Wash, and (c) Greenes Wash, a tributary of Santa Rosa Wash downstream from the Tat Momolikot damsite. The flow along Greenes Wash resulted mostly from a breakthrough of Santa Cruz River into the Greenes Wash area. The peak discharge along Santa Rosa Wash was estimated at 53,000 cubic feet per second at Vaiva Vo, and at 16,000 cubic feet per second just upstream from Greenes Wash.

59. Along Santa Rosa Wash downstream from the Tat Momolikot damsite, the September 1962 flood caused damage predominantly to agricultural facilities and crops. Agricultural damages were reported at $2,700,000, and included: (a) crop damage to about 6,500 acres of cotton in the early harvest stage, $1,600,000; (b) land damage, including erosion and silting on about 9,000 acres, $415,000; (c) damage to about 50 miles of concrete-lined irrigation ditches, to about 12 irrigation wells, and to 7 pumping facilities, $450,000; and (d) damage to farm machinery, $63,000. Floodwaters damaged about 30 miles of locally-built flood-control dikes estimated at $200,000. Fifteen farm residences suffered flood damage estimated at $38,000. Seven cotton gins in the area suffered $67,000 damage, most of which resulted from excessive wear on the equipment from the grit in the cotton. Damage to railroad tracks, several highway and road bridges, and 35 miles of county and State roads amounted to an estimated $175,000. Flood damage to utilities was estimated at $5,000. Ponded floodwaters remained on the land for several weeks in some low areas. This added substantially to the disruption of agricultural, business, and industrial operations.

60. Of the total $3,370,000 flood damage along Santa Rosa Wash below the Tat Momolikot damsite from the September 1962 flood, about $2,225,000 would have been prevented if Tat Momolikot Dam had been in operation. (See photographs Nos. 3 and 4.)



No. 3 Aerial view showing crop damage along Santa Rosa Wash about 6 miles south of Stanfield and looking upstream toward Tat Momolikot damsite. Sept. 1962.



No. 4 Aerial view showing road, railroad, and crop damage in the Santa Rosa Wash overflow area about 5 miles southeast of Maricopa. Sept. 1962.

61. A summary of the flood-damage estimate prepared from the flood-damage survey of the September 1962 flood in the Santa Rosa Wash area is given in the following table:

Summary of estimated damages, flood of 25-26 September 1962, overflow area considered in detail, Santa Rosa Wash, Ariz.

Type of property	Damages		
	Physical damages	Emergency costs and business losses	Total
Residential	$34,000	$4,000	$38,000
Business and industrial	58,000	155,000	213,000
Agricultural*	2,130,000	570,000	2,700,000
Railroad, highways, and bridges	166,000	9,000	175,000
Utilities	4,000	1,000	5,000
Flood-control works	182,000	18,000	200,000
Miscellaneous	6,000	33,000	39,000
Total	2,580,000	790,000	3,370,000

* Including irrigation works.

62. Flood damages from the September 1962 storms in other parts of the Santa Cruz River basin were estimated at $7,550,000, totaling about $10,920,000 for the entire Santa Cruz River basin (including Santa Rosa Wash basin). Additional flood damage, totaling about $390,000, occurred at Sells, Ariz. and vicinity, along a stream that drains into Mexico.

63. Damages from future floods.--Estimates of damages resulting from the October 1957 flood and the September 1962 flood along Santa Rosa Wash were used in developing and substantiating discharge-damage relationships in this area. However, in order to expand such relationships for larger floods, hydraulic and economic studies were made to determine the effect of floods of larger magnitudes on present and future development.

64. In estimating the damages from a single flood, consideration was given to the probable extent of the overflow area, to the types and value of property subject to damage, and to the extent of damage that would occur to each type of property from floodwaters of computed depth, velocity, and duration. An allowance was also made for appreciable ponding behind the east-west roads across the damage area. The selected magnitudes range from the discharge that would cause no appreciable damage to the

discharge of the standard project flood. The estimates of damages include physical damages, emergency costs, and business and financial losses that would be caused by the floods considered.

65. Estimates of damages from future floods over the next 100 years were computed and adjusted on the basis of estimated average future economic development of the overflow area. Estimates of damages that would occur under average future conditions in the overflow area considered in detail along Santa Rosa Wash as a result of floods of various magnitudes are given in the following tables:

Estimated damages resulting from a future flood with average magnitude of 51,000 cubic feet per second* in the overflow area considered in detail along Santa Rosa Wash, Ariz.

Type of property	Damages based on average future values**		
	Physical damages	Emergency costs and business losses	Total damages
Residential	$1,041,000	$234,000	$1,275,000
Business	437,000	124,000	561,000
Industrial	260,000	78,000	338,000
Agricultural	2,533,000	625,000	3,158,000
Irrigation works	241,000	33,000	274,000
Utilities	305,000	130,000	435,000
Railroad and RR. bridges	488,000	328,000	816,000
Highways, roads and highway bridges	426,000	85,000	511,000
Public facilities	590,000	118,000	708,000
Flood-control works	49,000	5,000	54,000
Total	6,370,000	1,760,000	8,130,000

* Standard project flood at Greenes Wash.
** Over next 100-year period (1962-2061) without flood control.

Estimated damages resulting from future floods of various average magnitudes in the overflow area considered in detail along Santa Rosa Wash, Ariz.

Flood magnitude	Overflow area	Damages based on average future values*		
		Physical damages	Emergency costs and business losses	Total
Cubic feet per second	Acres			
**51,000	56,000	$6,370,000	$1,760,000	$8,130,000
30,000	54,000	4,430,000	1,290,000	5,720,000
10,000	18,000	520,000	130,000	650,000
5,000	0	0	0	0

* Over next 100-year period (1962-2061) without flood control.
** Standard project flood at Greenes Wash.

66. Average annual damages from future floods.--A curve was drawn showing the relationship between peak discharges and average future damages for the overflow area considered in detail. This curve was combined with the discharge-frequency curve previously described to obtain a curve relating flood damages of varying amounts to the frequency of occurrences of such damages. (See pls. 1 and 2, appendix 4.)

67. The area under the damage-frequency curve represents average annual flood damage. Using present (1962) price levels, the average annual flood damages are estimated at $550,000 under present (1962) development, and at $605,000 under average future (1962-2061) development.

68. Intangible damages from future floods.--Future floods along Santa Rosa Wash would cause serious damages incalculable in terms of monetary value. Intangible damages from future floods would result from loss of lives, delay in shipment of perishable goods, interruption of passenger travel on railroads and highways, isolation of communities, interruption of homelife and of school and other community activities, interruption of public-utility services, and general lowering of community morale.

EXISTING IMPROVEMENTS

69. Corps of Engineers flood-control improvements.--No existing flood-control project in the Santa Rosa Wash basin is under the jurisdiction of the U.S. Army Corps of Engineers.

70. Improvements by other Federal and non-Federal agencies.--The U.S. Bureau of Indian Affairs has constructed numerous small check dams on tributaries upstream from the Tat Momolikot damsite to impound water for the use of range cattle. These works have no significant effect on the floodflow in the damage area being considered in detail. Levee and channel improvements were constructed by local interests at critical places along Santa Rosa Wash at a total estimated cost of $400,000. These works are adequate for the control of only small floods. Larger floods in the past have breached or destroyed similar works.

IMPROVEMENTS DESIRED

71. Public hearing.--A public hearing was held at Stanfield, Ariz., on March 31, 1960, by the Department of the Army, with the district engineer, U.S. Army Engineer District, Los Angeles, Corps of Engineers, presiding. The hearing was attended by about 75 persons, including representatives of other Federal agencies, officials of State and local agencies, and local interests.

72. Improvements desired by local interests.--At the public hearing, the Maricopa Flood Control District and the Stanfield Flood Control District jointly submitted a plan providing for a flood-control dam and reservoir on Santa Rosa Wash upstream from Vaiva Vo, Ariz. The U.S. Bureau of Indian Affairs, representing the Papago Indians, indicated that it was developing plans for a water-conservation project to provide additional water for irrigation in the Papago Indian Reservation. Development of the proposed project indicates the desirability of incorporating fish, wildlife, and recreation features.

73. Reasons advanced in justification of improvements desired.--Representatives of local interests stressed the need for flood control in the Santa Rosa Wash basin downstream from Vaiva Vo, Ariz., to (a) prevent inundation of developed residential, commercial, and industrial facilities in urban areas, particularly in the towns of Stanfield and Maricopa; (b) prevent inundation of farming areas; and (c) prevent interruption of transportation facilities and of utility services.

74. Representatives of the U.S. Bureau of Indian Affairs stressed the need for water-conservation improvements to provide irrigation water for use in the Papago Indian Reservation. The Bureau states that crop production in the reservation is almost negligible because of the lack of a firm supply of irrigation water but indicates that stored floodwaters, supplemented by water from proposed wells, could be used in an expanded agricultural area; with resultant improvement in the economic condition of the Indians on the reservation.

75. Bureau studies indicate that the water areas created by the proposed water-conservation improvements could be utilized to provide facilities for public use, including boating, fishing, hunting, and related recreational activities.

76. Opposition to the water-conservation features of the proposed plan has been voiced by the Buckeye Irrigation District. This district, located along the Gila River near Buckeye, Ariz., below the mouth of Santa Rosa Wash, lays claims to use of waters flowing along the Gila River. More detailed information on this subject is given under the previous heading "Water rights."

FLOOD PROBLEMS, WATER-CONSERVATION PROBLEMS, AND RELATED PROBLEMS

77. Flood problems.--Floods along Santa Rosa Wash downstream from the Papago Indian Reservation cause recurring damage of major proportions by eroding farmland, cutting streambanks, changing the shape and location of channels, overflowing stream channels, inundating farmland, depositing silt on crops; and damaging and destroying irrigation, communication, residential, municipal, and transportation facilities. In the overflow area considered in detail, about 45,800 acres of cultivated land, stock farms, several towns, railroads, and highways are subject to overflow and damage. These 45,800 acres of intensely developed irrigated farmland, plus about 200 more acres in the considered Vaiva Vo irrigation project, constitute about 48 percent of the total cultivated acreage in the lower Santa Rosa Wash Valley.

78. Because of the inadequate capacity of the Santa Rosa Wash channel, debris-laden floodwaters overflow and cause damage to land and improvements along essentially the entire length of the wash.

79. Water-conservation problems.--Most of the water used in the Santa Rosa Wash basin below the Papago Indian Reservation is obtained by pumping from underground basins. Overpumping in the agricultural sections of the basin is creating a water-shortage problem that could affect future agricultural economy of the area. Plans of the Bureau of Reclamation make provisions for furnishing supplemental water to this area from the proposed Central Arizona project, but such waters will probably not be adequate to satisfy the demands.

80. Under present conditions, utilization of the flows of the Santa Rosa Wash within the Papago Indian Reservation is very limited. Only about 200 acres are occasionally farmed when surface runoff is adequate to raise a crop. Because water is a vital factor in the economy of the area, maximum utilization of the available water supply is essential. Unregulated flows in Santa Rosa Wash are not adequate to satisfy the seasonal demands of irrigation on irrigable land along the wash. In addition, flood problems along Santa Rosa Wash are related closely to the problems of water conservation. Because of the flashy nature of the streamflow and the high sediment content of floodwaters, utilization of the runoff within the area is incomplete.

81. The need for the development of water-conservation improvements on the Papago Indian Reservation to assist in raising the economic standards of the Papago Indians has long been recognized by the Bureau of Indian Affairs. The Papago Development Program, approved by the Papago Tribal Council on November 26, 1948, and by the Secretary of the Interior on

May 24, 1949, included a proposal for development of 11,000 acres of irrigable land on the Papago Indian Reservation. Preliminary study by the Bureau of Indian Affairs indicated that a single-purpose irrigation project similar in scope to that considered in this report was economically feasible. On July 19, 1960, the Commissioner of Indian Affairs directed that feasibility reports be prepared for the future development of proposed Indian irrigation projects within the Papago Indian Reservation. Consideration by the Bureau of Indian Affairs of water conservation as a purpose in the proposed multiple-purpose plan is in compliance with the above directive.

82. Related problems.--Studies prepared by the U.S. Fish and Wildlife Service and the Arizona Game and Fish Department have pointed out the need in this area for the recreational use of water stored in a multiple-purpose reservoir and for fisheries in ponds to be located downstream from the dam.

PLANS OF IMPROVEMENT CONSIDERED

83. General.--Optimum utilization of the water resources of the Santa Rosa Wash basin requires coordinated developments for flood control, water conservation, fish and wildlife, and recreation.

84. The control of floods by various types of reservoirs and levee and channel improvements and by combinations of both was considered. Preliminary estimates indicate that the costs of improving the Santa Rosa Wash channel for a distance of about 25 river miles through the flood-problem area downstream from the Papago Indian Reservation, to provide the same degree of protection as the recommended plan, would be about $18,000,000. Because such costs would greatly exceed the cost of the flood-control features in the recommended plan, and because multiple-purpose features could not be achieved under the plan, no further consideration was given to a levee and channel improvement. Consideration was also given to the construction of detention basins along the tributaries; but, because of uncertainty about where storms would occur over the area, the construction of many such structures would be required. Investigation disclosed that such dams could not be economically justified. Therefore, no further consideration was given to construction of detention basins. Economies accrue to flood control, irrigation, fish, wildlife, recreation, and area-redevelopment interests by combining features under a multiple-purpose plan, as considered in this report, rather than construction of a single feature. (See discussion under a later heading entitled "Project formulation.")

85. The damsite was selected over other feasible damsites on the basis of (a) providing control of Santa Rosa Wash as far downstream as practicable to reduce residual flows in the damage area, (b) lower spillway costs, and (c) permitting development of the best irrigable Indian lands along Santa Rosa Wash. This damsite, the Tat Momolikot site, is located on the Papago Indian Reservation.

86. The U.S. Bureau of Indian Affairs is preparing a feasibility report on the water-conservation requirements for the development of about 1,640 acres of irrigable land (including about 200 acres presently cultivated) in the Papago Indian Reservation downstream from the Tat Momolikot damsite. The results of their studies have indicated the need for 15,000 acre-feet of storage in a reservoir at the Tat Momolikot site to supply water to those 1,640 acres of irrigable Indian land downstream from the damsite.

87. Preliminary studies showed that a multiple-purpose reservoir would be the best solution. Detailed consideration was therefore given to a multiple-purpose project to provide for flood control, water conservation, fish and wildlife, area redevelopment,

and recreation. The Corps of Engineers determined the flood-control requirements, the Bureau of Indian Affairs determined the water-conservation, land-development, and area-redevelopment requirements, and the U.S. Fish and Wildlife Service and Arizona State Game and Fish Department determined the fish and wildlife and recreation requirements. The design for the Tat Momolikot Dam and reservoir was prepared by the Corps of Engineers; the design for the Vaiva Vo irrigation project, by the Bureau of Indian Affairs; and the design for the fish and wildlife and recreation facilities by the Bureau of Indian Affairs, assisted by the Corps of Engineers, and in collaboration with the U.S. Fish and Wildlife Service and the Arizona State Game and Fish Department. Detailed information on the recommended multiple-purpose plan and pertinent information on other plans are given in following paragraphs.

88. Santa Rosa Wash multiple-purpose project (recommended plan).--The recommended plan for Santa Rosa Wash provides for (a) a multiple-purpose dam and reservoir on Santa Rosa Wash at the Tat Momolikot site (stream mile 43.4) and about 6-1/2 miles upstream from the Indian village of Vaiva Vo, Ariz., and (b) the development of 1,640 net acres of cultivated land in the Vaiva Vo irrigation project on the Papago Reservation downstream from the dam. The water supply distribution system would consist of (a) a main supply canal that would receive water from the dam and would deliver the water to laterals in the area proposed for irrigation development, (b) 13 wells and pumps along the laterals and the main canal to utilize the ground-water supplies, and (c) ponds at the upper end of the main canal to increase the ground-water recharge. These ponds would also be used as fish ponds. Recreation and hunting facilities would be located in the reservoir area and in the area of the fish ponds.

89. Tat Momolikot Dam and reservoir.--The dam at the Tat Momolikot site would be a compacted-earthfill structure with a height of about 66 feet above streambed. The crest of the dam (elevation 1,566) would be about 3 miles long. The spillway, partly excavated in hard rock through a saddle east of the right abutment of the dam, would have a reinforced concrete sill with a length of about 1,000 feet at elevation 1,547. At maximum water surface (elevation 1,559.5), the spillway would have a capacity of 142,000 cubic feet per second. The flood-control outlet works, consisting of an ungated concrete-lined rectangular notch 15.2 feet wide and 21 feet deep through the sill at the spillway crest, would have an invert elevation of 1,526 at the sill. The capacity of the flood-control outlet works would be about 4,600 cubic feet per second with the water surface at the spillway crest (elevation 1,547). This discharge would be small enough to provide a high degree of flood protection downstream and would still be large enough to empty the flood-control part of the reservoir in a reasonable time after floods.

90. Two compacted-earthfill saddle dikes would be constructed in the northeastern section of the reservoir area. Both dikes would have a crest elevation of 1,566 with a maximum height of about 17 feet. The crest lengths would be about 2,800 feet and 3,600 feet, respectively.

91. The conservation pool (15,000 acre-feet) would be drained through a 4.25-foot-diameter outlet conduit, extending through the dam embankment to a point just downstream from the embankment, where a canal would connect the outlet conduit to the main canal for the proposed Vaiva Vo irrigation project. A gate would be installed in the canal to permit the draining of the reservoir directly to the river. The inlet invert of the conduit would be at elevation 1,504. An intake tower with gates installed at intervals of about 5 feet between elevations 1,504 and 1,526 would permit drainage through the conduit from various levels within the conservation pool.

92. The reservoir (Lake St. Clair) at spillway-crest elevation 1,547 would have an area of about 12,000 acres and a capacity of 181,000 acre-feet, including 126,000 acre-feet for flood control, 15,000 acre-feet for water conservation, and 40,000 acre-feet for sediment. Provision is made for an accumulation of sediment for a 100-year period. About 2.3 miles of the road connecting Casa Grande with Sells, Ariz., would be raised in the reservoir area to elevation 1,538.5 (an elevation expected to be reached about once in 50 years). About 2 miles of graded service road would be provided to connect that highway to the damsite. Indian burial grounds within the reservoir area would be protected from inundation by an encircling dike. Provisions would be made for the relocation of community facilities, such as the well and church at Tat Momolikot Village.

93. The reservoir would reduce a flood with a peak discharge of 55,000 cubic feet per second (standard project flood) to an outflow of 4,600 cubic feet per second. Within the damage area (below the mouth of Greenes Wash), mostly as a result of uncontrolled flows downstream from Tat Momolikot damsite, the standard project flood of 51,000 cubic feet per second would be reduced to about 22,000 cubic feet per second. Under the operation of the proposed reservoir, average annual flood damages over a 100-year period in the flood-problem area downstream from the dam resulting from flows along Santa Rosa Wash and its tributaries would be reduced by about 87 percent.

94. As estimated by the Bureau of Indian Affairs, operation of Tat Momolikot Dam and reservoir for water conservation would develop an annual safe yield of 4,760 acre-feet, of which 3,620 would be released for direct irrigation of project lands and for maintenance of fish ponds, and 1,140 would be injected into underground storage. Pumping from deep wells would require an average

of 5,735 acre-feet annually to meet the total Vaiva Vo irrigation-project demand of 9,355 acre-feet per year. Studies made by the Bureau of Indian Affairs indicated that the annual well recharge of 1,140 acre-feet into the subsurface water supply, augmented by seepage from the reservoir, ponds, and irrigated land which would average 3,640 acre-feet annually, and by the estimated natural recharge of 1,000 acre-feet per year, would permit a total annual recharge to underground storage downstream from Tat Momolikot Dam and reservoir of about 5,780 acre-feet, slightly more than the 5,735 acre-foot requirement. The Bureau of Indian Affairs indicates it does not appear that operation of the recommended plan for water conservation would have an adverse effect on downstream water users who take nearly all their water from underground sources.

95. Vaiva Vo irrigation project.--Pertinent information on the Vaiva Vo irrigation project is given in the following subparagraphs:

(a) The Vaiva Vo irrigation project, as developed by the Bureau of Indian Affairs, would be located on the gentle slope on the west side of the Santa Rosa Valley between the Tat Momolikot damsite and a point approximately 2 miles north of the village of Vaiva Vo, a distance of about 8 miles. The lands under the project are utilized at the present time for year-round grazing by the Papago Indians, except for about 200 acres near the village of Vaiva Vo, which are used for irrigation farming when floodflows along Santa Rosa Wash are available. Land classification studies prepared by the U.S. Bureau of Indian Affairs indicate that, in the Vaiva Vo irrigation project area, 1,274 acres would be class 1, 301 acres would be class 2, and 65 acres would be class 3, totaling 1,640 acres. Surface runoff from the land adjoining the project on the west will be intercepted by diversion channels constructed to direct the runoff water to selected wasteways.

(b) The main supply canal would receive irrigation water at the downstream toe of the Tat Momolikot Dam from the gated outlet conduit. The canal, which would have a capacity of 60 cubic feet per second, would be approximately 6 miles long. It would supply water to fill the ponds to be used for ground-water recharge and for the propagation of fish, as well as to supply the project irrigation demand. Seven turnout structures would supply water to the laterals located at 1/2-mile intervals along the east side of the canal.

(c) The laterals would be concrete-pipe conduits. Risers would be provided to distribute irrigation water to individual field border strips. Approximately 1-3/4 miles of open concrete-lined ditch lateral would be constructed to deliver water to the existing ditch, which supplies water to the approximately 200 acres of the lands presently irrigated in the project.

(d) Thirteen wells would be installed along the laterals and the main canal. During periods of low flow from the reservoir, they would discharge pumped water directly into the canals or laterals. One of the wells would be used for supplying the fish ponds during periods when the reservoir is empty. The wells, with an average pumping capacity of 1,000 gallons per minute each at 50-foot drawdown, would be drilled to about the 500-foot level or about 375 feet below the present ground-water table.

(e) Adequate embankment material is available adjacent to and downstream from Tat Momolikot Dam. The borrow pits remaining after construction of the dam may be utilized as fish ponds. The fish ponds, which would be interconnected, would have an area of approximately 50 acres. The ponds will also serve as settling basins to clarify water to be injected in ground-water recharge wells.

96. Recreational, fish, and wildlife facilities.--Recreation and hunting facilities, consisting of access roads, boat ramps, sanitary facilities, and parking areas, would be provided in the northeastern area of the reservoir. Joint-use facilities for recreation, fish, and wildlife would be provided at and in the vicinity of the ponds downstream from the dam. These facilities would include picnic areas, playgrounds, maintenance building, toilets, access roads, parking areas, landscaping, boat docks, and utilities.

PLANNING AND ADMINISTRATION OF PROJECT LAND AND WATER AREAS

97. The Santa Rosa Wash project would be situated wholly on Indian land and, therefore, the use of all project land would be subject to the approval of the Papago Indians, and all project land would be administered by the U.S. Bureau of Indian Affairs in connection with the operation and maintenance of the project. Any reservoir that would be constructed in the Santa Rosa Wash basin within the Papago Indian Reservation and the lands surrounding the reservoir would be owned, developed, and controlled by the Papago Tribal Council, assisted by the U.S. Bureau of Indian Affairs and Federal and Arizona State fish and game interests, subject to flood-control-operation procedures specified by the Secretary of the Army. Therefore, the Papago Tribal Council would control all recreational, fishing, and hunting facilities and activities at the project. The Papago Tribal Council has indorsed the project and agreed to operate the recreational features for the benefit of all local interests. The favorable year-round climate and the proximity of the Phoenix and Tucson metropolitan areas to the proposed reservoir would appreciably contribute to the value of recreational features.

ESTIMATES OF FIRST COST AND ANNUAL CHARGES

98. Estimates of first cost.--The estimated first cost of the improvements considered in detail include expenditures for construction of (a) the Tat Momolikot Dam and reservoir, including relocation of roads and utilities, construction of an access road, and acquisition of rights-of-way; (b) the Vaiva Vo irrigation project, which includes water-conservation facilities (including land-development costs) outside the reservoir area; and (c) fish, wildlife, and recreational facilities, both inside and outside the reservoir area. Title to all lands in the Santa Rosa Wash multiple-purpose project area would remain in the hands of the Papago Indians. The Papago Tribal Council, recognizing that the irrigation features of the project would benefit the Tribe, agreed to make available to the United States without cost (a) appropriate rights to those lands required for construction of the dam and appurtenances, and (b) appropriate rights to those lands that would be required for construction of a water-conservation reservoir (up to elevation 1,535 feet). Payment would be made to the Tribe for use of additional lands required to provide the flood-control facilities. Human habitation would be prohibited in the reservoir area. Adjustments would be made for mineral rights, habitations, and other facilities presently in the reservoir area.

99. Estimates of cost were based on prices prevailing in September 1962. Allowances were made for the cost of engineering, overhead, inspection, and contingencies. No loss of taxes would result from construction of the project because it would be constructed entirely on Indian lands. Cost estimates for the Tat Momolikot Dam and reservoir were prepared by the Corps of Engineers; cost estimates for the Vaiva Vo irrigation project were prepared by the Bureau of Indian Affairs; and cost estimates for the recreational and fish and wildlife facilities were prepared jointly by the Corps of Engineers and the Bureau of Indian Affairs in cooperation with the U.S. Fish and Wildlife Service and Arizona State Game and Fish Department. Details of the estimated first cost of the improvements under the recommended plan are given in appendix 3, and a summary of those costs is given in the following table:

Estimated first costs of multiple-purpose project for Santa Rosa Wash, Ariz. (recommended plan) based on September 1962 prices.

Item	Cost
Tat Momolikot Dam and reservoir	*$5,360,000
Vaiva Vo irrigation project	995,000
Recreational facilities	**40,000
Fish and wildlife facilities (below Tat Momolikot Dam)	35,000
Total	6,430,000

* Does not include $81,000 expended for preauthorization studies.

** In reservoir area, $15,000; and below Tat Momolikot Dam, $25,000.

100. Estimates of annual charges.--The estimates of annual charges for the improvements considered in this report include (a) interest on the total investment, (b) amortization of the total investment in 100 years, and (c) average annual costs of maintenance and operation. The annual charges were computed using a 3-percent interest rate on the investment. Because of the low value of the desert-type grazing land in the reservoir area, no adjustment for net loss of productivity of land was considered necessary.

101. The total investment includes the first cost of the improvement plus interest during the construction period, which is estimated at 2 years for the dam and reservoir and at 2 years for the irrigation project of the U.S. Bureau of Indian Affairs. Estimates of investment and average annual charges for the recommended plan are given in the following table:

Estimated investment and average annual charges, recommended plan of improvement, Santa Rosa Wash, Ariz.
(based on September 1962 prices)

(a)	Federal first cost and total investment:	
	(1) Tat Momolikot Dam and reservoir project...	$5,360,000
	(2) Vaiva Vo irrigation project.....	995,000
	(3) Recreational facilities.....	40,000
	(4) Fish and wildlife facilities.....	35,000
	(5) Interest during construction, 3 percent on $6,430,000 times 2 years divided by 2.....	193,000
	(6) Total Federal first cost and investment.....	6,623,000
(b)	Federal annual charges:	
	(1) Interest, 3 percent on item (a)(6).....	199,000
	(2) Amortization of Federal investment in 100 years at 3 percent, 0.001647 times item (a)(6).....	11,000
	(3) Maintenance and operation.....	62,000
	(4) Total Federal annual charges.....	272,000

ESTIMATES OF BENEFITS

102. Tangible benefits.--Tangible benefits would accrue under the recommended plan from the prevention of flood damages; from development and utilization of additional irrigation and labor supplies; and from development of fish, wildlife, and recreation uses. Available information indicates that intensive utilization of the overflow areas that would be protected by the recommended improvements will continue even if flood-control improvements are not provided. Therefore, no appreciable tangible benefits would result from increased utilization of lands if the improvements should be constructed.

(a) Benefits from prevention of flood damage.--Construction of a multiple-purpose dam at the Tat Momolikot site would provide a high degree of flood protection to the area along Santa Rosa Wash downstream from the dam. About 46,000 acres of cultivated land, irrigation systems, the towns of Stanfield and Maricopa and several Indian villages, highway and railroad facilities, and utility systems downstream from the improvement would be protected from most floods that originate upstream from the improvements. Flows immediately downstream from the damsite would be reduced, as shown in the table below. However, flows originating downstream from the dam will combine with the controlled discharges to form residual flows along the entire reach of Santa Rosa Wash. Discharges at the point of reference (junction of Greenes Wash) for a damage-discharge curve were determined to reflect the average discharges over the entire damage reach, as shown in the following table:

Peak discharges on Santa Rosa Wash under uncontrolled conditions and with control at Tat Momolikot Dam

Flood frequency*	Peak inflow at Tat Momolikot Dam	Uncontrolled average discharges along Santa Rosa Wash within damage area	Peak discharges - control at Tat Momolikot Dam	
			Just below Tat Momolikot Dam	Average discharge over damage area
	Cubic feet per second	Cubic feet per second	Cubic feet per second	Cubic feet per second
0.5.....	**55,000	51,000	4,600	20,000
1.0.....	42,000	39,000	3,500	15,000
2.0.....	33,000	31,000	2,400	11,500
5.0.....	23,000	21,000	1,500	7,500
10.0....	16,500	15,500	1,000	5,400
20.0....	11,000	10,400	700	3,500

* Number of times in 100 years discharges would be equaled or exceeded.

** Standard project flood.

Using the data presented in the above table, and combining these data with damage-discharge relationships previously developed, damage-frequency curves were drawn. These curves indicate the damages not prevented (or residual damages) after construction of the recommended Tat Momolikot Dam. The total average annual flood damages along Santa Rosa Wash from the damsite to the Santa Cruz River would be reduced by Tat Momolikot Dam from $605,000 to $78,000. Average annual flood-control benefits would therefore amount to $527,000. More detailed information regarding the determination of flood-control benefits is given in Appendix 4: Benefits from Flood Control.

(b) Benefits from water conservation.--Under the completed Vaiva Vo irrigation project, the Bureau of Indian Affairs has indicated that:

(1) The expected land use of the 1,640 acres would be approximately as follows: alfalfa, 24 percent; cotton, 30 percent; barley, 41 percent; and farmstead and roads, 5 percent. The project would provide settlement opportunities to about 20 Papago Indian families, each having an average of 82 acres.

(2) The farm budget analysis, as presented in the following table, indicates that the project lands could pay $37.65 per acre on class 1 land and $34.49 per acre on class 2 land.

Farm budgets and financial analysis for representative farms
Vaiva Vo irrigation project, Arizona

Item	Unit	Class 1 land	Class 2 land
Budget number	No.	1	2
Irrigable area	acres	80	90
Irrigated area	acres	76	85
Cotton	acres	24	27
Barley	acres	33	37
Sorghum	acres	*22	*25
Alfalfa	acres	19	21
Pasture	acres	*37	*42
Farmstead, etc	acres	4	5
Total farm investment		$20,897	$20,529
Total work days	days	159	179
Operator	days	118	121
Hired and contract	days	41	58
Farm income			
Crop sales		$16,952	$17,705
Farm privileges		595	595
Total		17,547	18,300
Farm expenses			
Interest on investment		835	821
Operating expense		9,712	10,360
Total		10,547	11,181
Net farm income		7,000	7,119
Equity allowance		209	205
Family living		2,775	2,775
Payment capacity		4,016	4,139
Less 25% contingencies		1,004	1,035
Adjusted payment capacity per farm		3,012	3,014
Adjusted payment capacity per acre		37.65	34.49

* Acreage double-cropped.

(3) The water-conservation benefits were estimated by the Bureau of Indian Affairs. The primary benefits were arrived at by deducting the farm expenses from the gross farm income and adjusting for a 10-year development period. The secondary benefits were determined by applying secondary-benefit factors to the value of the products sold. The average annual primary water-conservation benefits from the recommended plan, which provides for the utilization of 9,355 acre-feet of water per year, were estimated at $124,000, and the average annual secondary water-conservation benefits were estimated at $134,000, totaling $258,000, as shown in the following table:

Computation of primary and secondary irrigation benefits, Vaiva Vo irrigation project, Ariz. (100-year life)*

Benefits	Subtotal	Total
Average annual primary benefits:		
Gross farm income	$354,005	
Farm expenses	213,521	
Net farm income (benefits before adjustment)	140,484	
Benefits after adjustment**		$124,000
Average annual secondary benefits:		
Cotton lint	134,038	
Cotton seed	10,246	
Barley	2,636	
Sorghum	1,586	
Alfalfa	2,479	
Pasture	570	
Benefits before adjustment	151,555	
Benefits after adjustment**		134,000
Total average annual benefits		258,000

* Estimated by the Bureau of Indian Affairs.
** Adjusted for 10-year development period.

(c) Fish, wildlife, and recreation benefits.--Benefits from fish and wildlife and recreational developments would accrue from operation of the recommended plan of improvement. The U.S. Fish and Wildlife Service and the Arizona Game and Fish Department have estimated that average annual fishery benefits of $45,000 and average annual hunting benefits of $4,000 would accrue from operation of the recommended project. Their studies indicated that (1) a figure of $1.50 per day per person for an annual 30,000 one-day visits would total $45,000 for fishery benefits, and (2) about 900 duck hunting recreational visits valued at $4.50 per visit would total about $4,000 for wildlife benefits. The Arizona Game and Fish Department estimated the average annual recreational benefits at $60,000, based on 37,500 people annually utilizing the recreation facilities (exclusive of fishing and hunting) times a factor of $1.60 per visitor-day. More detailed information on these benefits is contained in Appendix 6: Comments of Other Agencies.

(d) Area redevelopment benefits.--The Papago Indian Reservation is an area where underemployment currently exists. This area has been declared a redevelopment area under Public Law 87-27. The basis for measuring the area redevelopment benefits from operation of the recommended plan of improvement would be (a) the annual value of hired and contract labor necessary in the farming operations, estimated at $4,130, (b) the annual value of labor required for operation and maintenance of the works, estimated at $3,330, and (c) the annual value of labor required for project construction, estimated at $3,540. The Bureau of Indian Affairs estimates that average annual redevelopment benefits would be $11,000.

103. Intangible benefits.--Many benefits not susceptible of monetary evaluation would accrue from the operation of the improvements considered in this report. Such benefits would result from (a) the elimination or reduction of the danger of loss of life from floods, (b) the reduction in the menace of epidemics caused by flood damage to sewer and water systems, (c) the prevention of interruptions to traffic on transcontinental and other highways and to traffic on a transcontinental railroad, and (d) the prevention of interruptions to business transactions, to public and utility services, to home life, and to school and other normal community activities.

104. Summary of benefits.--Average annual tangible benefits from operation of the recommended plan of improvement are summarized in the following table:

Estimates of average annual tangible benefits from the recommended plan of improvement for Santa Rosa Wash, Ariz., under average future (1962-2061) conditions of development

Type of benefits	Average annual benefits
Flood control	$527,000
Water conservation:	
Primary - $124,000	
Secondary - 134,000	
Total	258,000
Fish and wildlife	49,000
Recreation	60,000
Area redevelopment	11,000
Total	905,000

PROJECT JUSTIFICATION

105. Summary of economics.--On the basis of a 100-year life for the Santa Rosa Wash multiple-purpose project (recommended plan), the total first cost (September 1962) would be $6,430,000; the total annual charges $272,000; the average annual benefits $905,000; and the benefit-cost ratio 3.3 to 1. Intangible benefits would add considerable weight to the justification of the improvements.

ALLOCATION AND APPORTIONMENT OF COSTS

106. Allocation of costs.--The separable costs-remaining benefits method was used in arriving at an equitable distribution of costs between the various purposes of the proposed project. The method consists of (a) determining the separable cost of including each function in the multiple-purpose project, and (b) making an equitable distribution of joint costs incurred for several purposes in common. Details of the method used are given in Appendix 5: Allocation of Costs.

107. This method of cost allocation (using a 100-year period of analysis) was applied both to the total estimated first cost and the estimated average annual maintenance and operation cost of the project. The project was broken down into two parts: the dam with its appurtenances and the remaining downstream facilities. Because there are no flood-control benefits to be derived from the facilities downstream from the dam, allocations to flood control were limited to the dam and appurtenances. The following tables show the proposed cost allocations for the two parts of the project:

Proposed allocation of costs, dam and appurtenances only, Santa Rosa Wash multiple-purpose project

Purpose	Estimated first cost		Estimated maintenance and operation	
	Sept. 1962 prices	Percentage	Average annual cost	Percentage
Flood control	$4,777,000	89	$6,000	47
Water conservation	322,000	6	2,000	15
Fish and wildlife	101,000	2	2,000	15
Recreation	127,000	2	3,000	23
Area redevelopment	48,000	1	0	0
Total	5,375,000	100	13,000	100

Proposed allocation of costs, facilities downstream from dam, Santa Rosa Wash multiple-purpose project

Purpose	Estimated first cost		Estimated maintenance and operation	
	Sept. 1962 prices	Percentage	Average annual cost	Percentage
Flood control...	0	0	0	0
Water conservation.....	$934,000	89	$33,000	68
Fish and wildlife.....	52,000	5	8,000	16
Recreation.....	56,000	5	7,000	14
Area redevelopment.....	13,000	1	1,000	2
Total.....	1,055,000	100	49,000	100

108. Apportionment of costs.--Pertinent information on the apportionment of costs is given in the following subparagraphs:

(a) Flood control.--All flood-control costs are considered to be nonreimbursable, because (1) the proposed project is a reservoir project, (2) the reservoir would be built on Indian lands, and (3) the benefits would accrue to both Indian and non-Indian lands.

(b) Water conservation.--Irrigation benefits would accrue solely to the Papago Indians. Water conservation costs are normally considered reimbursable without interest. However, the Bureau of Indian Affairs has informed the Corps of Engineers that under the act of July 1, 1932 (47 Stat. 54, Leavitt Act) these charges are deferred as long as the land remains in Indian ownership. If title to any of the lands involved in the proposed project were to pass from the Indians, reimbursement of a suitable portion of the charges would be made in a manner to be determined by the Secretary of the Interior.

(c) Recreation, fish and wildlife, and area redevelopment.--Monetary benefits from recreation, fish and wildlife, and area redevelopment would accrue to the Papago Indians. Costs allocated to such purposes are covered under existing laws authorizing programs for raising of the standard of living for Indians. Such costs are considered nonreimbursable.

PROPOSED LOCAL COOPERATION

109. Tat Momolikot Dam would be a multiple-purpose structure constructed wholly on the Papago Indian Reservation. The Papago Tribal Council, recognizing that the irrigation features of the project would benefit their people, agreed to make available to the United States without cost (a) appropriate rights to those lands required for construction of the dam and appurtenances, and (b) appropriate rights to those lands that would be required for construction of a water-conservation reservoir. A copy of the resolution of the Papago Council of May 4, 1962 is included in appendix 7.

110. Because the flood-control features of the recommended plan of improvement would provide protection from damaging floods along Santa Rosa Wash, and because this is a reservoir project for which local cooperation was determined on the basis of applicable laws, local interests would be required under Federal laws to:

(a) Establish and enforce floodway limits and regulations for Santa Rosa Wash on non-Indian land from the north boundary of the Papago Indian Reservation to the Santa Cruz River, and maintain the hydraulic capacity of the existing channel.

(b) Hold and save the United States free from damages (downstream from the Papago Indian Reservation) arising from construction, maintenance, and operation of the works for flood control.

(c) Hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the proposed project for flood control. The Pinal County, Ariz., Board of Supervisors, by resolution adopted August 27, 1962, indicated a willingness to furnish these items of local cooperation. A copy of the resolution is included in appendix 7.

111. The recommendations in this report are subject to the further conditions that the U.S. Bureau of Indian Affairs, an agency of the Federal Government, would (a) assure the maintenance of the hydraulic capacity of that portion of the existing Santa Rosa Wash lying within the Papago, Maricopa, and Gila River Indian Reservations downstream from the dam and (b) provide for adjustment of water-rights claims arising from construction, maintenance, and operation of the improvements for water conservation, fish, wildlife, and recreation purposes.

PROJECT FORMULATION

112. The multiple-purpose improvements recommended in this report would involve flood-control, water-conservation, recreation, fish and wildlife, and area-redevelopment purposes. Project formulation involving each of those purposes is discussed separately in the following subparagraphs.

(a) Flood control.--Tat Momolikot Dam and St. Clair Reservoir (part of the Santa Rosa Wash multiple-purpose project recommended in this report) would provide economically feasible flood protection to nearly all of the towns of Stanfield and Maricopa, Ariz., to several Indian villages, and to 46,000 cultivated acres along Santa Rosa Wash. The recommended dam would control all floods occurring above Tat Momolikot Dam with magnitudes up to that of the reservoir design flood (standard project flood) of 55,000 cubic feet per second to a maximum discharge of 4,600 cubic feet per second. Such a flood, which is expected to recur on the average of about once in 200 years, although slightly larger in peak discharge than the largest flood on record (September 1962 flood), would be twice its volume.

(b) The design flood was selected on the basis of economic factors and on the desired degree of protection to be provided. The large area subject to overflow along Santa Rosa Wash produces high-value crops. Because control of the standard project flood can be justified, a project designed for a lesser flood would be undesirable. The hazards of loss of life and the effects of disruption of community activities during the occurrence of floods are great and support the need for a high degree of protection in the Santa Rosa Wash overflow area.

(c) Local interests expressed agreement with the recommended plan.

(d) The control effected by Tat Momolikot Dam would prevent about 87 percent of the total average annual damages in the overflow area along Santa Rosa Wash between the damsite and the Santa Cruz River. However, floods originating below the damsite along Santa Rosa Wash would still cause damage to property in the overflow area.

(e) The benefit-cost ratio of flood-control benefits to those costs allocated to flood control amount to $527,000, divided by $162,000 (annual costs allocated to flood control), or 3.3 to 1. This item is a well-justified portion of the multiple-purpose project.

(f) A reservoir for flood control only at the Tat Momolikot Dam and reservoir would be well justified. However, a savings to flood-control interests of about $683,000 results from combining

flood control with the other features of the Santa Rosa Wash multiple-purpose project.

(g) Water conservation.--The Bureau of Indian Affairs has been conducting studies to determine the feasibility of providing additional irrigation water for the use of the Papago Indians. The damsite selected by the Bureau for water-conservation, recreation, and fish and wildlife purposes was also the most feasible for flood-control use. Plans of the Bureau of Indian Affairs and the Corps of Engineers were coordinated.

(h) The Vaiva Vo irrigation project (part of the multiple-purpose project recommended in this report), as developed by the Bureau of Indian Affairs, would provide for the development of 1,640 acres of irrigable land. The construction of this irrigation project in connection with the dam project would result in a significant contribution to the economic life of the Papago Indians.

(i) The benefit-cost ratio of water-conservation benefits to those costs allocated to water conservation amount to $258,000 divided by $76,000 or 3.4 to 1. This item is a well-justified portion of the multiple-purpose project.

(j) Water-conservation features could be justified in a single-purpose project at the same location as the recommended project. However, a saving of about $627,000 would accrue to the water-conservation features by combining water conservation with other features of the recommended Santa Rosa Wash multiple-purpose project.

(k) Recreation, fish, and wildlife.--The recreation and the fish and wildlife aspects are an important part of the multiple-purpose project recommended in this report. The fish and wildlife aspects would be developed by utilization of the waters contained in the water-conservation-recharge ponds to be located downstream from Tat Momolikot Dam. Waterfowl hunting would extend into the reservoir area. The recommended recreation features; such as boating, water skiing, and picknicking, would be located in and around the St. Clair Reservoir area and the area of the fishponds. Recreational, hunting, and fishery features would bring substantial benefits to the Papago Indians through renting boats, selling hunting and fishing equipment and accessories, and providing food and lodging to sportsmen and vacationers. Local interests have long felt the need for a water-recreation facility in this area and asked that it be considered in a multiple-purpose dam and reservoir project. Only minor costs are involved in developing these substantial potentials at the multiple-purpose project.

(l) Area redevelopment.--Information supplied by the U.S. Bureau of Indian Affairs indicates that the proposed irrigation project, as well as the other improvements under the recommended plan, would - in accordance with the program of the Area Redevelopment Administration - be reflected in the overall economic development program of the Papago Indian Reservation.

(m) Redevelopment benefits would accrue to the Papago Indian Reservation in the construction and operation of the recommended project from (1) annual farm employment, (2) annual employment in operating and maintaining the project work, and (3) the annual value of labor used in construction of the project works. No additional costs are involved to develop these benefits.

113. Adoption of the project would result in a Federal expenditure of $6,430,000. (No non-Federal costs or taxable facilities are involved.) Average annual charges, including $62,000 for maintenance and operation, would amount to $272,000.

114. Analysis of the alternative and incremental costs show that each function is justified in itself and that the multiple-purpose project permits optimum integration of all elements of the proposed project. All potentialities of the site were fully explored in developing the project.

115. Detailed information on the recommended plan as called for by Senate Resolution 148 is contained in a supplement to this report.

RELATIONSHIP OF RECOMMENDED PLAN TO COMPREHENSIVE PLAN FOR COLORADO RIVER BASIN

116. The recommended improvement would be an integral part of the improvements under the comprehensive plan for the Gila River basin--a unit of the comprehensive plan for the Colorado River basin. The recommended improvement would (a) provide for area redevelopment in the Papago Indian Reservation, (b) provide flood protection to an intensively developed agricultural area along Santa Rosa Wash near the towns of Stanfield and Maricopa and to lands presently developed and to be developed in the Papago Indian Reservation, (c) fully develop the water-supply potential of Santa Rosa Wash within the Papago Indian Reservation, and (d) develop the recreational, fish, and wildlife potentialities of the proposed works. Construction of the Tat Momolikot Dam would control one of the major flood threats in the lower Santa Cruz River basin. Although the Santa Cruz River and tributaries of the Santa Rosa Wash downstream from the Tat Momolikot damsite would still be uncontrolled, substantial damages occurring as a result of floods originating upstream from the damsite would be prevented. The flood problem along Santa Rosa Wash is not interconnected with flood problems in other parts of the Gila River basin. Floods along Santa Rosa Wash rarely cause damage downstream from its mouth. Information supplied by the U.S. Bureau of Indian Affairs indicates that the proposed irrigation project, as well as the other improvements under the recommended plan, would - in accordance with the program of the Area Redevelopment Administration - be reflected in the overall economic development program of the Papago Indian Reservation.

117. The Bureau of Reclamation is developing detailed plans for the importation of Colorado River water to central Arizona. This report assumes that the Central Arizona project will provide supplemental water to agricultural land within the overflow area of Santa Rosa Wash sufficient to maintain the value of agricultural property subject to flood damage. However, the recommended plan is well justified without additional waters. The plans of improvement recommended in this report would complement the plans of the Bureau of Reclamation.

118. The recommended plan would provide flood protection to a transcontinental railroad (Southern Pacific) and to Arizona State Highway 84. The probability of interruptions of travel on these routes would be thereby lessened with resultant beneficial

effects on the economy of the country. The Bureau of Public Roads and the Arizona Highway Department are preparing plans for completion of Interstate Route 8 through the overflow area of Santa Rosa Wash.

119. The recommended plan is in consonance with the desires of the Arizona Game and Fish Department to develop fisheries, recreation, and waterfowl-habitat areas in their State.

COORDINATION WITH OTHER AGENCIES

120. Conferences on the flood problems and possible remedial measures and on the interrelated problems of flood control, water conservation, area redevelopment, fish and wildlife, and recreation in the Santa Rosa Wash basin were held with representatives of the U.S. Bureau of Indian Affairs, other interested Federal and State agencies, the Stanfield and Maricopa Flood Control Districts, Pinal County, and other local interests.

121. Meetings were held on March 3, 1962, on June 19, 1962, and on February 14, 1963, with representatives of interested Federal, Tribal, State, and local agencies to present the proposed plan of improvement, to ascertain their views, and to insure that the proposed plan would be in consonance with any other plans that may be under consideration. The Bureau of Indian Affairs plans to submit a feasibility report covering recommendations for the nonreservoir portions of the proposed project. Copies of the U.S. Fish and Wildlife Service and Arizona Game and Fish Department reports pertaining to evaluation of the fish and wildlife benefits and recreation benefits submitted to the Bureau of Indian Affairs are included in Appendix 6: Comments of Other Agencies.

122. A draft of this report was transmitted to all Federal and State agencies that might have an interest in the recommended plan of improvement. A summary of significant comments received from interested agencies and of replies by the U.S. Army Engineer District, Los Angeles, where pertinent, is given in the following subparagraphs:

(a) The Bureau of Indian Affairs pointed out that it had coordinated with the Corps of Engineers in developing the feasibility report for the Santa Rosa Wash project and strongly concurs in the construction of Tat Momolikot Dam for multiple-purpose use. The Bureau pointed out that flood-control benefits will accrue to Indian lands in the Papago and Maricopa-Ak Chin reservations downstream from the proposed dam.

(b) The Bureau of Reclamation agreed to the desirability of construction of the recommended plan of improvement and stated that the recommended plan would complement Bureau plans, including the proposed Central Arizona project. The Bureau suggested that a supplemental water supply from the Central Arizona project should not be depended upon to fully compensate for the present ground water depletion. The U.S. Army Engineer District, Los Angeles, replied that,while a reduction in agricultural area would eventually take place within the overflow area of the Santa Rosa Wash, an increase in the productivity and in the value of crops and farming equipment plus more efficient use of water will tend to sustain, for a considerable time, present agricultural values subject to flood damage.

(c) The Bureau of Land Management stated that portions of Bureau-administered lands in the area below the proposed improvement will receive flood protection.

(d) The Bureau of Public Roads indicated that there are no Federal-aid highways subject to inundation in the reservoir area and that a number of Federal-aid roads below the proposed project would be benefitted considerably. The benefit to Interstate Highway Route 8 was stressed.

(e) The Bureau of Mines stated that four presently inactive and apparently abandoned mines could be flooded under extreme conditions. It was mentioned that a field investigation by the Bureau might be justified if private ownership rights were not resolved satisfactorily. Mining activity in the area might be improved as the result of improvement in the general economic activity in the area.

(f) The Federal Power Commission indicated that hydroelectric power plant facilities at the proposed reservoir would be uneconomical.

(g) The U.S. Bureau of Sport Fisheries and Wildlife stated that the proposed project includes the features of their recommendations made to the Bureau of Indian Affairs with respect to fishing and hunting facilities. They also suggest restriction on the use of motorboats and water skiing on the ponds in the interest of optimum use for fishing purposes. The U.S. Army Engineer District, Los Angeles, concurred that any water skiing or pleasure boating should be planned so as to provide a minimum of interference with hunting and fishing activities.

(h) The National Park Service approved the inclusion of recreational facilities in the project. A more detailed method of evaluating recreational benefits was suggested. A survey to determine the amount of salvage operations required on archeological sites in the area covered by the proposed project was suggested, when the project is authorized. The U.S. Army Engineer District, Los Angeles, noted that a change in recreation benefits will have a very minor effect on the overall economic justification of the project. Discussions between personnel of the Bureau of Indian Affairs and the National Park Service concluded that more detailed studies of recreational features were warranted after authorization of the project.

(i) The U. S. Forest Service stated that administration of the National Forests will not be affected by the proposed project.

(j) The U.S. Public Health Service questioned the effect of the project on the future water supply of the communities of Casa Grande, Maricopa, and Stanfield, Ariz. A vector analysis of the project was inclosed which noted that the reduction in flooding of lowlands expected from the proposed project should result in fewer natural aquatic habitats which are favorable for the production of mosquitoes and other insects of public health importance. It also pointed out that vector control measures should be included in the design and operation of the project. To prevent the breeding of mosquitoes, particular attention should be given in the reservoir area to the elimination of stagnant water created by flat slopes and weed growth. Fishponds below the dam should be provided with steep shorelines and operated for a minimum water depth of 2 feet. In the development of the recreational areas, prevention and control measures for terrestrial vectors, such as ticks, fleas, flies, and rodents, should also be included in design and operation of the project. The Service included a manual of standard practice in vector control for various features of the project. The U.S. Army Engineer District, Los Angeles, pointed out that the effect of the project on the water supplies of Casa Grande, Maricopa, and Stanfield would be negligible. If the project is authorized, recommendations contained in the vector evaluation will be given full consideration in the detailed design studies.

(k) The U.S. Housing and Home Finance Agency, Region VI, replied that they have no projects at present which would be affected by the proposed project.

(l) The Soil Conservation Service stated that the proposed project would provide more stability to the agricultural economy of the area and would eliminate the hazards from Santa Rosa Wash floods to soil and water conservation measures below the dam, thereby effecting savings to farmers and the Department of Agriculture.

(m) The representative of the Governor of Arizona for flood-control matters concurred with the recommendations of the district engineer.

(n) The Arizona Game and Fish Department fully concurs in the inclusion of fishing ponds and a recreational area as part of the multiple-purpose project. Mention was made regarding the necessity of balancing the benefits from water skiing against other water-oriented recreational uses. In reply, the district engineer, U.S. Army Engineer District, Los Angeles, agreed that water skiing should be planned to minimize its adverse effect upon fishing and hunting activities and that it is anticipated that the Bureau of Indian Affairs, which will be responsible for the development of the ponds, will give full consideration to this problem.

(o) The Colorado River Board of California and the Department of Water Resources of California both indicated that the interests of California and its agencies in the Colorado River would not be prejudiced by the proposed development.

CONCLUSIONS

123. The district engineer concludes that:

(a) A serious flood problem exists along Santa Rosa Wash downstream from Tat Momolikot damsite, and that the danger of loss of life and menace to health is great.

(b) An improvement is needed for development of the water resources and economic standards in the Papago Indian Reservation, and for development of fish, wildlife, and recreation resources for the enjoyment of all local interests.

(c) Economically feasible control of the floodflows and development of the water resources in the Papago Indian Reservation can be provided by the Santa Rosa Wash multiple-purpose project.

(d) The proposed improvement would prevent about 87 percent of the potential damages in the area, utilize an average annual water supply of 9,355 acre-feet to irrigate 1,640 acres in the Papago Indian Reservation, provide approximately 50 acres of small lakes (ponds) for fish and wildlife habitat, and provide recreation facilities along the perimeter of Lake St. Clair.

(e) The total first cost of the proposed improvement is estimated at $6,430,000 (September 1962 prices). Based on estimates of average annual charges of $272,000 and average annual benefits of $905,000, the benefit-cost ratio is estimated at 3.3 to 1.

(f) The proposed improvement is feasible from an engineering standpoint, is well justified by the tangible benefits alone, and is further justified by the intangible benefits.

RECOMMENDATIONS

124. The district engineer recommends:

(a) That the United States adopt a project for the improvement of Santa Rosa Wash by providing for (1) a dam and reservoir at the Tat Momolikot site on Santa Rosa Wash in the Papago Indian Reservation, Ariz.; (2) the Vaiva Vo irrigation project; and (3) fish, wildlife, and recreational facilities; all at an estimated total first cost of $6,430,000 (September 1962), and an estimated average annual cost of $62,000 for operation and maintenance.

(b) That the construction, operation, and maintenance of the recommended project, including necessary relocations and acquisition of rights-of-way, be accomplished by the United States at Federal expense; and further that (1) the Corps of Engineers construct Tat Momolikot Dam, St. Clair Reservoir, wildlife and recreational facilities in the reservoir area at an estimated Federal first cost of $5,375,000 (September 1962 prices) and a Federal annual cost for maintenance and operation of $13,000; (2) the Bureau of Indian Affairs construct the irrigation, recreation, fish, and wildlife improvements downstream from Tat Momolikot Dam at an estimated Federal first cost of $1,055,000 (September 1962 prices) and a Federal annual cost for maintenance and operation of $49,000.

(c) That 6 percent of the first cost of Tat Momolikot Dam, St. Clair Reservoir, and wildlife and recreational facilities in the reservoir area and 15 percent of the maintenance and operation costs of these facilities be allocated to water conservation; and that 89 percent of the first cost of irrigation, recreation, fish and wildlife improvements downstream from Tat Momolikot Dam and 68 percent of the maintenance and operation costs of these facilities be allocated to water conservation.

(d) That because water conservation benefits would accrue solely to the Papago Indians and, in accordance with laws applicable to the development of Indian lands, all costs allocated to water conservation be considered nonreimbursable so long as the lands remain in Indian ownership. Upon the transfer of title of any of the lands from Indian to non-Indian ownership, reimbursement of a suitable portion of the charges would be made in a manner to be determined by the Secretary of the Interior.

(e) That the remainder of the costs of the project be allocated to flood control, fish and wildlife, recreation, and area redevelopment purposes and be considered nonreimbursable.

(f) That construction of the recommended improvement be subject to the condition that local interests furnish assurances satisfactory to the Secretary of the Army that they will:

(1) establish and enforce floodway limits and regulations and perform necessary work on Santa Rosa Wash through non-Indian lands, from the north boundary of the Papago Indian Reservation to the Santa Cruz River, to maintain the hydraulic capacity of the existing channel; (2) hold and save the United States free from damages downstream from the Papago Indian Reservation as would arise from construction, maintenance, and operation of the works for flood control; and (3) hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the proposed project for flood control.

(g) That the Federal Government (Bureau of Indian Affairs) be responsible for adjustment of claims arising from construction and operation of the proposed project for other than flood-control purposes and for establishing and enforcing floodway limits and regulations and for performing necessary work on Santa Rosa Wash through the Papago, Maricopa, and Gila River Indian Reservations downstream from Tat Momolikot damsite, to maintain the hydraulic capacity of the existing channel.

(h) That the Papago Tribal Council make available to the Federal Government (1) appropriate rights to those lands required for construction of the dam and appurtenances, and (2) appropriate rights to those lands that would be required for construction of a water-conservation reservoir.

(i) That all monetary benefits (less maintenance, operation, and replacement costs) from operation of the project for uses other than flood control accrue to the Papago Indian Tribe.

(j) That the operation and maintenance of the entire project be under the administration of the Bureau of Indian Affairs, or a designated organization, approved by the Secretary of Interior and Secretary of the Army, subject to flood-control provisions prescribed by the Secretary of the Army.

(k) That the operation agency be responsible for requesting the annual nonreimbursable operation and maintenance funds for the Santa Rosa Wash, Ariz., multiple-purpose project.

7 Appendixes
(See table of contents)

EARL G. PEACOCK
Colonel, Corps of Engineers
District Engineer

SPDGP (1 Aug 63) 1st Ind
SUBJECT: Interim Report on Survey for Flood Control, Santa Rosa Wash, Ariz., Gila River Basin, Ariz. and N. Mex.

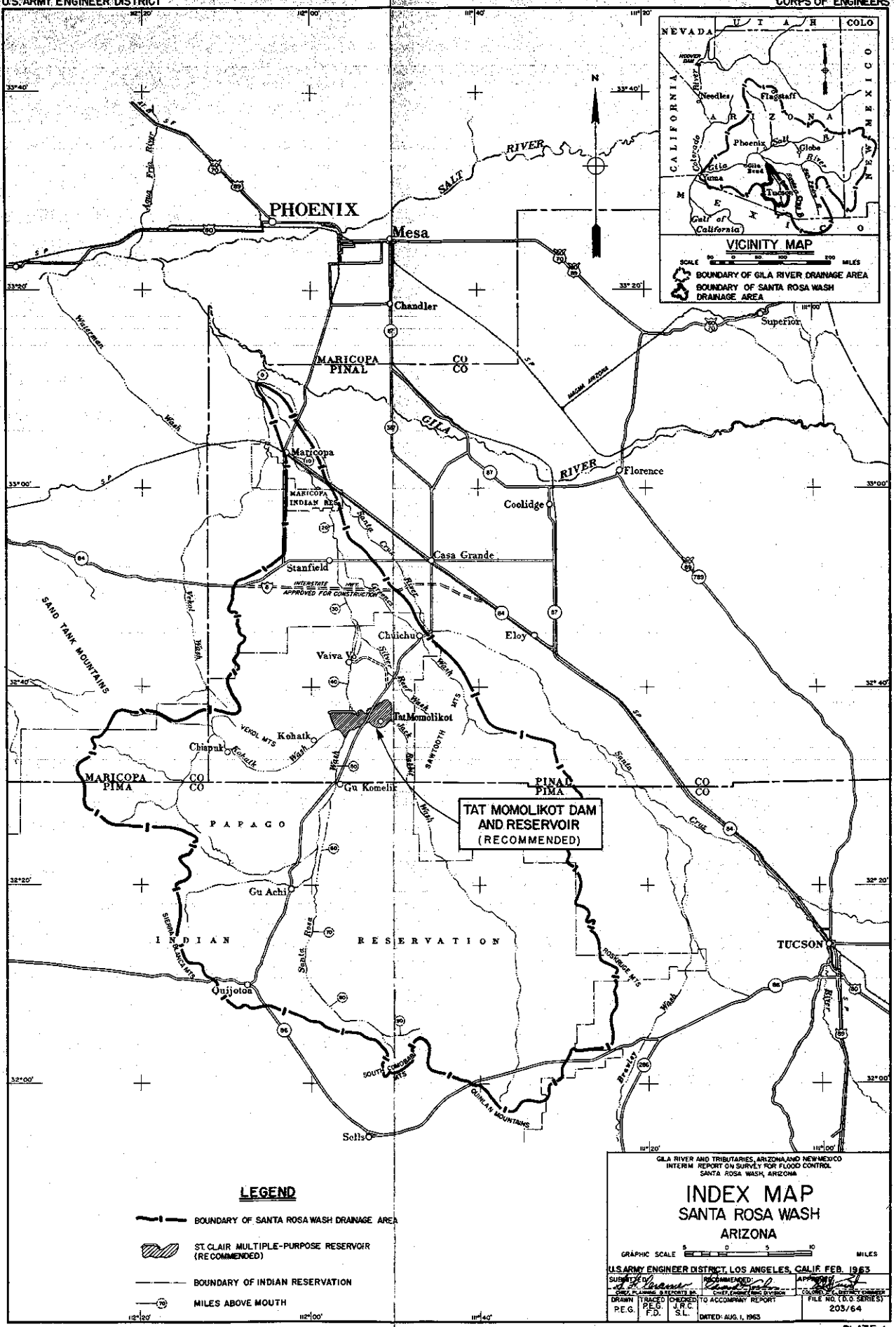
U S Army Engr Div, South Pacific, San Francisco, Calif 8 November 1963

TO: Chief of Engineers

I concur in the conclusions and recommendations of the District Engineer.

7 Incl
n/c

ARTHUR H. FRYE, JR.
Brigadier General, U. S. Army
Division Engineer


PHOENIX
Mesa
Chandler
Superior
SALT RIVER
GILA RIVER
Maricopa
Florence
Coolidge
Casa Grande
Stanfield
Eloy
Chuichu
Vaiva Vo
Tat Momolikot
Kohatk
Chiapuk
Gu Komelik
Gu Achi
Sells
Quijotoa
TUCSON
MARICOPA
PINAL
CO
CO
MARICOPA
PIMA
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CO
PINAL
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PAPAGO
INDIAN
RESERVATION
MARICOPA INDIAN RES.
SAND TANK MOUNTAINS
SAWTOOTH MTS
VEKOL MTS
SIERRA BACA MTS
SOUTH COMPADRE MTS
QUINLAN MOUNTAINS
ROSICRUCE MTS
Santa Cruz
Santa Rosa
Vekol Wash
Waterman Wash
Agua Fria River
Silver Reef Wash
Kohatk Wash
Brawley Wash
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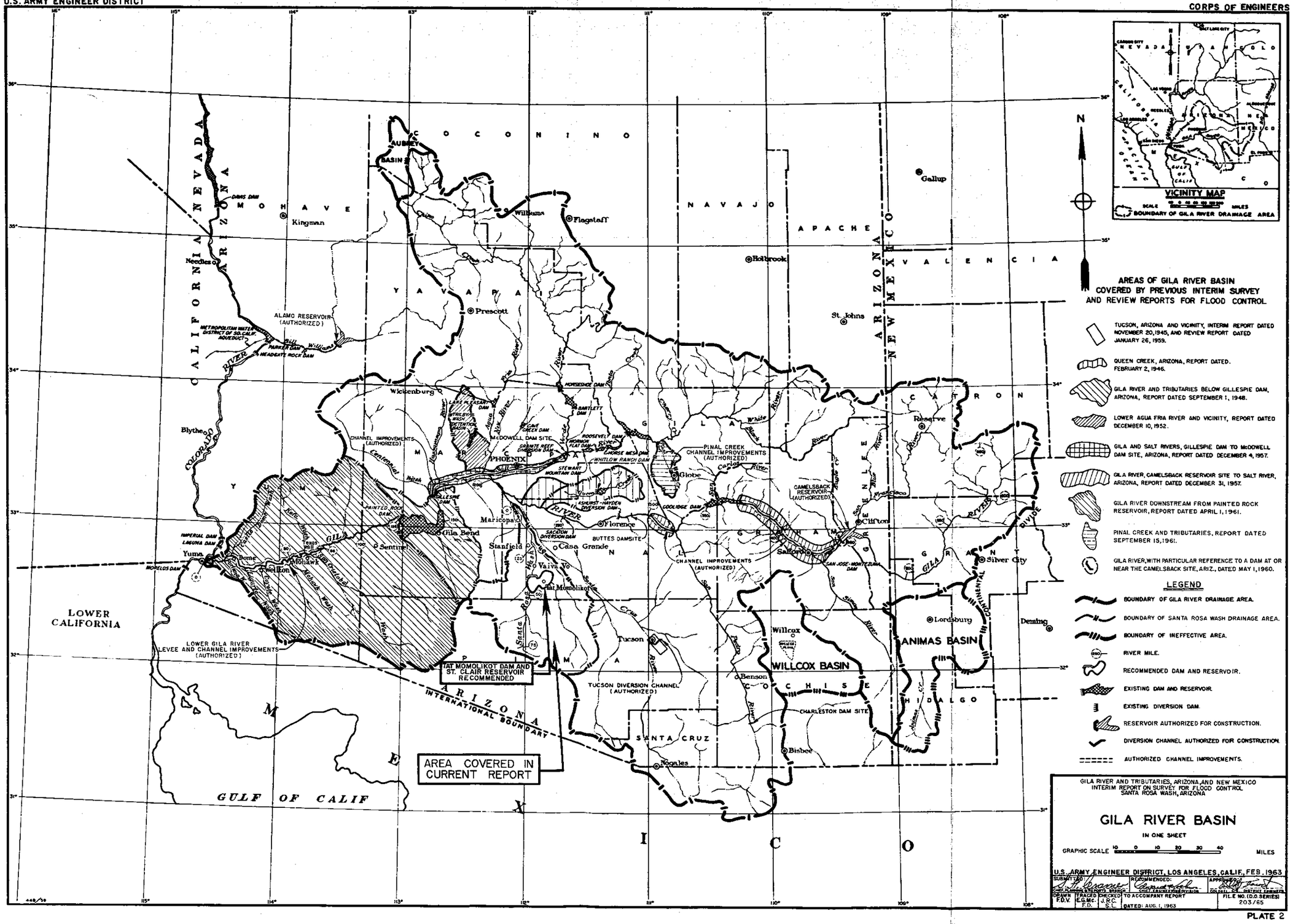
ARIZONA
GRAPHIC SCALE
MILES
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF. FEB. 1963
SUBMITTED:
RECOMMENDED:
APPROVED:
DRAWN P.E.G.
TRACED P.E.G. F.D.
CHECKED J.R.C. S.L.
TO ACCOMPANY REPORT
DATED: AUG. 1, 1963
FILE NO. (D.O. SERIES) 203/64

PLATE 1


VICINITY MAP
BOUNDARY OF GILA RIVER DRAINAGE AREA
N
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VALENCIA
CATRON
LOWER CALIFORNIA
GULF OF CALIF
ARIZONA
NEVADA
CALIFORNIA
NEW MEXICO
MEXICO
Kingman
Needles
Flagstaff
Williams
Prescott
Holbrook
Gallup
St. Johns
Reserve
Wickenburg
Blythe
Yuma
Phoenix
Globe
Clifton
Silver City
Lordsburg
Deming
Willcox
Tucson
Casa Grande
Florence
Maricopa
Gila Bend
Sentinel
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Safford
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WHITLOW RANCH DAM
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GILA RIVER AND TRIBUTARIES, ARIZONA, AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA
GILA RIVER BASIN
IN ONE SHEET
GRAPHIC SCALE 10 0 10 20 30 40 MILES
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF., FEB. 1963
SUBMITTED:
RECOMMENDED:
APPROVED:
CHIEF, PLANNING & REPORTS BRANCH
CHIEF, ENGINEERING DIVISION
FOR DIST. ENGR.
DRAWN F.D.V.
TRACED E.G.Mc. F.D.
CHECKED J.R.C. S.C.
TO ACCOMPANY REPORT
DATED: AUG. 1, 1963
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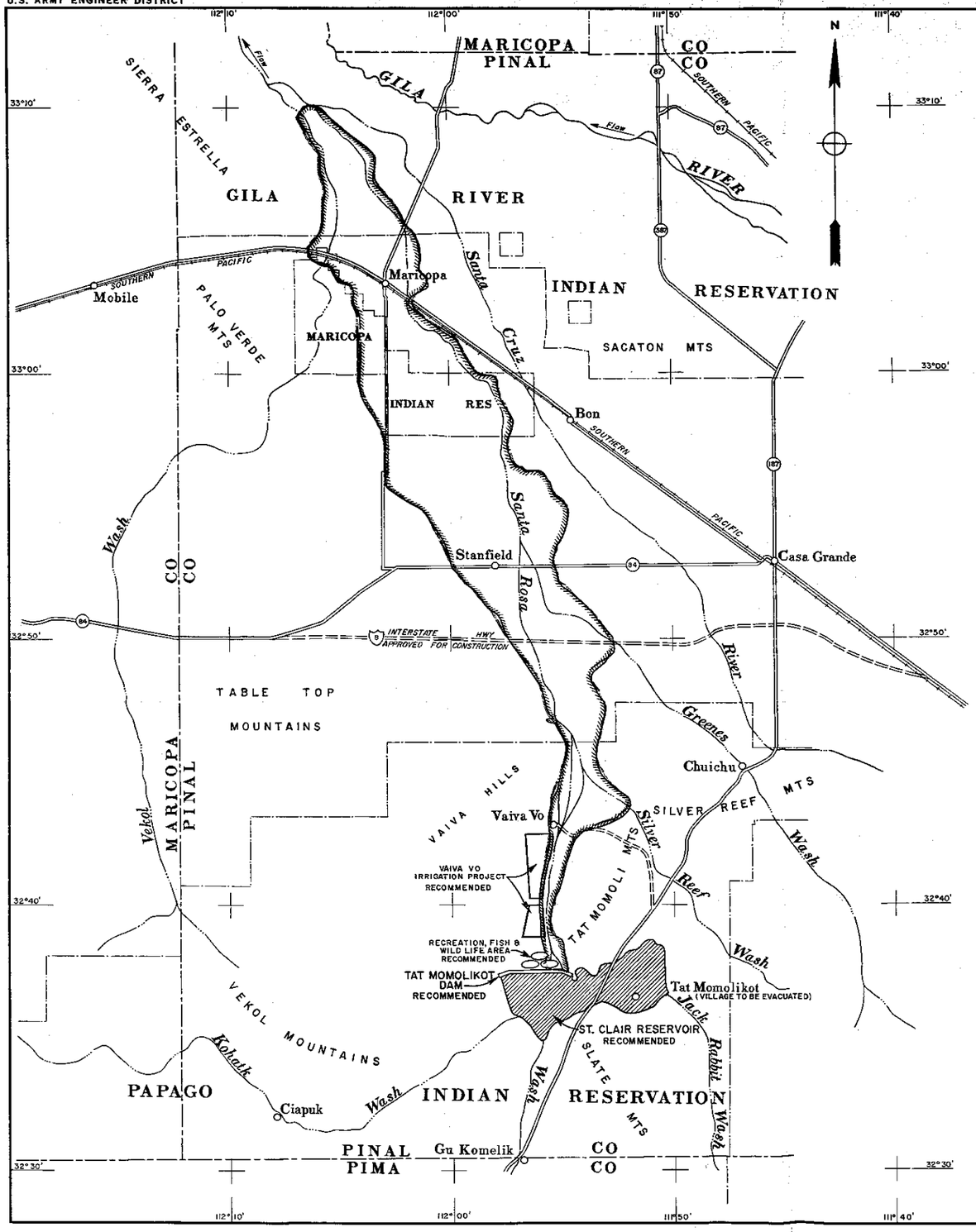

LEGEND

BOUNDARY OF AREA SUBJECT TO OVERFLOW BY STANDARD PROJECT FLOOD.

RESERVOIR RECOMMENDED.

GILA RIVER AND TRIBUTARIES, ARIZONA, AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

OVERFLOW AREA AND PLAN OF IMPROVEMENT

IN ONE SHEET

GRAPHIC SCALE 1 0 1 2 3 4 5 MILES

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF. FEB. 1963

SURVEY	RECOMMENDED	APPROVED
CHIEF, PLANNING & REPORTS BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, CE, DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (D. O. SERIES)
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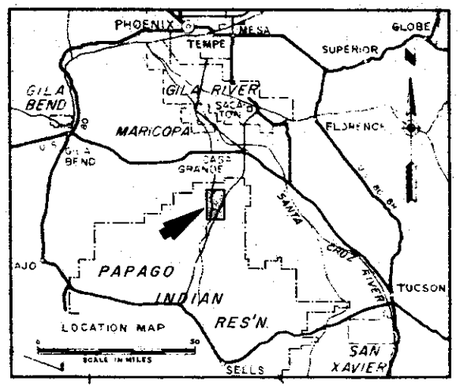
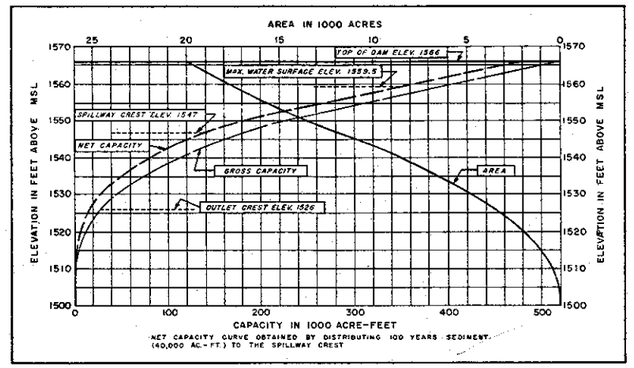
PLATE 3





CORPS OF ENGINEERS, U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
SUBMITTED WITH SURVEY FOR FLOOD CONTROL, SANTA ROSA WASH, ARIZONA, DATED AUGUST 1963

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS
PHOENIX AREA OFFICE
BRANCH OF LAND OPERATIONS

GENERAL MAP
VAIVA VO IRRIGATION PROJECT
A FEATURE OF THE
SANTA ROSA WASH MULTIPLE PURPOSE PROJECT
PAPAGO INDIAN RESERVATION
ARIZONA

DRAWN R.W.D. C.H.L.		RECOMMENDED
CHECKED J.H.J. F.L.G.		APPROVED
SCALE AS SHOWN	DATE MARCH 1963	DRAWING NO.

FILE NO. 203/75 PLATE 4

APPENDIX 1 - HYDROLOGY

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ. AND N. MEX.

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No.	Title
1.	Hydrologic map.
2.	Isohyets, total storm precipitation, Sept. 3-8, 1939.
3.	Isohyets, total storm precipitation, Oct. 31, 1957.
4.	Hydrograph, Tat Momolikot damsite, standard project flood.
5.	S-graph.
6.	Lag relationships.
7.	Depth duration relationships, probable maximum storm.
8.	Hydrograph, Tat Momolikot damsite, maximum probable flood.
9.	Streambed profiles, streams above Tat Momolikot damsite.
10.	Inflow-sediment relationship for conservation reservoirs in southwestern United States.
11.	Enveloping curves of peak discharges, streams in Arizona and New Mexico.

HYDROLOGY

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ., AND N. MEX.

SCOPE

1. This appendix contains descriptions of studies made to estimate the magnitude of (a) the standard project flood, (b) the maximum probable flood, and (c) the sediment storage, as required at the considered Tat Momolikot damsite on the Santa Rosa Wash, Ariz. These estimates are pertinent to flood-control planning discussed in the main report. The locations of the Tat Momolikot damsite and the boundary of the drainage area and drainage subareas are shown on plate 1.

GENERAL DESCRIPTION OF DRAINAGE AREA

2. Physiographic characteristics.--The Tat Momolikot damsite on Santa Rosa Wash is approximately 65 miles south of Phoenix (see pl. 1). The drainage area (1,750 square miles) is in parts of Pima, Pinal, and Maricopa Counties. The Papago Indian Reservation, in southern Arizona, is partially within the drainage area. The drainage area is characterized by scattered and irregular mountain ranges and wide intervening desert plains. The Santa Rosa Wash drains northward into the Santa Cruz River approximately 9 miles northwest of the town of Maricopa. The Santa Cruz River is a major tributary of the Gila River. The drainage area above the Tat Momolikot damsite is bounded on the east by Sawtooth, Waterman, and Roskruge Mountains; on the south by the Quinlan and South Comobabi Mountains; on the west by the Sierra Blanca and Sand Tank Mountains; and on the north by the Vekol and Tat Momoli Mountains. Between the mountain ranges there are some low divides where the drainage boundary is indistinct.

3. The drainage area above Tat Momolikot damsite comprises about 1,750 square miles and contains two major tributaries which join at the damsite. The streams, which are ephemeral, descend the slopes of the mountains to alluvial plains where the watercourses are not well defined and are unstable due to sediment deposition and erosion. The Kohatk Wash to the west drains 305 square miles; the main Santa Rosa Wash drains an area of 661 square miles; and the Jackrabbit Wash to the east drains an area of 784 square miles. The lengths of the three main streams: Kohatk, Santa Rosa, and Jackrabbit Washes, are approximately 36, 47, and 55 miles, respectively. Elevations in the area range from about 1,500 feet

above mean sea level at the damsite to about 6,800 feet in the Quinlan Mountains. The gradient of the channels ranges from about 300 feet per mile in the headwaters to about 20 feet per mile near the damsite.

4. The soils in this basin are extremely varied. The mountains consist of weathered native rock, while the valley floors contain unconsolidated gravels, sands, silts, and clays derived from these rocks. The rock materials are nearly equally divided between schists, granites, and older volcanic rocks such as basalt, with some small amounts of limestone appearing in the northern part of the basin at the site of the proposed dam. The soils of the mountain area are shallow and stony with bare rock outcrops. Desert and semidesert soils occur in the hills and valleys. The valley surface soils generally range from fine sandy loams to clay and are fairly deep.

5. Vegetal cover in the basin is sparse, consisting of various types of cacti, sagebrush, greasewood, and small trees such as mesquite and paloverde. This vegetation tends to be thicker and denser along and adjacent to the stream courses. There are areas with perennial grasses at the higher elevations. Covers of annual grasses occur in much of the basin after the winter rains.

6. Hydrometeorological characteristics.--The climate is typically desert in character, with short, mild winters and long, hot summers. High diurnal temperature variations are characteristic of the region. A summary of climatological data at Tucson, Ariz. is given in table 1. The prevailing winds are from the east and are usually light, although severe windstorms occur at rare intervals. The 90-year (1868-1957) mean annual precipitation ranges from about 9.0 inches at the damsite to about 16.0 inches in the headwater area with an average of 10.8 inches for the drainage area (see pl. 1). Precipitation is divided about equally between summer and winter seasons (see table 1).

7. Three types of storms produce precipitation in the Santa Rosa Wash basin: general winter storms, general summer storms, and local thunderstorms. A brief description of each storm type is given in the following subparagraphs.

(a) General winter storms usually occur during the period from December to March, inclusive. They originate over the Pacific Ocean as a result of the interaction between polar Pacific and tropical Pacific airmasses and move eastward over the basin. These storms, which often last for several days, reflect orographic influences and are accompanied by widespread precipitation in the form of snow or rain.

(b) General summer storms usually occur during the period from July to September, inclusive. They are associated with an influx of tropical maritime air originating over the Gulf of Mexico or the South Pacific Ocean and entering the area from a southeast to a southwest direction. Usually the influx of tropical air is caused by the circulation about a high-pressure area centered in southeastern United States, but occasionally it is caused by the remnants of a tropical hurricane. General summer storms are often accompanied by relatively heavy precipitation over large areas for periods up to 24 hours but showers may continue intermittently for as long as 3 days.

(c) Local thunderstorms can occur at any time of the year, either during general storms or as isolated phenomena. However, they are most common during the period from July to September, inclusive, when the basin is frequently covered by moist, unstable air originating over the Gulf of Mexico. These storms cover comparatively small areas and result in high-intensity precipitation of short duration (up to 3 hours).

8. Runoff characteristics.--Little streamflow occurs except during and immediately following the heavier precipitation, because climatic and drainage-area characteristics are not conducive to continuous runoff. Because of steep gradients, streamflow in the mountains increases rapidly in response to high-intensity precipitation and causes debris-laden flash floods to debouch onto the valley plains below. When the flood reaches the valley plains, it spreads out as overland flow, the velocities and peaks are reduced, the debris is deposited, and a considerable amount of flow is lost to streambed percolation. Vegetation, being sparse, has negligible effect on flood runoff.

9. Existing structures affecting runoff.--No major flood-control structures are in the Santa Rosa Wash drainage area. There are many small detention and diversion dams that have been constructed by the Bureau of Indian Affairs, but they have no appreciable regulating effect on large floods.

PRECIPITATION AND RUNOFF

10. Precipitation records.--Precipitation records are available for 53 precipitation stations in and near the drainage area. The longest record is for Casa Grande 3 SE, which has 76 complete years of record during the period 1880-1962, inclusive. There are 7 recording gages near the area, of which the longest period of record is for Tucson, University of Arizona, beginning in 1927. The areal coverage of precipitation stations is currently poor, there being only four active stations in the area at present.

The mean annual precipitation of stations with at least 5 years of record was determined by the theory of least-squares. The two Tucson stations, with a total 90-year almost continuous record, were selected as the base for extrapolation of records of short durations to a common 90-year period (see pl. 1). Pertinent data on precipitation stations are given in table 2 and station locations are shown on plate 1.

11. Runoff records.--No long-term runoff records are available for the Santa Rosa Wash drainage area. Three recording stream-gaging stations were installed on Santa Rosa Wash and Kohatk Wash (see pl. 1) in October 1954, of which one (Santa Rosa Wash, near Vaiva Vo) is still in operation. Pertinent data for these stations are given in table 3.

12. Storms and floods of record.--Historical accounts indicate that many damaging floods have occurred in the Gila River basin. Sizeable floods occurred in 1884, 1891, 1916, 1926, 1937, 1957, and 1962. Indications are that these floods were the result either of general storms or, in a few cases, of tropical cyclones centered in or near the Gila River basin. A description of the winter storms and floods of 1891, 1916, and 1937 is presented in appendix 2 of the report titled "Interim Report on Survey, Flood Control, Gila River and Tributaries below Gillespie Dam, Ariz.," and dated September 1, 1948. A description of the September 1939 storm (a general summer storm) and flood is presented herein because the information about it is essential to the development of the standard-project-flood hydrology. Descriptions are presented of the August 1954 storm (a local thunderstorm) and flood in the Queen Creek area approximately 60 miles northeast of the Santa Rosa Wash area,and also the October 1957 and September 1962 storms and floods which occurred in and near the Santa Rosa Wash area.

(a) Storm and flood of September 3-8, 1939.--The storm apparently had two centers covering large areas; one north and east of the Imperial Valley in California and one east of Needles in Arizona. The unusually heavy precipitation during the storm was associated with three tropical cyclones originating off the west coast of Mexico. A total of some 6 to 7 inches of precipitation fell over an area of more than 2,300 square miles within the center near Imperial Valley and over an area of more than 3,000 square miles within the center of the storm east of Needles, Calif. Precipitation intensities recorded by the first-order stations at Yuma and Phoenix were high. At Yuma, 2.17 inches of precipitation fell in 90 minutes; and at Phoenix, 2.41 inches fell in 6 hours. Isohyets of the total storm precipitation are shown on plate 2.

(b) No measurements of runoff were made in the Santa Rosa Wash area, but high peak discharges were measured on streams (with well-defined channels) near the centers of the storm. The Big Sandy River (a tributary of the Bill Williams River) below Burro Creek, at Signal, Ariz., had a peak discharge of about 100,000 cubic feet per second from an area of 2,670 square miles. Picacho Wash at All-American Canal, near Yuma, Ariz., had a peak discharge of 37,000 cubic feet per second from an area of 41.5 square miles.

(c) Storm and flood of August 19, 1954.--The storm and flood of August 19, 1954, according to available reports, was the most severe of record in the Queen Creek drainage area (approximately 60 miles northeast of the Santa Rosa Wash area). Very moist, warm, tropical air that originated over the Gulf of Mexico, entered Arizona and New Mexico from the south during the storm period, accompanied by widespread thunderstorm activity. Precipitation intensities were high during the first 3 hours of the storm. An estimated 100 square miles of area (near the storm center) had over 5 inches of precipitation.

(d) The peak discharge at the gaging station, Queen Creek at Whitlow Ranch damsite near Superior, Ariz. (area 143 square miles) was estimated at 42,900 cubic feet per second. No estimates of discharge are available for the Santa Rosa Wash area.

(e) Storm and flood of October 31, 1957.--The general summer storm of October 31, 1957 is noteworthy because of the hydrologic records available for the Santa Rosa Wash area. The storm was of tropical maritime origin. In and near the area the recorded precipitation varied from about 2 inches in the area around Stanfield to 1.05 inches at Picacho Reservoir, 1.89 inches at Sells, and 0.79 inch at Ajo. Greater depths of precipitation in the headwaters of the streams were likely, but records of amounts are not available. The precipitation continued with moderate to high intensities for a period of 2 to 3 hours at most stations. The isohyets of the total storm precipitation are shown on plate 3.

(f) The flooding of fields in the Stanfield-Maricopa area was the result of the failure of dikes along Santa Rosa Wash. A small conservation dam on Anegam Wash, a few miles west of Gu Achi, failed during the flood and caused several breaks in dikes protecting the road from Casa Grande to Quijotoa. The peak discharge of Santa Rosa Wash at Gu Komelik was estimated at 14,000 cubic feet per second and near Vaiva Vo at 10,000 cubic feet per second.

(g) Storm and flood of September 25-26, 1962.--The unusually heavy precipitation during the storm was associated with a

tropical storm originating off the west coast of Lower California. The main stream of moist air, which was about 70 miles wide, passed over Sells, the Tucson Mountains-Cortaro area, Oracle, and on into New Mexico. Heaviest rain fell during the night of September 25 and most of September 26. A total of 4 inches of precipitation occurred at Sells (14-R-15) in a 10-hour period on September 25 and 26. Estimates of depths of 7 inches were made for two locations, 7 and 12 miles west of the Arizona-Sonora Desert Museum.

(h) Preliminary peak discharges were estimated by the U.S. Geological Survey for the Santa Rosa Wash near Vaiva Vo as 53,000 cubic feet per second, and for the Santa Rosa Wash at State Highway 84 between Casa Grande and Stanfield as 12,800 cubic feet per second.

13. Relative magnitude of general storms.--The relative severity of past general storms in the Santa Rosa Wash area and the Gila River basin was determined by analyzing precipitation area-depth-duration relationships. The studies showed that although total precipitation for general winter storms is potentially large, the intensities in the Santa Rosa Wash area are low and infiltration losses reduce the discharge peak and runoff volume to less than would be produced by the critical general summer storm. The analyses indicated that, considering flood-producing characteristics, a storm such as that of September 3-8, 1939, would be the most critical one for the Santa Rosa Wash area.

SYNTHESIS OF STANDARD PROJECT FLOOD

14. General.--The standard project flood was developed according to criteria given in EM 1110-2-1411. The standard project storm for the drainage area was determined by evaluation of the most severe regional storms of record assumed critically centered over the area. Ground conditions reasonably favorable for flood runoff were assumed. Snow would not be a factor in the standard-project-flood synthesis.

15. Standard project storm.--The standard project flood for the Tat Momolikot damsite is based on the occurrence of a storm assumed equal in magnitude to that of September 3-8, 1939. The isohyetal map of total storm precipitation as it occurred is shown on plate 2. The storm was transposed directly over the area in such a position that the largest possible discharge would result at the damsite.

16. A unit-time interval of 1 hour was considered the most practical for storm computations to define adequately the computed hydrograph. The time distribution of the precipitation intensities for the parts of the project storm over the area (with 1 hour amounts expressed as percentage of total storm amounts) was made equal to the time distribution of precipitation in the same relative parts of the original storm as computed from intensity patterns determined under assignment SP 2-15 of the cooperative storm study program of the U.S. Weather Bureau and the U.S. Army Corps of Engineers. Depth-duration relationships for the subareas are given in table 4. The precipitation-intensity pattern is shown on plate 4.

17. Precipitation-runoff relationships.--Available precipitation and runoff records are not adequate for unit-hydrograph analyses of precipitation-runoff relationships within the drainage area. Therefore, precipitation-runoff relationships have been determined for this study by the application of a synthetic distribution graph, based on information obtained in hydrologic investigations made for other flood-control reports for streams in southwestern United States.

(a) Unit hydrograph.--The method used in this study for determination and application of the synthetic unit hydrograph, which is used in computing time distribution of runoff from precipitation, is similar to methods generally employed by the U.S. Army Corps of Engineers. For details of the method involved, reference is made to paragraphs 70-75, inclusive, in the district engineer's report titled "Hydrology, San Gabriel River and the Rio Hondo Above Whittier Narrows Flood-Control Basin with Addendum on the Hydrologic Effect of Diverting Outflow from Whittier Narrows Flood-Control Basin to Los Angeles River Via the Rio Hondo," dated December 20, 1944 and revised July 10, 1946.* After studying the area, the average S-graph developed for regional drainage areas of less than 1,500 square miles in the Gila River basin was considered applicable for determining the synthetic unit hydrographs for all subareas (see pl. 5).

(b) The lag-relationship curve used was derived from data developed in studies previously made of several areas in the Gila River basin and in southern California. The lag-relationship curve is shown on plate 6. The lag for all subareas was increased by 25 percent which is conservative on the basis that as there are very few definite, entrenched channels; the flow would spread out

* Report was approved by the Chief of Engineers in 2d Indorsement dated May 12, 1945 and 6th Indorsement dated October 1, 1946 on basic letter dated January 30, 1945, subject: "Hydrology, Whittier Narrows Flood-Control Basin, Los Angeles County Drainage Area, California."

essentially as sheet flow with a decrease in velocity and the lag would thus be increased. The values of lag and pertinent elements for the drainage subareas above Tat Momolikot damsite are given in table 5.

(c) Precipitation-loss rates, base flow, and snowmelt.--In the absence of adequate data concerning relationships of runoff to precipitation, loss rates were based on a field reconnaissance and on loss rates for regional drainage areas of similar physical characteristics. For the mountain areas a variable loss rate with an average of 0.35 inch per hour and a minimum of 0.15 inch per hour was considered applicable. For the valley areas a constant loss rate of 0.20 inch per hour was used. Studies of loss rates show that runoff occurs during periods when precipitation-intensity rates are less than loss rates indicated by the variable loss rate. Consequently, the loss rate was assumed at 90 percent of the precipitation intensity for the periods having an average precipitation intensity rate of less than the assigned loss rates stated above.

(d) Base flow is considered negligible for this drainage area. Allowance for snowmelt is inappropriate in this area for a storm occurring in the summer season.

18. Overland-flow percolation loss.--In addition to precipitation losses, there are losses due to percolation into the alluvial plain areas. In the absence of definitive data for these areas, rates were assumed on the basis of derived estimates for other Arizona areas and comparative soil characteristics. The assumed rate considered reasonable for the valley area is 0.20 cubic foot per second per wetted acre where the soils are finer textured. The percolation losses reduced the gross flood hydrograph approximately 25 percent.

19. Determination of standard project flood.--The standard project flood for the concentration point at Tat Momolikot damsite was determined by the following procedure: (a) determination of unit-time increments of precipitation for each subarea; (b) determination of effective precipitation by subtraction of loss rate; (c) determination of subarea surface-runoff hydrograph by application of synthetic-unit hydrograph values to the effective unit-period precipitation; and (d) determination of total flood hydrograph by channel routing, subtraction of percolation losses and combining subarea hydrographs.

20. The routing of the flood through the channels was accomplished by the successive average-lag method that is described in EM 1110-2-1408. The travel time of subarea G to the damsite is 15 hours and subareas C and D to the damsite is 8.7 hours.

21. Standard project flood.--The resulting peak discharge of the standard project flood at Tat Momolikot damsite is 55,000 cubic feet per second and the volume is 145,000 acre-feet. The flood hydrograph is shown on plate 4.

SYNTHESIS OF MAXIMUM PROBABLE FLOOD

22. General.--The maximum probable flood is defined as the flood that would result if the probable maximum precipitation for the drainage area were to occur at a time when ground conditions were conducive to maximum runoff. Such a flood is required in developing plans for the considered damsite.

23. Probable maximum precipitation.--A determination of probable maximum precipitation has not been made for the Santa Rosa Wash drainage area above Tat Momolikot damsite. Therefore, the estimate of the probable maximum precipitation for the area above Tat Momolikot damsite was based on the estimate given by the Hydrometeorological Section of the U.S. Weather Bureau in a letter dated January 14, 1958, subject: "Preliminary Estimate of Probable Maximum Precipitation for Bill Williams River Basin, Arizona, Above Proposed Alamo Damsite." This storm, of the tropical type, is believed applicable for the Santa Rosa Wash area after appropriate adjustments were made. The Santa Rosa Wash area is considered to be dynamically less effective than the Bill Williams River area. The ratio of the mean seasonal precipitation of Santa Rosa Wash to Bill Williams River is approximately 75 percent. The total precipitation used (to be conservative) was 90 percent of that for the Alamo damsite assumed centered over the drainage area above the considered Tat Momolikot damsite. The 72-hour average precipitation over the entire area is 12.7 inches. Depth-duration relationships for the subareas are given in table 6.

24. A unit-time interval of 1 hour was considered the most practical for storm computations to define adequately the computed hydrograph. Unit-time intensities of the selected 72-hour storm were based on the depth-duration relationship curve from the Hydrometeorological Section's letter on the Alamo damsite (see pl. 7). The precipitation intensities were arranged in order of time so that the maximum peak discharge was obtained. The precipitation-intensity pattern is shown on plate 8.

25. Precipitation-loss rates.--Loss rates considered applicable for ground conditions conducive to maximum runoff were used for the probable maximum storm. Accordingly, a constant rate of 0.15 inch per hour was assumed. As in the analysis of loss rates for the standard project flood, the assumption appeared reasonable that the loss rate during periods with intensity rates less than the 0.15 inch per hour would be only 90 percent of the precipitation-intensity rate.

26. Base flow is considered to compensate for percolation loss during the time of the maximum probable flood. Therefore, base flow and overland-flow percolation loss were not assumed to apply in determination of the maximum probable flood.

27. Maximum probable flood.--Computations to determine the maximum probable flood were similar to those for the standard project flood. The resulting peak discharge is 270,000 cubic feet per second and the volume is 484,500 acre-feet at the Tat Momolikot damsite. The flood hydrograph is shown on plate 8.

SEDIMENT-STORAGE ALLOWANCE

28. General.--An estimate of the volume of storage behind the considered Tat Momolikot dam that will be occupied by sediment at the end of a 100-year period is required for the design of the dam. Because of the lack of adequate observations of sediment carried by Santa Rosa Wash, the estimate is based on recorded data for other streams and existing reservoirs in the general area.

29. Topographical, geological, and hydrometeorological characteristics of the drainage area upstream from the Tat Momolikot damsite indicate a moderate sediment-production potential. The streambed profiles are shown on plate 9.

30. The method applied in this study to determine the sediment-storage allowance is based on the rate of sediment produced by the average annual runoff. The average annual runoff was estimated on the basis of the following runoff records:

Stream	Drainage area	Years of record*	Average annual runoff
	Square miles		Acre-feet
Santa Cruz River at:			
Continental, Ariz.	1,640	13	13,000
Tucson, Ariz.**	2,190	53	16,000
Cortaro, Ariz.**	3,520	16	20,200
Hassayampa River near Morristown, Ariz.	744	8	12,500
Santa Rosa Wash near Vaiva Vo, Ariz.**	1,782	5	12,000

* Period of record through 1959.
** See pl. 1.

The concurrent records were considered for the 5 years of record of Santa Rosa Wash and the other streams listed in the above table and found to be representative of the average annual runoff for the longer periods of record. Therefore, the estimated average annual flow that is considered reasonable for Santa Rosa Wash at the considered Tat Momolikot damsite is assumed conservatively to be 14,000 acre-feet (8 acre-feet per square mile of drainage area per year). The inflow-sediment relationship is based on observed sedimentation data for conservation reservoirs in southwestern United States as given in table 7 and shown on plate 10, using the estimated average annual inflow for Santa Rosa Wash. An average rate of sediment per square mile per year of 0.2 acre-foot was obtained from plate 10. This estimate of the sedimentation rate is similar to the estimate made by the Soil Conservation Service for the Trilby Wash area (about 75 miles northwest of the Santa Rosa Wash area) which has similar flowage characteristics to Santa Rosa Wash. Thus, an indicated volume of approximately 40,000 acre-feet of sediment would be moved into the considered St. Clair Reservoir during a 100-year period.

ADEQUACY OF FLOODS AND SEDIMENT-STORAGE ALLOWANCE

31. Standard project flood.--The standard project flood as developed is considered satisfactory for a flood that would be exceeded only on rare occasions. A comparison of flood magnitude is difficult because of insufficient data, but the use of the storm of the magnitude of the September 3-8, 1939 storm transposed to produce the most critical precipitation over the drainage area, as well as the use of comparatively low loss rates, is considered reasonable. The flood volume is believed to be conservatively large.

32. A comparison of the standard-project-flood peak discharge per square mile with enveloping curves of peak discharges is shown on plate 11. The plotted position for the peak discharge of Santa Rosa Wash standard project flood is relatively low. This is caused by the precipitation pattern with three periods of more intense precipitation, rather than one maximum period and also by the percolation losses applied to this flood. The August 1954 storm transposed over the area above Tat Momolikot damsite indicated a peak discharge of 120,000 cubic feet per second (70 c.f.s. per sq. mi.), and a volume of 95,000 acre-feet for a standard-project-peak flood. In this case where a reservoir is involved, a flood with critical volume is required for reservoir design. Also the storm of September 1962 would not produce a volume of runoff as large as the standard-project-flood volume. Furthermore, the enveloping curve for recorded and estimated peak discharges in Arizona and New Mexico is mostly defined by discharges from areas with steeper gradients, well-defined channels, and heavier precipitation than in the drainage area of Santa Rosa Wash.

33. Maximum probable flood.--The magnitude of the maximum probable flood is best indicated by the severity of the various hydrologic factors (storm magnitude and pattern, loss rate, and time distribution of runoff) on which the flood estimate is based. The occurrence of any of these flood-conducive conditions in the severity assumed for the synthesis would be infrequent; and obviously, a flood resulting from the combination of all of these conditions would be very severe. A further indication of the severity of the maximum probable flood is the fact that the peak discharge and volume are 2.3 and 3.3 times as large as the peak discharge of the flood from the transposed August 1954 storm and the volume of the standard project flood, respectively.

34. A comparison of the maximum-probable-flood peak discharge per square mile with enveloping curves of peak discharges is shown on plate 11.

35. Sediment-storage allowance.--The 100-year sediment-storage allowance, believed conservative for the considered St. Clair Reservoir, was determined from recorded data for reservoirs in Arizona. Conditions existing in the drainage areas above the reservoirs, given in table 7, during the period of record are believed to be reasonably representative of existing conditions above Tat Momolikot damsite when differences in runoff are taken into account.

PRIOR APPROVAL

36. The standard project flood, maximum probable flood, and sediment storage allowance determinations were approved by the Office, Chief of Engineers, in 2nd indorsement dated June 21, 1961, to basic letter dated June 1, 1961, subject, "Gila River and Tributaries, Arizona and New Mexico, Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona."

Table 1

Summary of climatological data at Tucson, Ariz., Santa Rosa, Wash, Gila River basin, Ariz.

Month	Temperatures			Precipitation		
	Mean monthly	Record highest*	Record lowest*	Mean monthly	Maximum monthly	Minimum monthly
	Degrees Fahrenheit	Degrees Fahrenheit	Degrees Fahrenheit	Inches	Inches	Inches
Jan...	50.2	87	16	.84	4.00	0
Feb...	53.0	92	20	.85	4.15	T
Mar...	57.8	92	26	.72	3.88	0
Apr...	64.5	102	27	.37	3.53	0
May...	72.4	107	38	.20	1.34	0
Jun...	81.9	111	47	.28	2.07	0
Jul...	86.1	111	63	2.19	6.24	.25
Aug...	84.0	109	61	2.19	7.93	.08
Sep...	80.1	107	48	1.14	4.28	0
Oct...	69.4	101	35	.56	2.62	0
Nov...	58.0	90	24	.78	4.61	0
Dec...	51.2	84	18	.99	5.85	0
Period of record**	67.4	111	16	***11.11	7.93	0

* Period of record: 1921-1950.
** 56 years, 1905-61, inclusive.
*** Mean annual precipitation.

Note.--Above data from U.S. Weather Bureau climatological data for Tucson, Ariz.

Table 2

Precipitation stations in and near Santa Rosa Wash drainage area, Santa Rosa Wash, Gila River basin, Ariz.

Number*	Station**	Elevation	Geographic Coordinates		Period of record		Complete years of record	90-year mean annual precipitation
			Latitude	Longitude	Recording	Non-recording		
		Feet	Degrees and minutes	Degrees and minutes				Inches
13-P-13..	South Phoenix..	1,195	33-23	112-04	.....	1915-62	39	7.33
13-P-14..	Buckeye.....	888	33-22	112-35	.....	1889-1962	62	7.35
13-P-46..	Laveen.....	1,110	33-20	112-09	.....	1948-62	14	7.66
13-P-49..	Maricopa 4W....	1,165	33-07	112-02	.....	1960-62	2	.....
13-Q-1...	Gila Bend.....	737	32-57	112-43	.....	1889-1962	51	5.90
13-Q-2...	Ventana Ranch..	2,300	32-29	112-15	.....	1923-28	0	.....
13-Q-3...	Ajo.....	1,763	32-22	112-52	1939-62	1913-62	47	8.42
13-Q-5...	Ajo Well.....	1,401	32-27	112-50	.....	1939-62	22	7.43
13-Q-6...	Hickiwan.....	2,200	32-21	112-29	.....	1936-40	3	.....
13-Q-7...	Santa Rosa.....	2,000	32-21	112-04	.....	1936-40	3	.....
13-Q-8...	San Simon.....	2,000	32-11	112-20	.....	1936-40	3	.....
13-Q-9...	Kerwo.....	2,200	32-04	112-35	.....	1936-40	3	.....
13-Q-14..	Gila Bend F.A.A. Airport.....	853	32-53	112-43	.....	1944-62	17	5.51
13-Q-15..	Maricopa 9SSW..	1,400	32-55	112-06	.....	1873-1959	68	7.13
13-Q-16..	Pisinemo.....	1,900	32-03	112-19	.....	1936-56	19	9.91
13-Q-17..	Covered Wells 1E.....	2,620	32-09	112-09	.....	1957-62	4	.....
13-Q-18..	Santa Rosa School.....	1,830	32-19	112-03	.....	1959-62	2	.....

See footnotes at end of table.

Table 2--continued

Precipitation stations in and near Santa Rosa Wash drainage area, Santa Rosa Wash, Gila River basin, Ariz.

Number*	Station**	Elevation	Geographic Coordinates		Period of Record		Complete years of record	90-year mean annual precipitation
			Latitude	Longitude	Recording	Non-recording		
		Feet	Degrees and minutes	Degrees and minutes				Inches
13-R-2...	Big Fields.....	1,900	31-55	112-08	.....	1936-40	3	.....
13-R-3...	Organ Pipe Cactus National Monument.....	1,678	31-56	112-47	.....	1944-62	19	8.50
14-P-18..	Mesa Experiment Farm....	1,225	33-25	111-52	.....	1896-1962	66	8.03
14-P-21..	Chandler.....	1,212	33-18	111-50	.....	1912-62	32	7.84
14-P-23..	Higley.....	1,332	33-20	111-42	.....	1915-22	7	.....
14-P-25..	Superior.....	2,995	33-18	111-06	1939-62	1920-62	42	17.78
14-P-31..	Sacaton.....	1,285	33-04	111-45	.....	1908-62	50	9.78
14-P-32..	Florence.....	1,500	33-02	111-23	.....	1875-1962	56	9.79
14-P-41..	Chandler Heights.....	1,445	33-13	111-41	.....	1941-62	22	8.51
14-P-51..	Superstition Mountain.....	1,950	33-23	111-26	1948-62	(1901-05 (1946-62	20	11.04
14-P-53..	Tempe 3S.....	1,180	33-23	111-56	.....	1905-52	47	8.22
14-P-66..	Ashurst Hayden Dam.....	1,638	33-05	111-15	.....	1957-62	5	.....
14-Q-1...	Casa Grande Ruins National Monument..	1,419	33-00	111-32	1939-62	1906-62	38	8.69

See footnotes at end of table.

Table 2--continued

Precipitation stations in and near Santa Rosa Wash drainage area, Santa Rosa Wash, Gila River basin, Ariz.

Number*	Station**	Elevation	Geographic Coordinates		Period of Record		Complete years of record	90-year mean annual precipitation
			Latitude	Longitude	Recording	Non-recording		
		Feet	Degrees and minutes	Degrees and minutes				Inches
14-Q-2...	Casa Grande 3SE.....	1,405	32-53	111-45	.....	1880-1962	76	8.15
14-Q-3...	Picacho.....	1,620	32-43	111-30	.....	1904-08	2	.....
14-Q-4...	Red Rock 6SW...	1,820	32-30	111-22	.....	1889-1962	41	10.93
14-Q-5...	Silverbell.....	2,740	32-23	111-30	.....	(1906-23 (1953-62	24	13.02
14-Q-6...	Tucson Nursery 4NW.....	2,245	32-18	111-03	1940-62	.....	22	.....
14-Q-8...	Cocklebur.....	2,000	32-42	111-54	.....	1936-40	3	.....
14-Q-11..	Aguirre Ranch..	2,100	32-15	111-35	.....	1936-40	3	.....
14-Q-14..	San Pedro.....	2,300	32-05	111-29	.....	1926-35	3	.....
14-Q-16..	Cortaro 3SW....	2,283	32-20	111-07	.....	1945-62	17	12.26
14-Q-17..	Eloy.....	1,565	32-45	111-33	.....	1951-62	11	8.79
14-Q-18..	Picacho Reservoir....	1,510	32-52	111-28	.....	1957-62	5	.....
14-Q-20..	Tucson Mountain Park....	2,850	32-15	111-10	.....	1943-57	11	10.75
14-Q-20B.	Arizona-Sonora Desert Museum.....	2,815	32-15	111-10	.....	1962	.....	.....

Table 2--continued

Precipitation stations in and near Santa Rosa Wash drainage area, Santa Rosa Wash, Gila River basin, Ariz.

Number*	Station**	Elevation	Geographic Coordinates		Period of record		Complete years of record	90-year mean annual precipitation
			Latitude	Longitude	Recording	Non-recording		
		Feet	Degrees and minutes	Degrees and minutes				Inches
14-R-8...	Bolsa.....	2,500	31-58	111-51	.....	1936-40	3	.....
14-R-9...	Fresnal Canyon.	3,600	31-55	111-40	.....	1936-40	3	.....
14-R-15..	Sells.....	2,375	31-55	111-53	.....	1911-62	32	11.42
14-R-17..	Anvil Ranch....	2,750	31-59	111-23	.....	1942-62	12	10.02
14-R-19..	Ruby Star Ranch.....	3,640	31-55	111-05	.....	1948-62	10	13.33
14-R-23..	Kitt Peak.....	6,840	31-58	111-36	.....	1960-62	2	.....
15-P-11..	Kelvin.....	1,785	33-06	110-58	.....	1917-62	39	13.59
15-Q-7...	Tucson, Fort Lowell.....	2,450	32-16	110-53	.....	1866-1891	21	.....
15-Q-10..	Tucson, UofA...	2,443	32-14	110-57	1927-62	1891-1962	69	11.14
15-Q-11B.	Tucson Weather Bu. Airport...	2,584	32-07	110-56	1948-62	1948-62	14	12.21
15-Q-44	Tucson, Campbell Ave.....	2,330	32-17	110-57	.....	1884-62	78	11.40
15-R-66	Sahuarita.....	2,690	31-58	110-58	.....	1957-62	5	.....

* Stations numbered in accordance with quadrangle-index system of the U.S. Army Engineer District, Los Angeles, Corps of Engineers.

** See pl. 1 for location.

Note.--Above data, except station number and 90-year (1868-1957) mean annual precipitation, obtained from publications of the U.S. Weather Bureau.

Table 3

Recording stream-gaging stations in the Santa Rosa Wash drainage area, Santa Rosa Wash, Gila River basin, Ariz.

No.*	Station	Latitude	Longitude	Period of Record	Drainage area	Peak discharge of record		Authority**
						Date	Discharge	
		Degrees and minutes	Degrees and minutes		Square miles		Cubic feet per second	
1....	Santa Rosa Wash at Gu Komelik near Sells, Ariz.....	32-30	111-57	1954-59	629	Oct. 31, 1957	14,000	U.S.G.S.
2....	Santa Rosa Wash near Vaiva Vo, near Sells, Ariz.....	32-40	111-56	1954-62	1,782	Sep. 25, 1962	***53,000	U.S.G.S.
3....	Kohatk Wash near Chiapuk, near Sells, Ariz.....	32-33	112-09	#1954-60	185	Jul. 20, 1955	2,830	U.S.G.S.

* See plate 1.
** U.S.G.S. - U.S. Geological Survey
*** Preliminary estimate
\# Discontinued June 30, 1960

Table 4

Standard project storm depth-duration relationship, Santa Rosa Wash, Gila River basin, Ariz.

Subarea designation*	Drainage area	Average depth of precipitation over the various subareas for indicated duration				
		Maximum 1-hour	Maximum 3-hour	Maximum 12-hour	Maximum 24-hour	Total storm**
	Square miles	Inches	Inches	Inches	Inches	Inches
A.....	305	0.63	1.62	2.30	4.13	6.20
B.....	166	.65	1.68	2.39	4.30	6.45
C.....	225	.62	1.61	2.29	4.12	6.19
D.....	270	.64	1.65	2.34	4.21	6.30
E.....	250	.67	1.74	2.46	4.42	6.60
F.....	193	.67	1.74	2.46	4.42	6.60
G.....	341	.66	1.71	2.42	4.34	6.50

* For location, see pl. 1.
** 72 hours.

Table 5

Lag and pertinent elements, Santa Rosa Wash, Gila River basin, Ariz.

Subarea	Drainage area	L	L_{ca}	S	$\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}$	Lag*
	Square miles	Miles	Miles	Feet per mile		Hours
A.....	305	38.4	22.6	28.6	163.6	9.5
B.....	166	23.6	12.0	38.1	45.8	5.8
C.....	225	26.8	12.8	48.5	49.3	6.2
D.....	270	28.4	15.2	81.0	48.0	6.1
E.....	250	44.6	22.1	54.9	133.2	8.8
F.....	193	37.5	17.0	45.3	86.2	7.8
G.....	341	23.7	10.7	124.5	22.7	4.5

* See pl. 6 for lag curve. Lag values have been increased 25 percent, which is conservative, on the basis that as there are very few definite entrenched channels; the flow would spread out essentially as sheet flow with a decrease in velocity, and the lag would thus be increased.

Table 6

Probable maximum storm depth-duration relationship, Santa Rosa Wash, Gila River basin, Ariz.

Subarea designation*	Drainage area	Average depth of precipitation over the various subareas for indicated duration				
		Maximum 1-hour	Maximum 3-hour	Maximum 12-hour	Maximum 24-hour	Total storm**
	Square miles	Inches	Inches	Inches	Inches	Inches
A.....	305	0.86	2.08	5.08	7.19	11.07
B.....	166	1.13	2.73	6.67	9.44	14.54
C.....	225	0.89	2.15	5.26	7.43	11.44
D.....	270	1.01	2.44	5.95	8.43	12.97
E.....	250	1.20	2.90	7.09	10.02	15.44
F.....	193	0.97	2.34	5.72	8.10	12.47
G.....	341	0.95	2.28	5.58	7.90	12.15

* For location see pl. 1.
** 72 hours.

Table 7

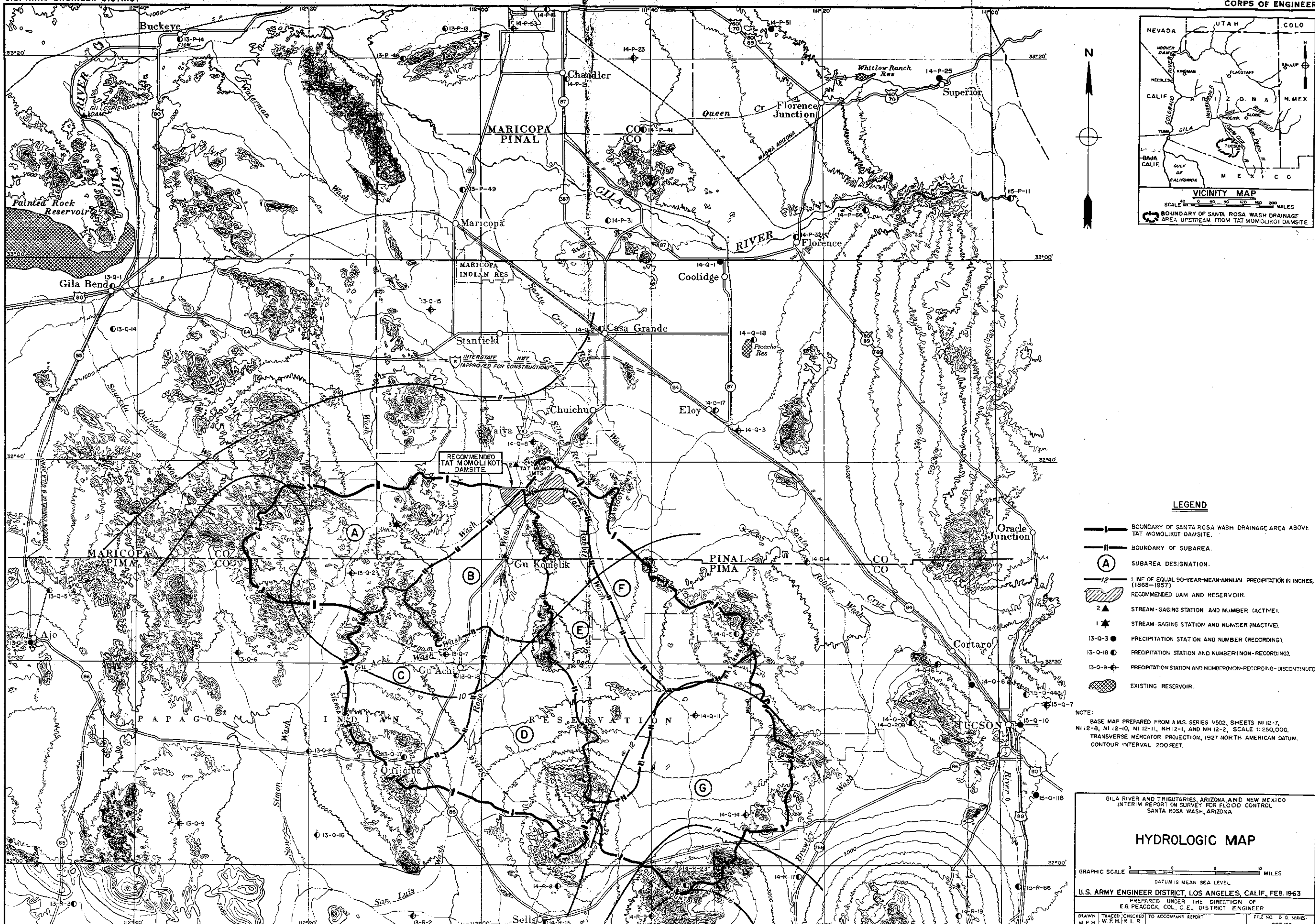
Observed sedimentation data for conservation reservoirs in southwestern United States, Santa Rosa Wash, Gila River basin, Ariz.

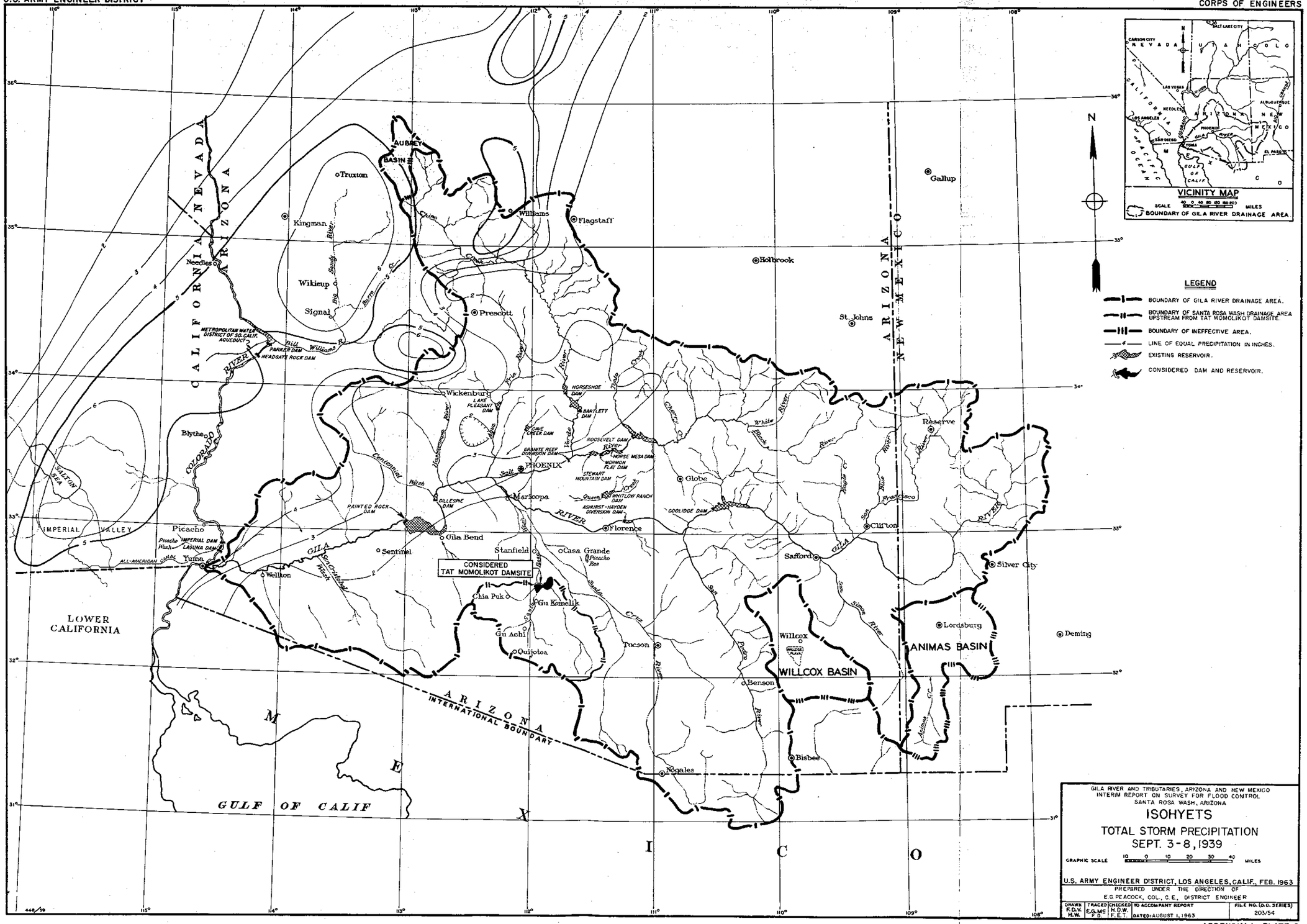
No.	Reservoir	State	Contributing drainage area	Period of record	Years of record	Total inflow for period of record	Total sediment deposit for period of record	Sediment deposit per sq. mi. per year	Inflow per sq. mi. per year
			Square miles			Acre-feet	Acre-feet	Acre-feet	Acre-feet
1...	San Carlos..	Ariz...	11,900	1928-47	18.2	4,640,600	57,494	*0.266	*21.4
2...	Lake Pleasant..	Ariz...	1,444	1928-41	12.9	(**)	8,044	(**)	(**)
3...	Roosevelt...	Ariz...	5,760	1909-46	36.8	29,186,000	140,600	.663	137.7
4...	Conchas.....	N. Mex.	6,950	1939-49	10.1	2,706,000	35,600	.506	38.2
5...	Elephant Butte.....	N. Mex.	25,866	1915-47	32.3	34,807,000	465,000	.556	41.7
6...	Lake Mead	Nev.-Ariz.	167,600	1935-48	13.7	181,296,000	1,425,000	.620	79.0
7...	Lake Hodges.	Calif..	301	1919-48	29.5	1,139,000	3,323	.375	128.3
8...	San Dimas...	Calif..	16	1922-44	22.1	50,200	488	1.37	141.0
9...	Sweetwater..	Calif..	181	1886-1927	39	740,000	6,170	.87	105.0
10..	Gilbralter..	Calif..	220	1920-31	11	206,000	2,100	.87	85.1

* The U.S. Bureau of Reclamation recommends 346,700 and 5,000 acre-feet for longtime average annual values of total inflow and sediment deposit, respectively, for San Carlos Reservoir. By applying these the average annual rate of sediment deposit and total inflow becomes 0.42 and 29.1, respectively.

** There is no complete record of inflow into Lake Pleasant for the period of observed sediment deposit. An estimate of the total inflow for period of sediment observation and longtime rate of total inflow and sediment deposit, based on records for Verde River (an adjacent stream), resulted in an average rate of sediment deposit and total inflow per square mile of drainage area of 0.56 and 42.5 acre-feet, respectively.

Note.--See curve on pl. 10.


Buckeye
Chandler
Florence Junction
Superior
Whitlow Ranch Res
MARICOPA
PINAL
Queen Cr
GILA RIVER
Painted Rock Reservoir
Maricopa
Florence
Coolidge
Gila Bend
MARICOPA INDIAN RES
Santa Cruz
Casa Grande
Stanfield
Picacho Res
INTERSTATE HWY (APPROVED FOR CONSTRUCTION)
Chuichu
Eloy
Vaiva Vo
RECOMMENDED TAT MOMOLIKOT DAMSITE
Oracle Junction
MARICOPA
PIMA
PINAL
PIMA
Gu Komelik
Ajo
Cortaro
Gu Achi
PAPAGO INDIAN RESERVATION
TUCSON
Quijotoa
Sells
San Luis
VICINITY MAP
NEVADA
UTAH
COLO
CALIF
ARIZONA
N. MEX
MEXICO
BOUNDARY OF SANTA ROSA WASH DRAINAGE AREA UPSTREAM FROM TAT MOMOLIKOT DAMSITE
LEGEND
BOUNDARY OF SANTA ROSA WASH DRAINAGE AREA ABOVE TAT MOMOLIKOT DAMSITE.
BOUNDARY OF SUBAREA.
SUBAREA DESIGNATION.
LINE OF EQUAL 90-YEAR-MEAN-ANNUAL PRECIPITATION IN INCHES. (1868—1957)
RECOMMENDED DAM AND RESERVOIR.
STREAM-GAGING STATION AND NUMBER (ACTIVE).
STREAM-GAGING STATION AND NUMBER (INACTIVE).
13-Q-3 PRECIPITATION STATION AND NUMBER (RECORDING).
13-Q-18 PRECIPITATION STATION AND NUMBER (NON-RECORDING).
13-Q-9 PRECIPITATION STATION AND NUMBER (NON-RECORDING-DISCONTINUED)
EXISTING RESERVOIR.
NOTE:
BASE MAP PREPARED FROM A.M.S. SERIES V502, SHEETS NI 12-7, NI 12-8, NI 12-10, NI 12-11, NH 12-1, AND NH 12-2, SCALE 1:250,000. TRANSVERSE MERCATOR PROJECTION, 1927 NORTH AMERICAN DATUM. CONTOUR INTERVAL 200 FEET.
GILA RIVER AND TRIBUTARIES, ARIZONA, AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA
HYDROLOGIC MAP
GRAPHIC SCALE MILES
DATUM IS MEAN SEA LEVEL
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF., FEB. 1963
PREPARED UNDER THE DIRECTION OF
E.G. PEACOCK, COL., C.E., DISTRICT ENGINEER
DRAWN W.F.H.
TRACED W.F.H. F.D.
CHECKED R L R F E T
TO ACCOMPANY REPORT DATED: AUGUST 1, 1963
FILE NO. D.O. SERIES 203/53



GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

ISOHYETS

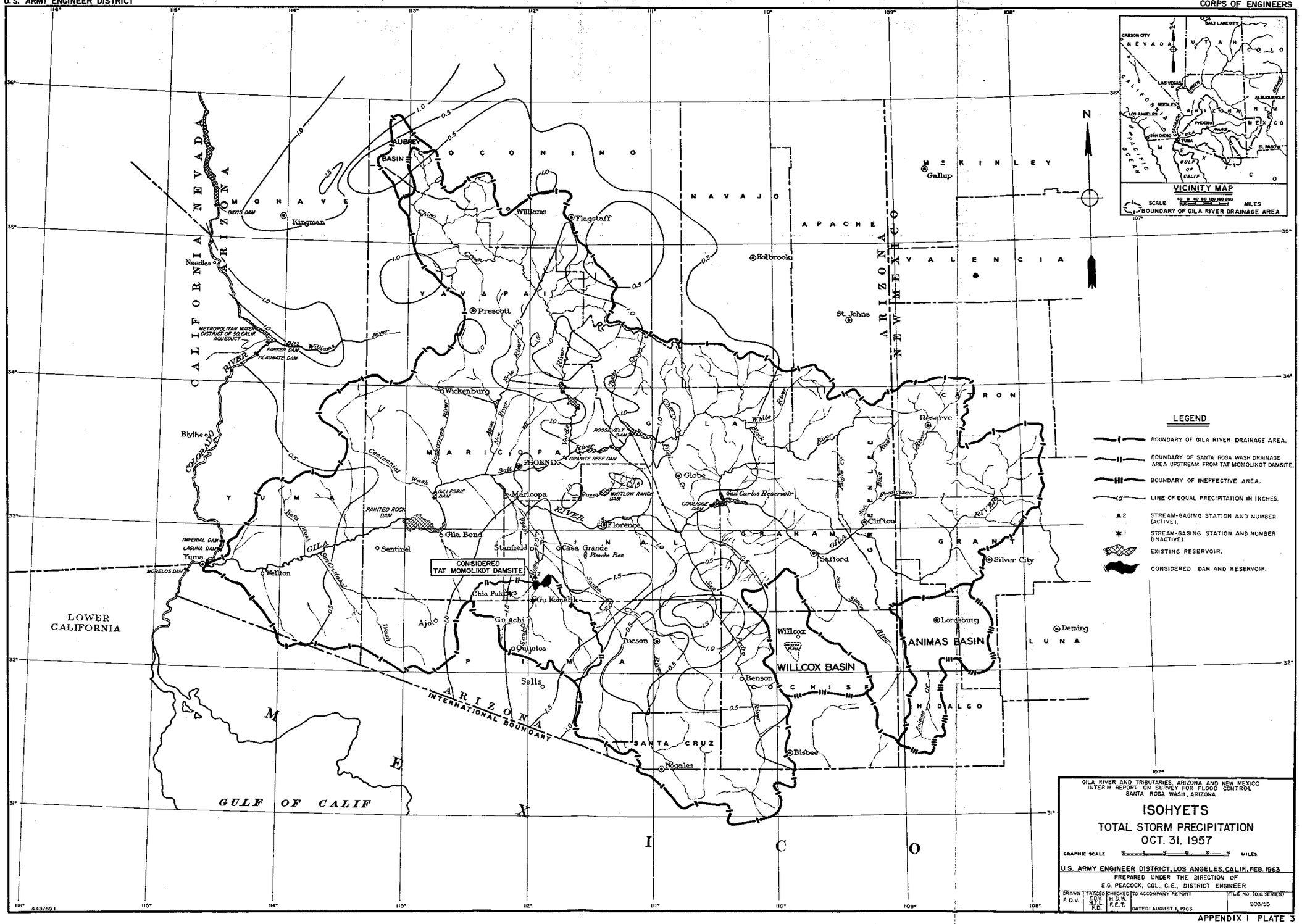
TOTAL STORM PRECIPITATION
SEPT. 3-8, 1939

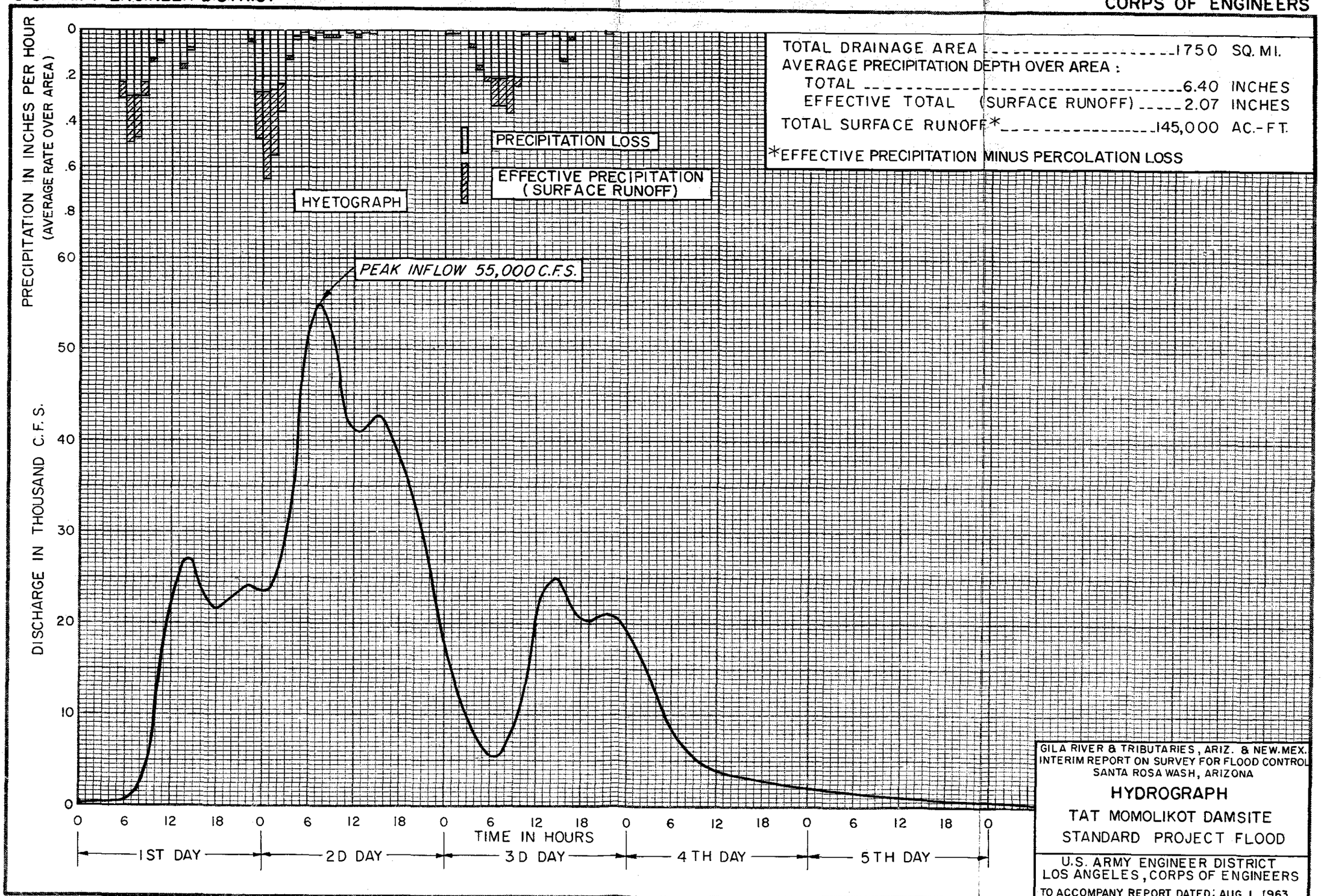
GRAPHIC SCALE 10 0 10 20 30 40 MILES

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF., FEB. 1963

PREPARED UNDER THE DIRECTION OF
E.G. PEACOCK, COL., C.E., DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (O.D. SERIES)
R.D.V. H.W.	E.G.M.E. F.D.	H.D.W. F.E.T.	DATED: AUGUST 1, 1963	203/54


VICINITY MAP
SCALE
MILES
BOUNDARY OF GILA RIVER DRAINAGE AREA
LEGEND
BOUNDARY OF GILA RIVER DRAINAGE AREA.
BOUNDARY OF SANTA ROSA WASH DRAINAGE AREA UPSTREAM FROM TAT MOMOLIKOT DAMSITE.
BOUNDARY OF INEFFECTIVE AREA.
LINE OF EQUAL PRECIPITATION IN INCHES.
STREAM-GAGING STATION AND NUMBER (ACTIVE).
STREAM-GAGING STATION AND NUMBER (INACTIVE)
EXISTING RESERVOIR.
CONSIDERED DAM AND RESERVOIR.
CONSIDERED TAT MOMOLIKOT DAMSITE
LOWER CALIFORNIA
GULF OF CALIF
INTERNATIONAL BOUNDARY
WILLCOX BASIN
ANIMAS BASIN
AUBREY BASIN
Kingman
Needles
Bullhead
Williams
Flagstaff
Prescott
Holbrook
Gallup
St. Johns
Wickenburg
PHOENIX
Globe
Reserve
Blythe
Yuma
Gila Bend
Sentinel
Maricopa
Florence
Casa Grande
Stanfield
Wellton
Ajo
Gu Achi
Gu Komelik
Chia Pukk
Tucson
Sells
Benson
Bisbee
Nogales
Safford
Clifton
Silver City
Lordsburg
Deming
Willcox
San Carlos Reservoir
Roosevelt Lake
Granite Reef Dam
Coolidge Dam
Whitlow Ranch Dam
Painted Rock Dam
Gillespie Dam
Parker Dam
Headgate Dam
Metropolitan Water District of So. Calif. Aqueduct
Imperial Dam
Laguna Dam
Morelos Dam
Davis Dam
Colorado River
Gila River
Salt River
Verde River
Bill Williams River
Centennial Wash
Hassayampa River
Agua Fria River
Rio Salado
Black River
White River
San Pedro River
Santa Cruz River
Rio Grande
Pecos River
Canadian River
Mogollon Rim
Mt. McKinley
Pacific Ocean
Gulf of Calif.
Salt Lake City
Carson City
Las Vegas
Los Angeles
San Diego
Needles
Phoenix
Tucson
El Paso
Albuquerque
Tucson
Yuma
Nevada
Utah
Colorado
California
Arizona
New Mexico
Mexico
N
GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA
ISOHYETS
TOTAL STORM PRECIPITATION
OCT. 31, 1957
GRAPHIC SCALE
MILES
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF. FEB 1963
PREPARED UNDER THE DIRECTION OF
E.G. PEACOCK, COL., C.E., DISTRICT ENGINEER
DRAWN F.D.V.
TRACED F.D.V. N.V.L. F.D.
CHECKED H.D.W. F.E.T.
TO ACCOMPANY REPORT
DATED: AUGUST 1, 1963
FILE NO. (D.G. SERIES) 203/55
449/59.1



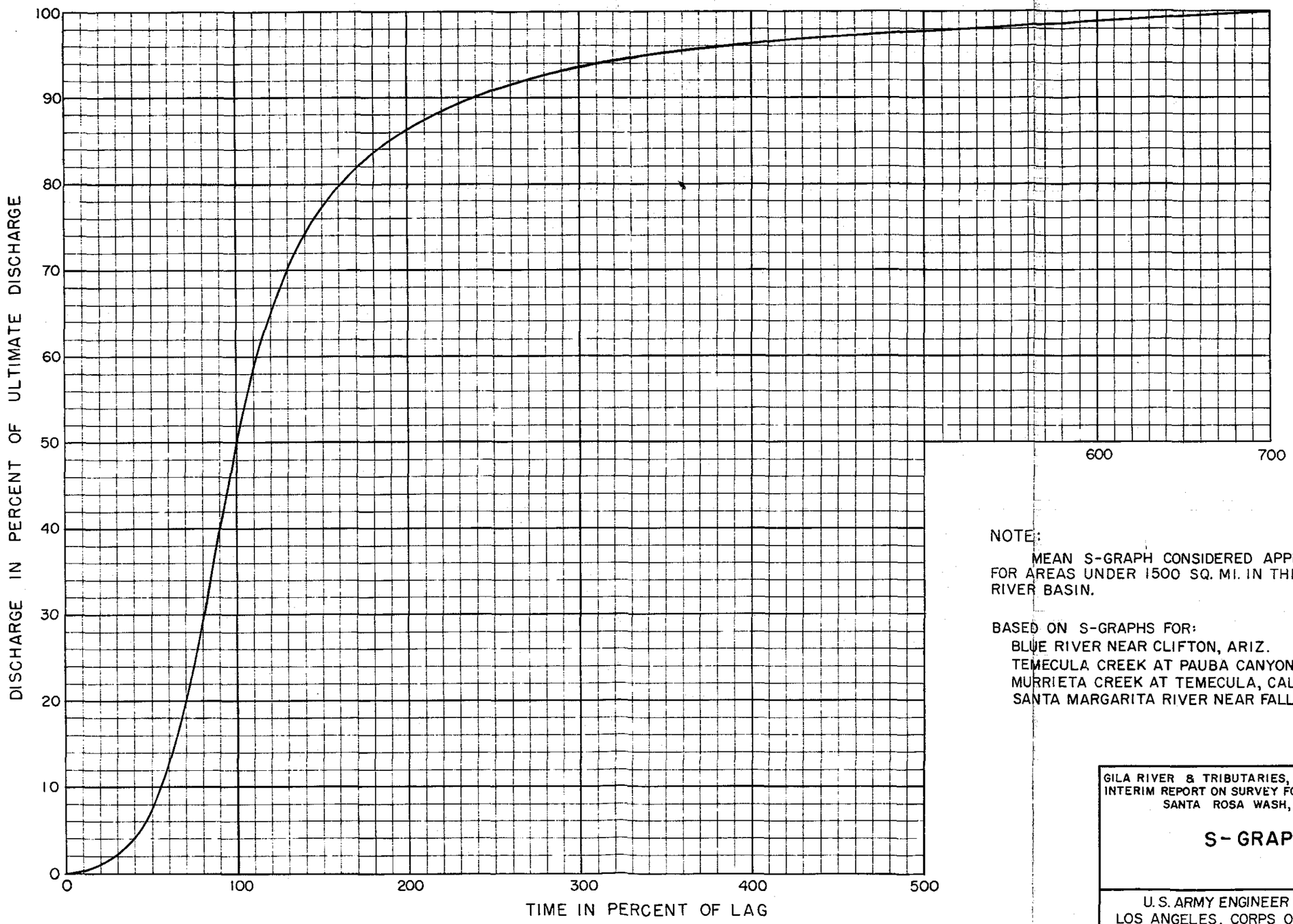
GILA RIVER & TRIBUTARIES, ARIZ. & NEW.MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

HYDROGRAPH

TAT MOMOLIKOT DAMSITE
STANDARD PROJECT FLOOD

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED: AUG. 1, 1963



NOTE:

MEAN S-GRAPH CONSIDERED APPLICABLE FOR AREAS UNDER 1500 SQ. MI. IN THE GILA RIVER BASIN.

BASED ON S-GRAPHS FOR:

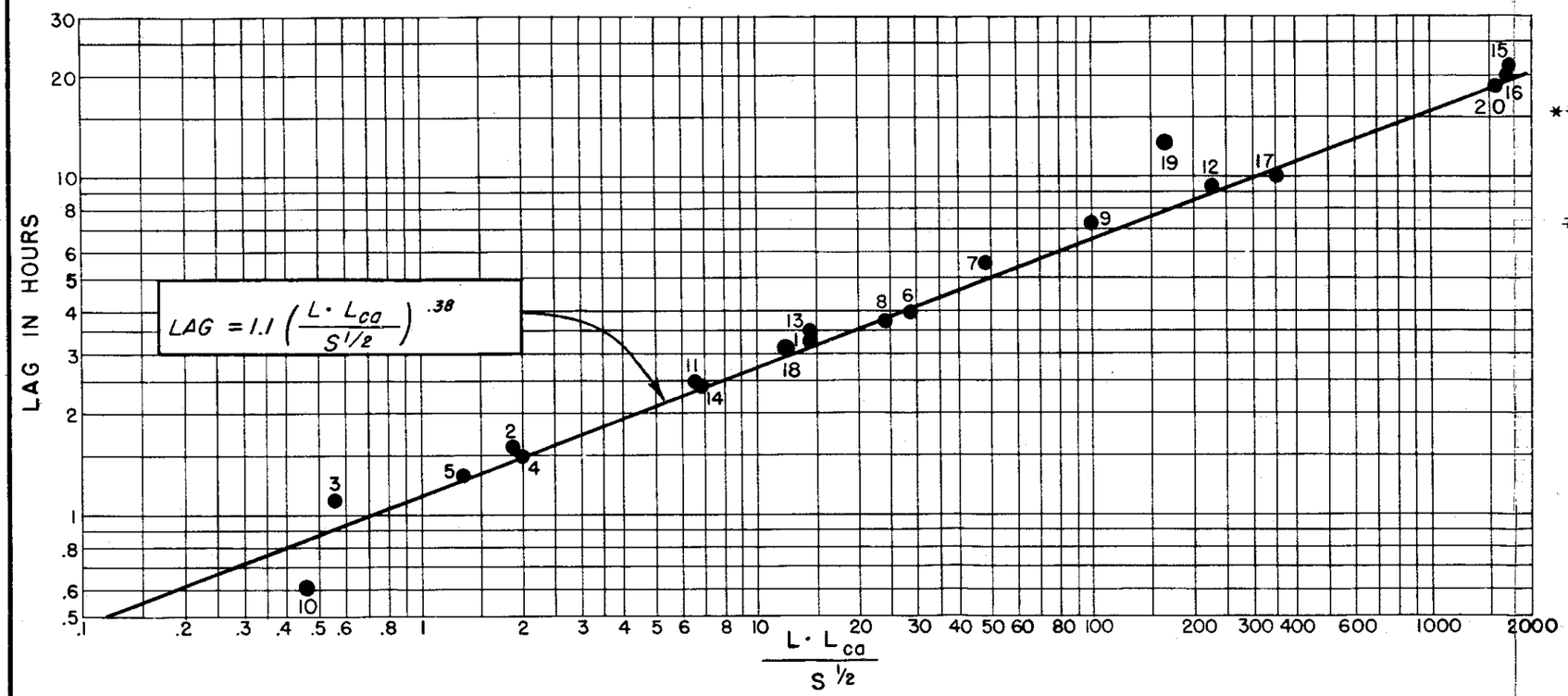
BLUE RIVER NEAR CLIFTON, ARIZ.
TEMECULA CREEK AT PAUBA CANYON, CALIF.
MURRIETA CREEK AT TEMECULA, CALIF.
SANTA MARGARITA RIVER NEAR FALLBROOK, CALIF.

GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

S-GRAPH

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

	DRAINAGE AREA SQ. MI.	L MILES	L_{ca} MILES	S FT/MI.	LAG HOURS
1. SAN GABRIEL RIVER AT SAN GABRIEL DAM, CALIF. *	162	23.2	11.6	350	3.3
2. WEST FORK SAN GABRIEL RIVER AT COGSWELL DAM, CALIF.	40.4	9.3	4.2	450	1.6
3. SANTA ANITA CREEK AT SANTA ANITA DAM, CALIF.	10.8	5.8	2.5	690	1.1
4. SAN DIMAS CREEK AT SAN DIMAS DAM, CALIF.	16.2	8.6	4.8	440	1.5
5. EATON WASH AT EATON WASH DAM, CALIF.	9.5	7.3	4.4	600	1.3
6. MURRIETA CREEK AT TEMECULA, CALIF.	220	27.2	10.3	95	4.0
7. SANTA CLARA RIVER NEAR SAUGUS, CALIF.	355	36.0	15.8	140	5.6
8. TEMECULA CREEK AT PAUBA CANYON, CALIF. **	168	26.0	11.3	150	3.7
9. SANTA MARGARITA RIVER NEAR FALLBROOK, CALIF.	645	46.0	22.0	105	7.3
10. EAST FULLERTON CREEK AT FULLERTON DAM, CALIF.	3.1	3.2	1.7	140	0.6
11. TUJUNGA CREEK AT BIG TUJUNGA DAM NO.1, CALIF.	81.4	15.1	7.3	290	2.5
12. SANTA MARGARITA RIVER AT YSIDORA, CALIF.	740	61.2	34.3	85	9.5
13. LOS ANGELES RIVER AT SEPULVEDA DAM, CALIF.	152	19.0	9.0	145	3.5
14. PACOIMA WASH AT PACOIMA DAM, CALIF.	27.8	15.0	8.0	315	2.4
15. GILA RIVER AT CONNER NO. 4 DAM SITE, ARIZ.	2840	131	71	29	21.5
16. SAN FRANCISCO RIVER AT JUNCTION WITH BLUE RIVER, ARIZ. ***	2000	130	74	32	20.6
17. BLUE RIVER NEAR CLIFTON, ARIZ. ***	790	77	37	65	10.3
18. SAN VICENTE CREEK AT FOSTER, CALIF.	75	182	7.4	111	3.2
19. SANTA ANA RIVER AT PRADO DAM, CALIF. #	1466	68	26	115	13.0
20. SALT RIVER NEAR ROOSEVELT, ARIZ.	4310	160	66	45	18.6



TERMINOLOGY

L = LENGTH OF LONGEST WATERCOURSE.

L_{ca} = LENGTH ALONG WATERCOURSE, MEASURED UPSTREAM, TO POINT OPPOSITE CENTER OF AREA.

S = OVER-ALL SLOPE OF DRAINAGE AREA BETWEEN HEADWATERS AND COLLECTION POINT.

LAG = ELAPSED TIME FROM BEGINNING OF UNIT RAINFALL TO INSTANT THAT SUMMATION HYDROGRAPH REACHES 50% OF ULTIMATE DISCHARGE.

* EXCLUDES AREA ABOVE COGSWELL DAM.

** PALOMAR MOUNTAIN PORTION. ENTIRE AREA IS 319 SQUARE MILES, OF WHICH 151 SQUARE MILES DID NOT CONTRIBUTE APPRECIABLE FLOOD FLOWS DURING THE FLOODS ANALYZED.

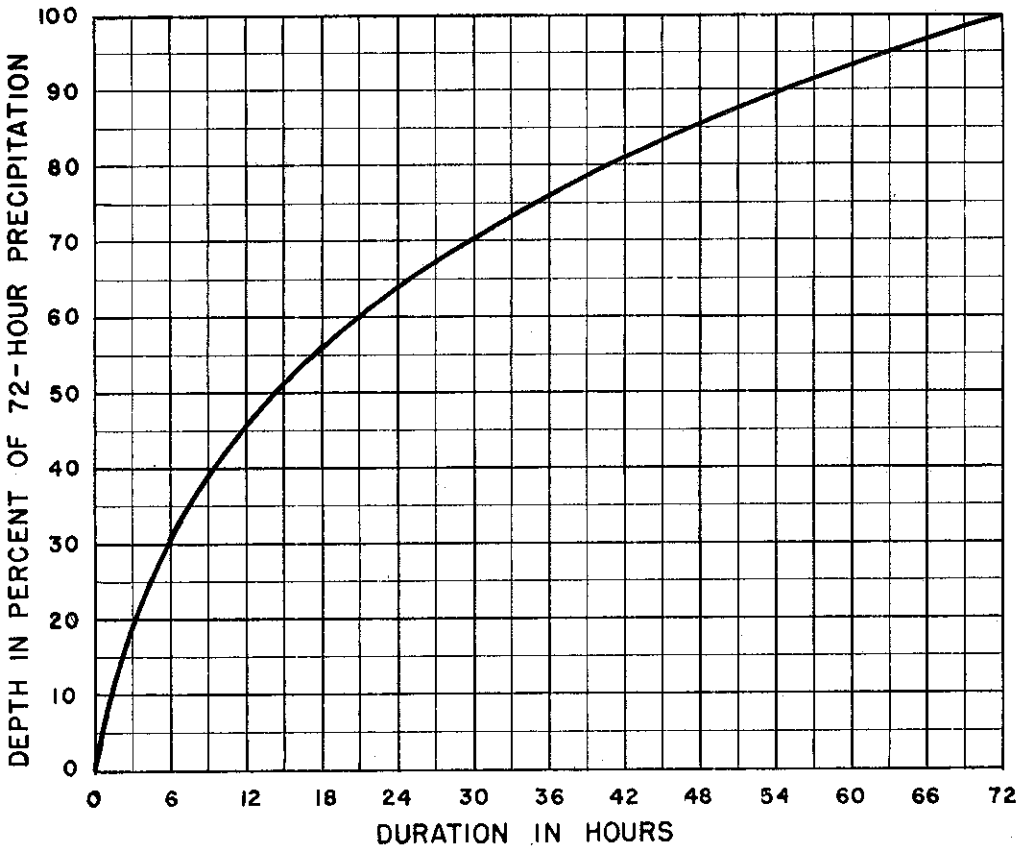
*** UNIT-GRAPH STUDY BASED ON RUNOFF RECORDS FOR SAN FRANCISCO RIVER AT CLIFTON (DRAINAGE AREA = 2790 SQ. MI.)

\# EXCLUDED 25 SQUARE MILES TRIBUTARY TO BALDWIN LAKE AND 767 SQUARE MILES TRIBUTARY TO LAKE ELSINORE.

GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

LAG RELATIONSHIPS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

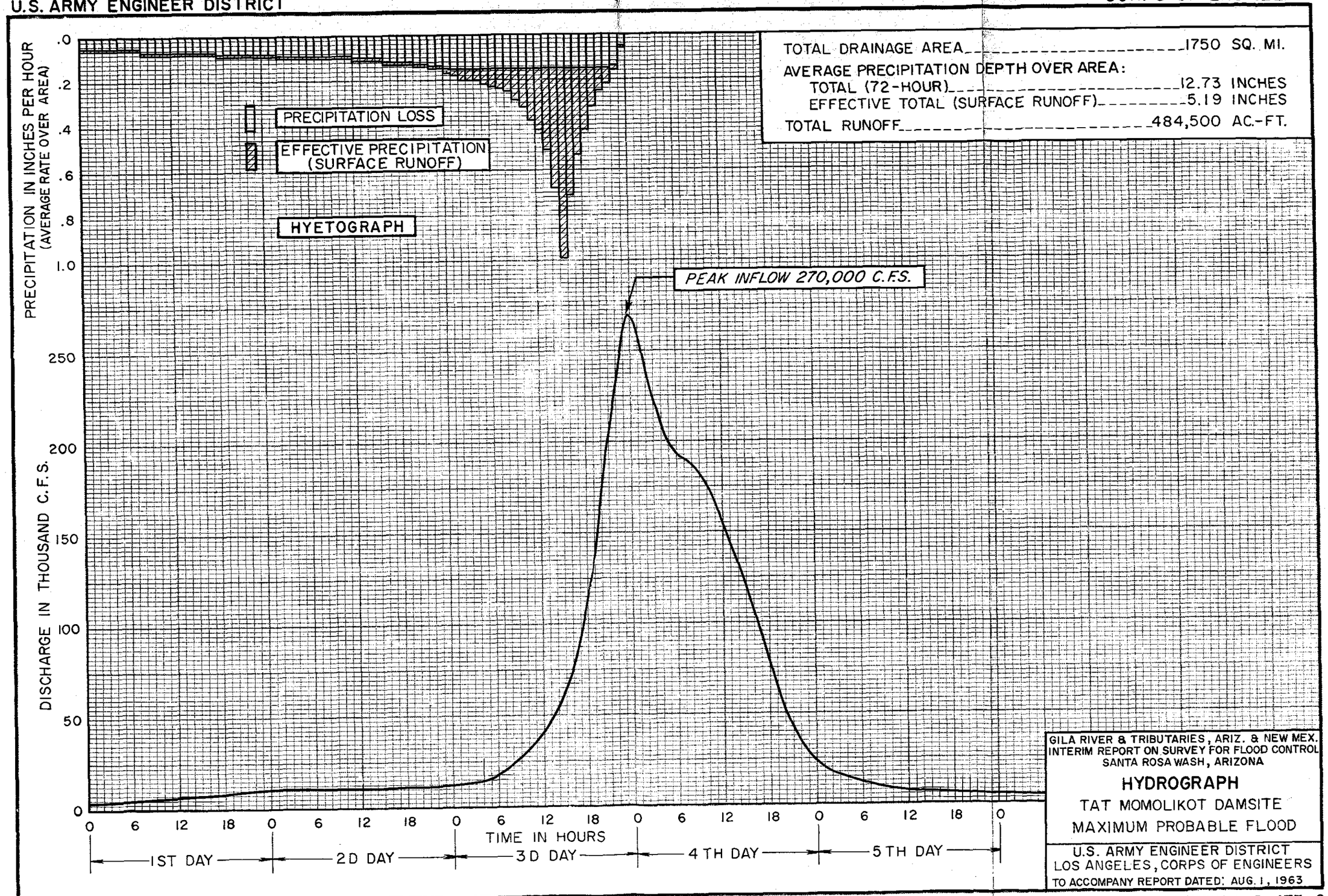


NOTE:
CURVE IS BASED ON DATA FROM U.S. WEATHER BUREAU'S LETTER DATED JANUARY 1958, SUBJECT "PRELIMINARY ESTIMATE OF PROBABLE MAXIMUM PRECIPITATION FOR BILL WILLIAMS RIVER BASIN, ARIZONA, ABOVE PROPOSED ALAMO DAMSITE."

GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

DEPTH-DURATION RELATIONSHIPS
PROBABLE MAXIMUM STORM

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

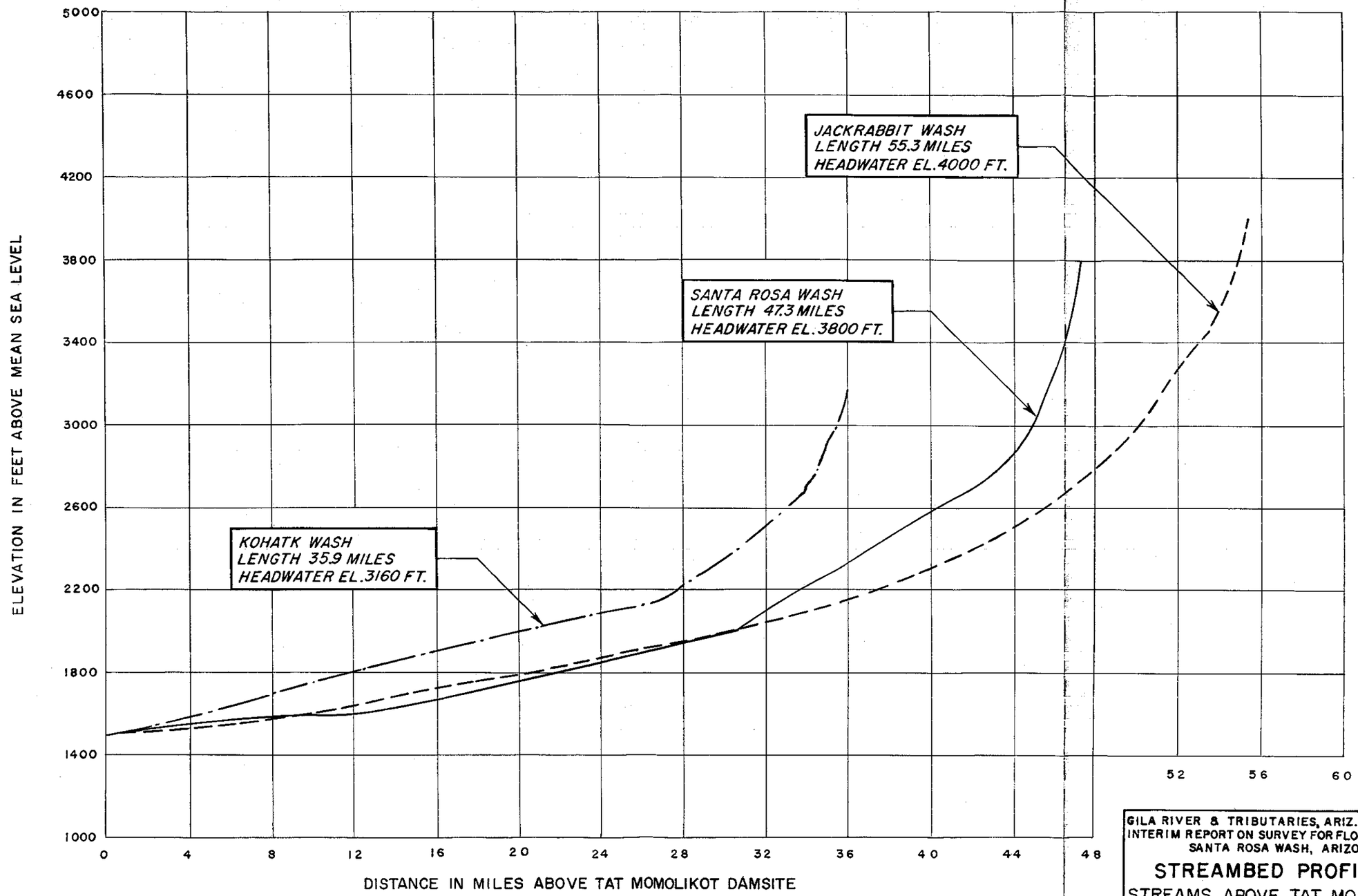


GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

HYDROGRAPH

TAT MOMOLIKOT DAMSITE
MAXIMUM PROBABLE FLOOD

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963



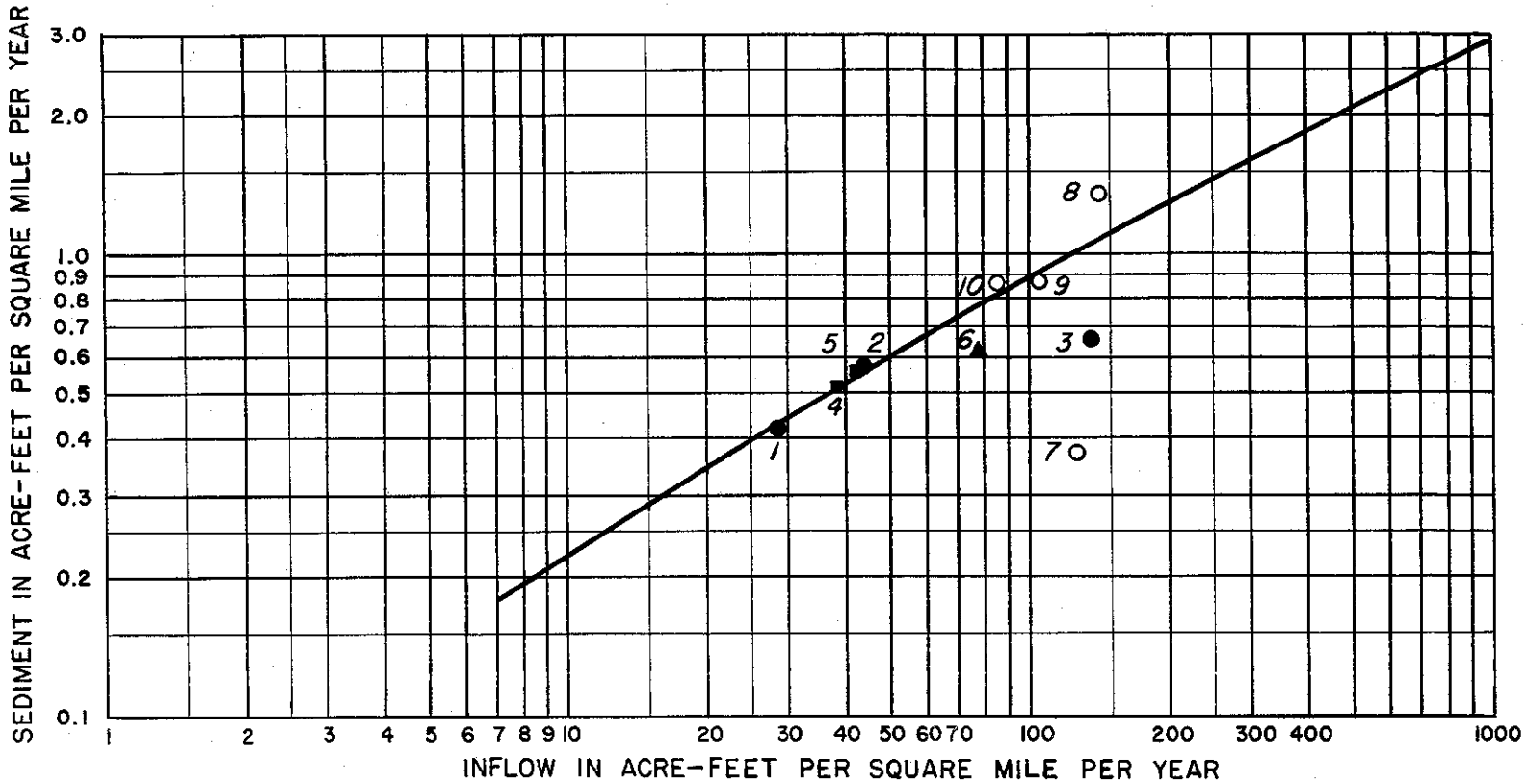
GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

STREAMBED PROFILES

STREAMS ABOVE TAT MOMOLIKOT DAMSITE

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED AUG. 1, 1963



LEGEND

- ● ARIZONA RESERVOIRS.
- ■ NEW MEXICO RESERVOIRS.
- ▲ NEVADA-ARIZONA RESERVOIR (LAKE MEAD).
- ○ CALIFORNIA RESERVOIRS.

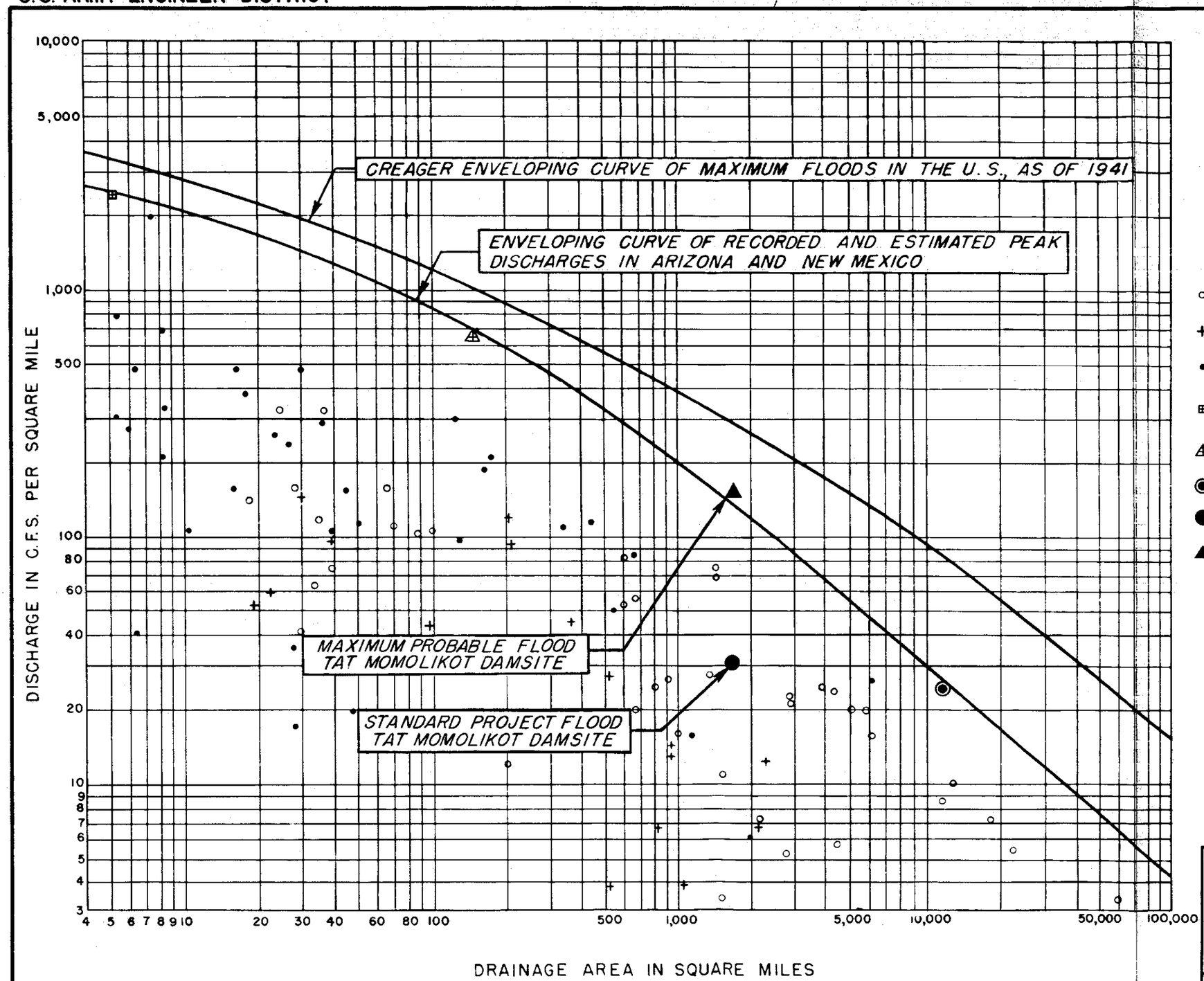
NOTE:
POINTS ARE NUMBERED TO CORRESPOND WITH RESERVOIRS SHOWN IN TABLE 7.

GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

INFLOW-SEDIMENT RELATIONSHIP FOR CONSERVATION RESERVOIRS IN SOUTHWESTERN UNITED STATES

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

FILE NO. 203/62



LEGEND

- ○ FLOODS FROM GENERAL RAIN OR SNOW MELT RUNOFF.
- + FLOODS FROM LOCAL SUMMER STORMS.
- • FLOOD TYPE UNDETERMINED.
- ⊞ ALDER CREEK AT MOUTH-LOCAL STORM.
- ◬ BEAR CREEK AT MOUTH-LOCAL STORM.
- ◉ SALT RIVER AT GRANITE REEF DAM – GENERAL STORM.
- ● STANDARD PROJECT FLOOD.
- ▲ MAXIMUM PROBABLE FLOOD.

GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

ENVELOPING CURVES OF PEAK DISCHARGES

STREAMS IN ARIZONA AND NEW MEXICO

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

APPENDIX 2 - BASES FOR DESIGN

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ. AND N. MEX.

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3.	St. Clair Reservoir, spillway and outlet rating curve
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B A S E S F O R D E S I G N

SANTA ROSA WASH, ARIZONA
GILA RIVER BASIN, ARIZ. AND N. MEX.

SCOPE

1. This appendix was prepared to describe the engineering design aspects of Tat Momolikot Dam and Lake St. Clair (referred to in this appendix as "St. Clair Reservoir"). The location and details of the dam and reservoir considered are shown on plate 1.

2. A brief engineering description is also included of the considered irrigation project. Details of this project are contained in a feasibility report of March 1963, prepared by the U.S. Bureau of Indian Affairs, Phoenix, Ariz., entitled "Vaiva Vo Irrigation Project, Papago Indian Reservation, Arizona." The location and general plan are shown on plate 4 of the main report.

IMPROVEMENTS CONSIDERED

3. Improvements considered in detail included multiple-purpose reservoirs of various capacities at three sites on Santa Rosa Wash, as follows: the Tat Momolikot site about 6 miles upstream from the village of Vaiva Vo, and two sites about 2 and 2.8 miles, respectively, downstream from the Tat Momolikot site. Consideration was also given to several nearby sites that had been considered by the U.S. Soil Conservation Service and the U.S. Bureau of Indian Affairs.

4. Investigations showed that lack of a suitable detached spillway site would preclude economically feasible construction of a multiple-purpose reservoir at any of the considered reservoir sites, excepting the Tat Momolikot site. Investigations also showed that a rectangular notch through the spillway would be more economical than an outlet through the dam embankment for discharge of the flood-control pool below spillway-crest elevation.

RECOMMENDED PLAN

5. General.--The recommended Tat Momolikot Dam and St. Clair Reservoir project would be located on Santa Rosa Wash (river mile 43.4) about 20 miles southwest of Casa Grande and about 6½ miles upstream from the town of Vaiva Vo. The proposed damsite coincides with the Jack Rabbit damsite considered by the U.S. Bureau of Indian Affairs. The recommended Vaiva Vo irrigation project would be located along the left bank of Santa Rosa Wash, extending for about 6 miles from the dam

to about ½ mile north of the town of Vaiva Vo, Ariz. The entire recommended plan (including the dam and irrigation project) is in the Papago Indian Reservation.

6. The recommended plan would provide for a multiple-purpose dam, an ungated outlet notch through the spillway, and a gated conservation outlet that may also be used as a drain through the embankment. Included in the plan are provisions to raise the highway, to protect the Indian burial grounds, and to construct two dikes across low saddles in the upper reaches of the reservoir. The Indian village, Tat Momolikot, would be vacated because the area would be subject to inundation.

7. The recommended plan would also provide for (a) development of 1,640 acres of cultivated land on the Papago Indian Reservation, (b) a main supply canal, which will receive water from the dam and will deliver water to laterals located in the area that is proposed for irrigation development, (c) ponds located at the upper end of the main canal to increase the ground-water recharge (these ponds would also be used as fish ponds), (d) thirteen wells and pumps located along the main canal, and laterals which would be used to develop the ground-water supplies and supplement low flows from the reservoir, and (e) development of fish, wildlife, and recreational facilities.

8. Tat Momolikot Dam - topography and geology.--The Tat Momolikot damsite is in the Santa Rosa Valley, which extends northward from the highlands north of Sells, Ariz., to the wide alluvial plain of the Santa Cruz River south of Maricopa, Ariz. Santa Rosa, Kohatk, and Jack Rabbit Washes, which flow into the St. Clair Reservoir site, are the main tributaries of the Santa Rosa Wash drainage basin upstream of the damsite, comprising an area of 1,744 square miles. The Jack Rabbit Wash enters the Santa Rosa Valley through a gap in the Tat Momoli Mountains. Santa Rosa and Jack Rabbit Valleys, which vary in widths from 10 to 15 miles and extend southward from the damsite approximately 40 miles, are bounded on the south by the Comobabi Mountains.

9. The Tat Momolikot Dam would abut against the south end of the Tat Momoli Mountains and extend due west about 3 miles across the Santa Rosa Wash at elevation 1,566 feet mean sea level. The right abutment of the dam would consist of a hard conglomerate of unknown thickness overlying hard limestone strata. The embankment foundation across the wash would be Recent alluvium. The gated conservation and drain outlet works, which would be a conduit through the dam, would likewise be founded on Recent alluvium. The spillway would be in a saddle of the right abutment and downstream of the axis of the dam. The spillway would be in hard limestone and in a mantle of hard caliche and conglomerate of unknown thickness. The ground-water table in the Santa Rosa Valley near the site is believed to be about 125 feet below the ground surface.

10. Foundation explorations.--Explorations in the vicinity include

seven test holes drilled along the axis and four wells drilled about 1 mile north of the left half of the embankment. The test holes were drilled in November 1958, and information on the test holes is presented in a report dated January 1959, prepared at the request of local interests, by John A. Carollo, Consulting Engineer, subject: "Feasibility Report of the Santa Rosa Flood Control Dam, Pinal County, Arizona." The holes were drilled to refusal, using a post-hole auger and a digging bar with a chisel bit; the maximum depth penetrated was about 8 feet. Disturbed samples were obtained from the test holes for laboratory tests which included mechanical analyses and Atterberg limit tests. The samples were classified by the revised Public Roads System. The wells have depths ranging from 350 to 700 feet, and were drilled in 1955 and 1956. The wells are completely cased and the casings range in diameter from 4 to 10 inches.

11. Foundation conditions.--The embankment at the right abutment would be founded on hard conglomerate of unknown thickness overlying hard limestone strata. The rest of the embankment and the conservation outlet would be founded on Recent alluvium. The surface of the Recent alluvium is soft silty clay. Underlying the surface materials at depths ranging from 1 to 4 feet is a 2- or 3-foot layer of hard caliche composed of sandy clay impregnated with lime deposits. Underlying the caliche is stiff clay and stiff sandy clay that extends to a depth of about 125 feet. The drillers' logs of the wells indicate that the sandy clay may contain isolated lenses of sand and gravel. Below a depth of 125 feet, the drillers' logs indicated alternate layers of sand and gravel and sandy clay. Ground water is at a depth of about 125 feet. The foundation for the spillway would be hard limestone overlain by a mantle of hard caliche and conglomerate of unknown thickness.

12. Embankment design.--The embankment would be about 16,500 feet long with a maximum height of 66 feet above streambed at centerline with a crest width of about 20 feet. Crest elevation would be 1,566 feet mean sea level. The embankment would be a homogeneous, compacted, earthfill structure with side slopes of 1 vertical on 2-1/2 horizontal. The location and sections of the embankment are shown on plate. 1. An exploratory trench would be provided along the axis of the dam; the trench would have a depth of 10 feet, a bottom width of 12 feet, and side slopes of 1 on 2. The embankment would be constructed of pit-run materials obtained from borrow areas adjacent to the embankment. Prior to placement of fill, the loose and soft topsoil overlying the caliche would be removed. The fill material would be moistened, placed in horizontal loose lifts, and compacted with sheep's-foot or rubber-tired rollers. Backfill around the conservation outlet conduit would be compacted to at least 95 percent of maximum density to prevent seepage along the conduit.

13. Stability of the embankment and foundation would not be a major problem in the design. Most settlement would occur during construction. As a result of the conservation pool (elevation 1,526 feet),

a steady seepage condition would be established through the lower part of the embankment. To prevent the seepage line from intersecting the downstream slope, an inclined and horizontal sand drain would be incorporated in the downstream part of the embankment. Owing to the low permeability of the embankment and foundation, the amount of seepage would be very small. Penetration of the seepage line into the embankment above elevation 1,526 feet would be very limited due to the short duration of the floods and to low permeability of the embankment. Underseepage would not be a problem, owing to the low permeability of the foundation.

14. Slope protection.--Slope protection would consist of a layer of quarrystone underlain by a quarry spalls filter. On the upstream slope, the stone layer would be 18 inches thick; and on the downstream side, the stone layer would be 12 inches thick. The filter layer would be 6 inches in thickness.

15. Selection of spillway.--Based on the reservoir-design-flood routing, the spillway crest elevation of 1,547 was selected. Three spillway sites were considered before the final selection was made. Economic studies were made for various lengths of an ogee-type spillway and a broad-crested, weir-type spillway. Results from the economic studies dictated selection of a 1,000-foot, broad-crested spillway.

16. Spillway.--The broad-crested spillway would be located in a saddle 2,000 feet northeast of the right abutment. The crest elevation was computed at 1,547 and a crest length of 1,000 feet. The spillway would be a reinforced concrete slab structure, partially on compacted earthfill. This concrete slab would have a level crest 10 feet wide and side slopes of 1 vertical on 2.25 horizontal. Excavated approaches to the concrete slab would have slopes of .002 on the upstream side and .005 on the downstream. Details of the spillway are shown on plate 1.

17. Saddle dikes.--Two saddle dikes would be constructed. Each dike would have a crest elevation of 1,566, a crest width of 20 feet, and a maximum height of about 17 feet. The crest lengths would be 2,800 feet and 3,600 feet. The structural design would be similar to that of the embankment of the main dam.

18. Hydraulic design.--The hydraulic design for Tat Momolikot Dam is based on the requirements of providing storage for water conservation, retention of debris carried into the reservoir from the drainage area, regulation of the reservoir-design-flood peak inflow of 55,000 cubic feet per second to a maximum outflow of 4,600 cubic feet per second, and the effective passing of the spillway design flood with a peak inflow of 270,000 cubic feet per second without endangering the dam.

19. Reservoir area and capacity.--The area curve was determined from U.S. Geological Survey quadrangle sheets, Army Map Service sheets, and the use of the U.S. Bureau of Indian Affairs' area-capacity curves for a proposed dam at the same location. The gross-capacity curve was

derived by computing increments of volume for intervals of 5 feet in elevation, using the average-end-area method. At the spillway crest, elevation 1,547, the reservoir will have an area of 12,000 acres and a natural gross capacity of 181,000 acre-feet. The reservoir volume to be allocated as sediment storage was determined by a study of the drainage basin, including the mean annual runoff at the site and by analysis of sediment accumulation rates in existing reservoirs in the southwestern United States. As a result of this study, it was estimated that 40,000 acre-feet of sediment would be deposited in the reservoir during a 100-year period. The sediment was assumed to be distributed in proportion to the reservoir area up to the spillway crest. The reservoir would have a net capacity, at the spillway crest, of 141,000 acre-feet. The reservoir area and gross capacity at the maximum water surface, elevation 1,559.5, would be 17,500 acres and 400,000 acre-feet, respectively. The area-capacity curves are shown on plate 2. The net capacity of 141,000 acre-feet below the spillway crest would be allocated as follows: 15,000 acre-feet, conservation storage; and 126,000 acre-feet, flood-control storage.

20. Outlet works.--

(a) Reservoir flood-control regulation outflow would be accommodated through a 15.2-foot rectangular notch cut through the built-up concrete spillway. The outlet notch would be directed to flow in Santa Rosa Wash approximately a quarter of a mile downstream of the embankment.

(b) An outlet consisting of a gated intake structure and a 51-inch circular conduit through the embankment would serve as a pool drain and conservation outlet. The top of the structure would be at the same elevation as the spillway crest. Conservation water would be released by the U.S. Bureau of Indian Affairs and used for irrigation, fish ponds, or ground-water recharge.

21. Reservoir-design-flood routing.--The reservoir-design-flood routings were based on the net reservoir capacity curve (see plate 2), free outflow through the 15.2-foot rectangular notch (see plate 3 for spillway and outlet rating curve), and the following assumptions: (a) reservoir filled to the top of the conservation pool, (b) elevation 1,526, and (c) a free discharge through the notch. These routings were made by the semigraphical method based on the equation: Change in storage is equal to the inflow minus outflow for a routing interval of 1 hour. The standard-project-flood peak inflow of 55,000 cubic feet per second would be controlled to an outflow of 4,600 cubic feet per second, and the maximum reservoir water surface would be elevation 1,547. At this elevation the reservoir water surface would have an area of 12,000 acres, and would effectively control a flood of 145,000 acre-feet. The spillway crest was set at this elevation (1,547). The time inflow-outflow and water surface relationships are shown on plate 4.

22. Spillway-design-flood routing.--The spillway-design-flood

routing was based on the reservoir net-capacity curve, plate 2; the spillway and outlet rating curve, plate 3; and on the same method used for the reservoir design flood. Again, the water surface was assumed to be at the maximum conservation pool and a precedent storm was routed, bringing the water surface to elevation 1,547 at the beginning of the maximum probable flood. The maximum probable flood peak inflow of 270,000 cubic feet per second would be reduced to an outflow peak of 142,000 cubic feet per second with a resulting maximum water surface of 1,559.5. Spillway flows would re-enter Santa Rosa Wash about 1,500 feet downstream of the dam embankment. The time-inflow-outflow reservoir water surface relationships for the spillway design routing are shown on plate 5.

23. Freeboard allowance.--In estimating the freeboard allowance between the maximum water surface and the top of the dam, consideration was given to possible wind setup, wave height, and ride-up while the water surface was at the maximum elevation of 1,559.5. The maximum fetch normal to the axis of the dam would be about 4.8 miles. With an assumed wind velocity of 60 miles per hour, the wind setup plus wave height and ride-up would be 5.9 feet; the top of the dam was set at 1,566.

24. Utilities.--The only known utilities that exist in the project area are gas and water pipelines. The gas line would be encased in concrete and pass under the embankment above the conservation pool elevation. The water line is in the reservoir area and would be inundated at infrequent intervals. No relocation of the water line is necessary.

25. Road relocation.--The highway between Casa Grande and Sells, Ariz., would be raised to a minimum elevation of 1,538.5, which is the computed water surface for floods with a probability of once in 50 years. Six 10- by 8-foot rectangular concrete culverts would be installed and approximately 2.3 miles of road would be raised to a maximum height of 13 feet.

26. Service road.--A graded road would be provided from the state highway to the main embankment. The road would be 2 miles in length and surfaced with gravel. Minimum elevation of the road would be 1,547, except at the junction with the highway. The road would cross the spillway on the crest and over the outlet notch on a bridge slab, thence across the top of the dam to the left abutment.

27. Water-conservation release.--Water from the conservation-storage pool would be released by gates through the outlet drain. The intake for the outlet drain would be a tower structure with gates installed at vertical intervals to secure the best water available within the conservation pool.

28. Indian burial grounds.--Indian burial grounds, located within

the reservoir, would be protected from inundation by an encircling dike. This dike would have a crest elevation of 1,548, a crest width of 12 feet, and a maximum height of 12 feet. To reduce the erosion effects of wind and rain on the slopes, a 6-inch blanket of gravelly sand would be provided. For location, see plate 1.

29. Tat Momolikot Village.--The village of Tat Momolikot* would be inundated by the reservoir design flood. The proposed plan of improvement includes provision for procuring all the buildings in the village, the water well and appurtenances, and vacating the area.

30. Diversion and care of water during construction.--During construction of the earth embankment, a section in the existing river channel would be left open for riverflows. The outlet notch in the spillway and the combination conservation outlet and drain under the embankment would be constructed before the embankment closure across the river channel is made. Closure of the embankment would be made during the dry period. Any riverflows would be diverted to the outlet drain.

31. Sources of construction materials.--Ample quantities of construction material would be available in the area and from nearby commercial plants. Quarrystone may be obtained from spillway excavation and from quarry sites on the right abutment. Portland cement may be obtained from Rillito, Ariz., about 70 miles from the project site. Aggregates for concrete would be available from sources previously approved for other projects. These sources include rock processing plants that are in the Salt River Valley, about 50 miles from the site.

32. Rights-of-way.--The reservoir and dam would be entirely within the Papago Indian Reservation. Permanent rights-of-way on the nonmineral land would be required for the area of the dam, spillway, and reservoir pool to elevation 1,535 feet. The reservoir pool would provide storage capacity for conservation water and sediment. Permanent rights-of-way would include the right to construct, operate, and maintain the structure and would prohibit human habitation. From elevation 1,535 feet to the spillway crest at elevation 1,547 feet, a restrictive easement with the right to flood and to prohibit human habitation would be required. Adjustments would be made for mineral rights in the reservoir area.

33. Pertinent design data on the Tat Momolikot Dam and St. Clair Reservoir are shown in the following tabulation:

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* Also known as Tat Momoli.

Pertinent data, Tat Momolikot Dam and St. Clair Reservoir

Drainage area	square miles	1,750
Standard project flood:		
Peak inflow	c.f.s.	55,000
Volume (5 days)	acre feet	145,000
Peak outflow	c.f.s.	4,600
Maximum probable flood:		
Peak inflow	c.f.s.	270,000
Volume (5 days)	acre feet	484,500
Peak outflow	c.f.s.	142,000
Storage allocations:		
Flood control	acre feet	126,000
Water conservation	acre feet	15,000
Area (at top of conservation pool)	acres	3,400
Sediment (100 years)	acre feet	40,000
Maximum water surface:		
Elevation	feet msl	1,559.5
Area	acres	17,500
Capacity (gross)	acre feet	400,000
Spillway (at elevation of broad crest weir):		
Elevation	feet msl	1,547
Area	acres	12,000
Capacity (gross)	acre feet	181,000
Reservoir length (water surface at spillway crest)	miles	3.5
Dam (earthfill):		
Crest length	feet	16,200
Crest elevation	feet msl	1,566
Streambed elevation	feet	1,500
Maximum height above streambed	feet	66
Freeboard	feet	6.5
Dikes (earthfill) (2):		
Crest length	feet	2,800 and 3,600
Maximum height above ground surface	feet	17
Spillway (detached, ungated, broad crest):		
Crest elevation	feet msl	1,547
Crest length	feet	1,000
Surcharge above crest spillway design flood	feet	12.5

Outlet (ungated, rectangular concrete notch):		
Crest length	feet	15.2
Crest invert elevation	feet msl	1,526
Height invert to spillway crest	feet	21
Maximum discharge (w.s. el. 1,547)	c.f.s.	4,600
Water conservation and drain outlet:		
Entrance elevation (invert)	feet msl	1,504
Conduit diameter	feet	4.25
Conduit length	feet	320
Discharge (w.s. el. 1,526)	c.f.s.	100

34. Vaiva Vo irrigation project - plan.--The Vaiva Vo irrigation project (as shown on plate 4 of the main report) will provide facilities for (a) use of stored reservoir waters for irrigation of farmlands; (b) wells drilled along the main canal and laterals, leading from St. Clair Reservoir, to provide a water supply when reservoir waters are not available; (c) ponds excavated downstream from the dam, forming approximately 50 acres of small lakes which will be available to assist ground-water recharge and for fisheries; and (d) recreation at the reservoir area. Information contained in the following paragraphs was taken from the U.S. Bureau of Indian Affairs' feasibility report of March 1963, entitled "Vaiva Vo Irrigation Project, Papago Indian Reservation, Arizona."

35. Land development.--The Vaiva Vo irrigation project lands, located on the gentle slope on the west side of the Santa Rosa Valley, extend northward approximately 6-1/2 miles from the Tat Momolikot damsite to a point approximately 1/2 mile north of the village of Vaiva Vo. The lands are utilized at the present time for year-round grazing by the Papago Indians, except for about 200 acres near the village of Vaiva Vo, which are used for irrigation farming when floodflows along Santa Rosa Wash are available. Land classification studies prepared by the U.S. Bureau of Indian Affairs in the irrigable area indicate that 1,274 acres would be class 1, 301 acres would be class 2, and 65 acres would be class 3, totaling 1,640 acres. Surface runoff from the land adjoining the project on the west will be intercepted by diversion channels constructed to direct the runoff water to selected wasteways.

36. Irrigation wells and distribution system.--The main supply canal would receive irrigation water at the downstream toe of the dam from the gated outlet conduit. The canal would have a capacity of 60 cubic feet per second and would be approximately 6 miles long. It would supply water to the combination ground-water recharge and fish ponds in addition to the project irrigation demand. Seven turnout structures will supply water to the laterals located at 1/2-mile intervals along the east side of the canal.

37. Thirteen wells will be installed along the main canal and laterals. During periods of low flow from the reservoir, they would discharge pumped water directly in the canals or laterals. One of the wells would be used for supplying the fishponds during periods when the reservoir is empty. The wells, with an average pumping capacity of about 1,000 gallons per minute each at 50-foot drawdown, would be drilled to about the 500-foot level, which is about 375 feet below the present ground-water table.

38. The laterals would be spaced at 1/2-mile intervals on the east side of the main canal. The laterals will be concrete pipe conduits, 21, 24, and 27 inches in diameter. Checks will be installed at 330-foot intervals to control the static head in the preceding 330-foot section of conduit. At 66-foot intervals, risers will be provided to distribute irrigation water to individual field border strips. Approximately 1-3/4 miles of open concrete-lined ditch lateral would be constructed to deliver water to the existing ditch, which supplies water to about 200 acres of the old lands of the project.

39. Project drainage would be accomplished by natural internal drainage and by surface-drainage ditches located at the lower ends of the field borders.

40. Ground-water-recharge ponds.--Several unlined, irregularly shaped ponds would be constructed from anticipated embankment borrow pits, downstream from the dam, to assist in recharging the underground water supply and provide for fisheries.

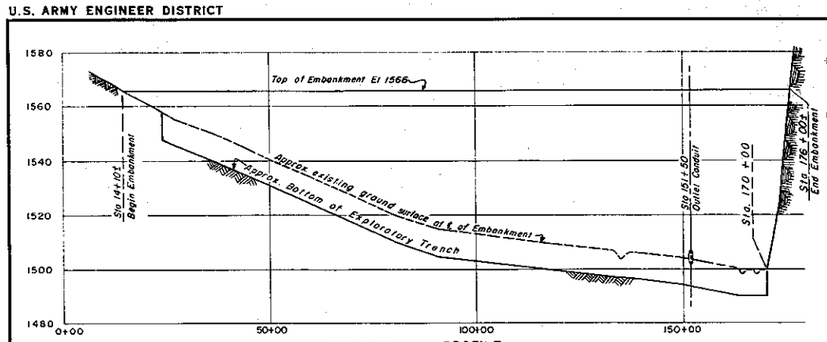
41. Fish and wildlife facilities.--The fishponds would be about 15 feet in depth and about 1/2 mile long each. A total of about 50 surface acres would be maintained for fish and wildlife purposes. Facilities would be made available for picnickers and campers.

42. Recreation facilities.--Facilities would be provided for (a) boating and water skiing in the reservoir area and (b) picnickers and campers in the area of the fishponds.

43. Pertinent design data for the Vaiva Vo irrigation project and the fish and wild life facilities are shown in the following tabulation:

Pertinent data, Vaiva Vo irrigation project

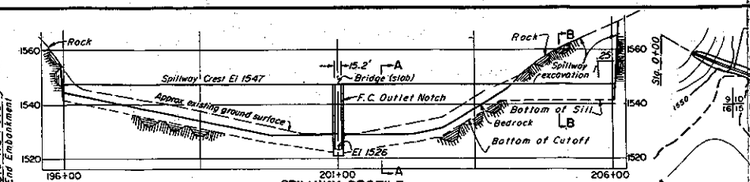
	Net irrigable area served	Length in miles	Initial capacity
Canals			
Main supply canal	1,640 acres	5.4	60 c.f.s.
Laterals (canals)	240 acres	1.5	10 c.f.s.
Laterals (pipe)	1,400 acres	5.3	5-20 c.f.s.
Deep wells and pumps			
Number and depth of wells	13 @ 400-600 ft.		
Capacity	1,000 gal. per min., average		
Dynamic head	175-225 ft.		
Land to be irrigated	1,640 acres		
Ground-water recharge and fishing ponds			
Area	50 acres		
Depth	15 ft.		



EMBANKMENT PROFILE

HORIZ. SCALE 1000 0 1000 2000 3000 FEET

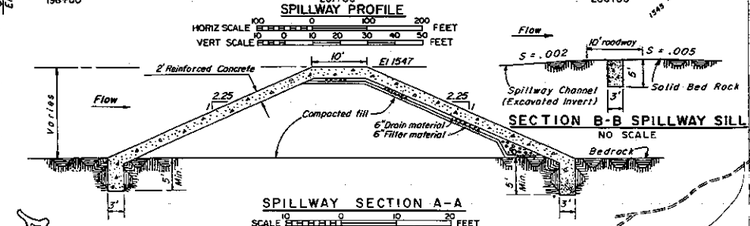
VERT SCALE 10 0 10 20 30 40 50 FEET



SPILLWAY PROFILE

HORIZ SCALE 100 0 100 200 FEET

VERT SCALE 10 0 10 20 30 40 50 FEET



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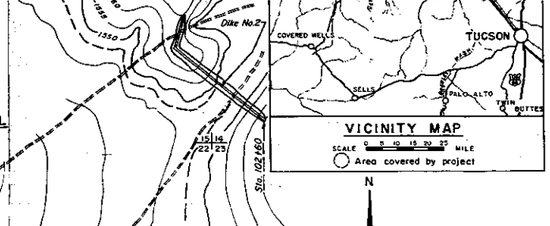

SECTION B-B SPILLWAY SILL

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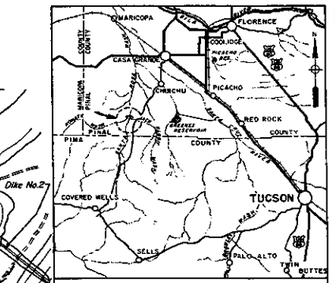

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Area covered by project

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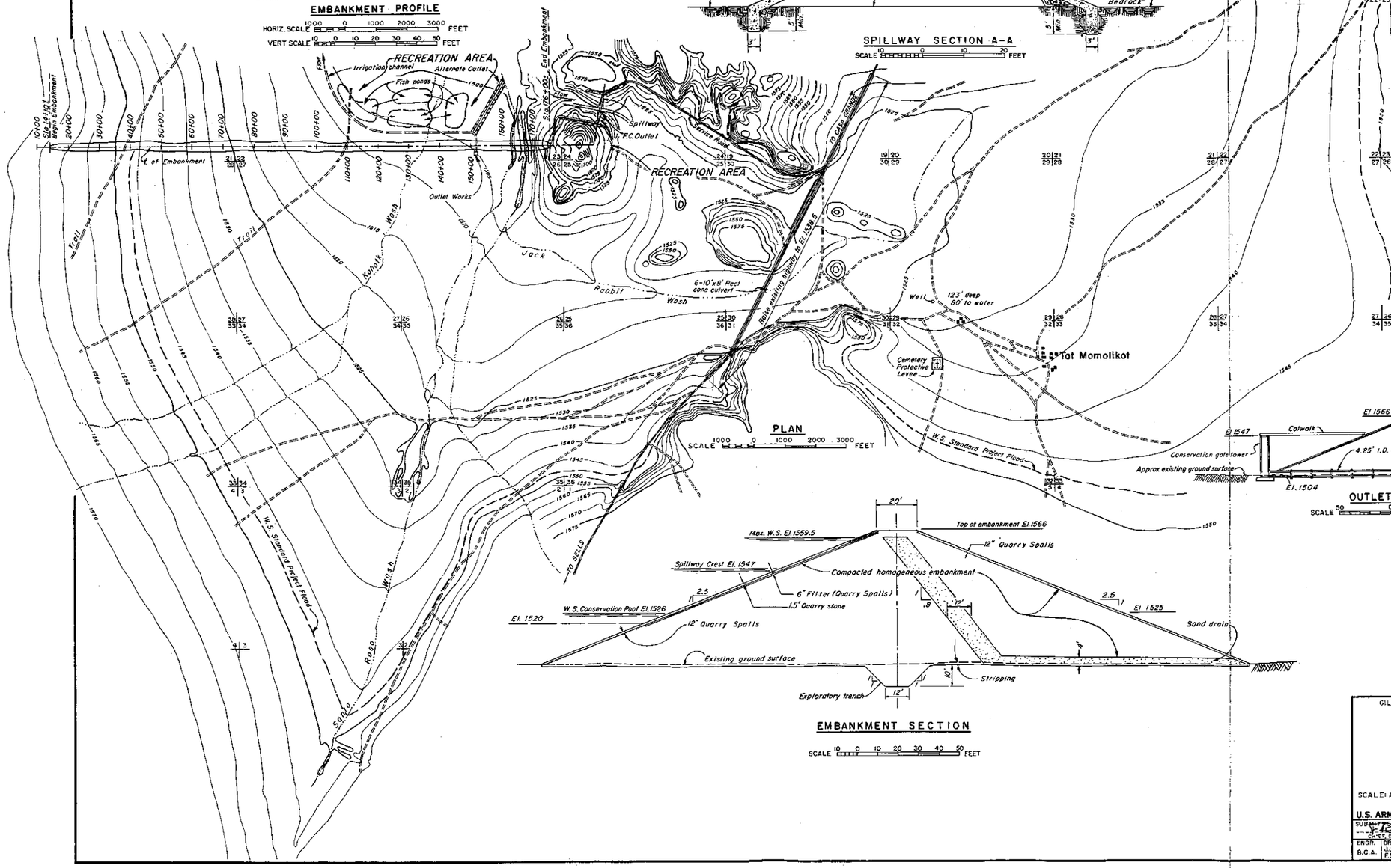

PLAN

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EMBANKMENT SECTION

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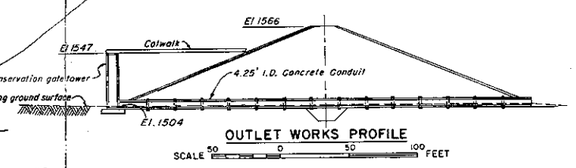


OUTLET WORKS PROFILE

SCALE 50 0 50 100 FEET

REFERENCE:

CONTOURS ON 25 FEET INTERVAL FROM U.S.G.S. QUADRANGLES SILVER REEF MOUNTAINS, ARIZONA, 1942 EDITION. ALL OTHER CONTOURS BY INTERPOLATION

CONTOUR INTERVAL IS 5 FEET AND 25 FEET.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

TAT MOMOLIKOT DAM

PLAN, PROFILE AND SECTIONS

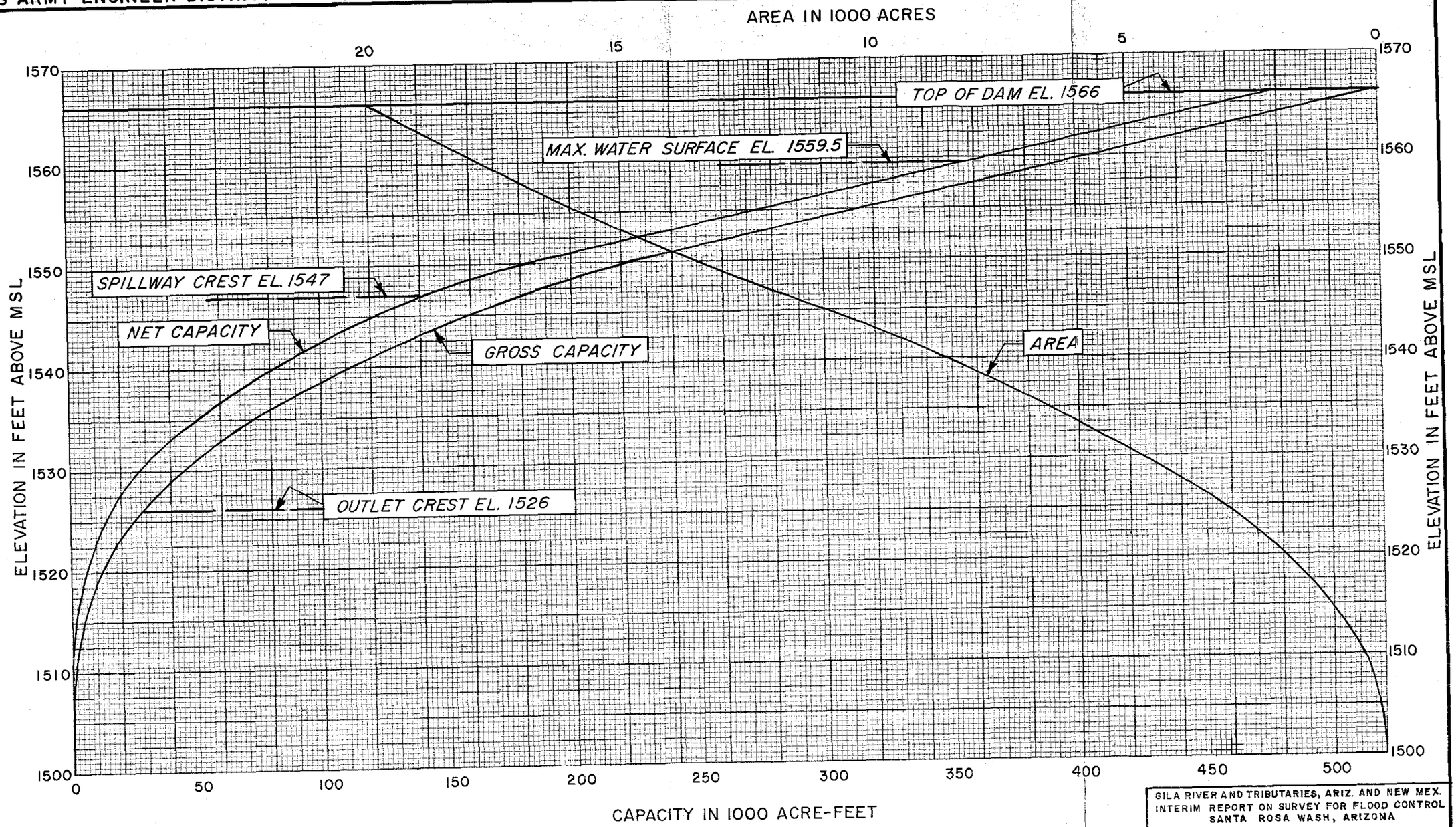
SCALE: AS SHOWN — SHEET 1 OF 1

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF. MAR. 1963

SUBMITTED	RECOMMENDED	APPROVED
CHIEF, DESIGN BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

ENGR.	DRAWN	CHECKED	TO ACCOMPANY REPORT	FILE NO. (D.O. SERIES)
B.C.A.	J.J.D. F.S.S.	A.A.K.	DATED: AUG. 1, 1963	203/67



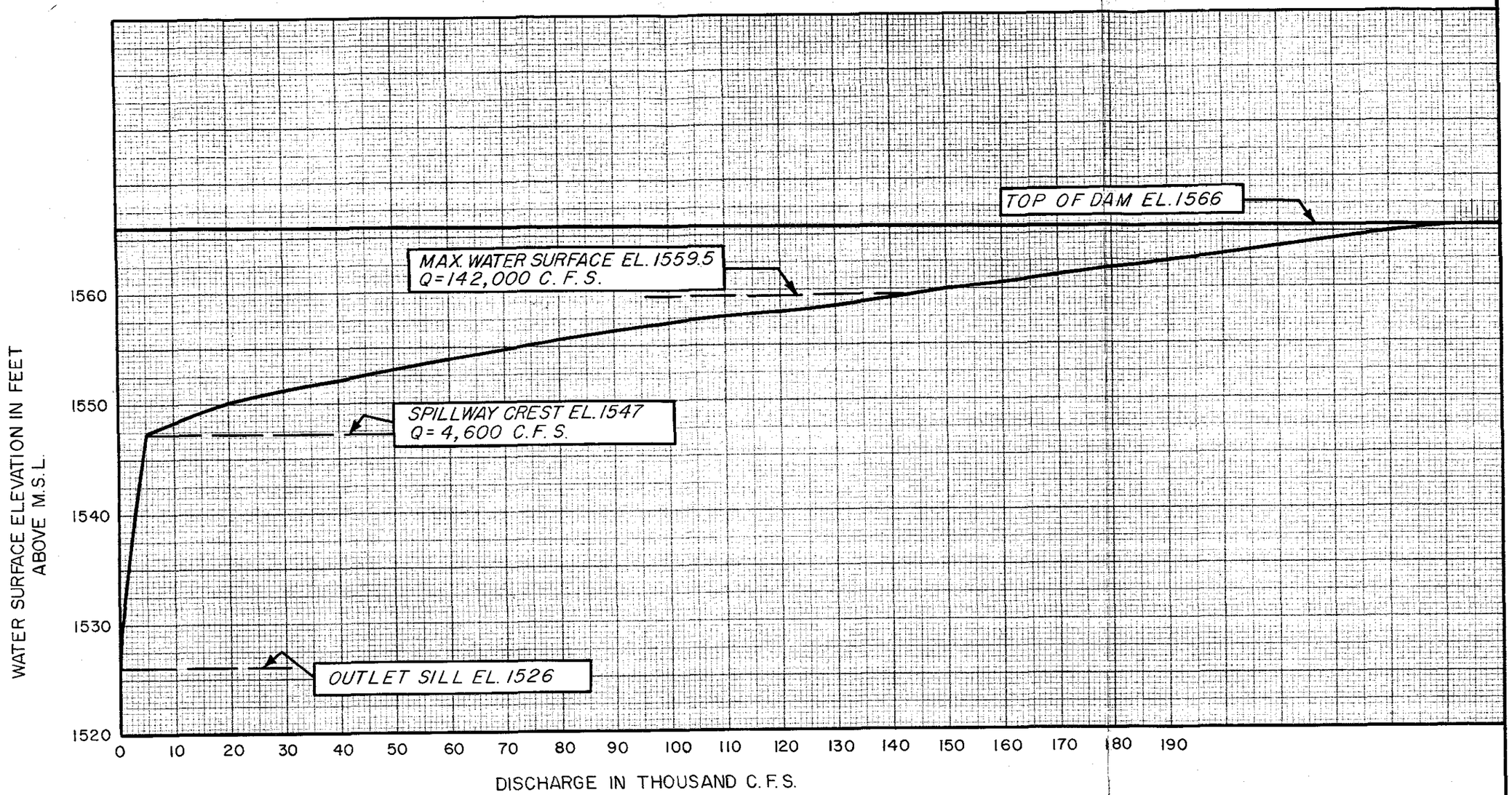
NET CAPACITY CURVE OBTAINED BY DISTRIBUTING 100 YEARS SEDIMENT (40,000 AC.-FT.) TO THE SPILLWAY CREST.

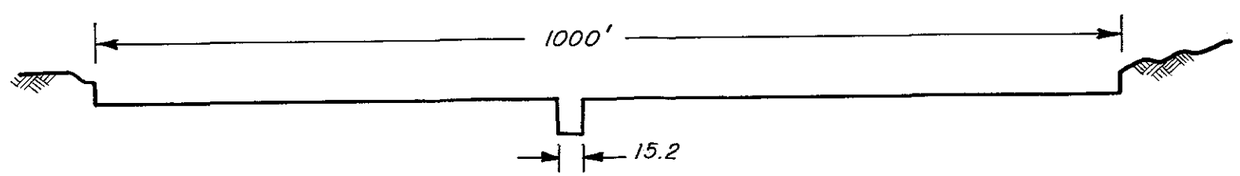
GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

AREA CAPACITY CURVES

ST. CLAIR RESERVOIR

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963





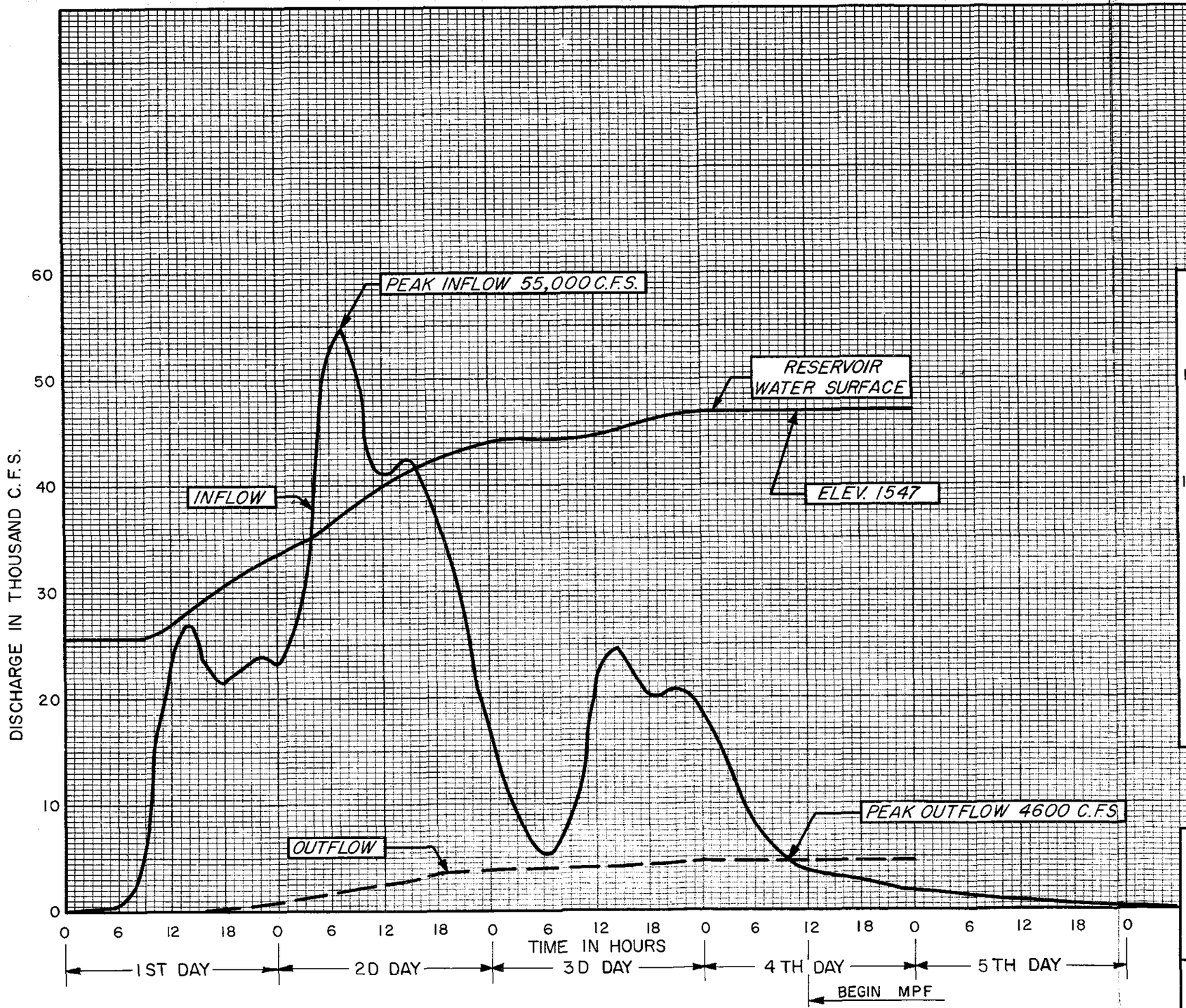
CROSS-SECTION OF SPILLWAY & OUTLET

GILA RIVER AND TRIBUTARIES, ARIZ, AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

SPILLWAY AND OUTLET RATING CURVE

ST. CLAIR RESERVOIR

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

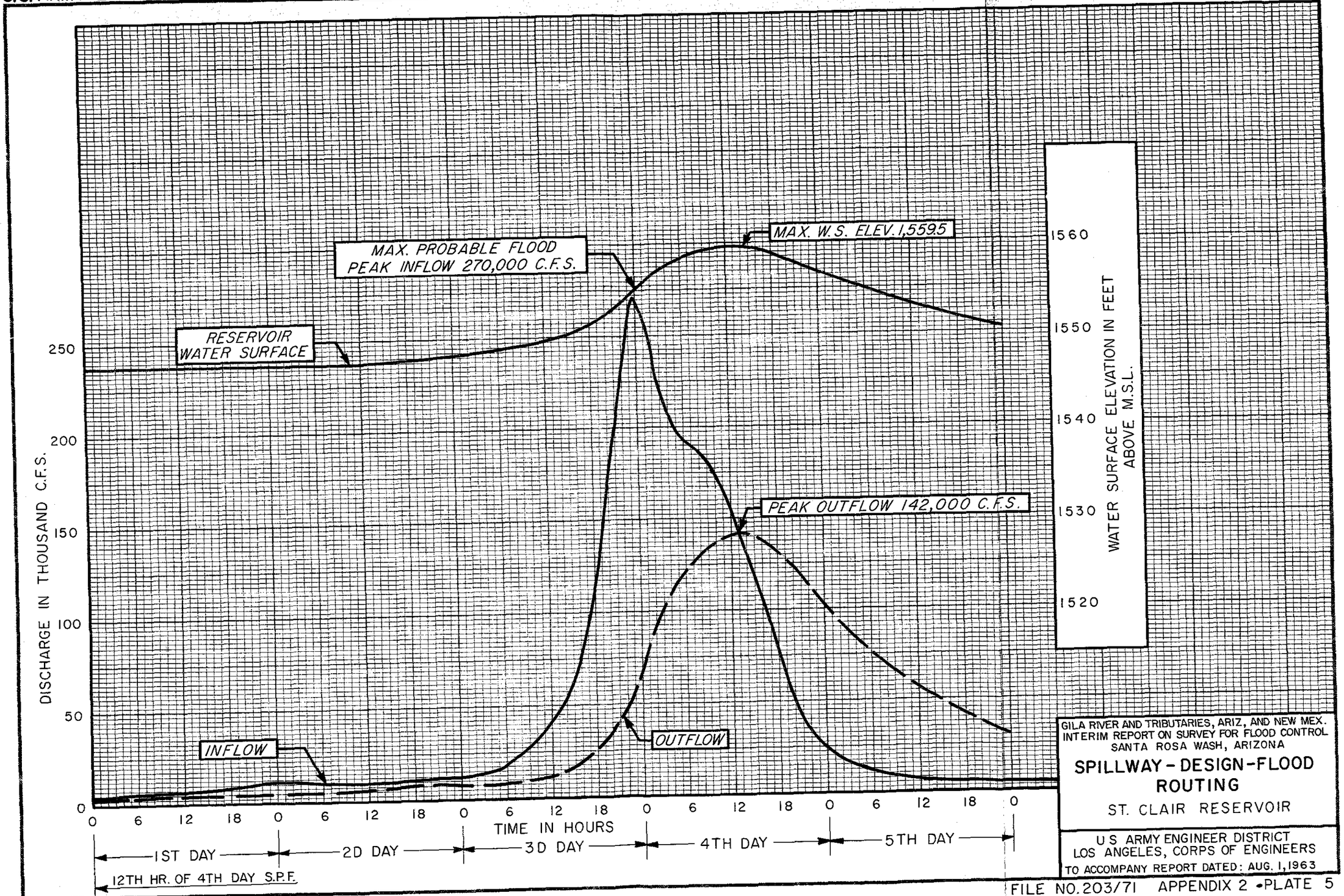


GILA RIVER AND TRIBUTARIES, ARIZ, AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

RESERVOIR-DESIGN-FLOOD ROUTING

ST. CLAIR RESERVOIR

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963



GILA RIVER AND TRIBUTARIES, ARIZ, AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

SPILLWAY-DESIGN-FLOOD ROUTING

ST. CLAIR RESERVOIR

U S ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

APPENDIX 3 - COST ESTIMATES

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ. AND N. MEX.

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COST ESTIMATES

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ. AND N. MEX.

1. Scope.--This appendix presents estimates of construction, annual maintenance and operation costs for the recommended Tat Momolikot Dam and St. Clair Reservoir; and from information received from the Bureau of Indian Affairs, a summary of costs of the Vaiva Vo irrigation project, fish, wildlife, and recreational improvements.

2. Tat Momolikot Dam.--A breakdown of estimated costs based on September 1962 price levels is presented for the construction of component parts of the dam and reservoir including contingencies, engineering, design, supervision and administration; and lands and damages.

(a) Unit prices.--Unit prices were developed from current material and labor costs typical to work of this nature in the vicinity of the project.

(b) Construction period.--Construction of the recommended dam would require about two years.

(c) Maintenance and operation.--Average annual maintenance and operation charges for the recommended dam and reservoir (including recreation and wildlife in the reservoir area) are estimated at $13,000.

(d) Rights-of-way.--An estimate of the value of the rights-of-way was made in August 1962. The mineral rights were evaluated in August 1961. Compensation for habitable buildings and support facilities in the reservoir area would be made to individual owners.

(e) Cost estimate.--The following table presents a detailed cost estimate for the dam and reservoir portion of the recommended plan:

Cost estimate for recommended Tat Momolikot Dam, Santa Rosa Wash, Ariz.

Cost acct. No.	Description	Unit	Estimated quantity	Unit price	Amount: Subtotal	Amount: Total
	FEDERAL COSTS					
01.	Lands and damages:					
	Mineral rights				$23,000	
	Lands, easements, and rights-of-way				276,000	
	Severance				20,000	
	Houses at Tat Momolikot Village				20,000	
	Acquisition costs				11,000	
	Total, land and damages					$350,000
02.	Relocations:					
.1	Roads				212,000	
.3	Utilities				5,000	
	Cemeteries (Protection)				13,000	
	Tat Momolikot well and meeting house				20,000	
	Contingencies				50,000	
	Total, relocations					300,000

Cost estimate for recommended Tat Momolikot Dam, Santa Rosa Wash, Ariz.--Continued

Cost acct. No.	Description	Unit	Estimated quantity	Unit price	Amount: Subtotal	Amount: Total
04.	Dams:					
.1	Dam:					
	Diversion and care of water	Lump sum.			10,000	
	Clearing and grubbing	Lump sum.			6,000	
	Excavation, common	Cu. yd.	260,000	$0.40	104,000	
	Excavation, rock	Cu.yd.	4,800	4.00	19,200	
	Fill embankment	Cu.yd.	3,800,000	0.45	1,710,000	
	Quarry spalls	Cu.yd.	109,200	4.50	491,400	
	Quarry stone	Cu.yd.	79,200	6.00	475,200	
	Sub-drain	Lump sum.			15,000	
	Hydrograph equipment	Lump sum.			4,000	
	Service road	Lump sum.			60,000	
	Contingencies				605,200	
	Subtotal, dam				3,500,000	
.3	Outlet works:					
	Excavation, rock	Cu.yd.	1,000	4.00	4,000	
	Concrete	Cu.yd.	310	30.00	9,300	
	Excavation, common	Cu.yd.	1,000	0.25	250	
	Backfill	Cu.yd.	500	0.80	400	
	Concrete pipe	Lin. ft.	320	33.00	10,560	
	Gates	Lump sum.			5,000	
	Concrete	Cu.yd.	400	60.00	24,000	
	Cement	Bbl.	1,100	5.00	5,500	
	Steel, reinforced	Lb.	90,000	0.17	15,300	
	Service bridge	Lump sum.			10,000	
	Contingencies				15,690	
	Subtotal, outlet works				100,000	

Cost estimate for recommended Tat Momolikot Dam, Santa Rosa Wash, Ariz.--Continued

Cost acct. No.	Description	Unit	Estimated quantity	Unit price	Amount: Subtotal	Amount: Total
04. .5	Auxiliary Dams:					
	Dikes:					
	Clearing and grubbing	Lump sum			$1,500	
	Excavation, common	Cu. yd.	16,000	0.40	6,400	
	Fill, embankment	Cu. yd.	112,000	0.45	50,400	
	Quarry spalls	Cu. yd.	9,200	4.50	41,400	
	Quarry stone	Cu. yd.	9,200	6.00	55,200	
	Contingencies				35,100	
	Subtotal, dikes				190,000	
	Spillway:					
	Excavation, rock	Cu. yd.	22,000	4.00	88,000	
	Fill, embankment	Cu. yd.	4,000	0.45	1,800	
	Concrete	Cu. yd.	3,150	28.00	88,200	
	Cement	Bbl.	4,820	5.00	24,100	
	Steel, reinforced	Lb.	310,000	0.17	52,700	
	Contingencies				55,200	
	Subtotal, spillway				310,000	
	Total, dams					$4,100,000
30.	Engineering and design					350,000
31.	Supervision and administration					260,000
	Total first cost of dam and appurtenances					5,360,000

3. Vaiva Vo irrigation project.--The estimated construction costs of the recommended Vaiva Vo irrigation project, as made by the Bureau of Indian Affairs, are based on September 1962 price levels and include allowances of 20 percent for contingencies and 10 percent for engineering and administration.

(a) Construction period.--According to the Bureau of Indian Affairs, the construction of the Vaiva Vo irrigation project would require about 2 years.

(b) Maintenance and operation.--Average annual maintenance and operation charges for the Vaiva Vo irrigation project (including fish, wildlife, and recreation below Tat Momolikot Dam) are estimated by the Bureau of Indian Affairs at $49,000.

(c) Rights-of-way, etc.--All construction would be on Papago Indian land. However, about $70,000 was included by the Bureau of Indian Affairs in the estimate for land resettlement and rights.

(d) Cost estimates.--The following tabulation presents a summary of the total first cost of the recommended Vaiva Vo irrigation project as estimated by the Bureau of Indian Affairs.

(1)	Wells and pumps (irrigation)	$289,000
(2)	Wells recharge	54,000
(3)	Main supply canal	162,000
(4)	Laterals	257,000
(5)	Land and rights	70,000
(6)	Intercepting dikes (to protect new irrigated land)	10,000
(7)	Land leveling	131,000
(8)	General property	22,000
	Total	$995,000*

*Includes $72,000 for engineering, design, supervision and administration.

4. Fish and wildlife facilities.--The estimated construction costs are based upon September 1962 prices. The following tabulation presents a summary of the total first cost of the recommended fish and wildlife facilities as estimated by the Bureau of Indian Affairs and the Corps of Engineers.

(a)	Well and pump at recharge ponds below the dam	$25,000
(b)	Additional fishing facilities (including wildlife, facilities above and below Tat Momolikot Dam).	10,000
	Total	$35,000*

*Includes $2,000 for engineering, design, supervision and administration.

5. Recreation facilities.--The estimated construction costs, as estimated by the Bureau of Indian Affairs and the Corps of Engineers, and based upon September 1962 prices, are as follows:

(a)	Initial development of recreation facilities below the dam	$25,000
(b)	Initial development of facilities at reservoir area	15,000
	Total	$40,000*

*Includes $3,000 for engineering, design, supervision and administration.

6. Summary.--The following tabulation presents the total cost of the Santa Rosa Wash multipurpose project (recommended plan) including Tat Momolikot dam and appurtenances, the Vaiva Vo irrigation project, fish and wildlife, and recreational facilities.

(a)	Dam and appurtenances	$5,360,000
(b)	Vaiva Vo irrigation project	995,000
(c)	Fish and wildlife facilities	35,000
(d)	Recreation facilities	40,000
	Total	$6,430,000*

*Includes $687,000 for engineering, design, supervision and administration.

APPENDIX 4 - BENEFITS FROM FLOOD CONTROL

SANTA ROSA WASH, ARIZONA
GILA RIVER BASIN, ARIZ. AND N. MEX.

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No.	Title
1.	Discharge-frequency curves
2.	Damage-discharge and damage-frequency curves
3.	Population curves

BENEFITS FROM FLOOD CONTROL

SANTA ROSA WASH, WITH PARTICULAR REFERENCE TO TAT MOMOLIKOT DAM NEAR VAIVA VO, ARIZ.

SCOPE

1. This appendix presents supplemental material on the determination of flood frequencies for Santa Rosa Wash and on the evaluation of flood-control benefits from the construction of the Tat Momolikot Dam and St. Clair Reservoir.

FLOOD FREQUENCIES AND MAGNITUDES

2. Because runoff records for the Santa Rosa Wash watershed are available only since Oct. 1954, the discharge-frequency curve, developed for the Santa Rosa Wash at junction with Greenes Wash in the principal damage area, was based on comparative analyses of discharge-frequency curves developed from annual peak discharges of the Santa Cruz River at Tucson, Ariz., and the San Pedro River at Charleston, Ariz. These basins are similar in area and have generally comparable physiographic and hydrometeorologic characteristics to the Santa Rosa Wash watershed. A study of rainfall records since 1880 was also used to verify the reasonableness of flood frequencies along Santa Rosa Wash. Annual peak discharges for the Santa Cruz River and San Pedro River are given in the following table:

Yearly peak discharges for Santa Cruz River and San Pedro River*

Year	Santa Cruz River at Tucson, Ariz. (drainage area (2,190 sq. miles)	San Pedro River at Charleston, Ariz. (drainage area 1,220 sq. miles)
	Cubic feet per second	Cubic feet per second
1905		***40,000
6		**4,000
7		**6,500
8		**8,000
9		**6,500
1910		**3,000
11		**6,500
12		**8,000
13		**6,500
14	15,000	***65,000

Yearly peak discharges for Santa Cruz River and San Pedro River (continued)

Year	Santa Cruz River at Tucson, Ariz. (drainage area 2,190 sq. miles)	San Pedro River at Charleston, Ariz. (drainage area 1,220 sq. miles)
	Cubic feet per second	Cubic feet per second
1915	4,400	**4,000
16	5,000	7,700
17	7,500	13,000
18	4,900	4,000
19	4,700	25,100
1920	1,950	4,500
21	4,000	19,000
22	2,000	3,720
23	2,050	5,200
24	135	1,900
1925	3,400	11,900
26	11,400	98,000
27	1,950	5,100
28	1,600	3,800
29	10,400	10,400
1930	1,770	9,740
31	9,200	24,500
32	4,200	7,000
33	6,100	9,600
34	6,000	5,000
1935	10,300	8,600
36	5,400	13,000
37	3,280	9,430
38	9,000	7,450
39	8,000	9,370
1940	11,300	31,000
41	2,490	10,800
42	1,670	2,870
43	4,510	8,650
44	6,530	3,430
1945	10,800	7,670
46	4,260	12,000
47	1,690	10,100
48	3,860	7,850
49	3,800	6,720
1950	9,490	6,070
51	5,020	5,730
52	3,820	7,850
53	5,900	8,590
54	9,570	23,600

Yearly peak discharges for Santa Cruz River and San Pedro River (continued)

Year	Santa Cruz River at Tucson, Ariz. (drainage area 2,190 sq. miles)	San Pedro River at Charleston, Ariz. (drainage area 1,220 sq. miles)
	Cubic feet per second	Cubic feet per second
1955	10,900	14,400
56	2,610	6,550
57	3,050	6,000
58	6,350	8,400
59	4,420	7,480
1960	6,140	3,900

* Discharges since 1914 at Tucson and 1916 at Charleston are recorded discharges reported in U.S. Geological Survey Water Supply Papers.

** Estimated peak discharges from rainfall data.

*** 1905 and 1914 discharges at Charleston are estimated from high water marks.

3. Derivation of discharge-frequency curves.--Discharge-curves for the Santa Cruz River and the San Pedro River were plotted on logarithmic probability paper from the preceding tabulated data by using L. R. Beard's table of plotting positions, as indicated in EM 1110-2-1450. The plotting position of the largest flood was determined by the equation $P = 100\ (1-0.5^{1/n})$ and other points were interpolated linearly to 50 percent and are symmetrical about 50 percent. P is the number of times in 100 years that the discharge would be equaled or exceeded, and n is the number of years of record. The curve drawn through the plotted points was checked, where applicable, by the Beard analytical method by computing the sum and difference of the mean and the standard deviation of the logarithms of peak flows and plotting these values at the 15.9 percent and 84.1 percent frequency intervals, respectively. Resultant frequency curves are shown on plate 1.

4. The slope of the curve for Santa Rosa Wash above 10,000 cubic feet per second was judged to lie between the slope of the curves for the Santa Cruz and San Pedro Rivers, but being more similar to that of the Santa Cruz River, which is nearer and more closely related physiographically. The slope of the San Pedro River curve below 10,000 cubic feet per second indicates the effect of more frequent orographic precipitation than would occur over the other two

basins. A rainfall study indicated the probability of 13 floods during the past 62 years equal to or greater than the 1957 flood at Greenes Wash. Based on analyses of estimated frequencies of standard project floods in the same general location, a frequency of 0.5 or once in 200 years was assumed for a standard project flood of 51,000 cubic feet per second at Greenes Wash. The frequency curve for Santa Rosa Wash in the vicinity of the junction of Greenes Wash is shown on plate 1.

PRESENT AND FUTURE DEVELOPMENT OF PROPERTY IN OVERFLOW AREA

5. Two estimates were made for property values in the overflow area along Santa Rosa Wash. The first estimate is based on present (1962) development, and the second on the average future development over the next 100-year period. Estimates of the 1962 values of land and improvements subject to flood damage were made by use of (a) assessed valuations adjusted to market value of the property, (b) valuation data supplied by local interests, and (c) field inspections and appraisals of the present development in the overflow areas. Potential crop losses were based on net crop values in the field at the time of most probable flood occurrences. Average future values were estimated principally by using population, residential, and business trends. For average future agricultural values, a detailed study was made of ground water depletion rates with allowance for supplementary use of Central Arizona project water delivered to the overflow area. The space available for future expansion was considered. The future development studies for this report were based on data and estimates supplied by the Arizona State Highway Planning Survey Department, Valley National Bank, Stanford Research Studies for Pinal County and Casa Grande Valley, and by opinions of private consultants.

6. Population predictions for Arizona, Pinal County, and Casa Grande were correlated and projected on a conservative basis to the year 2060. The population of Stanfield and Maricopa, starting with the 1960 census figures, was projected at a progressively decreasing rate of increase to reflect the slower potential development of the rural economy of the area. A conservative estimate of growth of approximately three times the present population was obtained for a 100-year period. See plate 3 for population curves.

7. Property valuations over the next 100-year period for residential, business, public, utility, and highway properties in urban parts of the overflow area will generally follow the urban population growth. Highway values other than in cities will show a large increase due to construction of new Interstate Highway 8 across the overflow area from east to west, 3 miles

south of Stanfield. An appreciable increase in the value of irrigation works would take place in connection with the Central Arizona project, which would tend to supplement and replace deep-well pumping.

8. The values of average future developments were discounted to present-worth amounts. In order to determine present worth of estimated future values in the overflow area, analysis of business, urban residential, urban utility, and public property was made, using 5-year intervals, on the basis of future developments increasing at the same rate as the estimated population increase. Highways were analyzed, using 10-year intervals, including the assumption that nearly $1 million worth of interstate highway would be constructed in the area by 1970. Railroads and flood-control works were judged to remain at about the present value. The methods established in EM 1120-2-118, appendix II, were used in the development of present-worth factors.

9. The results of these analyses indicate that over the next 100-year period the value of average future development of (a) residential, business, public, and highway properties in the urban area would be about 150 percent of the value of present developments, (b) irrigation facilities would show some increase because the Central Arizona project would increase the value of such facilities, and (c) flood-control works, railroads, and farm values would remain essentially the same as present values. Industrial, residential, road and utility values in rural areas would be only slightly higher than present values.

10. A summary of average future values is given in the main report, included under the paragraph heading "Type and value of property in the overflow area."

DAMAGES FROM FUTURE FLOODS

11. A summary of frequencies, peak discharges, and damages for present and average future conditions in the damage area, both under uncontrolled and controlled conditions, is given in the following table:

Summary of flood frequencies, discharges, and present and average future damages, Santa Rosa Wash overflow area, Ariz.

Number of times in 100 years that flood would be equaled or exceeded	Junction of Santa Rosa Wash and Greenes Wash		Total primary damages		
	Uncontrolled discharge	Discharge with project in operation	Present conditions without project	Average future conditions, 100-year period	
				Without project	Project in operation*
	Cubic feet per second	Cubic feet per second			
0.5	**51,000	20,000	$7,200,000	$8,150,000	$3,200,000
1.0	39,000	15,000	6,200,000	6,950,000	1,900,000
2.0	31,000	11,500	5,250,000	5,900,000	1,000,000
5.0	21,000	7,500	3,150,000	3,450,000	200,000
10.0	15,500	5,400	1,750,000	2,000,000	5,000
25.0	9,000	3,000	420,000	430,000	0
49.0	5,000	1,600	0	0	0

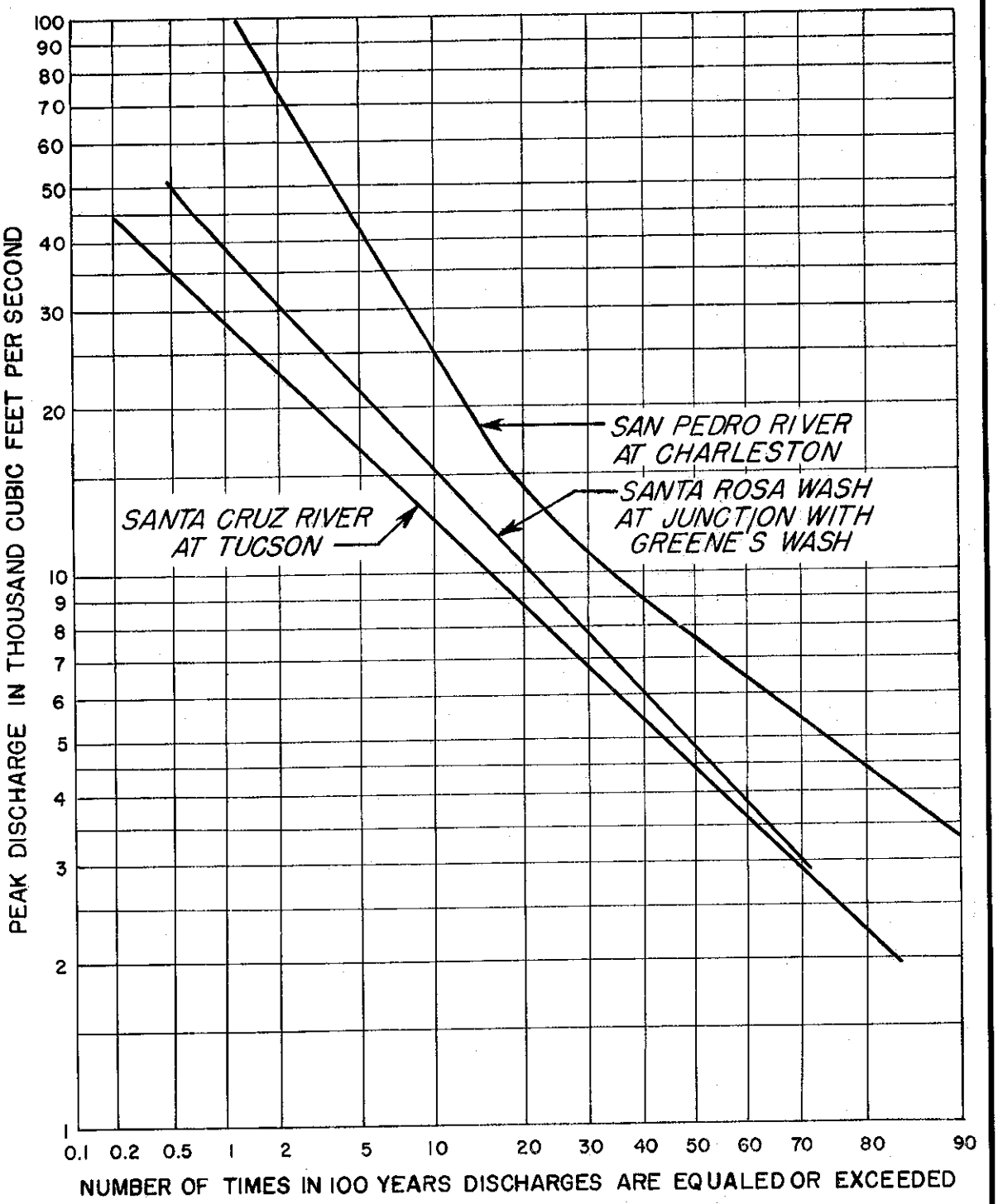
* Nonpreventable damage after completion of the recommended Tat Momolikot dam.

** Standard project flood.

12. Average annual flood damages.--A damage-discharge curve was prepared showing the relationship between peak discharge and damage in dollars to average future property values in the overflow area. See plate 2 for the damage-discharge curve under average future conditions, assuming no control. Values from the curve of average future damages were correlated with discharge-frequency data (plate 1) to obtain a damage-frequency curve (see plate 2 for curve under average future conditions). The area under the damage-frequency curve represents the average annual flood damages for the overflow area under average future conditions. Using the same procedure, a discharge-frequency curve, developed on the basis of the project in operation, was correlated with the damage-discharge curve to produce the non-preventable damage-frequency curve (see plate 2 for curve under average future conditions). The area under this curve represents the average annual damage not prevented by the proposed flood-control project. The following table shows average annual benefits from flood control for present values and 100-year average future values:

Average annual flood damages prevented by Tat Momolikot Dam and Reservoir

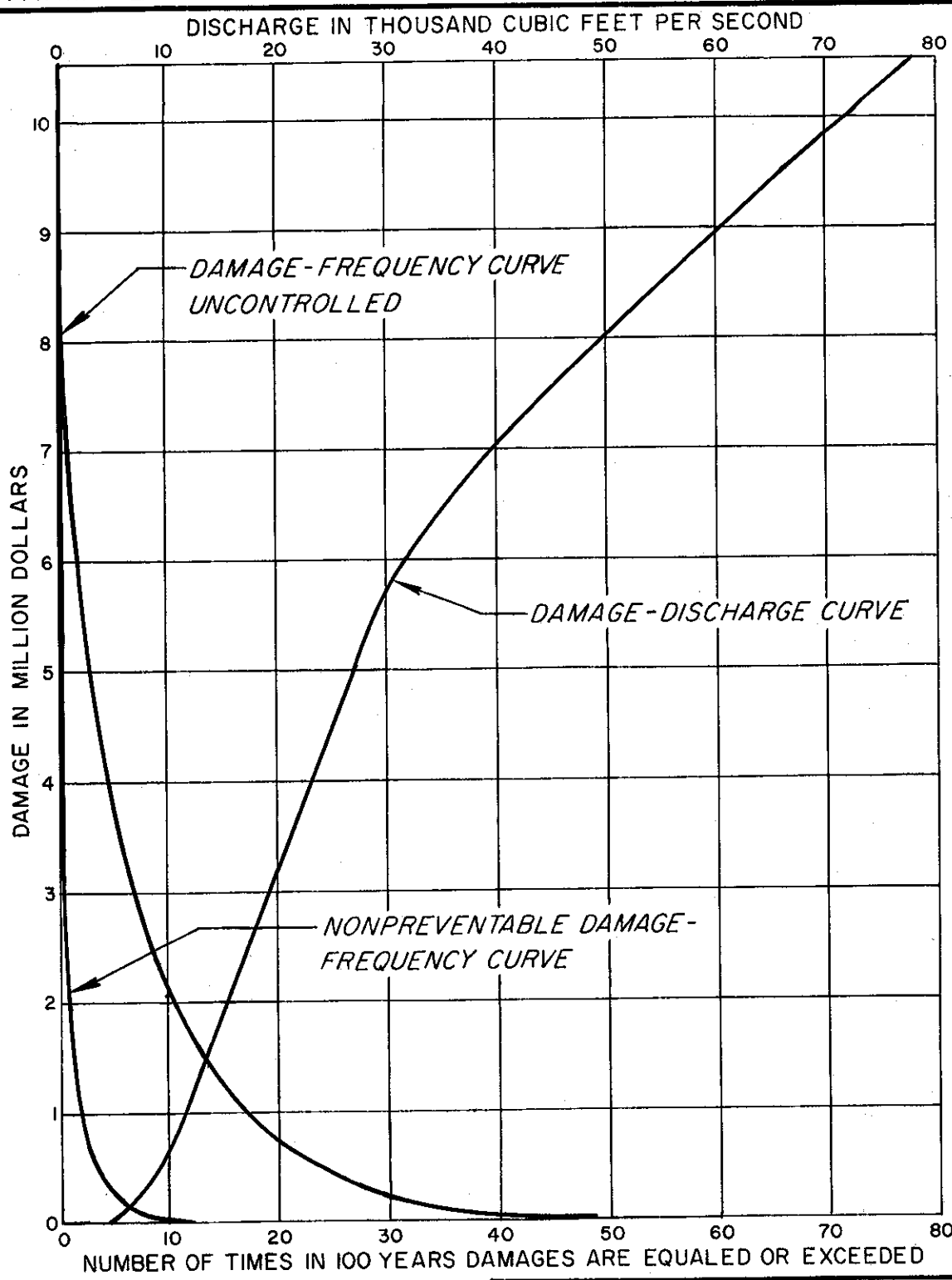
	Present conditions		Average future conditions	
	Without improvement	With improvement	Without improvement	With improvement
Average annual damages...	$550,000	$76,000	$605,000	$78,000
Average annual benefits..	--	474,000	--	527,000



GILA RIVER AND TRIBUTARIES, ARIZ., AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

DISCHARGE-FREQUENCY CURVES

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

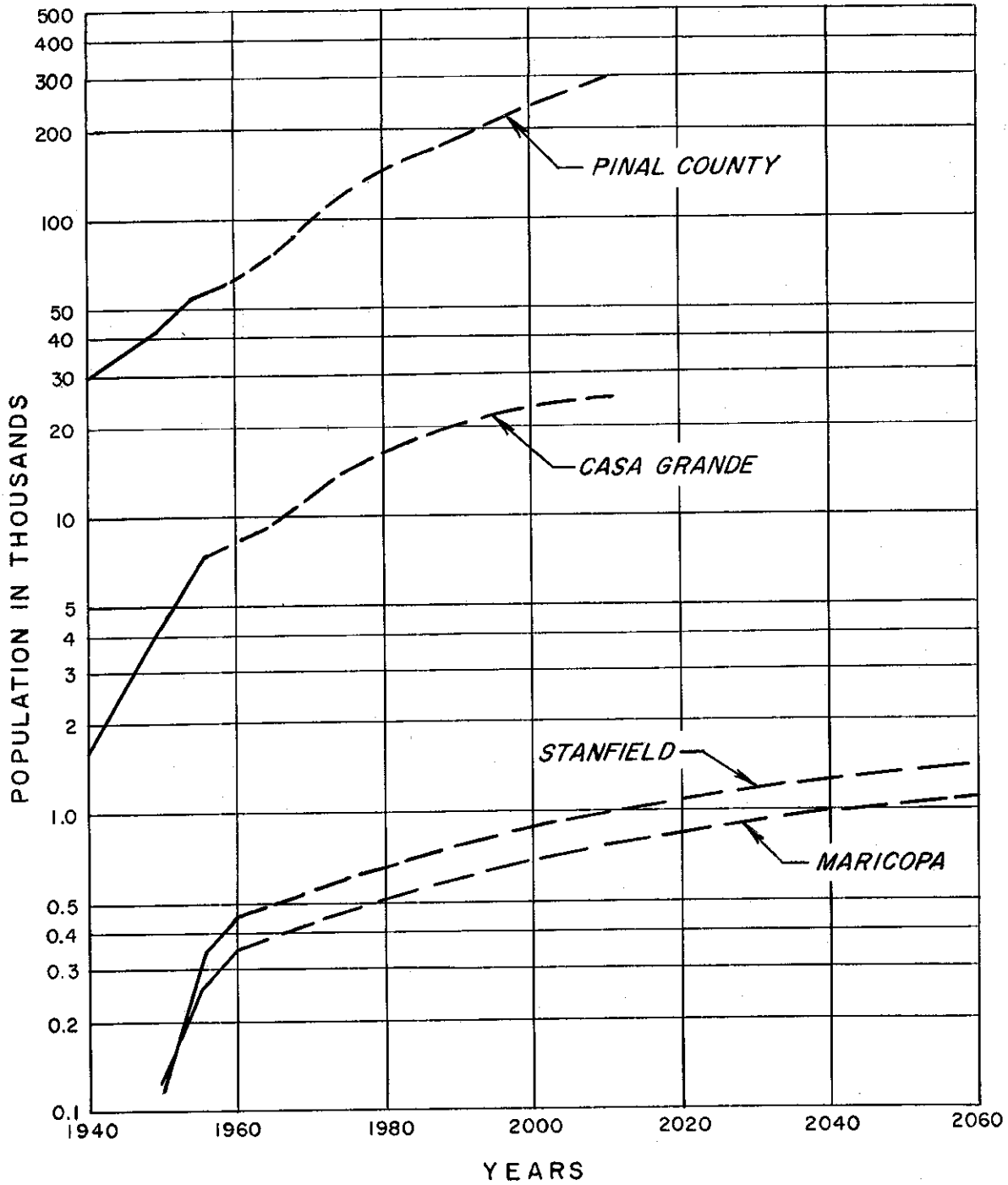


GILA RIVER & TRIBUTARIES, ARIZ., & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

DAMAGE-DISCHARGE AND DAMAGE-FREQUENCY CURVES

SANTA ROSA WASH

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963



LEGEND

—— ACTUAL

– – ESTIMATED

GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
SANTA ROSA WASH, ARIZONA

POPULATION CURVES

1940 - 2060

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: AUG. 1, 1963

APPENDIX 5 - ALLOCATION OF COSTS

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ. AND N. MEX.

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A L L O C A T I O N O F C O S T S

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ. AND N. MEX.

SCOPE

1. This appendix presents detailed information regarding the recommended allocation of the first costs and annual charges for the Santa Rosa Wash, Ariz. multiple-purpose project (recommended plan).

GENERAL

2. Flood-control, water-conservation, fish and wildlife, recreation, and area redevelopment benefits would be provided in the recommended plan. The recommended plan of improvement lies wholly within the Papago Indian Reservation and provides (a) for Tat Momolikot earthfill dam about 3 miles long and about 66 feet high located on Santa Rosa Wash about 6-1/2 miles above the Indian town of Vaiva Vo, Ariz. The reservoir (Lake St. Clair) at spillway crest elevation (1,547 feet) would be about 7-1/2 miles long and extend upstream from the dam about 4 miles, with provisions for recreation along its perimeter; and, (b) under the Vaiva Vo irrigation project, for (1) the development of about 1,640 acres of irrigable land along the left bank (west) of Santa Rosa Wash between Tat Momolikot dam and Vaiva Vo, Ariz., (2) 13 wells scattered throughout the land development area to furnish supplemental irrigation water during periods of low flow from Lake St. Clair, (3) an irrigation distribution system to convey water from the lake and wells to the irrigated land, and (4) several ponds, located adjacent to and downstream from Tat Momolikot Dam, for underground recharge and fishery purposes, and around which recreation facilities would be provided.

3. The first cost, based on September 1962 prices, of the Santa Rosa Wash multiple-purpose project (recommended plan), including lands, easements, and rights-of-way, is estimated at $6,430,000, consisting of $5,360,000 for Tat Momolikot dam and appurtenances; $995,000 for the Vaiva Vo irrigation project; $30,000 for fish and wildlife facilities; and $45,000 for recreation facilities. The annual cost of maintenance, operation, and replacements, based on September 1962 prices, is estimated at $62,000, including $12,000 for Tat Momolikot dam and reservoir; $41,000 for the Vaiva Vo irrigation project; $7,000 for fish and wildlife facilities; and $2,000 for recreation facilities.

4. Various methods of allocation of costs to the purposes of flood-control, water-conservation, fish and wildlife, recreation, and area redevelopment were considered, as follows: (a) separable costs-remaining benefits method, (b) priority of use method, and (c) incremental cost method. Consideration of all these methods indicates that, in this particular case, the separable costs-remaining benefits method is the preferable method. Detailed consideration of the other methods, as called for by Senate Resolution 148, 85th Congress, 2d session, adopted on January 28, 1958, are presented at the end of the report.

SEPARABLE COSTS-REMAINING BENEFITS METHOD

5. The method used for allocating costs is recommended in the report dated May 1950 and revised May 1958, entitled "Proposed Practices for Economic Analysis of River Basin Projects," prepared by the subcommittee on evaluation standards, Inter-Agency Committee on Water Resources. The subcommittee recommends use of the separable costs-remaining benefits method of cost allocation on Federal multiple-purpose river basin projects. The report states that "equitable distribution may be obtained by preventing costs allocated to any purpose from exceeding corresponding benefits; by requiring each purpose to carry at least its separable cost; and, within these maximum and minimum limits, by providing for proportional sharing of the savings resulting from multiple-purpose development."

6. The method consists of (a) determining the separable costs of including each function in the multiple-purpose project, and (b) determining an equitable distribution of costs incurred for several purposes in common. The separable cost for each project purpose is defined as the difference between the cost of the multiple-purpose project and the cost of the project with that purpose omitted. Joint cost is the difference between the cost of the multiple-purpose project as a whole and the total of the separable costs for all project purposes, and is allocated to each purpose in proportion to the remaining benefits.

7. The sum of the separable costs and the allocated joint cost for each purpose constitutes the total allocation to that purpose. Under the separable costs-remaining benefits method, the total cost allocated to each purpose will not be less than the cost of including that purpose in the project and will not be more than the capitalized value of benefits of that purpose or the cost of the most economical single-purpose alternative. The procedures developed in EM 1160-2-101 were applied.

8. Pertinent information on the application of the separable costs-remaining benefits method for a 100-year period of analysis (using an interest rate of 3 percent)for the recommended plan for the Santa Rosa Wash multiple-purpose project is given in the following table:

Table 1

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of annual costs						
Benefits	$527,000	$258,000	$49,000	$60,000	$11,000	$905,000
Alternate costs	189,000	102,000	24,000	25,000	(*)	340,000
Benefits limited by alternate costs	189,000	102,000	24,000	25,000	11,000	351,000
Separable costs	150,000	64,000	10,000	11,000	0	235,000
Remaining benefits	39,000	38,000	14,000	14,000	11,000	116,000
Allocated joint costs	12,000	12,000	5,000	5,000	3,000	37,000
Total allocation, project costs	162,000	76,000	15,000	16,000	3,000	272,000
Allocation of maintenance and operation costs						
Separable costs	3,000	32,000	9,000	9,000	0	53,000
Allocated joint costs**	3,000	3,000	1,000	1,000	1,000	9,000
Total allocation, maintenance and operation	6,000	35,000	10,000	10,000	1,000	62,000
Allocated costs, dam and appurtenances***	6,000	2,000	2,000	3,000	0	13,000
Percent of allocated costs, dam and appurtenances	47	15	15	23	0	100
Allocated costs, remaining facilities	0	$33,000	$8,000	$7,000	$1,000	$49,000
Percent of allocated costs, remaining facilities	0	68	16	14	2	100
Specific costs	0	****$28,000	****$5,000	0	0	$33,000

See footnotes at end of table.

Table 1--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of maintenance and operation costs (continued)						
Allocated joint-use costs, dam and appurtenances.....	$6,000	$2,000	$2,000	$3,000	0	$13,000
Allocated joint-use costs, remaining facilities.....	0	5,000	3,000	7,000	$1,000	16,000
Allocation of investment						
Annual investment cost#.....	156,000	41,000	5,000	6,000	2,000	210,000
Allocated investment.....	4,920,000	1,293,000	158,000	189,000	63,000	6,623,000
Allocation of construction expenditures						
Specific investment.....	815,000	874,000	26,000	23,000	0	1,738,000
Investment in joint-use facilities.....	4,105,000	419,000	132,000	166,000	63,000	4,885,000
Interest during construction of joint-use facilities##.....	119,000	12,000	4,000	5,000	2,000	142,000
First costs of all joint-use facilities.....	3,986,000	407,000	128,000	161,000	61,000	4,743,000
First costs of joint-use facilities, dam and appurtenances***.....	3,986,000	322,000	101,000	127,000	48,000	4,584,000

See footnotes at end of table.

Table 1--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of construction expenditures (continued)						
First cost of remaining joint-use facilities.....	0	$85,000	$27,000	$34,000	$13,000	$159,000
First cost of specific facilities.....	###$791,000	****$849,000	****$25,000	****$22,000	0	1,687,000
Total first cost, dam and appurtenances.....	4,777,000	322,000	101,000	127,000	48,000	####5,375,000
Percent of first cost, dam and appurtenances....	89	6	2	2	1	100
Total first cost, remaining facilities.....	0	$934,000	$52,000	$56,000	$13,000	$1,055,000
Percent of first cost, remaining facilities.....	0	89	5	5	1	100
Grand total, first costs.....	$4,777,000	$1,256,000	$153,000	$183,000	$61,000	$6,430,000

* Exceeds value of benefits.

** In proportion to remaining benefits.

*** Because no flood-control benefits would accrue from those facilities downstream from the dam (joint-use facility) all joint-facility costs for flood control were allocated to the dam and reservoir and remaining joint costs were allocated in proportion to the total joint costs for each purpose.

**** Applies to remaining facilities.

\# Total allocation, maintenance and operation subtracted from total allocation, project costs.

\#\# One-half of 2 years at 3 percent.

\#\#\# Applies to dam and appurtenances.

\#\#\#\# Including $15,000 for recreation facilities in reservoir area.

9. The hypothetical projects considered for alternate costs for the various purposes are described in the following subparagraphs.

(a) For flood control only.--Because of the high costs of spillway excavation required by a lower dam, the dam would have a height of 64 feet above streambed, only 2 feet lower than the multipurpose dam. A 13-foot conduit through the dam would be provided for a combination pool drain and flood-control outlet. There would be no downstream development.

(b) For water conservation only.--A dam with a height of 39 feet above streambed would be provided to create a reservoir with provision for a conservation pool, allowance for silt, and a side spillway. Downstream development would include settling ponds and all the development for agriculture proposed for the multiple-purpose project but without provision for recreation or fish and wildlife. Plans for this project were developed by the Bureau of Indian Affairs.

(c) For recreation only.--No dam was provided. The project consisted of picnic grounds, a trailer camp, a swimming pool, a golf course, a playground, an office, parking facilities, landscaping, and utilities. The scale of these facilities would be at such magnitude as to attract the equivalent visitor-attendance as the recreation portion of the multipurpose project.

(d) For fish and wildlife only.--Fish ponds, stocked with fish, greater in area than those provided downstream from the proposed multipurpose dam, were provided. Enough well capacity was provided to maintain the ponds. An attendant's office, parking, and sanitary facilities were provided.

(e) Costs of these alternative projects are shown in the following table.

Table 2

Alternate costs for Santa Rosa Wash multiple-purpose project

Item	Flood control	Water conservation	Fish and wildlife	Recreation
INVESTMENT				
First cost:				
Construction.....	$4,990,000	$1,774,000	$262,000	$150,000
Relocations.....	330,000	0	0	0
Lands and rights..	620,000	90,000	8,000	10,000
Total first cost.....	5,440,000	1,864,000	270,000	160,000
Interest during construction (1/2 of 2 years at 3 percent).....	163,000	56,000	8,000	5,000
Total investment.....	5,603,000	1,920,000	278,000	165,000
ANNUAL CHARGES				
Interest and amortization, 100 years at 3 percent.....	177,000	61,000	9,000	5,000
Maintenance and operation.....	12,000	41,000	15,000	20,000
Total annual charges*.....	189,000	102,000	24,000	25,000

* These are also referred to as annual alternate costs.

10. The hypothetical projects considered for separable costs for the various purposes are described in the following subparagraphs.

(a) The project in which flood control would not be provided would be the same as part (b) of the preceding paragraph, except that the recreation, fish, and wildlife features proposed in the multiple-purpose project would be provided.

(b) For the project in which water conservation would not be provided, the dam and appurtenances would be the same as in the multiple-purpose project. In lieu of the ponds downstream from the dam, a permanent pool, stocked with fish, would be maintained in the 15,000 acre-feet allotted to water conservation in the multiple-purpose project. A recreation area would be provided upstream from the pool.

(c) The project in which fish and wildlife facilities would not be provided would be the same as the multiple-purpose project except that the ponds would not be stocked with fish; and parking and other facilities downstream from the dam would be somewhat reduced in size.

(d) The project in which recreational facilities would not be provided would be the same as the multiple-purpose project except that picnic grounds, upstream boat ramps, and other specific recreational facilities would be omitted, and parking and other facilities at the ponds downstream from the dam would be reduced in size.

(e) Costs for these projects and separable costs for each purpose are shown in the following table.

Table 3

Separable costs for Santa Rosa Wash multiple-purpose project

Item	Multiple-purpose project	Flood control	Water conservation	Fish and wildlife	Recreation
INVESTMENT					
First cost of projects with one purpose omitted (except multiple-purpose project):					
Construction	$5,710,000	$1,849,000	$4,565,000	$5,645,000	$5,620,000
Relocations	300,000	0	330,000	360,000	360,000
Land and rights	420,000	90,000	582,000	400,000	400,000
Total first costs	6,430,000	1,939,000	5,477,000	6,405,000	6,380,000
Interest during construction (1/2 of 2 years at 3 percent)	193,000	58,000	164,000	192,000	191,000
Total investment	6,623,000	1,997,000	5,641,000	6,597,000	6,571,000
ANNUAL CHARGES					
Interest and amortization, 100 years at 3 percent	210,000	63,000	178,000	209,000	208,000
Maintenance and operation	62,000	59,000	30,000	53,000	53,000
Total annual charges	272,000	122,000	208,000	262,000	261,000
Separable total annual charges*	--	150,000	64,000	10,000	11,000
Separable maintenance and operation costs**	--	3,000	32,000	9,000	9,000

* Difference between multiple-purpose project and project with purpose omitted. Also known as separable annual costs.

** Difference between multiple-purpose project and project with purpose omitted.

11. Pertinent information regarding specific costs is given in the following tables.

Table 4

Itemized specific costs for Santa Rosa Wash multiple-purpose project

First costs:	
Flood control:	
Dikes	$190,000
Flowage easement	301,000
Relocations	300,000
Total	791,000
Water conservation:	
Wells and pumps	289,000
Canals and conduits	162,000
Laterals	257,000
Intercepting channels and dikes	10,000
Farm unit development	131,000
Total	849,000
Fish and wildlife:	
Well and pump	25,000
Recreation:	
Picnic grounds	2,000
Playground	5,000
Ramp and road	15,000
Total	22,000
Maintenance and operation (annual):	
Flood control	0
Water conservation:	
Irrigation development downstream from ponds	28,000
Fish and wildlife:	
Restocking ponds with fish	5,000
Recreation	0
Area redevelopment	0

Table 5

Specific costs for Santa Rosa Wash multiple-purpose project

Item	Flood control	Water conser-vation	Fish and wildlife	Recreation
INVESTMENT				
First cost:				
Construction.....	$190,000	$849,000	$25,000	$22,000
Relocations.....	320,000	0	0	0
Land and rights.....	281,000	0	0	0
Total first cost..	791,000	849,000	25,000	22,000
Interest during construction (1/2 of 2 years at 3 percent).....	24,000	25,000	1,000	1,000
Total investment.....	815,000	874,000	26,000	23,000
ANNUAL CHARGES				
Maintenance and operation.....	0	28,000	5,000	0

APPENDIX 6 - COMMENTS OF OTHER AGENCIES

SANTA ROSA WASH, ARIZ.
GILA RIVER AND TRIBUTARIES, ARIZ. AND N. MEX.

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SCOPE

This appendix includes the comments of Federal and State agencies on this report. Where pertinent, replies of the U.S. Army Engineer District, Los Angeles, are included.

In reply refer to:

Land Operations
341.9.1

UNITED STATES
DEPARTMENT OF THE INTERIOR
Bureau of Indian Affairs
Phoenix Area Office
P. O. Box 7007
Phoenix 11, Arizona

May 15, 1963

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Your reference:
SPLGP-F

Dear Sir:

Reference is made to your letter of 11 April 1963, and the copy of your Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona, transmitted therewith.

We understand that this reply to your letter will be attached to your final report. For the information of its readers, the Bureau of Indian Affairs is a cooperating Federal Agency in the Santa Rosa Wash Multiple Purpose Project and has prepared a feasibility report for the Vaiva Vo Irrigation Project, a unit of the multiple purpose project, which is to be submitted to the Congress as a basis for authorization of construction.

The Bureau of Indian Affairs concurs in and supports the construction of Tat Momolikot Dam as recommended by the District Engineer, U. S. Army Engineer District, Los Angeles, Corps of Engineers.

Flood control benefits as provided for by the recommended Santa Rosa Wash Project will accrue to lands of the Papago Indian Reservation adjacent to the Santa Rosa Wash, downstream from the Tat Momolikot damsite to the reservation boundary; also, land within the Maricopa-Ak Chin Indian Reservation will receive flood control benefits.

The conservation storage provided by the Tat Momolikot Dam and St. Clair Reservoir is a necessary feature in maintaining the water supply for the irrigation of the lands of the proposed Vaiva Vo Irrigation Project.

The Bureau of Indian Affairs submits the following comments on the contents of the interim report, some of which are necessary because of revisions made in the Bureau of Indian Affairs report that should be reflected in the Corps of Engineers' report:

1. Page 36, Paragraph 95. Vaiva Vo Irrigation Project. Subparagraph (b) line 3, change 80 to 60.

2. Page 43, Subparagraph (b). Benefits from water conservation. In second subparagraph, line 2, change $34.65 to $37.65; line 3, change $31.49 to $34.49.

3. Page 44, the table: Farm budgets and financial analysis for representative farms, Vaiva Vo Irrigation Project, Arizona.
   A revised table is submitted herewith.

4. Appendix 2, page 2-11, length of main supply canal, change 4.9 to 5.4, and 80 cfs to 60 cfs.

5. Appendix 2, page 2-9, paragraph 34. Vaiva Vo Irrigation Project - Plan. Subparagraph (c). The wording should be revised to read: "(c) ponds excavated downstream from the dam, forming approximately 50 acres of small lakes which will be available to assist groundwater recharge and for fisheries;".

6. Appendix 2, page 2-10, paragraph 36, line 4, the figure 80 should be changed to 60.

The Bureau of Indian Affairs appreciates the fine cooperation of the Corps of Engineers in the joint formulation of plans for the Santa Rosa Wash Multiple Purpose Project.

Sincerely yours,

/s/ George W. Hedden
Assistant Area Director

Attachment

cc:
Supt., Papago Agency
Papago Tribal Council (Thru: Supt., Papago Agency)
Commissioner, Bureau of Indian Affairs, Washington, D.C.

Table No. 7

FARM BUDGETS AND FINANCIAL ANALYSIS FOR REPRESENTATIVE FARMS
VAIVA VO IRRIGATION PROJECT - ARIZONA

Item	Class 1 Land	Class 2 Land
Budget No.	1	2
Irrigable Area	80	90
Irrigated Area	76	85
Cotton	24	27
Barley	33	37
Sorghum	(22)	(25)
Alfalfa	19	21
Pasture	(37)	(42)
Farmstead, etc.	4	5
Total Farm Investment	$ 20,897	$ 20,529
Total Work Days	159	179
Operator	118	121
Hired and Contract	41	58
Farm Income		
Crop Sales	$ 16,952	$ 17,705
Farm Privileges	595	595
Total	$ 17,547	$ 18,300
Farm Expenses		
Interest on Investment	835	821
Operating Expense	9,712	10,360
Total	10,547	11,181
Net Farm Income	7,000	7,119
Equity Allowance	209	205
Family Living	2,775	2,775
Payment Capacity	4,016	4,139
Less 25% Contingencies	1,004	1,035
Adjusted Payment Capacity Per Farm	3,012	3,014
Adjusted Payment Capacity Per Acre	$ 37.65	$ 34.49

Figures within ( ) indicate acreage double-cropped.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Region 3
Boulder City, Nevada

In reply
refer to:
3-700

May 13, 1963

Your reference:
SPLGP-F

District Engineer
U. S. Army Engineer District,
Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

We have reviewed the Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona, transmitted by your letter of April 11, 1963, and have the following general comments:

The proposed Santa Rosa Dam would provide flood control, fish and wildlife conservation, recreation, area redevelopment, and water conservation benefits for more efficient water utilization in the Santa Rosa portion of the Papago Indian Reservation and in the Maricopa-Stanfield area. These benefits are valuable and needed.

The proposed Santa Rosa Wash Project would not be in conflict with any plans for the area being considered by the Bureau of Reclamation but would complement Bureau plans, including those for the proposed Central Arizona Project.

We note that the report implies that the Central Arizona Project, if constructed, would stabilize the economy of the area by bringing in a supplemental water supply. Our studies indicate that the current overdraft of the ground-water basins is in the neighborhood of 2,200,000 acre-feet annually. The amount of water that may be available to Arizona from a central Arizona project depends, of course, upon a decision by the Supreme Court; however, in any event it has never been contemplated to be in

the magnitude of 2,200,000 acre-feet. Even with the Central Arizona Project, over-all water use would exceed over-all supply. Areas which would receive Central Arizona Project water, and in what quantity, are currently unknown factors.

We appreciate the opportunity to comment upon this planned development which could materially contribute to the economic well being of the area.

Sincerely yours,

/s/ A. B. West
Regional Director

In duplicate

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 7, California

SPLGP-F

1 August 1963

Mr. A. B. West
Regional Director
Bureau of Reclamation
Region 3
Boulder City, Nevada

Dear Mr. West:

This is in reply to your letter of 13 May 1963 in which you commented on a draft of our interim report on survey for flood control, Santa Rosa Wash, Arizona.

We note that you agree to the desirability of construction of the recommended plan of improvement and that the recommended plan would complement Bureau plans, including those for the proposed Central Arizona Project.

Reference is made to paragraph 4 of your letter wherein you point out that the proposed Central Arizona Project would not satisfy existing water requirements. This fact was recognized in our evaluation of average future flood-control benefits from construction of the recommended plan of improvement, as discussed below.

a. It is estimated that present water use in the area subject to overflow (46,000 agricultural acres) along Santa Rosa Wash amounts to about 210,000 acre-feet per year.

b. The flood area is located above a trough in the ground water basin. Analysis of water levels and depths to ground water shows that the rate of decline of the ground water basin under the overflow area is considerably less than the rate of decline of the ground water basin under adjoining areas. As the water table continues to recede, the lands at the circumference of the ground water basin, beyond the overflow area, would be the first to be retired from agricultural uses. The remaining underground water plus imported water would then be available for use in the remaining area.

1 August 1963

c. In consideration of average future agricultural conditions, allowing for importation of supplemental water from the Central Arizona Project, it was estimated that the cultivated acreage in the overflow area would eventually be reduced about one-third.

d. Technical improvements, such as increased pumping efficiency, better soil moisture determination, improvements in irrigation layout and land leveling, improved application techniques such as sprinkling, and the growing of crops requiring less water would either make more water available at an economical price or allow more efficient use of available water.

e. Increased productivity would increase the yields of crops and increase the value of crops per acre.

As the result of the factors indicated above, it is estimated that agricultural values under average future conditions would at least equal present agricultural values in the overflow area.

We will revise our report to summarize this concept.

Sincerely yours,

/s/ EARL G. PEACOCK
Colonel, Corps of Engineers
District Engineer

In reply refer to:

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
State Office
3022 Federal Building
Phoenix 25, Arizona

R&F
1650

April 30, 1963

District Engineer
U.S. Army Engineer District
P.O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

Your letter of April 11, 1963 (reference: SPLGP-F) requested comments on the Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona. This report has been reviewed and our comments follow.

Public lands administered by the Bureau of Land Management within the Santa Rosa Watershed include only a few scattered tracts which are located downstream from the proposed improvements. These lands, because of their limited acreage and isolated location, are not under intensive management, and the proposed works of improvement included in the report are not expected to materially affect Bureau of Land Management programs within the watershed. Completion of the proposed work will, however, be of benefit to a portion of Bureau administered lands by providing protection from flood damage.

Sincerely,

/s/ Fred J. Weiler
State Director

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
230 N. 1st Avenue
Phoenix 25, Arizona

April 19, 1963

In reply refer to:
07-02.6
SPLGP-F

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

We have reviewed the Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona. The report was forwarded with your letter of April 11, 1963.

It appears from the data submitted in the Report that there are no Federal-aid Highways in the area subject to inundation by the recommended Tat Momolikot Damsite. There are a number of Federal-aid Highways below the proposed flood control project that would benefit considerably should the project be completed. In particular, Interstate Highway Route 8 now being built south of Stanfield would benefit from a control of flood flows in the Santa Rosa Wash since the effectiveness of the highway bridge at this point is limited to the capacity of the existing channel. This channel appears to be completely inadequate to handle the larger flood flows capable of being generated on this watershed.

Thank you for the copy of the report furnished, and we will appreciate receiving further information on the proposed project as it becomes available.

Sincerely yours,

W. H. BAUGH
Division Engineer

/s/ By
J. ERICKSON
District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
Region III

Office of
Regional Director

224 New Custom House
Denver 2, Colorado

April 30, 1963

Your reference:
SPLGP-F

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

The "Interim Report on Survey for Flood Control, Santa Rosa Wash, Ariz.," distributed for field comment with your memorandum of April 11, 1963, has been reviewed by Bureau of Mines personnel at our Arizona Field Office, Tucson.

Coincidentally, our most recent comments on this study were submitted to your office precisely 3 years earlier -- on April 11, 1960 -- in response to a Notice of Initiation of Investigation. Those comments still are valid.

Four inactive mines -- the Jack Rabbit, Turning Point, and two Orizaba openings -- will be very close to the maximum flood-storage level for the reservoir behind the Tat Momolikat Damsite. These mines could be flooded by rising waters under extreme conditions. However, if not pumped, the workings below a shallow local water table are flooded anyway. Possibly the shaft collars are above the highest water level that might be reached in the reservoir, but this would have to be verified.

No property damage would result from flooding if the operations are considered to be abandoned, which apparently is their current status. The limited information available on the silver-gold deposits developed by the mine workings indicates that they are marginal under present or foreseeable conditions and, therefore, do not constitute a valuable reserve that might be lost because of the project. Nevertheless, at least some of these deposits appear to be on patented mining claims, and private ownership rights may be involved.

Further investigation by the Bureau of Mines probably would not develop much more information on the ore reserve potential of mines near the proposed reservoir because the inaccessible workings cannot be examined. However, if private ownership rights are involved and have not been resolved to the satisfaction of the Government, a field investigation may be justified. An investigation and report, which would include an effort to verify the conclusions as to mineral potential, would cost a minimum of $600.

Other mines and prospects in the general area would not be adversely affected by the proposed flood control project. In fact, they might be benefited by a general economic improvement of the area, particularly if the Papago Indian tribe is enabled to promote mineral development by reason of improved financial conditions. The Lake Shore oxidized copper deposit, about 7 miles south of the proposed dam, is one of these properties and the only developed one of any consequence in the immediate area.

Very truly yours,

/s/ D. O. Kennedy
Acting Regional Director
Region III

FEDERAL POWER COMMISSION
REGIONAL OFFICE
555 Battery Street, Room 415
San Francisco 11, Calif.

85-Gila R.
W/A 61

April 25, 1963

Colonel Earl G. Peacock
District Engineer
U.S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Colonel Peacock:

We have made a brief review of your preliminary "Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona," (Gila River Basin), copy of which was transmitted to us by Mr. Koehm's letter of April 11, 1963.

Our review indicates that the proposed Tat Momolikot dam and St. Clair reservoir would be operated for flood control, irrigation, conservation, and ground-water recharge purposes; and that the ungated flood control notch in the spillway would empty the reservoir in a short time after floods to a level providing a maximum head of about 25 feet. Even if the total runoff at the reservoir site were available for power generation, the average flow would be about 14 cfs and the dry year flow about 1.5 cfs. Furthermore, the flow would be intermittent and not available several months each year. Any proposed powerplant would be small and the annual cost per kw of installed capacity very high.

Under these circumstances -- small annual output, no dependable peaking capacity, and high unit cost -- hydroelectric powerplant facilities at the proposed reservoir would be uneconomical. We therefore recommend that hydroelectric power facilities be omitted from the proposed project.

We appreciate the opportunity to review and comment on the contemplated Santa Rosa Wash flood control project. We would like to have a copy of your General Design Memorandum when it becomes available.

Sincerely yours,

Robert H. Griffin
Acting Regional Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. Box 1306
Albuquerque, New Mexico

May 9, 1963

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

We refer to your letter dated April 11, 1963, which requested our Bureau's comments on your proposed "Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona."

The proposal is for a multiple purpose project including water conservation, fish and wildlife conservation, recreation, and area redevelopment as well as flood control. The project includes the Vaiva Vo Irrigation Project located on lands of the Papago Indian Reservation. The fish and wildlife purpose will be accommodated in accordance with the recommendations and suggestions which were contained in our memorandum report dated July 20, 1962, to the Area Director, Bureau of Indian Affairs, Phoenix, Arizona, entitled "Vaiva Vo Irrigation Project, Papago Indian Reservation, Arizona--Bureau of Sport Fisheries and Wildlife report." A copy of that report is enclosed.

It is noted that your proposed report makes reference to the possibility that recreation features such as boating and water skiing would be an important aspect of the four ponds. We suggest that the Papago Tribe may wish to consider controlling or restricting motor boating and water skiing in the interest of optimum use of the ponds for fishing.

The opportunity extended to us to review your proposed report for the project is appreciated.

Sincerely yours,

/s/ Carey H. Bennett, Chief
Division of Technical Services

Enclosure

cc:
Director, Arizona Game and Fish Department, Phoenix, Arizona
Area Director, Bureau of Indian Affairs, Phoenix, Arizona
Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Salt Lake City, Utah

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. Box 1306
Albuquerque, New Mexico

July 20, 1962

Memorandum

To: Area Director, Bureau of Indian Affairs, Phoenix, Arizona

From: Acting Regional Director

Subject: Vaiva Vo Irrigation Project, Papago Indian Reservation, Arizona - Bureau of Sport Fisheries and Wildlife report

This memorandum may be regarded as our Bureau's report on the above project and is intended for inclusion in your feasibility report. It has been prepared under authority of and in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) in response to a request dated March 6, 1962, from your office. It is based on the plan presented in the statistical summary sheets provided with that letter. The report has been prepared in cooperation with the Arizona Game and Fish Department. It has received the concurrence of that Department as indicated by the letter of May 7, 1962, signed by R. J. Smith, Director.

The Vaiva Vo Project is an important adjunct to the proposed flood control work of the Corps of Engineers for Santa Rosa Wash. The principal feature for flood control is Tat Momolikot Dam to be located on the reservation at the confluence of Jackrabbit, Santa Rosa, and Kohatk washes. The irrigation project area will extend from the dam to a point about 2 miles north of the village of Vaiva Vo.

There will be a minimum of 15,000 acre-feet of conservation capacity behind Tat Momolikot Dam. Flood flows will be retained in this space for later release to the irrigation area of 1,680 acres. During periods when the reservoir is empty, irrigation water will be supplied from 13 deep wells throughout the project area. Ground water recharge is expected from the reservoir and from irrigation also.

In addition, it is planned that fish ponds totaling about 50 surface acres will be built below the dam. These ponds also will be maintained by releases from the reservoir, or by pumping.

With proper management, the project will result in high benefits related to fishing and waterfowl hunting. The Arizona Game and Fish Department, in a letter report dated May 22, 1961, estimated the expected use by sportsmen of a 50-acre lake as part of the project. Their fishing estimate was based on comparisons with data gathered on existing lakes of comparable size, including Pena Blanca and Woods Canyon Lakes. The prediction was that 30,000 fisherman-days annually will be supported by 50 acres of water.

The Arizona Game and Fish Department also forecasted that there will be about 900 duck-hunting days associated with the project if 50 acres of water is maintained, basing this estimate on waterfowl and hunting surveys of waters in the general region.

The above estimates are the most competent of any that could be obtained. Using the interim schedule of values for recreational aspects of fish and wildlife approved by the Inter-Agency Committee on Water Resources, we find that annual monetary benefits of $45,000 for fishing and $4,000 for waterfowl hunting may be attributed to the project if free public access is provided.

The interim schedule of values is used in making benefit-cost studies and cost allocations for multiple-purpose water development projects. The above annual benefits totaling $49,000 are contingent upon maximum public use of the area. They do not necessarily have any calculable relationship to the values which would accrue to the economy of the reservation.

Economic benefits could accrue to the Papago people. We have made no particular study of their magnitude or how they may be realized. It is apparent, however, that some of the ways in which there may be an increase in income to the project area include the following: (1) Selling bait and other equipment to fishermen; (2) renting boats; (3) selling hunting equipment; (4) providing food and lodging to sportsmen. Economic benefits to the Papago people on a substantial basis would result only if intensive fishing and waterfowl management is applied.

When the fishing ponds are designed and built, it is suggested that special attention be given to provisions for flow between them and also to their depth. This latter factor is important during the hot summer to maintain proper ecological balance with emphasis on aquatic weed control. Our preliminary suggested criterion, pending an examination of the general topography of the pond basins, is that there should be a minimum of 25 acres at least 15 feet in depth.

It is recommended:

1. That the proposed fishing ponds be constructed to maintain the proper ecological balance and to prevent undue growth of aquatic vegetation; specific criteria for this recommendation to be provided at such time as more detailed project plans are available.

We appreciate this opportunity to comment on what appears to be a very desirable project for fish and wildlife and to contribute to the feasibility report. Be assured that facilities of our Branch of Fishery Management Services remain available to your Bureau and the Papago people, if additional technical assistance is needed with respect to construction and operation of the proposed fish and wildlife areas.

/s/ William T. Krummes

Copies (10)

Distribution:

(2) Director, Arizona Game and Fish Department, Phoenix, Arizona
(2) District Engineer, Corps of Engineers, U. S. Army, Los Angeles, California
(2) Regional Director, Region 3, National Park Service, Santa Fe, New Mexico
(2) Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Salt Lake City, Utah

U. S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F

29 July 1963

Mr. Carey H. Bennett
Chief, Division of Technical Services
Fish and Wildlife Service
U.S. Bureau of Sport Fisheries and
Wildlife
P. O. Box 1306
Albuquerque, New Mexico

Dear Mr. Bennett:

Thank you for your review and comments on the proposed interim report on survey for flood control, Santa Rosa Wash, Arizona, as presented in your letter of 9 May 1963.

This office will not be responsible for development of the details of the recreational features at the ponds to be located downstream from the dam; that responsibility will probably reside with the Bureau of Indian Affairs. However, we concur that any water skiing or pleasure boating should be planned so as to provide a minimum of interference with hunting and fishing activities.

We are confident that the Bureau of Indian Affairs will give full consideration to your comments.

Sincerely yours,

/s/ EARL G. PEACOCK
Colonel, Corps of Engineers
District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
Southwest Region
Santa Fe, New Mexico

In reply refer to:
L7423

May 2, 1963

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

Thank you for the opportunity to review and comment on your Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona.

We were pleased to learn that this multiple-purpose project will provide for recreation. We were interested to note on page 46 that the average annual recreational benefits were computed on the basis of $1.60 per person per day. The $1.60 factor is no longer being used by the National Park Service. The interim method now used by this Service is based on a more detailed interpretation of the $1.60 factor. Separate estimates of the number of people who might engage in different types of recreational activities are made for each project. The monetary value per visitor-day may, therefore, vary for each reservoir.

The area of the Tat Momolikot Dam (and Lake St. Clair) and the proposed new irrigated lands of the Vaiva Vo Project are known to contain archeological sites. A survey, to determine the amount of salvage excavations necessary, will be made as soon as the project is authorized.

Sincerely yours,

/s/ Leslie P. Arnberger
Assistant Regional Director,
Resource Planning

U. S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F

8 August 1963

Mr. Leslie P. Arnberger
Assistant Regional Director
Resource Planning
National Park Service
Southwest Region
Santa Fe, New Mexico

Dear Mr. Arnberger:

This is in reply to your letter of 2 May 1963 commenting on our interim report on survey for flood control, Santa Rosa Wash, Arizona.

We note that you approve of the desirability of incorporating recreation as a purpose in the proposed multiple-purpose project. With respect to your comment regarding the value of benefits per recreation day, this office has been using a range of values from about $0.50 to $1.50 per user-day for general recreation, pending determination of more finite values. We believe that the recreation at the proposed reservoir should be at the upper end of the scale, because of the absence of water-based recreation in the general area.

It should be noted that the recreation benefits are about 6 percent of the total benefits and the presently estimated cost of recreation facilities is less than 1 percent of the total estimated costs. Therefore, the estimates for the recreation features have only a minor effect on the overall economic justification.

We understand that your discussions with the Bureau of Indian Affairs concluded that more detailed studies of the recreational features are warranted after authorization of the project. We would be pleased to coordinate with your office and the Bureau of Indian Affairs at that time in developing the optimum recreational program at the proposed project.

If the project is authorized, we will inform your office in sufficient time to enable you to make the desired archeological surveys and salvage operations.

SPLGP-F

8 August 1963

Mr. Leslie P. Arnberger

Your continued cooperation in our water resource planning activities is appreciated.

Sincerely yours,

/s/ SHELTON B. BILES
Major, Corps of Engineers
Acting District Engineer

cc: B.I.A.

UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Arizona State Office
Room 6029 Federal Building
Phoenix 25, Arizona

May 6, 1963

Mr. H.W. Thompson, Chief
Engineering Division
Corps of Engineers
751 S. Figueroa Street
Los Angeles 17, California

Dear Sir:

Reference is made to your letter of April 11, 1963, file number SPLGP-F requesting our comments about the Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona.

The report recommends (1) a multiple-purpose dam and reservoir at the Tat Momalikot site on Santa Rosa wash upstream from Vaiva Vo, Arizona, (2) the Vaiva Vo irrigation project (3) fish, wildlife and recreational facilities, and (4) improvement of the economic standards of the Papago Tribe in the Papago Indian Reservation. All of these works of improvements are on the Indian Reservation. The benefits of irrigation, fish and wildlife improvements are solely for the Indians.

The flood control benefits of the proposed program are principally non-Indian, in the flood plain of the Santa Rosa Wash and the Santa Cruz below its confluence with Santa Rosa Wash. It is this phase of the program which is of principal interests to the Soil Conservation Service. The proposed flood control works, if installed, will:

(1) Provide more stability to the agricultural economy of the area and to the towns and villages in the area and adjacent to it.

(2) Almost eliminate the hazards of floods from the upper Santa Rosa Wash watershed to soil and water conservation measures below the dam, thereby reducing conservation costs to farmers and the United States Department of Agriculture which supplies technical assistance and cost sharing to farmers in their conservation programs. In addition, the proposed flood control works will speed up the planning and application of soil and water conservation measures and reduce the farmers' cost per unit of production.

There are no Watershed Protection and Flood Prevention Projects (P.L. 566) in the watershed and none proposed at present.

Sincerely yours,

/s/ Robt. V. Boyle
State Conservationist

cc: E.J. Core
L.A. Hill

UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
2180 Milvia Street
Berkeley 4, California

April 24, 1963

Colonel Earl G. Peacock
District Engineer
U. S. Army Engineer District, L.A.
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Colonel Peacock:

The enclosed letter addressed to me is intended to respond to the request of your office for field level comments on the Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona.

The contents of the letter are self-explanatory with respect to the views of the U. S. Forest Service, Southwestern Region, Albuquerque, New Mexico.

Sincerely yours,

/s/ Kirk M. Sandals
River Basin Representative
Pacific Southwest

Enclosure

UNITED STATES
DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Southwestern Region
517 Gold Avenue, SW
Albuquerque, New Mexico

April 16, 1963

In reply refer to
3520
Your ref: 4-11

Mr. Kirk M. Sandals, Chairman
Pacific Southwest Inter-Agency Committee
Soil Conservation Service
2180 Milvia Street
Berkeley 4, California

Dear Mr. Sandals:

We have reviewed the Interim Report on Survey for Flood Control Santa Rosa Wash, Arizona, issued by the Los Angeles District Corps of Engineers.

We find that no National Forest lands lie within the Santa Rosa Wash drainage and administration of the National Forests will in no way be affected by the Santa Rosa Wash Flood Control Project.

Thank you for the opportunity for this review.

Sincerely yours,

FRED H. KENNEDY
Regional Forester

/s/ By: L. W. Darby

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Regional Office

Public Health Service
447 Federal Office Building
San Francisco 2, California

May 9, 1963

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Attention: Edward Koehm, Chief
Engineering Division

Ref: SPLGP-F

Dear Mr. Koehm:

Please refer to your letter of April 11, 1963 regarding the interim report for flood control on Santa Rosa Wash, Arizona.

This interim report has been reviewed with regard to the public health aspects. Our comments are as follows:

(1) Some study has been devoted to the effect of the project on underground water resources downstream from the proposed dam site by the Bureau of Indian Affairs and the Corps of Engineers. It is incumbent on us to point out that the water supplies for three communities (Casa Grande, Maricopa, and Stanfield) are involved and that no mention is made in the report of any concern over these facilities. The development by the Bureau of Indian Affairs of 1,640 acres of land near Vaiva Vo for irrigation would represent a consumptive use and would reduce the amount of water available for downstream users. There is an indication on page 36, paragraph 94, that operation of the project would not affect downstream users who take their supplies from underground sources. It is our strong recommendation that unless this indication has been fully investigated, studies should be initiated for complete documentation.

(2) We do not foresee any present need for reservoir storage for the purpose of water quality control in the stream.

(3) The creation of pools of water may afford the possibility of vector breeding during the period that the water surfaces exist. A vector evaluation of the project has been made and a copy is enclosed for your information. It is suggested that you make copies

of this vector evaluation available to the local sponsoring organizations so that they will have information on potential vector problems associated with the proposed project and the measures which may be used for preventing or controlling these problems.

Sincerely yours,

/s/ PAUL W. EASTMAN
Regional Program Director
Water Supply & Pollution Control

Enclosure

VECTOR EVALUATION OF THE PROPOSED CORPS OF ENGINEERS SANTA ROSA WASH FLOOD CONTROL PROJECT, PINAL COUNTY, ARIZONA

U. S. Public Health Service, Communicable Disease Center
Technology Branch, State Aids Section
Greeley, Colorado

and

Arizona State Department of Health
Phoenix, Arizona

May 1963

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VECTOR EVALUATION OF THE PROPOSED CORPS OF ENGINEERS SANTA ROSA WASH FLOOD CONTROL PROJECT, PINAL COUNTY, ARIZONA

INTRODUCTION

This vector evaluation is based upon a review of the Corps of Engineers' report entitled "Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona," dated March 31, 1963. The Corps of Engineers' report concerns the construction of a multiple-purpose dam and reservoir at the Tat Momolikot site on Santa Rosa Wash upstream from Vaiva Vo, Arizona. The District Engineer recommends (1) that the Corps of Engineers construct Tat Momolikot Dam, St. Clair Reservoir, wildlife, and recreational facilities in the reservoir area, and (2) that the Bureau of Indian Affairs construct the irrigation, recreation, fish and wildlife improvements downstream from Tat Momolikot Dam. A summary of pertinent information concerning the proposed project is attached to this report.

ANTICIPATED EFFECTS OF THE PROPOSED PROJECT ON VECTOR PROBLEMS

Mosquitoes are the principal vectors which might be affected by the proposed project. Several species of mosquitoes of public health importance including *Culex tarsalis* and *Culex quinquefasciatus*, recognized vectors of encephalitis, and the vicious-biting *Aedes vexans* may be produced in large numbers in the area when suitable aquatic habitats are present. Basic information concerning pertinent biological characteristics of these mosquitoes is given in Appendix A.

Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the United States and the area in which the proposed project is located. Records of the U. S. Department of Agriculture show that equine encephalitis cases occurred in Pinal County and/or adjoining counties during 15 years of the 16-year period 1940 through 1955 for which records are available. Records of the Arizona State Department of Health show that 3 human encephalitis cases occurred in Pinal County in 1960. Additional information concerning the public health and socio-economic importance of mosquito and other vector problems associated with water resource developments is presented in Appendix B.

The reduction in flooding of lowland areas expected from the proposed project should result in a reduction in natural aquatic habitats which are favorable for the production of mosquitoes and other insects of public health importance. Portions of the reservoir that have a steep shoreline with little or no vegetation and are exposed to strong wave action will be unfavorable for the production of mosquitoes and other aquatic insects of public health importance and will require no special vector prevention or control measures. Mosquito production may occur in tributary embayments and other marginal areas of the reservoir where the topography is flat and the water is shallow, protected from wave action, and contains emergent vegetation or flotage. The proposed fish ponds also may

result in conditions favorable for production of mosquitoes unless they are properly constructed and maintained. Information concerning reservoir preparation, maintenance, and water level management in relation to mosquito prevention and control is presented in Appendix C.

The development of water-related recreational and other public use areas in conjunction with the proposed project may result in the exposure of humans to vectors of terrestrial origin including arthropods such as ticks, fleas, and flies, and rodents such as ground squirrels, chipmunks, and mice. In order to minimize public health hazards at waterside recreational areas, appropriate prevention and control measures for both aquatic and terrestrial vectors should be carried out.

RESPONSIBILITY FOR VECTOR CONTROL

Responsibility for vector prevention and control is normally associated with land ownership or operating rights. The agency, group, or individuals responsible for various aspects of the proposed project should therefore be prepared to accept full responsibility for the prevention and control of vector problems resulting from the design, construction, operation, or maintenance of the proposed project.

RECOMMENDATIONS

In order to minimize public health hazards associated with the proposed project, every possible effort should be made to avoid creating conditions which will increase populations of mosquitoes

and other arthropods and rodents of public health importance. It is therefore recommended that:

1. Where applicable, the "Principles and Practices for Prevention and Control of Vector Problems Associated with Reservoirs" outlined in Appendix D be adhered to in the design, construction, and maintenance of Tat Momolikot Dam and St. Clair Reservoir.
2. Where applicable, the "Principles and Practices for Prevention and Elimination of Mosquito Sources Associated with Irrigation" outlined in Appendix E be adhered to in the development and operation of the Vaiva Vo irrigation project.
3. The following principles and practices be followed in the design, construction, and operation of the proposed fish ponds:
   a. Borrow areas resulting from construction of the ponds be located where they will be permanently inundated during the mosquito-production season, if possible.
   b. The ponds be designed and constructed so that a minimum water depth of two feet can be maintained during the mosquito-production season.
   c. The shores of the ponds be steep to minimize the growth of marginal vegetation.

APPENDIX A

Biology of Mosquitoes

This discussion is intended to provide only basic information concerning some of the more pertinent biological characteristics of mosquitoes commonly associated with water resource developments. These mosquitoes represent four important genera or groups: Anopheles, Culex, Aedes, and Psorophora. All mosquito species have four distinct stages in their life cycle: the egg, the larva ("wiggler"), the pupa ("tumbler"), and the adult. A characteristic common to all mosquitoes is that they live in water continuously from the time the eggs hatch until the adults emerge. The aquatic stages generally occur in shallow water with an abundance of vegetation and flotage, and where they are protected from wave action. They do not occur in the deep open waters of lakes, ponds, or streams.

On the basis of egg-laying habits, mosquitoes may be divided into temporary-water and permanent-water species. The Aedes and Psorophora are temporary water breeders which deposit their eggs on the moist soil of areas where surface water has receded. Hatching of the eggs is stimulated by subsequent floodings. The eggs may remain dormant for long periods, sometimes for several years if conditions are unfavorable for hatching. Normally, the eggs hatch more or less simultaneously soon after they are flooded. In contrast, the Anopheles and Culex usually lay their eggs on the surface of permanent and semipermanent bodies of water. The eggs usually hatch within a few days after oviposition. For both the temporary-water and permanent-water mosquitoes, time between hatching of eggs and emergence of adults varies with species and environmental conditions, especially water temperature. Development of the aquatic stages may be completed in as little as four days in hot weather while several weeks may be required in cool weather. Aedes and Psorophora mosquitoes generally develop more rapidly than the Anopheles and Culex.

Adult mosquitoes mate soon after emergence and the female begin seeking blood meals, which most species require before laying eggs. The biting habits of adult mosquitoes vary with species. Anopheles and Culex mosquitoes feed mainly at night while Aedes and Psorophora species feed both at night and in the daytime. Most species exhibit a peak of biting activity during a one- or two-hour period immediately after sundown. The Aedes and Psorophora species are aggressive and vicious biters of both man and livestock. Culex tarsalis, a vector of encephalitis, feeds readily on a wide range of hosts including man, wild and domestic birds, and livestock.

The flight range of mosquitoes varies widely with species and environmental conditions. The direction and distance of travel are greatly influenced by availability of food, shelter, and wind conditions. Availability of food is probably the most important factor influencing the movement of mosquitoes in many areas. If an adequate food supply is close to the production sites, adult mosquitoes probably will not travel far from their sources. On the other hand, mosquitoes may travel several miles when adequate food supplies are not available nearer their larval habitats. The normal flight range of the Anopheles and Culex mosquitoes is usually considered to be about one mile, although recent studies have shown that certain species such as C. tarsalis may travel several miles under certain environmental conditions. Most Aedes and Psorophora species are strong fliers and are known to range several miles from their larval habitats.

APPENDIX B

Public Health and Socio-Economic Importance of Vector Problems Associated with Water Resource Developments

Several groups of arthropods and rodents associated with the development and utilization of water resources may create serious public health and socio-economic problems. These include species that are vectors of disease organisms or serve as reservoirs of these organisms or which otherwise interfere with man's health and welfare.

Mosquitoes

Approximately a dozen species of mosquitoes of public health and socio-economic importance may be produced in habitats associated with irrigation, impoundments, and other water resource developments. Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the United States. Mosquitoes obtain the encephalitis viruses from wild vertebrates and then transmit them to horses and humans. There are no effective chemotherapeutic measures for preventing or treating human cases; and some individuals, particularly children, who recover from encephalitis often suffer permanent mental disability. Three principal types of mosquito-borne encephalitis occur in the United States. Eastern encephalitis (EE) occurs mainly in the Atlantic and Gulf Coast States from New Hampshire to Texas, but sometimes extends as far inland as Wisconsin. St. Louis encephalitis (SLE) occurs chiefly west of the Mississippi River and in several of the Central States. The third type, western encephalitis (WE), is confined primarily to the states west of the Mississippi River.

Culiseta melanura and several species of Aedes mosquitoes are believed to be involved in the transmission of EE. The principal vector of both WE and SLE in the Far West is *Culex tarsalis*, a mosquito which is widely distributed west of the Mississippi River. In the Central States, *Culex pipiens* and *Culex quinquefasciatus* are believed to be important in the transmission of SLE. Aedes and other mosquitoes may also be involved as secondary vectors of encephalitis. Both western and St. Louis encephalitis are endemic in many western areas, and outbreaks of WE among horses and of WE and SLE among humans have been rather widespread. In recent years, outbreaks of encephalitis have occurred in irrigated areas in the Texas High Plains (1956), in the Intermountain States (1957), in the Lower Rio Grande Valley (1957), in Utah and New Mexico (1958), and in Wyoming (1960).

The occurrence of malaria outbreaks as a result of improperly prepared reservoirs in the Southeastern States is well documented. Malaria has also been associated with irrigation in several states including California, New Mexico, Texas, and in the rice-growing areas of the Mississippi Delta. This disease has been almost eradicated from the United States; and at present, there is no significant malaria transmission anywhere in the Nation. The malaria vectors (Anopheles quadrimaculatus in the East and Anopheles freeborni in the West) are still prevalent in some areas where favorable habitats are present. These mosquitoes constitute a potential hazard for the establishment of new foci of malaria transmission, particularly in situations where the disease may be reintroduced from foreign countries. This was well illustrated at Lake Vera in California during the summer of 1952, where 35 cases of malaria occurred among Camp Fire Girls. The source of their infections was traced to a soldier who had an attack of malaria while camping at the lake.

Several vicious-biting species including Aedes vexans, Aedes dorsalis, and Aedes nigromaculis may be produced in habitats associated with irrigation and other water resource projects. These mosquitoes often create public health problems aside from the transmission of specific diseases. Such health hazards are illustrated by the results of surveys made by the U. S. Public Health Service in irrigated areas in northern Montana. In three-fourths of the families surveyed, mosquitoes severely annoyed both adults and children and interfered with their normal outdoor activities during the summer months. Mosquito bites caused some degree of injurious reaction in 8 out of 10 people interviewed; and in one section, 40% of the individuals examined by the physician showed evidence of secondary infection of mosquito bites. Some individuals, particularly children, frequently required medical attention and sometimes even hospitalization for treatment of secondary infections and occasional allergic reactions caused by mosquito bites.

In addition to their public health importance, mosquitoes often create other serious problems in both rural and urban areas. Their vicious biting reduces the efficiency of farm workers and sometimes hinders the harvesting of crops. Dense populations of attacking mosquitoes have been reported to kill livestock. The constant attacks of even moderate populations of these insects may reduce the vitality of farm animals and prevent proper feeding, thereby causing reduced weight gains and lower milk and egg production. Mosquitoes are vectors of encephalitis, anaplasmosis, fowl pox, and several other important diseases of animals. These diseases kill large numbers of farm animals each year. Together, mosquito annoyance and mosquito-transmitted diseases undoubtedly result in losses of millions of dollars to farmers every year.

Large numbers of biting mosquitoes also cause serious economic losses by reducing the efficiency of industrial workers, lessening the value of real estate, restricting outdoor recreational activities, and reducing attendance at outdoor business establishments such as drivein theatres and eating places.

The economic magnitude of the irrigation-mosquito problem alone is illustrated by expenditures for abatement of these insects. For example, in California over $5,000,000 is spent annually to control encephalitis and other irrigation mosquitoes and it has been estimated that at least twice this amount would be required to provide adequate control throughout the State. Approximately $200,000 is spent each year for mosquito abatement in a few irrigated areas in Utah. Many urban communities in other western irrigated areas spend large sums of money each season for chemical control to provide partial protection from mosquitoes. Individual families also spend sizable amounts of money each summer for household sprays, mosquito repellents, livestock sprays, and medicine for treatment of mosquito bites. The total cost of controlling irrigation mosquitoes, together with the other serious economic losses they cause, runs into many millions of dollars each year. Thus, mosquitoes are a major economic liability in many irrigated areas.

Other Aquatic Insects

Several other groups of aquatic insects may be produced in sufficient numbers in habitats associated with water resource projects to create public health and economic problems. Deer flies and horse flies (Tabanidae) are produced along the margins of impoundments and in seeps and marshes in irrigated areas. These insects are vicious biters of both man and livestock and are sometimes involved in the transmission of diseases such as tularemia and anthrax. Some species of small gnats of the family Heleidae are also vicious biters and often produce severe reactions and vesicular lesions. These gnats are produced in damp areas of many irrigated valleys as well as salt marshes and other wetland areas. In certain areas, black flies (Simuliidae) plague both man and livestock with their irritating and painful bites. They are normally produced in streams but sometimes occur in large numbers in irrigation conveyance systems. The small nonbiting midges (Tendipedidae) and the phantom midges (Chaoborinae) are another group of pestiferous insects which may be produced in impounded water. These insects are attracted to lights in tremendous numbers and cause severe human annoyance. An example is the Clear Lake gnat, Chaoborus astictopus, which creates serious problems at the resort areas in Lake County, California.

Terrestrial Arthropods and Rodents

Each summer, many millions of people visit picnic sites, campgrounds, cabins, and other water-related recreational facilities along the shores of reservoirs. In addition to mosquitoes and other insects of aquatic origin, these people are often exposed to terrestrial arthropods such as ticks, mites, fleas, and flies and rodents including ground squirrels, rats, mice, and chipmunks. The public health importance of these arthropods and rodents involves a number of human diseases including Rocky Mountain spotted fever, Colorado tick fever, tularemia, relapsing fever, tick paralysis, typhus, plague, bacillary dysentery, and typhoid. The bites of certain arthropods also cause considerable irritation, discomfort, and annoyance.

APPENDIX C

Reservoir Preparation, Maintenance, and Water Level Management in Relation to Mosquito Prevention and Control

Man-made impoundments range in size from large multipurpose reservoirs with thousands of acres to small farm ponds of less than an acre. Mosquito-producing conditions associated with both large and small impoundments are basically similar but vary greatly in magnitude. They include emergent vegetation and/or floating debris in shallow water areas which are protected from wave action; undrained depressions, borrow pits, sloughs, and marshes within the summer fluctuation zone; and rising or constant pool levels which cause the water to remain in relatively flat areas with vegetation for more than four or five consecutive days during the mosquito production season. Several species of Anopheles and Culex mosquitoes, including Culex tarsalis, are frequently produced in impoundments that have protected shallow water areas with emergent vegetation and/or flotage. The flat vegetated areas of reservoirs and ponds, which are alternately inundated and exposed by fluctuating water levels, may also be highly favorable for the production of several species of Aedes and Psorophora mosquitoes. Aedes vexans is one of the most common and widespread of these species. It is almost axiomatic that reservoirs and ponds which are free of vegetation and flotage do not produce mosquitoes.

It is often difficult to control mosquito production on a reservoir that has not been properly prepared prior to impoundage. Clearing and drainage are the principal reservoir preparation measures for mosquito prevention and control. The overall objective of these measures is to prevent or minimize the development of favorable mosquito-producing habitats in any portion of the reservoir which is within flight range of human population.

Clearing includes removal of trees, underbrush, vines, fences, and debris from the reservoir basin. For mosquito control purposes, the normal summer fluctuation zone should be completely cleared except for isolated trees and sparse vegetation located along abrupt shorelines that will be exposed to wave action. It is not necessary to clear timber from the deeper portions of the reservoir basin where it will be completely submerged at normal summer minimum pool elevation. Timber rooted below the normal summer minimum pool level but extending above that elevation may be felled and securely tied down in lieu of disposal. This practice sometimes has advantages in

fisheries management. Where clearing operations extend over several seasons, it is sometimes necessary to remove regrowth from the normal summer fluctuation zone immediately prior to impoundage.

Borrow pits, depressions, marshes, and sloughs which will be flooded when the reservoir is at maximum pool level and which will retain water at lower pool levels may be serious mosquito sources. Drainage ditches should be provided for all such areas, particularly those located within the normal summer fluctuation zone. These ditches should insure complete drainage of the areas when the reservoir recedes and permit fluctuation of water levels in them when the reservoir is at higher elevation. Such drainage ditches may also serve to prevent the stranding of fish when the lake recedes. Logs, drift, and other debris should be removed from natural drainageways and existing ditches where such work is indicated for mosquito prevention and control. Permanent shoreline improvement measures can sometimes be employed to eliminate mosquito-producing areas in reservoirs when the normal summer fluctuation zone is limited to a few feet.

Since the effectiveness of naturalistic, preventive, and permanent mosquito control measures is determined by the amount of clean water surface they create, it is essential that ponds and reservoirs be properly maintained after they have been impounded. Furthermore, maximum mosquito control benefits from water level management can be realized only when impoundments are properly prepared and maintained. Several phases of water level control, such as flood surcharge, constant level pool, cyclical fluctuation, and/or seasonal recession, can sometimes be adapted to various types of impoundments in order to minimize conditions favorable for mosquito production. Certain phases may be used to control vegetation and flotage or they may be used primarily to destroy mosquito larvae. A flood surcharge above the upper normal pool level for a few days in the spring prior to the mosquito production season followed by a sharp drawdown is effective in stranding objectionable flotage. The invasion of marginal vegetation can be limited by holding the reservoir at a constant level during the early spring growth period. This phase is especially important since it increases the effectiveness of subsequent fluctuation and/or recession. Seasonal water level recession alone or in combination with periodic fluctuation is an effective control measure since it provides a clean shoreline which is unfavorable for mosquito production. In some irrigation storage reservoirs, the normal water releases during the growing season usually result in a drawdown that keeps the pool level below encroaching marginal vegetation, thereby providing a clean shoreline that is unfavorable for mosquito production.

Recreational areas, especially those with facilities where people may remain overnight, should be located along sections of the reservoir which have the lowest potential for the production of mosquitoes and other aquatic insects of public health importance. Proper consideration should also be given to terrestrial vector problems in selecting recreational sites. Where necessary, full provision should be made for the prevention and control of both types of vector problems.

APPENDIX D

Principles and Practices for Prevention and Control of Vector Problems Associated with Reservoirs

I. Prevention and Source Reduction Measures

A. For Mosquitoes and Other Aquatic Insects

1. All borrow pits and other potential ponding areas associated with construction of the dam, relocation of highways or roads, etc., which are located above maximum pool level should be made self-draining.

2. Prior to impoundage, the reservoir basins should be prepared as follows:

   a. The normal summer fluctuation zone of the permanent pool should be completely cleared except for isolated trees and sparse vegetation along abrupt shorelines which will be exposed to wave action.

   b. Dense stands of timber rooted below the normal summer minimum pool level but extending above that elevation should be cleared. In some situations such timber may be felled and securely tied down in lieu of disposal.

   c. Borrow pits, depressions, marshes, and sloughs which will be flooded by the reservoir at maximum pool level and which would retain water at lower pool levels should be provided with drains to insure complete drainage or fluctuation of water within them.

   d. If the summer fluctuation zone of the permanent pool is limited to a few feet, consideration should be given to "building out" mosquito-producing areas located within flight range of population groups or recreational areas through the use of measures such as deepening and/or filling. This would minimize the need for repetitive measures for controlling vegetation and mosquito production.

3. After impoundage, the following maintenance measures should be carried out in all potential mosquito-producing areas located within flight range of human population groups or recreational areas frequented by significant numbers of persons:

APPENDIX E

Principles and Practices for Prevention and Elimination of Mosquito Sources Associated with Irrigation

A. Project Conveyance and Distribution Systems

1. Lining or other satisfactory seepage control measures should be provided for all sections of canals and laterals located in porous material where excessive leakage would result in waterlogged areas, seeps, and ponds.

2. Drains should be installed to prevent ponding of excess irrigation water and natural runoff along the upper side of canals and laterals. All drainage crossing or inlet structures should be placed on grade to avoid ponding.

3. Borrow areas should be self-draining to keep them from retaining ponded water.

4. Where possible, provision should be made to prevent turnouts and other hydraulic structures from retaining residual water when they are not being used.

5. Effective measures should be provided to prevent ponding of leakage from water control structures.

6. Every effort should be made to establish delivery schedules which will provide farmers with adequate but not excessive amounts of water at proper intervals to insure efficient irrigation of the crops concerned.

7. Vegetation and debris which would retard normal flows should be periodically removed from conveyance channels, water control structures, and drains.

B. Project Drainage Systems

1. Trunk drainage systems should be installed to insure complete removal and proper disposal of excess irrigation water, natural runoff, and seepage from both irrigable and non-irrigable lands affected by the distribution and use of irrigation water on the project.

2. Drainage ditches should be designed, constructed, and maintained so as to minimize ponding in the channels and to insure free flows at all times.

3. Provision should be made to prevent water from ponding behind spoil banks.

4. Underdrains, culverts, inlets, etc., should be placed on grade to prevent ponding.

C. Irrigated Farms

1. The sponsoring agency and other organizations concerned with irrigation agriculture or mosquito control should do everything possible to encourage irrigation farmers to use the following irrigation and drainage practices which will prevent or minimize mosquito sources:

   a. The farm supply system, drainage system, and field layouts should be properly fitted to the topography, soil, water supply, crops to be grown, and irrigation methods to be used.

   b. All surface irrigated fields should be properly leveled or graded to provide for efficient water application and removal of excess water without ponding.

   c. An adequate drainage system should be provided for removal of excess water from all portions of the farm.

   d. Irrigation methods should be used which will provide optimum irrigation efficiencies.

   e. Application of irrigation water should be limited to that required to fill the crop root zone plus unavoidable losses and excess water needed to prevent upward movement of salts.

ATTACHMENT

Summary of Pertinent Information Concerning the Proposed Santa Rosa Wash Flood Control Project, Pinal County, Arizona

The following information concerning the proposed project has been abstracted from the Corps of Engineers' report entitled "Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona," dated March 31, 1963.

RECOMMENDED PLAN

The recommended plan for Santa Rosa Wash provides for (a) a multiple-purpose dam and reservoir on Santa Rosa Wash at the Tat Momolikot site (river mile 43.4) and about 6½ miles upstream from the Indian Village of Vaiva Vo, Arizona, and (b) the development of 1,640 new acres of cultivated land in the Vaiva Vo irrigation project on the Papago Reservation downstream from the dam. The water supply distribution system would consist of a (a) main supply canal that would receive water from the dam and would deliver the water to laterals in the area proposed for irrigation development, (b) 13 wells and pumps along the laterals and the main canal to utilize the ground-water supplies, and (c) ponds at the upper end of the main canal to increase the ground-water recharge. These ponds would also be used as fish ponds. Recreation and hunting facilities would be located in the reservoir area and in the area of the fish ponds.

The Corps of Engineers' report recommends that (1) the Corps of Engineers construct Tat Momolikot Dam, St. Clair Reservoir, wildlife, and recreational facilities in the reservoir area and (2) the Bureau of Indian Affairs construct the irrigation, recreation, fish and wildlife improvements downstream from Tat Momolikot Dam.

Tat Momolikot Dam and Reservoir

The dam at the Tat Momolikot site would impound a reservoir (Lake St. Clair) of 181,000 acre-feet capacity with surface area of about 12,000 acres. About 2.3 miles of the road connecting Casa Grande with Sells, Arizona, would be raised in the reservoir area. Operation of the reservoir would develop an annual safe yield of 4,760 acre-feet, of which 3,620 would be released for direct irrigation of project lands and for maintenance of fish ponds, and 1,140 would be injected into underground storage.

Vaiva Vo Irrigation Project

The Vaiva Vo irrigation project, as developed by the Bureau of Indian Affairs, would be located on the gentle slope on the west side of the Santa Rosa Valley between the Tat Momolikot damsite and a point approximately 2 miles north of the village of Vaiva Vo, a

distance of about 8 miles. Surface runoff from the land adjoining the project on the west will be intercepted by diversion channels constructed to direct the runoff water to selected wasteways.

The main supply canal would receive irrigation water at the downstream toe of the Tat Momolikot Dam from the gated outlet conduit. The canal, which would have a capacity of 80 cubic feet per second, would be approximately 6 miles long. It would supply water to fill the ponds to be used for ground-water recharge and for the propagation of fish, as well as to supply the project irrigation demand. Laterals would be concrete-pipe conduits. Approximately 1-3/4 miles of open concrete-lined ditch lateral would be constructed to deliver water to the existing ditch, which supplies water to the approximately 200 acres of the lands presently irrigated in the project.

Adequate embankment material is available adjacent to and downstream from Tat Momolikot Dam. The borrow pits remaining after construction of the dam may be utilized as fish ponds. The fish ponds, which would be interconnected, would have an area of approximately 50 acres. The ponds will also serve as settling basins to clarify water to be injected in ground-water recharge wells.

Recreational, Fish, and Wildlife Facilities

Recreation and hunting facilities, consisting of access roads, ramps, sanitary facilities, and parking areas, would be provided in the northeastern area of the reservoir. Joint-use facilities for recreation, fish, and wildlife would be provided at and in the vicinity of the ponds downstream from the dam. These facilities would include picnic areas, playgrounds, maintenance buildings, parking areas, boat docks, and utilities. The favorable year-round climate and the proximity of the Phoenix and Tucson metropolitan areas to the proposed reservoir would appreciably contribute to the value of the recreational features.

U. S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F

6 August 1963

Mr. Paul Eastman
Regional Program Director
Water Supply and Pollution Control
Public Health Service, DHEW
447 Federal Office Building
San Francisco 2, California

Dear Mr. Eastman:

Thank you for the constructive comments contained in your letter of 9 May 1963, with regard to the interim report for flood control, Santa Rosa Wash, Arizona.

Studies made by the U.S. Geological Survey show that very little ground-water recharge from surface flow occurs in this area except in streambeds. When flow occurs, considerable lateral seepage is lost by evaporation and transpiration. Only rare floods produce flows of sufficient duration to appreciably affect ground-water recharge.

The U.S. Geological Survey also estimates that the natural underground recharge passing the damsite is about 2,000 acre-feet per year. The Bureau of Indian Affairs estimates that approximately 1,000 acre-feet of this amount would be consumed by the Vaiva Vo irrigation project. This amount is extremely small as compared to the present 470,000 acre-feet presently being pumped for irrigation in the Maricopa-Stanfield area. On the other hand, flood-control operation would prolong floodflows and would permit increased recharge from surface waterflow. It is believed that this increased recharge would more than compensate for the ground water withdrawals.

If the project is authorized, recommendations contained in your vector evaluation will be given full consideration in the detailed design studies. In accordance with your suggestion, a copy of the vector evaluation is being made available to the Bureau of Indian Affairs. That agency will probably maintain and operate the entire project.

SPLGP-F
Mr. Paul Eastman

6 August 1963

It should be noted that the design discharge of the main supply canal for the Vaiva Vo irrigation project, as indicated on page 17 of the vector analysis, has been reduced from 80 to 60 cubic feet per second.

Your continued cooperation in our water resource planning activities is appreciated.

Sincerely yours,

/s/ EARL G. PEACOCK
Colonel, Corps of Engineers
District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
TOPOGRAPHIC DIVISION
345 Middlefield Road
Menlo Park, California
Davenport 5-6761

June 10, 1963

Lt. Col. W. S. Crumlish
Acting District Engineer
Corps of Engineers
751 South Figueroa Street
Los Angeles 17, California

Dear Col. Crumlish:

Reference is made to your letter SPLGP-F dated May 28.

As of this date we do not have substantial comment on your report "Survey for Flood Control, Santa Rosa Wash, Arizona."

Very truly yours,

/s/ Robert O. Davis
Pacific Region Engineer

HOUSING AND HOME FINANCE AGENCY
OFFICE OF THE REGIONAL ADMINISTRATOR
989 Market Street
San Francisco 3, California

REGION VI

June 7, 1963

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

In reference to your "Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona," the subject of your letter of May 28, 1963, please be advised that we have no projects at present which would be affected by a flood-control program in that locality.

Sincerely yours,

Paul Emmert
Regional Director,
Community Facilities

ARIZONA HIGHWAY DEPARTMENT

Phoenix 7, Arizona

10 June 1963

District Engineer
U. S. Army Engineer District,
Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

RE: SPLGP-F
Interim Report on Survey for Flood
Control, Santa Rosa Wash, Arizona

Dear Sir:

In accordance with your letter of 11 April, I have reviewed the subject report which recommends a multiple-purpose project for the Santa Rosa Wash.

It has been shown that the improvements are feasible from an engineering and economic standpoint, and that local interests have expressed, by resolution, their agreement to the plan and their willingness to provide the local cooperation required. It should be noted that all water rights must be resolved as a condition to the project.

In view of the advantages noted, I therefore concur with the recommendations of the District Engineer.

Very truly yours,

/s/ MARTIN TONEY
Engineer of Bridges and Dams

MT:hh

cc: Gov. Paul Fannin

ARIZONA GAME & FISH DEPARTMENT
State Office Building
Phoenix 7, Arizona

May 7, 1963

Air Mail

District Engineer
U. S. Army Engineer District, L. A.
P. O. Box 17277, Foy Station
Los Angeles 17, California

Re: File No. SPLGP-F
Santa Rosa Wash, Arizona

Dear Sir:

We appreciate the opportunity to review and comment on the Preliminary Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona. As suggested in your transmittal letter of April 11, 1963, we have discussed the project as provided in the report with Mr. Martin Toney, Engineer of Bridges and Dams, Arizona Highway Department.

The Arizona Game and Fish Department has been interested in this proposed project throughout much of the preliminary engineering considerations. Our letter dated May 22, 1961, to Robert H. Rupkey, Engineer, Bureau of Indian Affairs, Phoenix office, discusses various aspects of the proposed project. Some reference to the information contained therein is included in your interim report.

Our Department concurs fully in the proposals to include in the project the four fishing ponds below the dam and the proposed recreational area is discussed in the interim report and shown on Plate 4 and Appendix 2, Plate 1. We are certain they will prove of great benefit to southern Arizona residents and of monetary value to the Papago Indian Tribe. We note with interest that one of the irrigation wells is proposed for use in maintaining the lake should sufficient runoff water not be available at times.

Reference is made to the use of the four ponds totaling 50 surface acres for water skiing and we would like to express the thought that if such use is permitted on all of the ponds it will probably curtail greatly other water oriented recreation uses.

District Engineer May 7, 1963

Our Department appreciates the opportunity of working with the Corps of Engineers and the Bureau of Indian Affairs in this project in conjunction with the Bureau of Sport Fisheries and Wildlife. If we can be of further assistance throughout the project activities do not hesitate to call upon us.

Sincerely,

R. J. Smith, Director

/s/ By: O. N. Arrington, Chief
Special Services

ONA:o

cc: Bureau of Indian Affairs
U. S. Fish and Wildlife Service
Martin Toney, Arizona Highway Department

U. S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F

29 July 1963

Mr. R. J. Smith
Director
Arizona Game and Fish Department
State Office Building
Phoenix 7, Arizona

Dear Mr. Smith:

Thank you for your concurrence in the recreation and fish and wildlife features recommended in the proposed interim report on survey for flood control, Santa Rosa Wash, Arizona, as indicated in your letter of 7 May 1963.

While this office will not be responsible for development of the details of the recreational features at the ponds to be located downstream from the dam, we are agreed that water skiing should be planned so as to minimize its adverse effect upon fishing and hunting activities. We are confident that the Bureau of Indian Affairs will give full consideration to your comments.

Sincerely yours,

/s/ EARL G. PEACOCK
Colonel, Corps of Engineers
District Engineer

ARIZONA GAME & FISH DEPARTMENT

105 State Office Building Phoenix 7, Arizona 271-4295

May 22, 1961

Mr. Robert H. Rupkey, Engineering Division
Bureau of Indian Affairs
P. O. Box 7007
Phoenix, Arizona

Dear Mr. Rupkey:

This is in reference to your request for our evaluation of fish and wildlife benefits which can be expected to result from a 50 surface acre recreational impoundment in connection with the proposed multipurpose dam on Santa Rosa Wash at the Vaiva Vo site near the north boundary of the Papago Indian Reservation. As discussed over the phone, our delay in replying has been the result of the proposed change in methods of evaluating federal water construction projects by the U. S. Fish and Wildlife Service through the use of a schedule of values assigned to hunting and fishing by the Inter-Agency Committee on Water Resources. The game and fish departments of the southwestern states have not agreed to accept this schedule for their use in preparing reports authorized by the Coordination Act, P.L. 85-624.

This letter may be considered as our Department's preliminary evaluation of the proposed 50 surface acre Vaiva Vo Lake subject to revision after further engineering details have been developed by your office and the Corps of Engineers. We appreciate the opportunity to offer our comments.

We are attaching herewith a copy of our statement before the Senate Select Committee on National Water Resources. On Pages 4 and 5 you will find a discussion of the economic value of fish and wildlife resources in Arizona with particular reference to a survey of expenditures of hunters and fishermen conducted by the Department in 1956. A comparable survey is currently being conducted for our Department by the University of Arizona Bureau of Business and Public Research. You will note that fishermen expenditures alone in the State in 1956 amounted to the equivalent of $1,000 per surface acre of fishing water within the borders of the State, excluding the Colorado River. The Colorado and its lakes were not included because the majority of those fishing there come from California, Nevada and other states and made their expenditures outside Arizona.

Therefore, on a statewide basis, a 50 surface acre lake would be expected to result in an expenditure of at least $50,000 annually by fishermen alone, based on 1956 costs and 1956 fishing license holders. Both have increased.

The application of this $1,000 per surface acre value cannot be made to every area of the State. Isolation, poor access, a short season of use as in the high mountainous country, distance from population centers, success of fishery management and other factors will result in some lakes receiving less use than others. Thus, if $1,000 per surface acre is the average annual expenditure within the State, some isolated, seasonal, low fish population lakes are certain to result in less than a $1,000 per surface acre annual expenditure. Conversely, lakes easily accessible near populated centers in yearlong mild climate are certain to result in fishing expenditures of more than $1,000 per surface acre if they can be managed for optimum fish production and have even a minimum of public recreational inducements.

The proposed Vaiva Vo Lake will be located approximately 15 miles south of Highway 84 between Gila Bend and Casa Grande, and less than 20 miles from transcontinental Highway 93 between Tucson and Phoenix. Thus the proposed impoundment will be readily accessible and will lie between the two major population centers of the State. The distance by road from either Phoenix or Tucson is about 70 miles, almost all paved highway. The population of the metropolitan areas of both cities is in excess of 700,000. Pinal County another 65,000; about 65% of the State total. Undoubtedly the proposed, centrally located lake in a yearlong mild climate, near tourist centers will attract maximum recreational use. Expenditures of fishermen alone can be expected to exceed $1,000 per surface acre, or $50,000 annually under a present day economy.

It is contended by some that expenditures of hunters and fishermen cannot be used in making estimates of recreational hunting and fishing benefits comparable to other benefits resulting from a water development project because the other benefits are based on market values. Those supporting the use of sportsmen expenditure figures obtained from the National Surveys of the U.S. Fish and Wildlife Service and comparable State surveys contend those receiving the sportsman's dollars pass them on to others in business and living requirements, the same as the dollars received by the farmer for farm products. In assigning flood control benefits the cost of replacing a building, bridge or fence is determined by the dollar expenditure necessary to reconstruct it. In that these contentions have many facets which have not been satisfactorily resolved, we will use approaches other than the $1,000 per surface acre value for fishing to develop alternate estimates of the recreational value of the proposed 50 surface acre lake at Vaiva Vo.

The 50 surface acre Pena Blanca Lake constructed by our Department and first opened to fishing in 1958 is located 18 miles northwest of Nogales, 12 miles from Highway 89 over a narrow, winding gravel road. Recreational use has been measured by U.S. Forest Service road counters and analyzed by University of Arizona Wildlife Research Unit personnel. Annual visitations total approximately 115,000. Only about 30,000 or 26% are fishermen. Of the 85,000 non-fishermen annually 28% gave touring or sightseeing as the purpose of the trip; 26% picnicking; 9% swimming; 4% boating; 4% hiking; 3% camping.

The 50 surface acre Woods Canyon Lake was constructed by our Department in 1956 on the Mogollon Rim approximately 30 miles from Payson, 60 from Winslow and 120 from Phoenix. Sitgreaves National Forest personnel with the aid of entrance road counters tabulated over 46,000 visitors on weekends only during the five summer months of 1960. There was no breakdown of recreational pursuits, although fishing is a major incentive. However, it has not yet become a high producing lake, the catch per man has been comparatively low and the fish generally small.

Woods Canyon is not near a population center and the gravel roads to it certainly do not provide the paved highway access that Vaiva Vo will enjoy. If the lake were in a yearlong recreational area, those using it for fishing alone would surely equal or exceed the 30,000 that visit Pena Blanca Lake to fish annually.

From the above known use figures on 50 surface acre Pena Blanca Lake, augmented by known figures from 50 surface acre Woods Canyon Lake, both artificially created away from population centers with poor access, it can be conservatively estimated that the proposed Vaiva Vo Lake on an Indian Reservation, readily accessible and closer to 65% of the State's population, will attract at least 30,000 anglers annually, excluding those interested in other recreational pursuits, if it is managed for optimum fish production.

The attached schedule of the Inter-Agency Committee on Water Resources which has been proposed for use by federal construction agencies, but has not been considered acceptable by southwestern game and fish departments, places a maximum value of $1.00 to $3.00 per recreational day for cold water and bass fishing on a stream or lake, 50¢ to $1.50 per day for warm water fishing. In an area without nearby lakes in arid Arizona, surely the $1.50 per day must be assigned to Vaiva Vo as a warm water lake for an annual value of $45,000 from 30,000 one-day angler visits. Bass fishing would be a major attraction at Vaiva Vo and thus it might be considered reasonable to assign a mid-range figure of $2.00 for "bass fishing" for an annual value of $60,000. These figures are comparable to the $1,000 per surface acre evaluation developed through the use of fishing expenditures in 1956.

The estimated value of Vaiva Vo for hunting has been developed by Wes Fleming, Department waterfowl biologist for the past ten years. The proposed impoundment is strategically located to attract a maximum number of waterfowl during migration and to hold waterfowl for wintering purposes. The lake would lie 60 miles east of the Painted Rock-Theba area; 30 miles west of Picacho Lake; 60 miles south of Papago Park and 60 miles southeast of the Arlington-Buckeye areas. The above mentioned areas hold a wintering population of ducks that average 15,300. This number represents an average of 60% of all ducks that are counted on the mid-winter waterfowl inventory that takes place annually during the first week in January in cooperation with the U.S. Fish and Wildlife Service. The proximity of the proposed development to the Casa Grande-Maricopa agricultural area would further enhance the value of the lake for waterfowl as a wintering and migration resting area.

A body of water the size of the proposed lake would attract and hold migrating birds that would serve as a huntable population in a wide area to the north and in the scattered tanks to the south, east and west. Band returns from waterfowl banded during the season in the Salt River Valley show that an average of 5.5% of the banded birds were killed the same season they were banded. Only four of the 82 returns were from out of state. The sample was 1,490 banded ducks. Studies have established that approximately 1/3 of the hunters report the taking of banded birds. Therefore, approximately 15% of a winter population of ducks in the Salt River Valley are bagged by hunters. The removal would be higher if the bands could be placed on the birds soon after they enter the watering area. Thus the 15% removal represents a minimum figure.

The location of the proposed lake is near the center of a human population which provides 50% of the State's duck hunters. This estimate is from duck stamp sales in Phoenix, Tucson, Casa Grande, Chandler, Mesa and Gila Bend. The total stamp sales in Arizona vary between 7,500 to 12,000 annually. Therefore, a portion of the 3,750 to 6,000 hunters living near the proposed lake could take advantage of increased populations and habitat resulting from the development.

To gain some predevelopment estimate of the number of ducks that would use the lake as a wintering area, the following waterfowl counts are presented:

Papago Park	25 acres	3,000 - 6,000 ducks
Ramsey Pond	10 acres	8,000 - 10,000 ducks
Picacho Lake	Variable	3,000 - 11,000 ducks
Recker Pond	3 acres	2,000 - 3,000 ducks
Painted Rock	200 acres	1,000 - 3,500 ducks
Arlington and Buckeye Ponds	40 acres	8,000 - 32,000 ducks

Assuming the proposed lake is managed as a resting area, it is reasonable to expect a wintering population of some 4,000 to 8,000 ducks.

Using the above harvest percentage estimate of 15% and assuming an average of 6,000 ducks, a harvest in the area affected by the proposed lake could be expected to reach 900 ducks from the wintering population. A value of $5.00 per duck bagged has been substantiated and used as a conservative figure in Arizona and other states. This places the value of Vaiva Vo at $4,500 annually for waterfowl benefits.

Hunters in southern Arizona have averaged 1.4 ducks per day. Thus the 900 birds bagged would provide for 642 duck hunting recreational days. The Inter-Agency Committee on Water Resources schedule places the recreational value for waterfowl hunting at $1.50 to $4.50 per day. It seems reasonable to use the maximum figure for an arid region such as southern Arizona. Therefore the annual value of duck hunting based on the above schedule would be $2,889.00 for the assumed wintering population.

The migration of birds passing through the southern part of the State is a group independent of the wintering population affecting the banding studies. To estimate the volume of this migration it becomes necessary to apply the hunting success from areas to the south of Vaiva Vo. Duck hunt questionnaire data in 1956-57 season showed that 2,050 hunters hunted the Tucson-Nogales area and took an average of 7.3 ducks per season for a total harvest of 14,665 ducks. To obtain a harvest of this number the volume of movement through Santa Cruz Valley, Altar Valley and the Papago Indian Reservation to Mexico must be substantial. The assumption of a 20% removal of the migrating birds would place the volume at 73,325 ducks. Assuming further, that the development would influence only 10% of this movement, 7,333 would stop at the 50 acre resting area. It seems logical that a portion of these migrants would remain on the lake for several days, forage in the surrounding habitat and be available for hunting recreation. A 5% kill of the birds would add 367 ducks in the hunter's bag directly attributable to the increased habitat of the proposed lake. The kill of migrants represents 261 recreational days. At $4.50 per day an annual value is $1,174.00.

The combined total of the above estimates of recreational values from duck hunting attributable to the proposed Vaiva Vo Lake using the Inter-Agency schedule is $4,060.00

Using the $5.00 per duck bagged figure, the combined total will place the recreational value of the Vaiva Vo Lake for waterfowl hunting at $6,300.00 annually.

In summary, the above estimates of the value of the proposed Vaiva Vo Lake for fishing and hunting ranges from $49,000 to $66,000. Therefore, our Department will place the estimated value of these two recreational pursuits conservatively at $55,000.

The Bureau of Reclamation has had under consideration for some time a multi-purpose dam at what is known as the Buttes site about 14 miles by road northeast of Florence. The maximum pool will contain about 5,500 surface acres, the conservation and sediment storage pool about 4,000 acres, the flowline for irrigation gates 800 surface acres and a dead storage of 300 surface acres. A continually maintained lake of 200 surface acres will result in a permanent fishing and recreational facility.

The National Park Service has prepared a preliminary planning report on the development of the Buttes Reservoir for recreational use, dated December, 1958. The following are excerpts from the above report:

> "(The 200 surface acre lake) will provide a much needed additional area to help satisfy a growing demand for aquatic recreation in this heavily populated region of Arizona."
>
> "Although the operation of the reservoir is not conducive to intensive recreational development, adequate and well planned facilities for day-use will be used."
>
> "The rejuvenation of the copper mining industry and the construction of new smelters at Hayden and San Manuel have increased the wealth and population of the communities upstream from the reservoir."
>
> "If fishing can be realized in this reservoir, this will be another popular recreational use."
>
> "(The area) must be designed to withstand intensive use."
>
> "Many economic benefits are generated from the availability of adequate recreational facilities at water control projects. However, a long study of the subject has convinced economists of the National Park Service that such benefits cannot be measured scientifically in monetary terms. The Service, however, believes that its experience warrants a 'judgment value' approach to assigning certain monetary values to potential recreation benefits of such projects.

An estimate in monetary terms of the recreation values of a reservoir with development as proposed is based on the estimated number of visitors expected to use the area, multiplied by a visitor day factor. Research by statisticians of the National Park Service has produced a factor or derived monetary value of $1.60 per visitor day for all types of recreation.

Therefore, it is conservatively estimated that 150,000 people will visit Buttes Reservoir annually. Using the factor of $1.60 per visitor day, the annual monetary recreational benefit of this project would equal $240,000."

The above evaluations are for recreation only, excluding fishing, for a 200 surface acre lake with a fluctuating shoreline which is "not conducive to intensive recreational development." To compare the estimated recreational value of this 200 acre lake with the proposed 50 surface acre lake at Vaiva Vo, in a comparable area adjacent to the same population centers, the estimated recreational use for Buttes can be divided by four. This would place the estimated recreational use, exclusive of fishing and hunting, at 37,500 people annually and an annual monetary value of $60,000. These uses would include camping, picnicking and the attraction of the public to any water in arid southern Arizona.

We trust the above preliminary analyzation will be of value to your agency and to the Corps of Engineers in providing for a needed recreational facility in connection with the proposed Santa Rosa Wash multipurpose project. As your engineering analyzations progress, we will appreciate being advised if we can be of further assistance in any way.

Sincerely,

R. J. Smith, Director

/s/ By: O. N. Arrington,
Lands Division

ONA:gfh

ADDRESS REPLY TO
P.O. Box 388
Sacramento 2, Calif.

The Resources Agency of California
DEPARTMENT OF WATER RESOURCES

1120 N Street, Sacramento

June 28, 1963

Colonel Earl G. Peacock
District Engineer
U. S. Army Engineer District
Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Colonel Peacock:

Your proposed "Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona, (with Appendixes)" was received on May 23, 1963. This department has reviewed the report in accordance with the provisions of Public Law 534, Seventy-eighth Congress, Second Session.

It is understood that the Colorado River Board of California has already submitted its comments on the report.

According to the report, the recommended project would provide for the construction of a multiple-purpose dam and reservoir on Santa Rosa Wash, in the southern part of Arizona principally for flood control and irrigation at an estimated cost of $6,430,000, including $995,000 for irrigation works.

Our review of the report indicates that the interest of the State of California in the Colorado River would not be prejudiced by the proposed developments.

The opportunity to review your report is appreciated.

Sincerely yours,

/s/ WM. E. WARNE

Director

STATE OF CALIFORNIA
COLORADO RIVER BOARD OF CALIFORNIA
909 South Broadway
Los Angeles 15

May 8, 1963

Colonel Earl G. Peacock
District Engineer
U. S. Army Engineer District
P. O. Box 17277, Foy Station
Los Angeles 17, California

Colonel Peacock:

This is in reference to the letter of April 11, 1963, from Mr. Edward Koehm, Chief, Engineering Division, transmitting a copy of your proposed preliminary "Interim Report on Survey for Flood Control, Santa Rosa Wash, Arizona" for our review and comment.

We note that the project would be a multipurpose project which would provide, among other things, flood protection and irrigation benefits.

It appears that the interests of California and its agencies in the Colorado River would not be prejudiced by the proposed developments.

Receipt of the report and the opportunity to review it are appreciated.

/s/ Dallas E. Cole
Chief Engineer

GWL:dd

APPENDIX 7 - RESOLUTIONS BY LOCAL INTERESTS

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ., AND N. MEX.

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APPENDIX 7 - RESOLUTIONS BY LOCAL INTERESTS

SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ., AND N. MEX.

RESOLUTION OF THE PAPAGO COUNCIL

RES. NO. 1239

NOW, LET IT BE RESOLVED BY THE PAPAGO INDIAN TRIBAL COUNCIL, THAT

Recognizing the advantages that will accrue to the Sif Oidak District and to the Papago Indian Reservation from construction of a multiple-purpose dam and reservoir on Santa Rosa Wash about 6-1/2 miles upstream from Vaiva Vo, Arizona, for water conservation, fish and wildlife, recreation, and flood control not only in the present generation but also to future generations, the Papago Indian Tribal Council with consent of the Sif Oidak District herewith goes on record approving and supporting the proposed construction of the multiple-purpose reservoir, subject to the following agreements, considerations, and understandings:

a. The dam, reservoir, and appurtenances will be turned over to the Bureau of Indian Affairs, U. S. Department of the Interior, for operation and maintenance, subject to flood-control operation regulations to be prepared by the Secretary of the Army.

b. All monetary proceeds from operation of the water conservation, fish and wildlife, and recreation features of the project, less replacement, operating, and maintenance expenses, will accrue to the Papago Indian Tribe.

c. The Papago Indian Tribal Council agrees to make available to the United States (1) appropriate rights to those lands required for construction of the dam and appurtenances, and (2) appropriate rights to those lands that would be required for construction of a water-conservation reservoir. Rights-of-entry to the damsite and vicinity will be granted to personnel and equipment engaged in preconstruction activity, construction work, and subsequent operation, maintenance, and periodic inspection of the improvement. The Council, however, understands and expects that a fair and equitable settlement will be made to the Papago Indian Tribe for the use of the additional lands required to provide the flood-control facilities. (Such lands will be located above elevation 1,535 feet, the proposed elevation of the emergency spillway for the water-conservation reservoir, and below elevation 1,547 feet, the proposed elevation of the spillway for the multiple-purpose reservoir.)

With respect to the Indian burial ground (located near Tat Momolikot), we have been informed that the burial ground would be protected by a levee and that an access road would be provided, all at no cost to the Papago Indian Tribe.

We also understand that a fair market value will be paid to the owners for all residences and improvements, including the village of Tat Momolikot, regardless of the location of these improvements within the reservoir area.

We understand further that the community facilities, such as the well and the community church, will be relocated, if desired by Tat Momolikot Village.

We understand that the responsibility of naming the proposed dam and reservoir resides with the Papago Indians.

The foregoing Resolution was on May 4, 1962 duly enacted by a vote of 13 for, 3 against, and 4 not voting, by the Papago Council, pursuant to authority vested in it by Sec. 2 (a) Article V of Constitution of the Tribe, ratified by the Tribe on December 12, 1936, and approved by the Secretary of the Interior on January 6, 1937, pursuant to Section 16 of the Act of June 18, 1934, (Stat. 984), and amended to add Article (1) on April 9, 1960, by the Papago Tribe, and approved May 9, 1960, by the Secretary of the Interior. Said ordinance is effective as of the date of its approval by the Superintendent of the Papago Agency, and is subject to the rescission by the Secretary of the Interior pursuant to Section 6, Article V of the Constitution and By-Laws of the Papago Tribe.

THE PAPAGO COUNCIL

/s/ BY: Enos J. Francisco
Enos J. Francisco
Chairman

ATTEST:

/s/ Claudina R. Chavez
Claudina R. Chavez, Secretary

RESOLUTION OF PINAL COUNTY BOARD OF SUPERVISORS

R E S O L U T I O N

Whereas, act of Congress, Public Law 761, Seventy-fifth Congress, approved June 28, 1938, authorized a preliminary examination and survey for flood control on the Gila River and tributaries, Arizona and New Mexico; and

Whereas, a multiple-purpose project for flood control, irrigation, fish and wildlife, and recreation along Santa Rosa Wash is being considered in an interim report on survey under preparation by the District Engineer, U.S. Army Corps of Engineers, at Los Angeles, California, in coordination with the Area Director, Bureau of Indian Affairs, Phoenix, Arizona;

Whereas, protection against damage from floods originating upstream from the proposed damsite would be provided to property along Santa Rosa Wash by a dam under consideration for construction by the United States upstream from Vaiva Vo, Arizona; and

Whereas, Section 3 of Public Law 738, Seventy-fourth Congress, provides that no money appropriated shall be expended on the construction of any project until States, political subdivisions thereof, or any other responsible local agencies have given assurances satisfactory to the Secretary of the Army that they will assume certain enumerated obligations; and

Whereas, Arizona Revised Statutes, Article 2, Title 45, Chapter 10, Section 45-2323, authorizes the Board of Supervisors of any county, separately or severally, to cooperate with the United States for the construction of a flood-control project within any such county or counties for local flood protection, as authorized by any act of Congress; and

Whereas, the Board of Supervisors of Pinal County has considered the need for flood control along Santa Rosa Wash and has agreed that it go on record as supporting the flood-control program under consideration by the United States Army Engineers;

Now, therefore, be it resolved by the Board of Supervisors of Pinal County, that, if a multiple-purpose project, which would include a dam upstream from Vaiva Vo to control flows along Santa Rosa Wash, be found economically feasible and be authorized by act of Congress, the Board of Supervisors of Pinal County will participate to the best of its ability by assuming the following obligations:

a. Establish and enforce floodway limits and regulations for Santa Rosa Wash from the north boundary of the Papago Indian Reservation to Santa Cruz River (excluding Indian land), and maintain the hydraulic capacity of the existing channel.

b. Hold and save the United States free from damages (downstream from the Papago Indian Reservation) arising from construction, maintenance, and operation of the works for flood control.

c. Hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the proposed project for flood control.

Be it further resolved that this resolution be entered in the minutes of the Board of Supervisors of the County of Pinal and that the clerk of said county be, and she is hereby directed to forward a certified copy of this resolution to the District Engineer, U. S. Army Engineer District, Los Angeles, Corps of Engineers, P. O. Box 17277, Foy Station, Los Angeles 17, California.

Passed and approved by the Board of Supervisors of Pinal County this 27 day of August, 1962.

/s/ Jay Bateman
Chairman

/s/ David C. Davis

/s/ Estill Osborn

ATTEST:

/s/ Ann Edens

CERTIFICATION

I, Ann Edens, the duly appointed and qualified clerk of the Board of Supervisors of Pinal County, Arizona, do hereby certify the foregoing is a true and correct copy of a resolution adopted by the said Board of Supervisors on Aug. 27, 1962.

/s/ Ann Edens
Clerk

SUPPLEMENT

INFORMATION CALLED FOR BY
SENATE RESOLUTION 148

SANTA ROSA WASH, ARIZONA
GILA RIVER BASIN, ARIZ., AND N. MEX.

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SANTA ROSA WASH, ARIZ.
GILA RIVER BASIN, ARIZ. AND N. MEX.

Information called for by
Senate Resolution 148, 85th Congress
Adopted January 28, 1958

1. Problems considered.--This report considers the flood, water conservation, fish and wildlife, recreation, and area redevelopment problems in Santa Rosa Wash Basin, Ariz. The basin is about 70 miles south of Phoenix, Ariz., and 70 miles northwest of Tucson, Ariz. Santa Rosa Wash, which is a tributary of the Santa Cruz River (a tributary of the Gila River above the Salt River), comprises about 2,400 square miles. This report is concerned primarily with the flood problems on Indian and non-Indian lands along Santa Rosa Wash downstream from Tat Momolikot damsite in the Papago Indian Reservation and with related water conservation, area redevelopment, recreation, and fish-and-wildlife development in the Papago Indian Reservation.

2. Floodflows in excess of 5,000 cubic feet per second overtop the banks and cause major damage to agricultural, residential, commercial, public, industrial, irrigation, transportation, and utility properties downstream from the Papago Indian Reservation. Such flows would also cause major damage to lands, crops, and irrigation facilities in the Vaiva Vo irrigation project under consideration for the Papago Indian Reservation by the U.S. Bureau of Indian Affairs.

3. Consideration was given to the needs of the Papago people for irrigated land as a source of food and income. Consideration was also given to the need (as determined by studies of the U.S. Fish and wildlife Service and the Arizona Game and Fish Department) for such recreational and fish-and-wildlife facilities as could be incorporated in a multiple-purpose project.

4. Recommended improvement.--The Santa Rosa Wash multiple-purpose project, which would be wholly within the Papago Indian Reservation, would provide for the Tat Momolikot Dam and St. Clair Reservoir, the Vaiva Vo irrigation project, and related recreational and fish-and-wildlife facilities. Some area redevelopment benefits would be realized from the recommended plan. Pertinent information on the plan of improvement is given in the following subparagraphs.

(a) Tat Momolikot multiple-purpose-dam project.--Tat Momolikot Dam would be an earthfill structure about 66 feet high above streambed and 3 miles long extending across Santa Rosa Wash at a point about 6-1/2 miles upstream from Vaiva Vo, Ariz.

(b) St. Clair Reservoir would provide a storage capacity of 181,000 acre-feet, including 126,000 acre-feet for flood control, 15,000 acre-feet for water conservation, and 40,000 acre-feet for 100-year sediment accumulation. The reservoir design-flood peak

inflow of 55,000 cubic feet per second would be reduced to a maximum peak outflow of 4,600 cubic feet per second through an ungated notch in the spillway. About 87 percent of the average annual flood damages downstream from the dam would be prevented. The ungated spillway would reduce the spillway design flood from a peak inflow of 270,000 cubic feet per second to a peak outflow of 140,000 cubic feet per second without endangering the dam.

(c) A gated outlet structure (capacity 60 cubic feet per second) would be constructed through the dam for drainage purposes and to release an average annual amount of 4,760 acre-feet of conservation water for use in the Vaiva Vo irrigation project.

(d) Public facilities would be provided in the reservoir area for boating, water skiing, and wild fowl hunting.

(e) Vaiva Vo irrigation project.--The Vaiva Vo irrigation project would extend for about 6-1/2 miles along the west bank of Santa Rosa Wash from a point just downstream from the dam to Vaiva Vo, Ariz. About 1,640 net acres of irrigable land would receive water from St. Clair Reservoir through a distribution system. Wells installed along laterals and the main distribution canal would supplement the irrigation supply during periods when water was unavailable from St. Clair Reservoir.

(f) Several ponds with a total area of about 50 surface acres would be constructed just downstream from Tat Momolikot Dam to (1) assist in recharging the underground water supply, and (2) provide areas for fishing, picnicking, and camping, and for use as a wildlife habitat. A well would be provided to maintain water in the ponds when water was unavailable from the reservoir in order to maintain the ponds as fisheries.

5. Project costs.--Estimated first costs for recommended project, based on September 1962 prices, are as follows:

Item	Estimated first cost (all Federal)
Tat Momolikot Dam and St. Clair Reservoir.....	$5,360,000
Vaiva Vo irrigation project.....	995,000
Recreational facilities.....	40,000
Fish and wildlife facilities.....	35,000
Total.....	6,430,000

The average annual cost (all Federal) for operation and maintenance is estimated at $62,000.

6. Benefit-cost ratio.--Average annual costs and benefits and benefit-cost ratios for the recommended project, developed on the basis of an economic life of 100 years as well as an economic life of 50 years, are given in the following tables. An interest rate of 3 percent was applied - September 1962 prices were used.

Item	Life of project	
	100 years	50 years
Average annual costs (all Federal):		
Interest and amortization	$210,000	$257,000
Maintenance and operation	62,000	62,000
Total	272,000	319,000

Item	Life of project	
	100 years	50 years
Average annual benefits:		
Flood control	527,000	510,000
Water conservation	258,000	250,000
Fish and wildlife	49,000	49,000
Recreation	60,000	60,000
Area redevelopment	11,000	14,000
Total	905,000	883,000
Ratio of benefits to costs	3.3 to 1	2.8 to 1

7. Current and future needs.--The recommended project is feasible from an engineering standpoint.

(a) Operation of the project for flood control would provide substantial protection to agricultural, residential, commercial, public, utility, highway, and railroad properties in the Stanfield-Maricopa area, Ariz. The plan of improvement should meet all the foreseeable justifiable needs of Santa Rosa Wash for protection against damaging floods originating above Tat Momolikot Dam.

(b) The development of 1,640 net acres of irrigated land on the Papago Indian Reservation would result in the raising of the living standards of the Papago Tribe now and in the foreseeable future. The project fully develops the water supply potential of Santa Rosa Wash within the Papago Indian Reservation.

(c) The recreation and fish and wildlife features of the

recommended project would be enjoyed by a large population in the surrounding area indefinitely. The operation of these facilities included in the recommended plan would materially contribute to their growing need in Arizona in the foreseeable future. All proceeds from operation of the project for recreation and fish and wildlife (less replacement, maintenance, and operation) would accrue to the Papago Tribe and provide further means of raising their living standards now and in the future. The proposed project permits full development of the recreation, fish, and wildlife resources.

8. Allocation of costs.--The recommended plan is a multiple-purpose project and would provide for flood control, water conservation, area redevelopment, recreation, and fish and wildlife. Information on allocation of costs for both 100- and 50-year-project life on the basis of (a) the method of cost allocation used in the basic report (the Separable Costs-Remaining Benefits method), (b) the Priority of Use method, and (c) the Incremental Cost method are shown in the following tables. Since completion of these studies, the interest rate for the report was changed from 2-7/8 percent to 3 percent. Because of the minor effect of this change on the comparative results of the alternative studies for the allocation of costs, the tables following were not revised.

Table 1

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of annual costs						
Benefits	$609,000	$258,000	$49,000	$60,000	$11,000	$987,000
Alternate costs	183,000	100,000	24,000	25,000	(*)	332,000
Benefits limited by alternate costs	183,000	100,000	24,000	25,000	11,000	343,000
Separable costs	144,000	62,000	10,000	11,000	0	227,000
Remaining benefits	39,000	38,000	14,000	14,000	11,000	116,000
Allocated joint costs	12,000	12,000	5,000	5,000	3,000	37,000
Total allocation, project costs	156,000	74,000	15,000	16,000	3,000	264,000
Allocation of maintenance and operation costs						
Separable costs	3,000	32,000	9,000	9,000	0	53,000
Allocated joint costs**	3,000	3,000	1,000	1,000	1,000	9,000
Total allocation, maintenance and operation	6,000	35,000	10,000	10,000	1,000	62,000
Specific costs	0	28,000	5,000	0	0	33,000
Allocated joint-use costs	6,000	7,000	5,000	10,000	1,000	29,000
Percentage allocation of joint-use maintenance and operation	21	24	17	35	3	100

See footnotes at end of table

Table 1--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of investment						
Annual investment cost***	$150,000	$39,000	$5,000	$6,000	$2,000	$202,000
Allocated investment	4,912,000	1,277,000	164,000	197,000	65,000	6,615,000
Allocation of construction expenditures						
Specific investment	814,000	873,000	26,000	23,000	0	1,736,000
Investment in joint-use facilities	4,098,000	404,000	138,000	174,000	65,000	4,789,000
Interest during construction of joint-use facilities****	114,000	11,000	4,000	5,000	2,000	136,000
First costs of all joint-use facilities	3,984,000	393,000	134,000	169,000	63,000	4,743,000
Percentage allocation of first costs of all joint-use facilities	84.0	8.3	2.8	3.6	1.3	100.0
First costs of joint-use facilities, dam and appurtenances	#$3,984,000	$339,000	$116,000	$146,000	$54,000	$4,639,000
Percentage allocation of first cost of dam and appurtenances	85.9	7.3	2.5	3.1	1.2	100.0

See footnotes at end of table.

Table 1--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of construction expenditures (continued)						
First cost of remaining joint-use facilities	0	$54,000	$18,000	$23,000	$9,000	$104,000
Percentage allocation of first costs, remaining joint-use facilities	0	51.9	17.3	22.1	8.7	100.0
First cost of specific facilities	##$791,000	###$849,000	###$25,000	###$22,000	0	$1,687,000
Total first cost, dam and appurtenances	4,775,000	339,000	116,000	146,000	54,000	5,430,000
Total first cost remaining facilities	0	903,000	43,000	45,000	9,000	1,000,000
Grand total, first costs	4,775,000	1,242,000	159,000	191,000	63,000	6,430,000

* Exceeds value of benefits.
** In proportion to remaining benefits.
*** Total allocation, maintenance and operation subtracted from total allocation, project costs.
**** One-half of 2 years at 2-7/8%.
\# Because no flood control benefits would accrue from those facilities downstream from the dam (joint-use facility) all joint-facility costs for flood control were allocated to the dam and reservoir and remaining joint costs were allocated in proportion to the total joint costs for each purpose.
Applies to dam and appurtenances.
Applies to remaining facilities.

Table 2

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 50-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of annual costs						
Benefits	$590,000	$250,000	$49,000	$60,000	$14,000	$963,000
Alternate costs	224,000	114,000	26,000	26,000	(*)	390,000
Benefits limited by alternate costs	224,000	114,000	26,000	26,000	14,000	404,000
Separable costs	178,000	69,000	10,000	11,000	0	268,000
Remaining benefits	46,000	45,000	16,000	15,000	14,000	136,000
Allocated joint costs	15,000	15,000	5,000	5,000	5,000	45,000
Total allocation, project costs	193,000	84,000	15,000	16,000	5,000	313,000
Allocation of maintenance and operation costs						
Separable costs	3,000	32,000	9,000	9,000	0	53,000
Allocated joint costs**	3,000	3,000	1,000	1,000	1,000	9,000
Total allocation, maintenance and operation	6,000	35,000	10,000	10,000	1,000	62,000
Specific costs	0	28,000	5,000	0	0	33,000
Allocated joint-use costs	6,000	7,000	5,000	10,000	1,000	29,000
Percentage allocation of joint-use maintenance and operation	21	24	17	35	3	100
Allocation of investment						
Annual investment costs***	$187,000	$49,000	$5,000	$6,000	$4,000	$251,000
Allocated investment	4,928,000	1,291,000	132,000	158,000	106,000	6,615,000

See footnotes at end of table.

Table 2--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 50-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of construction expenditures						
Specific investment	$814,000	$873,000	$26,000	$23,000	$ 0	$1,736,000
Investment in joint-use facilities	4,114,000	418,000	106,000	135,000	$106,000	4,879,000
Interest during construction of joint-use facilities****	114,000	12,000	3,000	4,000	3,000	136,000
First cost of all joint-use facilities	4,000,000	406,000	103,000	131,000	103,000	4,743,000
First cost of joint-use facilities, dam and appurtenances	#4,000,000	349,000	89,000	112,000	89,000	4,639,000
Percentage allocation of first cost, dam and appurtenances	86.3	7.5	1.9	2.4	1.9	100.0
First cost of remaining joint-use facilities	0	$57,000	$14,000	$19,000	$14,000	104,000
Percentage allocation of first cost remaining joint-use facilities	0	54.9	13.4	18.3	13.4	100.0
First cost in specific facilities	##$791,000	###$849,000	###$25,000	###$22,000	0	$1,687,000
Total first cost dam and appurtenances	4,791,000	349,000	89,000	112,000	$89,000	5,430,000
Total first cost remaining facilities	0	906,000	39,000	41,000	14,000	1,000,000
Grand total first costs	4,791,000	1,255,000	128,000	153,000	103,000	6,430,000

See footnotes on following page.

Table 2--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using separable costs-remaining benefits method (September 1962 price levels), 50-year period of analysis

* Exceeds value of benefits.
** In proportion to remaining benefits.
*** Total allocation, maintenance and operation subtracted from total allocation, project costs.
**** One-half of 2 years at 2-7/8%.
\# Because no flood-control benefits would accrue from those facilities downstream from the dam (joint-use facility) all joint-facility costs for flood control were allocated to the dam and reservoir and remaining joint costs were allocated in proportion to the total joint costs for each purpose.
\#\# Applies to dam and appurtenances.
\#\#\# Applies to remaining facilities.

Table 3

Allocation of costs for Santa Rosa Wash multiple-purpose project, using priority of use method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of total annual costs						
Benefits	$609,000	$258,000	$49,000	$60,000	$11,000	$987,000
Alternate costs	183,000	100,000	24,000	25,000	(*)	332,000
Benefits limited by alternate costs	183,000	100,000	24,000	25,000	11,000	343,000
Specific costs	25,000	55,000	6,000	1,000	0	87,000
Remaining benefits	158,000	45,000	18,000	24,000	11,000	256,000
Assigned costs	158,000	0	9,000	10,000	0	177,000
Total allocation, project costs	183,000	55,000	15,000	11,000	0	264,000
Allocation of maintenance and operation						
Alternate costs	12,000	41,000	15,000	20,000	0	88,000
Justifiable expenditures	12,000	41,000	15,000	20,000	0	88,000
Specific costs	0	28,000	5,000	0	0	33,000
Remaining justifiable expenditures	12,000	13,000	10,000	20,000	0	55,000
Assigned costs	12,000	0	7,000	10,000	0	29,000
Percentage of assigned costs	42	0	24	34	0	100
Allocated costs	$12,000	$28,000	$12,000	$10,000	0	$62,000
Allocation of investment						
Annual investment costs**	171,000	27,000	3,000	1,000	0	202,000
Allocated investment	5,600,000	884,000	98,000	33,000	0	6,615,000

See footnotes at end of table.

Table 3--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using priority of use method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of construction expenditures						
Specific investment	$814,000	$873,000	$26,000	$23,000	0	$1,736,000
Investment in joint-use facilities	4,786,000	11,000	72,000	10,000	0	4,879,000
Interest during construction of joint-use facilities***	134,000	0	2,000	0	0	136,000
First cost of all joint-use facilities	4,652,000	11,000	70,000	10,000	0	4,743,000
First cost of joint-use facilities, dam and appurtenances****	4,639,000	0	0	0	0	4,639,000
Percentage allocation of first cost, dam and appurtenances	100	0	0	0	0	100
First cost of remaining joint-use facilities	13,000	11,000	70,000	70,000	0	104,000
Percentage allocation of first cost, remaining joint-use facilities	12.5	10.6	67.3	9.6	0	100.0
First cost of specific facilities	#$791,000	##$849,000	##$25,000	##$22,000	0	$1,687,000
Total first cost, dam and appurtenances	5,430,000	0	0	0	0	5,430,000

See footnotes at end of table.

Table 3--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using priority of use method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Total first cost, remaining facilities	$13,000	$860,000	$95,000	$32,000	0	$1,000,000
Grand total, first cost	5,443,000	860,000	95,000	32,000	0	6,430,000

* Exceeds value of benefits.

** Total allocation, maintenance and operation subtracted from total allocation, project costs.

*** One-half of 2 years at 2-7/8%.

**** Because no flood control benefits would accrue from those facilities downstream from the dam, the entire cost of joint-use facilities in the dam and appurtenances is borne by flood control. Remainder of flood control allocation is used in downstream facilities.

\# Applies to dam and and appurtenances.

\#\# Applies to remaining facilities.

Table 4

Allocation of costs for Santa Rosa Wash multiple-purpose project, using priority of use method (September 1962 price levels), 50-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of total annual costs						
Benefits	$590,000	$250,000	$49,000	$60,000	$14,000	$963,000
Alternate costs	224,300	113,800	25,500	26,300	(*)	389,900
Benefits limited by alternate costs	224,300	113,800	25,500	26,300	14,000	403,900
Specific costs	30,900	61,100	6,000	900	0	98,900
Remaining benefits	193,400	52,700	19,500	25,400	14,000	305,000
Assigned costs	193,400	0	10,000	10,700	0	214,100
Total allocation, project costs	224,300	61,100	16,000	11,600	0	313,000
Allocation of maintenance and operation						
Alternate costs	12,000	41,000	15,000	20,000	0	88,000
Justifiable expenditures	12,000	41,000	15,000	20,000	0	88,000
Specific costs	0	28,000	5,000	0	0	33,000
Remaining justifiable expenditures	12,000	13,000	10,000	20,000	0	55,000
Assigned costs	12,000	0	7,000	10,000	0	29,000
Percentage of assigned costs	42	0	24	34	0	100
Allocated costs	$12,000	$28,000	$12,000	$10,000	0	$62,000

See footnotes at end of table.

Table 4--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using priority of use method (September 1962 price levels), 50-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Allocation of investment						
Annual investment costs**	$212,300	$33,100	$4,000	$1,600	0	$251,000
Allocated investment	5,595,000	873,000	105,000	42,000	0	6,615,000
Allocation of construction expenditures						
Specific investment	814,000	873,000	26,000	23,000	0	1,736,000
Investment in joint-use facilities	4,781,000	0	79,000	19,000	0	4,879,000
Interest during construction of joint-use facilities	134,000	0	2,000	0	0	136,000
First cost of all joint-use facilities***	4,647,000	0	77,000	19,000	0	4,743,000
First cost of joint-use facilities, dam and appurtenances	4,639,000	0	0	0	0	4,639,000
Percentage allocation of first cost, dam and appurtenences****	100	0	0	0	0	100
First cost of remaining joint-use facilities	8,000	0	77,000	19,000	0	104,000

See footnotes at end of table.

Table 4-continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using priority of use method (September 1962 price levels), 50-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Area redevelopment	Totals
Percentage allocation of first cost remaining joint costs.....	7.7	0.0	74.0	18.3	0	100
First cost of specific facilities	#$791,000	##$849,000	##$25,000	##$22,000	0	$1,687,000
Total first cost, dam and appurtenances...	5,430,000	0	0	0	0	5,430,000
Total first cost remaining facilities.....	8,000	849,000	102,000	41,000	0	1,000,000
Grand total first cost	5,438,000	849,000	102,000	41,000	0	6,430,000

* Exceeds value of benefits.

** Total allocation, maintenance and operation, subtracted from total allocation project costs.

*** One-half of 2 years at 2-7/8%.

**** Because no flood control benefits would accrue from those facilities downstream from the dam, the entire cost of joint-use facilities in the dam and appurtenances is borne by flood control. Remainder of flood control allocation is used in downstream facilities.

\# Applies to dam and appurtenances.

\#\# Applies to remaining facilities.

Table 5

Allocation of costs for Santa Rosa Wash multiple-purpose project, using incremental cost method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Totals
Allocation of annual costs*					
Separable costs	$144,000	$62,000	$10,000	$11,000	$227,000
Assigned costs	37,000	0	0	0	37,000
Allocated costs	181,000	62,000	10,000	11,000	264,000
Allocation of maintenance and operation costs					
Separable costs	3,000	32,000	9,000	9,000	53,000
Assigned costs	9,000	0	0	0	9,000
Total allocation, maintenance and operation	12,000	32,000	9,000	9,000	62,000
Specific costs	0	28,000	5,000	0	33,000
Allocated joint-use costs	12,000	4,000	4,000	9,000	29,000
Percentage allocation of joint-use maintenance and operation	41	14	14	31	100
Allocation of investment					
Annual investment costs**	$169,000	$30,000	$1,000	$2,000	$202,000
Allocated investment	5,534,000	982,000	33,000	66,000	6,615,000
Allocation of construction expenditures					
Specific investment	814,000	873,000	26,000	23,000	1,736,000
Investment in joint-use facilities	4,720,000	109,000	7,000	43,000	4,879,000
Interest during construction of joint-use facilities***	132,000	3,000	0	1,000	136,000
First cost of all joint-use facilities	4,588,000	106,000	7,000	42,000	4,743,000
First cost of joint-use facilities, dam and appurtenances****	4,588,000	35,000	2,000	14,000	4,639,000

See footnotes at end of table.

Table 5--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using incremental cost method (September 1962 price levels), 100-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Totals
Allocation of construction expenditures (continued)					
Percentage allocation of first cost, dam and appurtenances	98.8	0.8	0.3	0.1	100.0
First cost of remaining joint-use facilities	0	$71,000	$5,000	$28,000	$104,000
Percentage allocation of first cost, remaining joint-use facilities	0	68.3	4.8	26.9	100.0
First cost of specific facilities	#$791,000	##$849,000	##$25,000	##$22,000	$1,687,000
Total first cost, dam and appurtenances	5,379,000	35,000	2,000	14,000	5,430,000
Total first cost, remaining facilities	0	920,000	30,000	50,000	1,000,000
Grand total, first costs	5,379,000	955,000	32,000	64,000	6,430,000

* Area redevelopment does not apply in this method.

** Total allocation, maintenance and operation subtracted from total allocation, project costs.

*** One-half of 2 years at 2-7/8 percent.

**** Because no flood control benefits would accrue from those facilities downstream from the dam (joint-use facility) all joint-facility costs for flood control were allocated to the dam and reservoir and remaining joint costs were allocated in proportion to the total joint costs for each purpose.

\# Applies to dam and appurtenances.

\#\# Applies to remaining facilities.

Table 6

Allocation of costs for Santa Rosa Wash multiple-purpose project, using incremental cost method (September 1962 price levels), 50-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Totals
Allocation of annual costs*					
Separable costs	$178,000	$69,000	$10,000	$11,000	$268,000
Assigned costs	45,000	0	0	0	45,000
Allocated costs	223,000	69,000	10,000	11,000	313,000
Allocation of maintenance and operation costs					
Separable costs	3,000	32,000	9,000	9,000	53,000
Assigned costs	9,000	0	0	0	9,000
Total allocation, maintenance and operation	12,000	32,000	9,000	9,000	62,000
Specific costs	0	28,000	5,000	0	33,000
Allocated joint-use costs	12,000	4,000	4,000	9,000	29,000
Percentage allocation of joint-use maintenance and operation	41	14	14	31	100
Allocation of investment					
Annual investment costs**	$211,000	$37,000	$1,000	$2,000	$251,000
Allocated investment	5,561,000	975,000	26,000	53,000	6,615,000
Allocation of construction expenditures					
Specific investment	814,000	873,000	26,000	23,000	1,736,000
Investment in joint-use facilities	4,747,000	102,000	0	30,000	4,879,000
Interest during construction of joint-use facilities***	132,000	3,000	0	1,000	136,000
First cost of all joint-use facilities	4,615,000	99,000	0	29,000	4,743,000
First cost of joint-use facilities, dam and appurtenances****	4,615,000	19,000	0	5,000	4,639,000

See footnotes at end of table.

Table 6--continued

Allocation of costs for Santa Rosa Wash multiple-purpose project, using incremental cost method (September 1962 price levels), 50-year period of analysis

Item	Flood control	Water conservation	Fish and wildlife	Recreation	Totals
Allocation of construction expenditures (continued)					
Percentage allocation of first cost, dam and appurtenances	99.4	0.5	0	0.1	100.0
First cost of remaining joint-use facilities	0	$80,000	0	$24,000	$104,000
Percentage allocation of first cost, remaining joint-use facilities	0	76.9	0	23.1	100.0
First cost of specific facilities	#$791,000	##$849,000	##$25,000	##$22,000	$1,687,000
Total first cost, dam and appurtenances	5,406,000	19,000	0	5,000	5,430,000
Total first cost, remaining facilities	0	929,000	25,000	46,000	1,000,000
Grand total, first costs	5,406,000	948,000	25,000	51,000	6,430,000

* Area redevelopment does not apply in this method.

** Total allocation, maintenance and operation subtracted from total allocation, project costs.

*** One-half of 2 years at 2-7/8 percent.

**** Because no flood control benefits would accrue from those facilities downstream from the dam (joint-use facility) all joint-facility costs for flood control were allocated to the dam and reservoir and remaining joint costs were allocated in proportion to the total joint costs for each purpose.

\# Applies to dam and appurtenances.

\#\# Applies to remaining facilities.

Table 7

Separable costs for Santa Rosa Wash multiple-purpose project

Item	Multiple-purpose project	Flood control	Water conservation	Fish and wildlife	Recreation
First costs of projects with one purpose omitted (except multiple-purpose project)					
Construction	$5,710,000	$1,849,000	$4,565,000	$5,645,000	$5,620,000
Relocations	300,000	0	330,000	360,000	360,000
Land and rights	420,000	90,000	582,000	400,000	400,000
Total first costs	6,430,000	1,939,000	5,477,000	6,405,000	6,380,000
Interest during construction 1/2 of 2 years at 2-7/8 percent	185,000	56,000	157,000	184,000	183,000
Total investment	6,615,000	1,995,000	5,634,000	6,589,000	6,563,000
Annual costs of interest and amortization:					
100 years at 2-7/8 percent interest	202,000	61,000	172,000	201,000	200,000
50 years at 2-7/8 percent interest	251,000	76,000	214,000	250,000	249,000
Annual cost of maintenance and operation	62,000	59,000	30,000	53,000	53,000
Total annual costs					
100-year basis	264,000	120,000	202,000	254,000	253,000
50-year basis	313,000	135,000	244,000	303,000	302,000
Separable total annual costs*					
100-year basis		144,000	62,000	10,000	11,000
50-year basis		178,000	69,000	10,000	11,000
Separable maintenance and operation costs**		3,000	32,000	9,000	9,000

* Difference between multiple-purpose project and individual purpose in line titled "Total annual costs."

** Difference between multiple-purpose project and individual purpose in line titled "Annual cost of maintenance and operation."

Table 8

Alternate costs for Santa Rosa Wash multiple-purpose project

Item	Flood control	Water conservation	Fish and wildlife	Recreation
First costs				
Construction	$4,990,000	$1,774,000	$262,000	$150,000
Relocations	330,000	0	0	0
Land and rights	620,000	90,000	8,000	10,000
Total first costs	5,440,000	1,864,000	270,000	160,000
Interest during construction, 1/2 of 2 years at 2-7/8 percent	156,000	54,000	8,000	5,000
Total investment	5,596,000	1,918,000	278,000	165,000
Annual cost of interest and amortization				
100 years at 2-7/8 percent interest	171,000	59,000	9,000	5,000
50 years at 2-7/8 percent interest	212,000	73,000	11,000	6,000
Annual cost of maintenance and operation	12,000	41,000	15,000	20,000
Total annual alternate costs				
100-year basis	183,000	100,000	24,000	25,000
50-year basis	224,000	114,000	26,000	26,000

Table 9

Specific costs for Santa Rosa Wash multiple-purpose project

Item	Flood control	Water conservation	Fish and wildlife	Recreation
First costs				
Construction	$190,000	$849,000	$25,000	$22,000
Relocations	320,000	0	0	0
Land and rights	281,000	0	0	0
Total first costs	791,000	849,000	25,000	22,000
Interest during construction, 1/2 of 2 years at 2-7/8 percent	23,000	24,000	1,000	1,000
Total investment	814,000	873,000	26,000	23,000
Annual cost of interest and amortization				
100 years at 2-7/8 percent interest	25,000	27,000	1,000	1,000
50 years at 2-7/8 percent interest	31,000	33,000	1,000	1,000
Annual cost of maintenance and operation	0	28,000	5,000	0
Total annual specific costs				
100-year basis	25,000	55,000	6,000	1,000
50-year basis	31,000	61,000	6,000	1,000

9. Local cooperation.--The terms of local cooperation for the recommended project would provide that prior to construction, local interests furnish assurances satisfactory to the Secretary of the Army that they will (a) establish and enforce floodway limits and regulations for Santa Rosa Wash from the north boundary of the Papago Indian Reservation to Santa Cruz River (excluding Indian land), and maintain the hydraulic capacity of the existing channel; (b) hold and save the United States free from damages (downstream from the Papago Indian Reservation) arising from construction, maintenance, and operation of the works for flood control; and (c) hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the proposed project for flood control.

10. Papago Tribe cooperation.--The Papago Indian Tribal Council agrees to make available at no cost to the United States (a) appropriate rights to those lands required for construction of the dam and appurtenances, (b) appropriate rights to those lands that would be required for the water-conservation portion of the reservoir, and (c) rights-of-entry to the damsite and vicinity for personnel and equipment engaged in preconstruction activity, construction work, and subsequent operation, maintenance, and periodic inspection of the improvement.

11. Other Federal agency cooperation.--The Federal Government (Bureau of Indian Affairs) would (a) assure the maintenance of the hydraulic capacity of the portion of the existing Santa Rosa Wash channel lying within Indian Reservation land from Tat Momolikot damsite to the Santa Cruz River; and (b) provide for settlement of water-rights claims arising from construction and operation of the recommended plan of improvement for water conservation and recreational purposes.

12. Extent of interest in project.--(a) Local interests desire protection along Santa Rosa Wash to prevent flood losses and eliminate interruptions to irrigation, highway, railroad, and utility services. They also are keenly interested in an improvement that would include recreational features. They have offered to cooperate fully as required. Local interests have already expended about $400,000 to provide partial flood protection in the area.

(b) The Papago Indian Tribal Council has indicated interest in a multiple-purpose dam and reservoir project on their reservation for water conservation, fish and wildlife, recreation, and flood control. They recognize the economic advantages that would accrue to the Tribe.

(c) Studies prepared by the U.S. Fish and Wildlife Service and the Arizona State Game and Fish Department have pointed out the need in this area for recreation, fish, and wildlife facilities.

13. Other plans considered.--(a) Preliminary consideration was given to a 25-mile-long levee and channel improvement along Santa Rosa Wash in the flood-problem area. Such an improvement could not be economically justified.

(b) Consideration was given to the construction of detention basins, but such plans were found to be infeasible.

(c) Three other damsites on Santa Rosa Wash between the recommended Tat Momolikot damsite and Vaiva Vo, Ariz., were considered but were declared infeasible because of (1) excessive spillway costs and (2) a dam farther downstream would encroach upon the Bureau of Indian Affairs' Vaiva Vo irrigation project.

(d) Since the Santa Rosa Wash multiple-purpose project (recommended plan) provides economically feasible protection to the considered overflow area along the Santa Rosa Wash, an area redevelopment program in the Papago Indian Reservation, and satisfies all requirements for the other considered purposes (water conservation, recreation, and fish and wildlife), further detailed studies were restricted to that plan.