

**FLOOD DAMAGE REPORT  
PHOENIX METROPOLITAN AREA  
DECEMBER 1978 FLOOD**

**PUBLISHED BY  
U. S. ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT  
NOVEMBER 1979**

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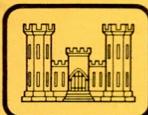
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# Flood Damage Report

## Phoenix Metropolitan Area December 1978 Flood

### November 1979



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A. AUTHORITY. This report is submitted under the authority of Public Law 84-99, Chapter 194 in accordance with U.S. Army Corps of Engineers Regulation ER 500-1-1, "Emergency Employment of Army and Other Resources - Natural Disaster Procedures."

B. SCOPE. Maricopa County experienced two Presidentially declared flood disasters in 1978. This report is a preliminary assessment of damages resulting from the second flood disaster which occurred December 17-23, 1978. The first flood disaster occurred in February and March of 1978 and is described in a separate report.<sup>1</sup> The damages in both reports are restricted to those caused by inundation or erosion by floodwater, or by flood-transported debris within the Phoenix Metropolitan Area (see Plate 1). Damages to the Salt River Project upstream of the study area are also included. SRP provides water and power for area residents, who depend upon the damaged facilities. Direct rain and wind damages are excluded.

The main purpose of a flood damage report is to record historical information that would otherwise be lost. Traffic delay costs are a real loss that cannot be directly measured. However, because of the attention being given to flood control in the Phoenix Metropolitan Area (see Section VI), traffic delay costs are included in this report. The estimated traffic delay costs of \$12 million are a significant portion of the total \$51.8 million in flood damages reported.

While this report focuses only on the Phoenix Metropolitan Area, the December 17th to 23rd period saw flood conditions widespread throughout Arizona. Other heavily damaged areas will be addressed in another Corps flood damage report soon to be released. These areas include Winslow and Williams, Arizona, and the remainder of the affected Gila River Basin, extending into New Mexico.

On May 18, 1979, the National Weather Service published "Report on the Arizona Floods of December 16-20, 1978." This report describes the meteorological conditions that caused the extensive flooding during December 17-23, the data collection and communication systems that made timely predictions and warnings possible, and the dissemination of forecast statements and warnings. The report also describes public response to the forecasts and warnings, and evaluates the leadership and effectiveness of National Weather Service field offices in handling the December 16-20 storm.

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<sup>1</sup> Flood Damage Report, 28 February - 6 March 1978 on the Storm and Floods in Maricopa County, Arizona; U.S. Army Corps of Engineers, Los Angeles District; February 1979.

C. BACKGROUND. The Phoenix Metropolitan Area is located within the valleys of four major rivers. The Salt River flows through the southern part of the urbanized area. The Agua Fria and Verde Rivers flowing from the north constitute the western and northeastern boundaries of the area. The Gila River passes through the southwestern portion of the metropolitan region and receives the flow of the Salt and Agua Fria Rivers. The combined waters flow westward toward the Colorado River. The area drained by these rivers extends as far north as the San Francisco Peaks, east to the Continental Divide in New Mexico, and south into Mexico. Most of the rivers would flow continuously through the Phoenix Metropolitan Area, were it not for major upstream reservoirs. These dams are designed and operated primarily to capture surface water supplies and, as a result, river beds in the Phoenix Metropolitan Area are normally dry.

Major floods through the urbanized area are infrequent. Since Roosevelt Dam on the Salt River was constructed in 1911, flows in excess of 50,000 cfs have occurred six times prior to the March and December, 1978 floods. The occurrence of two major floods in less than one year makes 1978 a period of unusual hydrologic activity. For Phoenix area residents, 1978 was a year of record flood damages.

Even a small flow in the normally dry river beds creates considerable disruption for valley residents. Only the major thoroughfares bridge the Salt River, and only a few of these crossings are designed to span major floods. Other crossings, both at the major rivers and at numerous washes throughout the valley, use the stream beds. Numerous sand and gravel operations are located in the floodway.

Outside the stream beds, urban development has encroached on the flood plains over the last several decades because of both intense development pressure in the area and the low perception of flood hazards. The flood plains also contain prime agricultural land, irrigated in part by flows diverted from the rivers. Few areas along the major floodways are protected by dikes, levees, or channels of any sort. Floodproofing is uncommon.

D. SUMMARY. Flood damages reported in this document are those sustained within the Phoenix Metropolitan Area. The disaster area affected by the Salt, Gila, and Agua Fria Rivers is an arid valley with infrequent rain and streamflow. The storms and floods are detailed in terms of precipitation and runoff. Discharges peaked at 140,000 cfs on the Salt River and 60,000 cfs on the Agua Fria River. The function and the response mechanism of public assistance programs is outlined. Statewide, Federal expenditures exceeded \$132 million. In the Phoenix Metropolitan Area, physical damages, net income losses, and emergency costs totaled \$51.8 million. Damages are categorized by type of land use: Residential, Commercial, Industrial, Agricultural, and Public. Physical damages to public facilities exceeded \$20 million. Damages are discussed by location along each river: the Salt River (\$39 million),

the Gila River (\$7.3 million), and the Agua Fria River (\$5.5 million). An authorized Corps project, New River and Phoenix City Streams, would have prevented \$215,000 in damages on Location 1 of the Agua Fria River. The Central Arizona Water Control Study, undertaken by the Bureau of Reclamation and the Corps of Engineers, is evaluating flood control on the Salt and Gila Rivers. In the Allenville Flood Control Study, the Corps is considering small project alternatives for that community under Section 205 of the Flood Control Act of 1948, as amended (see Section VI).

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## II.

### GENERAL DESCRIPTION OF DISASTER AREA

A. **DISASTER DECLARATIONS.** Governor Bruce Babbitt declared a state of emergency December 18, 1978. Mayor Margaret Hance declared a state of emergency in the City of Phoenix, December 19, 1978. Thursday, December 21, President Jimmy Carter declared Maricopa, Gila, Graham, Greenlee, Pima, and Navajo counties disaster areas. Yavapai, Pinal, Santa Cruz, and Coconino counties were declared disaster areas by the President on December 26, 1978.

B. **LOCATION.** The damages addressed in this report occurred in the greater Phoenix Metropolitan Area, located in south central Arizona. The specific areas assessed include the flood plains of the Salt, Gila and Agua Fria Rivers within the boundaries of the Phoenix Metropolitan Area (See Plate 1). Damages along the Salt River are recorded from Granite Reef Dam west to its confluence with the Gila River near 115th Avenue. Damages along the Gila River are recorded from 115th Avenue west to Oglesby Road near the Town of Buckeye. Damages along the Agua Fria River are recorded from Lake Pleasant south to the Gila River confluence.

C. **CLIMATE.** Most of the drainage area has an arid, subtropical climate, characterized by hot summers, mild winters, and infrequent rainfall. Summer thunderstorms, of high intensity but short duration, normally account for most of the annual rainfall but are responsible for less than half of the annual runoff. In the higher elevated portions of the drainage area, the climate is somewhat cooler, with greater precipitation, and with considerable snow during the winter months.

D. **TOPOGRAPHY.** Settlements in Maricopa County are located in the river valleys of the Gila River and its principal tributaries: the Salt and the Agua Fria Rivers. The Phoenix Metropolitan Area, situated in the Salt River Valley, is effectively surrounded by the Phoenix Mountains to the north, the McDowell Mountains to the northeast, the Usony Mountains to the east, the South Mountains to the south, the Sierra Estrella to the southwest, and the White Tank Mountains to the northwest. Only to the west and southeast do the rolling desert plains typical of the metropolitan area continue uninterrupted. The highest elevation in the county is Four Peaks (7,657 feet) in the McDowell Mountains. The Salt River flows into the Gila River southwest of central Phoenix at an elevation of 925 feet.

E. **RIVERS AND STREAMS.** The principal rivers in Maricopa County are the Gila and its major tributary, the Salt. The Agua Fria River joins the Gila River below its confluence with the Salt River. New River and Skunk Creek are, in turn, tributary to the Agua Fria River. The Verde River is the major tributary of the Salt. Additional inflow to these watercourses is contributed by numerous washes, creeks, and urban runoff.

F. CANALS. In addition to the natural watercourses, the metropolitan Phoenix area is crisscrossed by canals which deliver irrigation water from the Salt River to the agricultural areas west and southeast of the central city.

A. METEOROLOGY. The period of November 1978 through January 1979 was characterized by a series of upper level low pressure centers which developed off the west coast of Baja California and which moved northeastward into the southwestern United States, giving most of Arizona unusually heavy, warm rains. The most intense of these lows began to approach the coast on December 15 and 16, at the same time that a deep low pressure trough was dropping southward from the Gulf of Alaska. As these two lows combined just off the Californi coast, the circulation around the resulting system brought a strong flow of very warm, moist tropical air from the equatorial Pacific Ocean northward into Arizona and triggered heavy rainfall through most of the State. Where this strong flow encountered mountain ranges, such as the Bradshaws, Mazatzals, Sierra Anchas, and the Mogollon Rim, the orographic uplift of the air resulted in even much heavier precipitation than that which occurred in the valleys. Because of the tropical nature of the air mass, the snow levels throughout most of the storm were generally 7,000 to 8,000 feet above sea level in the northwestern portions of Arizona and as high as 10,000 to 11,000 feet in southeast Arizona and western New Mexico. Near the end of the storm the snow levels generally dropped several thousand feet. A more detailed meteorological description of this storm and an evaluation of the National Weather Service forecasts issued at the time of the event can be found in "Report on the Arizona Floods of December 16-20, 1978," prepared by the U.S. Department of Commerce, NOAA, National Weather Service, Salt Lake City, Utah, May 18, 1979.

B. PRECIPITATION. Total precipitation in the storm of December 16-20, 1978 ranged from less than 1 inch in the northeastern and far southwestern portions of Arizona to nearly 10 inches in the Mazatzal Mountains northeast of Phoenix. A large area of the central mountains of Arizona received over 5 inches. Plate 2 in an isohyetal map of the total precipitation in Arizona during the period December 16-20, 1978. This plate was reproduced and slightly modified for updated data, with permission of the National Weather Service, from their "Report on the Arizona Floods of December 16-20, 1978" (U.S. Department of Commerce, NOAA, National Weather Service, May 18, 1979). A tabulation of total rainfall in this storm at selected National Weather Service stations can be found in Appendix 1 of that NOAA report.

Plate 3 contains mass rainfall curves for two U.S. Forest Service stations and two U.S. Geological Survey stations for the storm period. Light rain began in parts of Arizona late December 16, but did not become significant until the morning of December 17. As can be seen in Plate 3, the heaviest rainfall at most stations occurred between approximately noon December 17 and late evening December 18. Few if any extreme intensities over short durations (such as in the heaviest summer thunderstorms) occurred during this December 1978 storm, but rates of .25 to .5 inch per hour were relatively common throughout the foothill and mountain areas of central Arizona on December 17 and 18. Precipitation tapered off rapidly by the early hours of December 19, with only a few light rain or snow showers lingering into December 20.

C. RUNOFF. Runoff from the storm of December 16-20, 1978 was heavy throughout most of Arizona and western New Mexico. The main stems of the Gila, Salt, Verde, Agua Fria, Bill Williams, and Little Colorado Rivers, as well as a number of major tributaries to these rivers, experienced especially large discharges, some of which are the greatest ever recorded, according to preliminary U.S. Geological Survey data.

A list of available peak discharges at stations along the main stems and major tributaries to the Gila, Salt, Verde, Agua Fria, and Bill Williams Rivers, plus Show Low Creek, can be found in Table 1. It must be cautioned that these figures are approximate and represent preliminary U.S. Geological Survey data which are subject to revision. Most of the values are taken from regular USGS gaging stations, although some are from partial-record USGS stations, and a few represent special slope-area measurements made by the USGS.

The flood crests began traveling down the smaller tributaries early December 18, reaching the larger creeks and rivers late December 18, and continuing down the main stems of the major rivers from December 19 through December 22. Most of the rivers experienced a single major crest, although some rivers experienced two prominent crests of nearly equal magnitude, separated in time by 12 to 36 hours--one crest from runoff on the main stem and the other from major tributary inflow (such as was seen on the Gila River below the mouth of the San Francisco River). Regulated releases from reservoirs further complicated these travel patterns on some streams. Plates 4 and 5 contain preliminary hydrographs of the discharges on the Salt and Verde Rivers, respectively. On Plate 4 the solid line represents the total combined inflow to Roosevelt Lake, including runoff from the Salt River, Tonto Creek, and the ungaged area. The peak of this combined inflow (computed by the U.S. Corps of Engineers from preliminary data furnished by the U.S. Geological Survey and the Salt River Project) occurred at 2200 hours December 18, with a calculated value of 152,300 cubic feet per second (cfs). The dashed line on Plate 4 represents the release from Stewart Mountain Dam (the lowerst of the four Salt River Project dams on the Salt River). On Plate 5 the solid line represents the discharge on the Verde River below Tangle Creek, just upstream from Horseshoe Reservoir, while the dashed line depicts the releases from Bartlett Dam (the lower of the two Salt River Project dams on the Verde River).

The preliminary peak discharge of 123,000 cfs for the Verde River below Tangle Creek (as shown on Plate 5, and as listed in Table 1) was reported by the U.S. Geological Survey in their summary of preliminary peaks for December 1978. However, the peak of the preliminary hydrograph--92,400 cfs--results from implementation of the March 1979 rating curve. U.S. Geological Survey personnel made a field discharge measurement before the Verde River crest, which indicated a flow in excess of 100,000 cfs. Because of this measurement, the flow at the maximum stage was reported as 123,000 cfs--the result of a shift in the rating curve. U.S. Corps of Engineers personnel, however, working with data from the December 1978 flood and implementing the shift used in

computing the peak, were unable to justify the subsequent volume for the hydrograph of the Verde River below Tangle Creek. Discussions with the USGS, addressing this issue, led to a suggestion that the prior rating curve be used to establish the hydrograph shape and volume. As a result, the preliminary hydrograph was depicted on Plate 5, using a previous rating curve, although the USGS measurement indicates that the actual peak, as discussed previously, may have been greater than 100,000 cfs. No final decision has yet been made, but the hydrograph shown should be a good indication of the shape and volume of the December 1978 flood from the Verde River below Tangle Creek. If the peak discharge of 123,000 cfs should subsequently be confirmed, it would represent the discharge of record at that location (a value, however, which may have been exceeded during the flood of February 1891).

The heavy runoff of December 17-23, 1978 resulted in considerable flooding in many parts of Arizona. Detailed descriptions of the flooding and flood damages in Arizona can be found elsewhere in this report and in the Corps of Engineers "Flood Damage Report, December 1978, New Mexico and Arizona, excluding the Phoenix Metropolitan Area," as well as the National Weather Service "Report on the Arizona Floods of December 16-20, 1978."

There are a number of reasons for the heavy runoff in Arizona during December 1978. The most important of these include:

1. Unusually heavy antecedent precipitation throughout most of Arizona and western New Mexico during November 1978 tended to saturate the ground and render it highly conducive to runoff.
2. Very cold weather during early December 1978 froze the ground in many higher elevation areas, rendering it even more conducive to immediate and near total runoff.
3. Moderate snowfall down to elevations below 5,000 feet in early December 1978 provided a snowpack of sufficient depth to significantly contribute to the runoff as it melted during the warm, heavy rain of December 16-20. (The snowpack was not so deep, however, that it was able to absorb the December 16-20 rainfall, except at the very highest elevations.)
4. The very high snow levels of the December 16-20 storm combined with the other factors to result in a high proportion of runoff to incident precipitation at elevations up to 8,000-9,000 feet.
5. Relatively high intensities of rainfall were widespread in areal extent occurred during the period and lasted (sometimes on and off) from midday December 17 through late December 18.

6. Heavy rainfall and runoff throughout the winter of 1977-1978 (especially February and March of 1978) and again in November 1978 resulted in abnormally large storages in the Salt River Project and Carl Pleasant Reservoirs. Because of these conditions, there was very little available storage space in these reservoirs at the beginning of the December 16-20, 1978 storms; and therefore, large flood releases down the Salt, Verde, and Agua Fria Rivers became necessary, beginning December 18. Through a careful monitoring of existing and predicted rainfall and watershed conditions, however, it was possible for the operators of these reservoirs to mitigate the flood peaks on the downstream portions of these rivers, and consequently on the Gila River downstream from the mouth of the Salt River. Farther upstream on the Gila River, conditions were not so critical in December 1978. Because of a large amount of available storage space in San Carlos Reservoir in December 1978, the entire volume of the late 1978 and early 1979 runoff from the upper Gila was stored in the reservoir, and none of this water reached the downstream areas. (San Carlos Reservoir finally filled and spilled slightly--for the first time in its history--during the late spring of 1979.)

Table 1

PEAK DISCHARGES FOR DECEMBER 1978  
 Preliminary Data from U.S. Geological Survey

Station Code	Stream-Gaging Stations	Drainage Area (sq mi)	Date	Time	Gage Height (ft)	Peak Discharge (cfs)
3905.00	Show Low Creek near Lakeside	68.6	12/18	1615	9.16	5,000
3920.00	Show Low Creek below Jaques Dam	73.0	12/18	1630	7.36	2,000
4244.50	Big Sandy River near Wikieup	2,800			13.90	28,000
4244.70	Kirkland Creek near Kirkland	109	12/18	1900	5.74	1,800
4249.00	Santa Maria River near Bagdad	1,210	12/18	1500	6.66 <sup>a</sup>	17,000
4795.00	Gila River near Laveen	20,615	12/21	1900	10.18	10,000 <sup>b</sup>
4890.00	Santa Cruz River near Laveen	533	12/22	1030	16.11	4,200
4891.00	Black River near Maverick	315	12/18	1300	8.64	10,000
4892.00	Packeta Creek at Maverick	14.8				
4897.00	Big Bonito Creek near Fort Apache	119			9.36 <sup>a</sup>	4,800*
4905.00	Black River near Fort Apache (100 yr)58,000, (50 yr)35,000	1,232			24.2	38,000 <sup>±</sup> *
4910.00	North Fork White River near McNary	66				
4924.00	East Fork white River near Fort Apache	38.8			3.62	450
4940.00	White River near Fort Apache	632	12/18	2115	15.71 <sup>a</sup>	13,800*
4965.00	Carrizo Creek near Show Low	439			15.1	15,000 <sup>±</sup>
4975.00	Salt River near Chrysotile	2,849			17.80	68,000 <sup>±</sup>
4978.00	Cibecue Creek near Chrysotile	295			10.2	7,600
4978.50	Canyon Creek near Globe	316	12/19		17.8	19,000 <sup>±</sup>

\* Indicates new peak discharge of record

a From inside high water marks or peak indicator

b Approximately 3,440 cfs in main channel and 6,500 cfs (gage height 10.27 ft.) in overflow

Table 1

## PEAK DISCHARGES FOR DECEMBER 1978 (Cont'd)

Station Code	Stream-Gaging Stations	Drainage Area (sq mi)	Date	Time	Gage Height (ft)	Peak Discharge (cfs)
4979.80	Cherry Creek near Globe	200			16.2	10,000 <sup>±*</sup>
4985.00	Salt River near Roosevelt	4,306	12/19	0130	29.0	94,600 <sup>±</sup>
4988.70	Rye Creek near Gisela	122	12/18	0430	5.85	3,500 <sup>±</sup>
4990.00	Tonto Creek Above Gun Creek	675	12/18	0900	14.2	42,000 <sup>±</sup>
5020.00	Salt River below Stewart Mountain Dam	6,232	12/19	0800	22.22	53,000 <sup>±*</sup>
5055.50	Verde River below Camp Verde	4,670	12/18	2200	19.7	57,000*
5079.80	East Verde River near Childs	328	12/18	0800	12.7	10,000
5080.00	Verde River below East Verde River near Childs		12/19	0700	26.27	80,600
5083.00	Wet Bottom Creek near Childs	36.4	12/18	0330	15.26	6,500 <sup>±*</sup>
5085.00	Verde River below Tangle Creek above Horseshoe Dam	5,872	12/19	0800	21.36	123,000 <sup>*d</sup>
5100.00	Verde River below Bartlett Dam	6,185	12/18	1600	22.54	75,400
5101.00	East Fork Sycamore Creek near Sunflower	4.49	12/18		4.80	300
5102.00	Sycamore Creek near Fort McDowell	164	12/18	0515	10.82	9,500
5113.00	Verde River near Scottsdale	6,600	12/18			(e)
5121.00	Indian Bend Wash at Scottsdale	62			1.53	200
5121.70	Salt River at Jointhead Dam, Phoenix		12/19	0500	10.1 <sup>+</sup>	140,000 <sup>f</sup>
5122.00	Salt River tributary in South Mountain Park, Phoenix	1.75				0
5124.00	Cave Creek at Phoenix	252			5.08	725
5125.00	Agua Fria River near Mayer	588	12/18 <sup>c</sup>		14.3g	18,300

\* Indicates new peak discharge of record

c About

d See discussion under RUNOFF (text, Sec. III.C.)

e To be determined

f 60 year flood

g From inside high water marks or peak indicator.

Table 1

## PEAK DISCHARGES FOR DECEMBER 1978 (Cont'd)

<u>Station Code</u>	<u>Stream-Gaging Stations</u>	<u>Drainage Area (sq mi)</u>	<u>Date</u>	<u>Time</u>	<u>Gage Height (ft)</u>	<u>Peak Discharge (cfs)</u>
5128.00	Agua Fria River near Rock Springs	1,130	12/18		27.2	52,800*
5129.70	New River near Rock Springs	67.3	12/18	2230	6.60	5,380
5137.80	New River at New River	83.3	12/18	2230	7.90	5,200
5138.00	New River at Bell Road, near Peoria	187	12/19	0330	11.95	8,000 <sup>±</sup>
5138.35	Skunk Creek near Phoenix	64.6	12/18	0200	5.90	60
5138.60	Agua Fria River at Avondale		12/19	1030	6.48	30,000 <sup>±</sup>
5155.00	Hassayampa River at Box Damsite, near Wickenburg	417			11.58	10,000 <sup>±</sup>
5174.00	Centemial Wash at SPRR bridge near Arlington				8.28	
5175.00	Centemial Wash near Arlington	1,810				0
5195.00	Gila River below Gillespie Dam		12/20	1330	17.0	122,000*
	Gila River inflow into Painted Rock Reservoir		12/21	0745	17.0	126,000 <sup>h</sup>
	Agua Fria River below Lake Pleasant (releases)		12/19	0100- 0400		60,000 <sup>i</sup>
	Black Canyon Wash near Black Canyon City		12/18			22,300

\* Indicates new peak discharge of record

<sup>h</sup> From Corps of Engineers, Los Angeles District

<sup>i</sup> From Maricopa County Water Conservation District No. 1

Table 1

## PEAK DISCHARGES FOR DECEMBER 1978 (Cont'd)

<u>Station Code</u>	<u>Partial-Record Stations</u>	<u>Date</u>	<u>Time</u>	<u>Gage Height (ft)</u>	<u>Peak Discharge (cfs)</u>
478600	Queen Creek Tributary No. 3 at Whitlow Dam				2
479200	Queen Creek Tributary at Apache Junction				5
488650	Vekol Wash near Stanfield				
498900	Gold Creek near Payson			6.72	
501300	Tortilla Creek at Tortilla Flat			10.05	4,400
512300	Cave Creek near Cave Creek			7.3	7,200
512700	Aqua Fria River Tributary No 2 near Rock Springs	12/18		4.92	260
513830	New River (at Keefer Hill) near Phoenix	12/18		5.06	
516500	Hassayampa River near Morristown			11.67	10,000 <sup>±</sup>
516600	Ox Wash near Morriston			2.11	200
517000	Hassayampa River near Arlington	12/19	0030	2.73	
519600	Rainbow Wash Tributary near Buckeye			0	
519750	Bender Wash near Gila Bend			0	
519760	Sauceda Wash near Gila Bend			0	
519780	Windmill Wash near Gila Bend			0	
520100	Military Wash near Sentinel			0	
520200	Balck Gap Wash near Ajo			0	
520230	Crater Range Wash near Ajo			0	

IV.

PUBLIC ASSISTANCE AND EMERGENCY PROGRAMS

In the weeks that followed the flood, government agencies and private charitable organizations at all levels provided assistance to the flood victims. Assistance included many forms:

- a. provision of immediate necessities to flood victims;
- b. payments to Federal Insurance Administration policy holders;
- c. funds to repair damaged roadways and other public facilities; and
- d. loans to repair or to replace eligible damaged property.

The outlay of these funds does not relate directly to the damages reported. The types and amounts of funds committed to disaster relief provide an alternative indicator of the extent and nature of the damages sustained statewide and in the region. The committed Federal funds shown in Table 2 apply to the entire state, while the American Red Cross aid shown on Table 3 applies to Maricopa County only. The principal programs are discussed below along with the procedure followed in making disaster declarations.

A. FEDERAL PROGRAMS. The principal Federal agencies offering direct post flood emergency assistance were: The Federal Disaster Assistance Administration (FDAA)<sup>1</sup> of the Department of Housing and Urban Development; the Small Business Administration (SBA) of the Department of Commerce; and, the Farmers Home Administration and the Agricultural Stabilization and Conservation Services (ASCS) of the Department of Agriculture. The FDAA administered two programs: one under Section 404 of the Disaster Relief Act of 1974 (PL 93-288) to provide temporary housing to people who were evacuated or driven from their homes by floodwaters; and another under Section 402 and 419 of the same act to repair or restore public facilities damaged by the flood.

Through casualty loss claims filed with individual and business tax returns, the Internal Revenue Service will be crediting business and personal loss at the end of the 1978 tax year. Estimates of these credited amounts are not available.

B. STATE PROGRAMS. Several of the Federal programs shown on Table 2 were administered by the State. For example, the State provided individual and family grants for housing and food through the Arizona Department of Economic Security (DES). DES also processed additional unemployment insurance claims for people who became unemployed because of flooding.

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<sup>1</sup>Now the Federal Emergency Management Agency (FEMA).

Table 2

ESTIMATE OF DISASTER RELIEF FUNDS RELEASED STATEWIDE  
DECEMBER 1978 FLOOD  
(1,000)

<u>AGENCY</u>	<u>AMOUNT</u>
Farmers Home Administration (Agricultural losses from flooding)	\$40,000
Small Business Administration (Home, personal property, and business damages)	18,600
Federal Highway Administration (Road and bridge damages)	21,800
U.S. Forest Service (Road, trail, and land damages)	10,000
Agricultural Stabilization & Conservation Service	3,800
Soil Conservation Service	6,000
U.S. Army Corps of Engineers	1,000
Bureau of Indian Affairs	3,500
Federal Aviation Administration (Sky Harbor Radar System)	350
Federal Insurance Administration (Payments to those insured against flooding)	3,100
Food and Nutrition Service, U.S. Dept. of Agriculture <sup>a</sup> (Food stamps and commodities)	3,840
President's Disaster Relief Fund (Temporary housing, disaster employment assistance, individual family grant program, and other public assistance programs)	20,400
TOTAL FEDERAL EXPENDITURES <sup>b</sup>	\$132,390

a. Administered by the State of Arizona through the Department of Economic Security (DES).

b. The funds released above represent disbursements and may not relate directly to damages.

SOURCE: Office of the Federal Coordinating Office and the FDAA.

C. OTHER ASSISTANCE. The American Red Cross and numerous other volunteer organizations spent time and offered direct financial aid to flood disaster victims. The Red Cross was the only organization with available cost estimates of assistance. Table 3 is a breakdown of the \$67,500 expended by the Red Cross in Maricopa County.

D. DISASTER DECLARATION PROCESS. Once an area has been flooded, six steps must be taken to qualify it for federal disaster assistance. These are shown on Figure 1. Initially, the county coordinator reports county disaster conditions to the State Division of Emergency Services. If conditions are of an extreme magnitude, the Division of Emergency Services requests the Governor to declare the county a disaster area, thereby making it eligible for State funds. The Governor's decision is based on a preliminary estimate of flood damages as reported by an assessment team for the Division of Emergency Services. If the damages are in excess of the State's \$750,000 disaster spending limit, the Governor requests a disaster declaration from the President. The President goes through a similar process to that followed by the Governor, requiring a preliminary report of flood damages. In the event of a Presidential disaster declaration, counties become eligible for federal assistance; a Federal disaster assistance coordinator is chosen by the President. At this point the State and Federal governments agree on the roles they will assume in administering disaster relief through the types of programs listed in Table 2.

Table 3

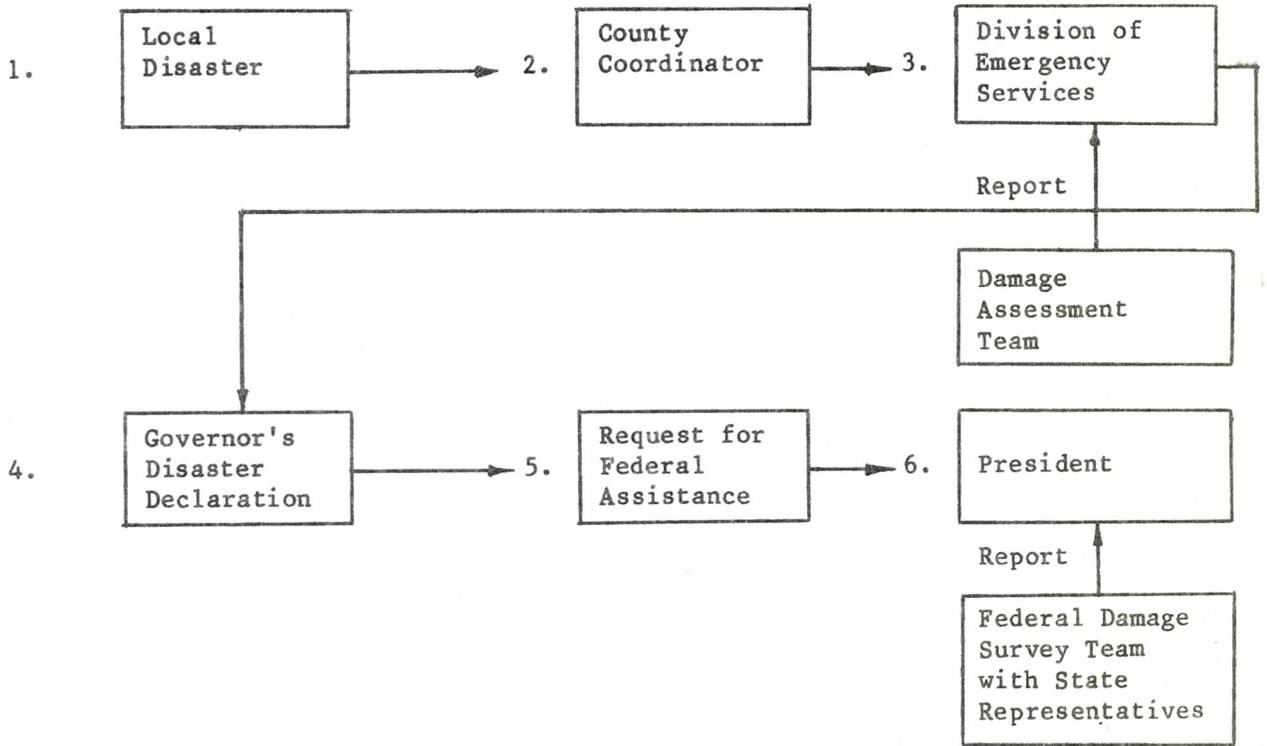
AMERICAN RED CROSS DIRECT AID TO FLOOD VICTIMS IN MARICOPA COUNTY  
(December 1978)

<u>Type of Aid</u>	<u>Amount</u>
Food, Clothing & Maintenance	\$56,500
Medical and Nursing	500
Mass Care	9,500
Building & (Minor) Repair Work	200
Occupational Supplies & Equipment	200
Household Furnishings	600
Total Relief Commitments	\$67,500

Source: American Red Cross, Public Relations Department

Figure 1

FEDERAL DISASTER ASSISTANCE FUNDING



## V.

## DESCRIPTION OF FLOOD DAMAGES

A. SUMMARY OF FLOOD DAMAGES. The most severe hydrologic event recorded on the Salt River, a flow of 300,000 cfs, occurred in 1891. By comparison, the USGS estimates that a peak of 140,000 cfs of water was released from the Granite Reef Dam spillway during both the February-March and the December, 1978 floods. Flooding was more severe along the Agua Fria River in the December, 1978 flood than during the February-March event.

Plates 6-14 outline the flood overflow boundaries on the Salt and Gila Rivers. The Corps based these boundaries upon aerial photography and limited field checks. As with all of the information in this report, these plates are a preliminary assessment of flood overflow boundaries.

A very real loss not included in damage estimates is the loss of life directly attributable to the flooding. The Red Cross reported twelve deaths statewide. Of these, three deaths occurred within the study area when a four-wheel drive vehicle attempted to cross the Salt River at a point where barricades erected earlier had been removed. The Red Cross did not report the death of an SRP workman in a flood related fire at Stewart Mountain Dam. Floodwaters started an electrical fire at the SRP dam.

Flood damages totaled \$51.8 million and are summarized in Table 4, below. Forty percent of the damages (\$20.5 million) were related to public roads and bridges. Of these, traffic delay losses were about \$12 million. Traffic delay represents income losses in that vehicle operating costs increased with slow speeds and individuals lost the opportunity to engage in other activities while in their cars longer. Damages related to all types of public uses totaled \$34.9 million (67%).

Table 4

SUMMARY OF ALL FLOOD DAMAGES  
(1,000)

<u>Land Use</u>	<u>Physical Damages</u>	<u>Income Losses</u>	<u>Emergency Costs</u>	<u>Total</u>
Agricultural	\$ 3,829	\$ 1,808	\$ 56	\$ 5,693
Commercial	1,396	703	26	2,125
Industrial:				
Sand & Gravel	3,098	1,930	215	5,243
Other	797	359	10	1,166
Public:				
Roads & Bridges	8,009	12,016	485	20,510
Other	12,519	1,056	847	14,422
Residential	2,486	81	30	2,597
TOTALS	\$ 32,134	\$ 17,953	\$ 1,669	\$ 51,756

In the remainder of this section, flood damages are analyzed by type, by land use, and by location.

B. TYPES OF FLOOD DAMAGES. Damages are classified within three principal types: physical damages, income losses, and emergency costs. Each activity affected by a flood has losses of one and more of these types.

1. Physical damages include damages to or loss of buildings; loss of contents including furnishings, equipment, materials, or finished products; cost of cleanup; loss of roads, bridges, power lines; and so forth.

2. Income losses are lost wages or lost net profits which result from the inability to operate normally. Income losses include plant shutdown, days out of work, decline in trade, and traffic delay. The main agricultural income loss derives from disrupted normal cropping patterns.

3. Emergency costs are expenses which would otherwise not have been required without the flood. These include the costs of evacuation, flood fighting, disaster relief, and increased expense of normal operations during the flood, including fire, police, and other public services.

Table 5 summarizes flood damages by type.

Table 5  
SUMMARY OF FLOOD DAMAGES BY TYPE  
December 1978  
(1,000)

Type	Salt River	Gila River	Agua Fria River	Total
Physical damages	\$ 23,488	\$ 5,483	\$3,163	\$32,134
Income losses	14,190	1,569	2,194	17,953
Emergency costs	1,278	259	132	1,669
Total	\$ 38,956	\$ 7,311	\$5,489	\$51,756

Income losses represented 35% of all damages reported. All but \$6 million of the lost income was from traffic delay. The effect from closed river crossings was so significant because it lasted three weeks and impacted the lives of almost every resident in the area. Physical damages amounted to 62% of the total damages. The remaining 3% of the damages were emergency costs. More than half of the damages of each type were public damages.

C. SUMMARY OF FLOOD DAMAGES BY LAND USE AFFECTED. Flood damages for the Salt, Gila, and Agua Fria Rivers are presented by five major land use categories:

Public	Industrial
Residential	Agricultural
Commercial	

Industrial uses are divided into two subcategories: "sand and gravel", the predominant industrial use affected by the floods; and "other". Similarly, public uses are divided into "roads and bridges" and "other" subcategories.

Public uses other than roads and bridges include sewage treatment plants, public recreational facilities, airports, and government owned properties. In addition, damages to major privately owned utilities were included in this category because of similarities in the types of facilities and manner of operation. Table 6 summarizes flood damages by land use.

Table 6

SUMMARY OF FLOOD DAMAGES BY LAND USE  
December 1978  
(1,000)

<u>Land Use</u>	<u>Salt River</u>	<u>Gila River</u>	<u>Agua Fria River</u>	<u>Total</u>
Agricultural	\$ 964	\$4,374	\$ 355	\$ 5,693
Commercial	1,364	326	435	2,125
Industrial:				
Sand & Gravel	3,921	45	1,277	5,243
Other	1,163	3	1,166	
Public:				
Roads & Bridges	17,985	1,526	1,999	20,510
Other	13,377	502	543	14,422
Residential	182	1,535	880	2,597
TOTALS	<u>\$38,956</u>	<u>\$7,311</u>	<u>\$5,489</u>	<u>\$51,756</u>

Damages to public facilities and industrial firms along the Salt River represent about 70% of all losses suffered within the study area. Including losses along the Gila and Agua Fria Rivers, public and industrial losses were more than 80% of all damages reported. Agricultural losses made up about 11% of the total damages, followed by residential damages (5%), and commercial losses (4%).

The December, 1978 flood had a significant impact on Maricopa County's agricultural sector, which had also suffered heavily during the February-March flood. Agricultural damages exceeded \$5 million

dollars. The most extensive damage (\$4.4 million) occurred in the Gila River flood plain. Interviews with local residents indicate that much of the December flood damage was on land which had not been affected in the March 1978 flood. This can be explained by the fact that the Gila River cut new channels into farmland which had previously been unaffected by floodwaters. Thirty-seven percent of all the agricultural damage costs reported represent land damage. Table 7 summarizes agricultural damages.

The greatest commercial losses occurred along the heavily urbanized portions of the Salt River -- between 48th Street and 115th Avenue. These accounted for nearly \$1.4 million of the total \$2.1 million commercial damages in the area. An auto wrecking yard accounted for 60% of the \$0.4 million in commercial damages on the Agua Fria River. Commercial losses on the Gila River totaled \$0.3 million. The largest losses occurred to the Phoenix International Raceway and a cock gaming establishment. Industrial damages totaled \$6.4 million, of which damage to sand and gravel firms totaled \$5.2 million. Almost 75% of the sand and gravel damages occurred along overflow areas of the Salt River. Most of the remaining damages were along the Agua Fria River. Sand and gravel operations are typically located in or near riverbeds in order to be close to their source of raw materials. There were 17 sand and gravel operations on the Salt River, nine on the Agua Fria River, and one on the Gila River. Income losses due to plant shutdown and unmet contractual obligations represent more than one third of the damages. Physical losses were nearly 60% of the total losses to sand and gravel operations.



The Salt River flood plain is viewed from the air after December flood waters receded.

Table 7

SUMMARY OF AGRICULTURAL DAMAGES  
December 1978 Flood  
(1,000)

Description of Loss	Agua Fria River		Gila River		Salt River			
	1 <sup>a</sup>	2	4	5	6	7	9	10
Land (reshaping & clearing)	\$108	\$15	\$121	\$459	\$870	\$503	\$10	\$4
Crop	51	9	74	206	199	126	1	-
Equipment	82	24	110	371	393	133	8	1
Livestock	-	-	15	-	8	1	-	-
Business	59	7	99	529	273	174	2	-
Emergency	-	-	-	46	9	1	-	-
Total	\$300	\$55	\$419	\$1,611	\$1,752	\$938	\$21	\$5
Total Agricultural Damage - Agua Fria River					\$ 355			
Total Agricultural Damage - Gila River					4,374 <sup>b</sup>			
Total Agricultural Damage - Salt River					964			
Total Agricultural Damage					\$5,693			

- a. Locations 3 and 8 reported no damages and are not in the above table.  
b. Includes losses by the Buckeye Irrigation District of \$592,000 incurred along the Gila River, but not allocated to specific locations.  
- Less than \$500

Source: Arizona State Agricultural Stabilization and Conservation Service; Field Investigations

Table 8 provides a breakdown, by river, of physical damages to roads and bridges. In addition to these damages, the Metropolitan Area sustained losses from traffic delays. These losses have been estimated for the additional time and vehicle operation costs resulting from: traveling extra miles to reach an open river crossing, and operating the vehicle at reduced speeds. The estimated additional time was valued at \$4.92<sup>1</sup>. The estimated value of drivers time lost exceeded \$6 million. The total cost of transportation delays incurred between December 16, 1978 and January 6, 1979 is estimated at \$12 million; \$10.7 million for the Salt River, and \$1.3 million for the Agua Fria River.<sup>2</sup> Roads were closed for many months and other floodflows delayed repair work in January. However, traffic delays after January 6th were insignificant at some crossings and not directly related to the December flood at major bridges.

No transportation delays were estimated for the Gila River, although all of its crossings were closed by the flood. Nine-thousand vehicles cross the Gila River daily. However, these crossings may often be used for access to better east-west roadways to Phoenix. While significant traffic delays resulted from the flooding on the Gila, estimates of their value would not be accurate with the data available.

Facilities included in the "other" public land use category which received major damage include Sky Harbor International Airport (\$4.6 million), Mountain Bell (\$611,000), Arizona Public Service Company (\$2 million), and the Salt River Project (\$5.5 million). A summary of damages to major utilities is provided in Table 9. Most of the SRP damage occurred upstream at storage reservoirs. These damages are included in the totals shown in this report, although the sites are outside of the Phoenix Metropolitan Area.

Residential damages, which totaled \$2.6 million, occurred primarily along the Gila and the Agua Fria Rivers. Allenville and Holly Acres were severely flooded in the February-March event. Both communities on the Gila River suffered extensive damage again in December. Damages in December, 1978 totaled \$120,000 and \$1 million, respectively. Residents of Allenville are expected to be relocated permanently to another portion of the county. Residential damages totaled \$800,000 on the Agua Fria River, mainly in Hatfield Acres and Rose Garden Lanes.

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<sup>1</sup> "A Manual on User Benerfit Analysis of Highway and Bus Transit Improvements," the American Association of State Highway and Transit Officials, Washington, D.C., 1977.

<sup>2</sup> The methodology used was based on the Arizona Department of Transportation's "Analysis of Motorists User Costs with Only Three Salt River Crossings Open." This methodology was modified to account for the reopenings of transportation networks and to measure motorists user costs for the Agua Fria River.

Table 8

MAJOR ROAD AND BRIDGE DAMAGES  
(1,000)

Agua Fria River		Gila River		Salt River	
Road/Bridge	Amount	Road/Bridge	Amount	Road/Bridge	Amount
Bell Road	\$ 95	Airport Road	\$ 82	Alma School Road	\$ 171
Camelback Road	52	Allenville (Silt clearing)	3	Bush Highway	14
Glendale Avenue	75	Baseline Road	N.A.	Gilbert Road	43
Harmony Lane	-	Beloat Road	7	Hayden Road	402
Hatfield	4	Bullard Avenue	107	Hohokam Freeway Approach	30
Jomax Road	6	Cotton Lane	2	McKellips Road	169
Lake Pleasant Road	159	El Mirage Road	N.A.	Mill Ave Crossing	171
Lower Buckeye Road	49	Holly Acres	29	Scottsdale Road	160
McDowell Road	47	Jack Rabbit Trail	100	7th Avenue	301
Northern Avenue	112	Miller Road	N.A.	19th Avenue	2,500 <sup>a</sup>
Olive Avenue	55	115th Avenue	196	35th Avenue	195
Rose Garden Lane	15			51st Avenue	61
Sun Valley Lane	2			67th Avenue	63
107th Avenue	11			75th Avenue	1
115th Avenue	9			91st Avenue	102
117th Avenue	4			107th Avenue	12
118th Avenue	4			7th Street	133
119th Avenue	1			16th Street	2,500 <sup>a</sup>
				24th Street	97
				40th Street	100
				48th Street	28
Total, Agua Fria	\$710	Total, Gila	\$526	Total, Salt	\$7,253 <sup>b</sup>

a. \$5 million in total repair cost is estimated for the 19th Avenue and 16th Street crossing.

b. \$5,000 in damages to a road in the Salt River-Pima-Maricopa Indian Community reservation is not included.

- Less than \$500.

N.A. not available

Source: City of Phoenix Engineering Inspectors Department; Maricopa County Transportation Planning Office.

Table 9

DAMAGES TO MAJOR UTILITIES  
(1,000)

<u>Name of Utility</u>	<u>River/Location</u>	<u>Physical Damages</u>	<u>Income Losses</u>	<u>Emergency Costs</u>	<u>Total</u>
Arizona Public Service	Agua Fria River	\$ 212	b	6	\$ 218
	Gila River	240		9	249
	Salt River	<u>1,536</u>		<u>18</u>	<u>1,554</u>
APS Total					<u>\$2,021</u>
Mountain Bell	Agua Fria River	62			\$ 62
	Gila River	180			180
	Salt River	<u>369</u>			<u>369</u>
Mountain Bell Total					<u>\$ 611</u>
Salt River Project	Salt River				
	Horse Mesa Dam	1,320			
	Roosevelt Dam	625			
	Stewart Mt. Dam	256			
	Verde River				
	Bartlett Dam	2,160			
	Horseshoe Dam	<u>50</u>			
Total Salt River Project		<u>4,411</u>	<u>600</u>	<u>470</u>	<u>\$5,481</u>
Total Damages					<u>\$8,113</u>

a. Preliminary SRP figures - subject to revision.

b. No damages reported for blank cells.

Sources: Arizona Public Service Company, Mountain Bell, Salt River Project

D. SUMMARY OF FLOOD DAMAGES BY LOCATION. Damages are presented in Table 10 for each of the ten locations or segments of the flood plain which were assessed. Damage data is further classified according to type of loss and property use for each watershed and reach. The location boundaries, by watershed, are:

Agua Fria River:

- Location 1 - Confluence with Gila River to Indian School Road;
- Location 2 - Indian School Road to Bell Road;
- Location 3 - Bell Road to Waddell Dam;

Gila River:

- Location 4 - U. S. Highway 80 to Watson Road;
- Location 5 - Watson Road to Perryville Road;
- Location 6 - Perryville Road to 115th Avenue;

Salt River:

- Location 7 - 115th Avenue to 35th Avenue;
- Location 8 - 35th Avenue to 48th Street;
- Location 9 - 48th Street to Country Club Drive;
- Location 10 - Country Club Drive to Granite Reef Dam.



Releases from Lake Pleasant washed out dip crossings on the Agua Fria River, such as the road shown above.

1. LOCATION 1 - AGUA FRIA RIVER - CONFLUENCE WITH GILA RIVER TO INDIAN SCHOOL ROAD.

Damages to industrial sand and gravel operations were \$465,000, the largest portion of the total losses reported for this location. Damages in Location 1 totaled \$980,000. Damages to the sand and gravel operations were mainly in the form of damaged conveyors, flooded materials, water filled pits, and business losses.

Location 1 is the most sparsely populated reach of the Agua Fria River flood plain, yet the most intensely farmed. Although only minor damages to the residential sector were reported (\$3,000), the population of Avondale was directly affected as 3,000 persons were evacuated in response to flood warnings. Damages incurred by the agricultural sector made it the second ranking loss category. Approximately 222 agriculture acres were damaged, with an estimated loss of \$300,000. The main crop produced in this area is cotton, followed by alfalfa. One dairy and one feedlot operation also incurred substantial damages from the December flood.

Two public establishments, a sanitary landfill in Glendale and a sewage treatment plant in Avondale, accounted for the \$114,000 in non-transportation related public damages. Two 5-acre lagoons and a primary sewage treatment pond sustained damages at the Avondale Treatment Plant. In addition, public damages to roads and bridges amounted to \$96,000 and required re-routing of about 5% of the area's average daily traffic flow. Resulting traffic delay costs are not available by location.

2. LOCATION 2 - AGUA FRIA RIVER - INDIAN SCHOOL ROAD TO BELL ROAD.

Losses in Location 2 were similar to those in Location 1 and totaled an estimated \$954,000. The greatest dollar loss, \$344,000, was to public roads and bridges. This location is the site of the only major Agua Fria River crossings which remained open during the flood. Heavy congestion at these crossings resulted in additional travel costs and time delays for motorists. These losses are, however, not included in the total of direct public losses to roads and bridges discussed here.

An auto wrecking establishment reported most of the \$285,000 in commercial losses incurred. The yard was engulfed by from 4 to 6 feet of water, displacing stockpiled cars. After floodwaters receded, cars were found miles from the original site. The rest of the damages to commercial property took place in El Mirage. Water soaking of parking lots and inside carpeting were typical of the damages suffered. The four sand and gravel operations in this reach sustained damages totaling \$212,000. Business losses and materials swept away by floodwaters explain the damages at these operations. Most of the \$57,000 in residential damages occurred in the community of El Mirage. El Mirage, located 20 miles northwest of Phoenix, has a population of 4,000. About four city blocks in the southeastern portion of the community were

flooded. The average household experienced \$2,000 in damages. These included damage to yards, walls, floors, carpeting, and contents. Although only a small percentage of homes were affected by the December flood, local sources estimate that 80% of the residents evacuated in response to flood warnings.

Agricultural production in Location 2 is similar in nature to that in Location 1, and cotton is the primary crop. The magnitude of damages in this reach, however, was substantially less.

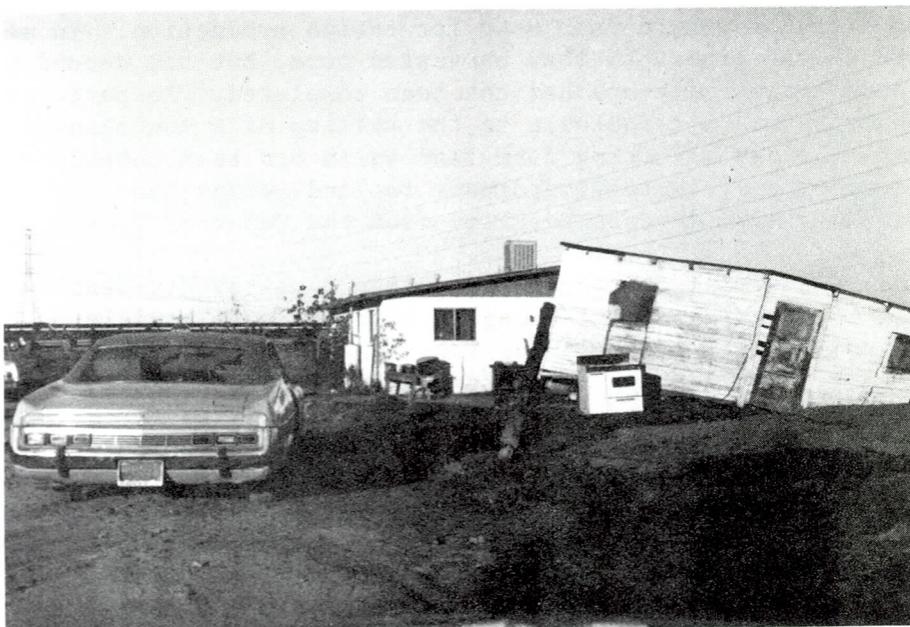
### 3. LOCATION 3 - AGUA FRIA RIVER - BELL ROAD TO WADDEL DAM.

Estimated total damages for this location are \$2 million. Releases of 60,000 cfs of water from Lake Pleasant Reservoir resulted in serious flooding to areas in Location 3 which had previously been unaffected by floodwaters. The greatest monetary loss occurred in the residential sector. Two communities, Hatfield Acres and Rose Garden Lanes, reported damages totaling \$820,000 or 41% of the nearly \$2 million in damages for Location 3. These communities are located 10 to 14 miles downstream of Lake Pleasant Reservoir and were evacuated early on the morning of December 19th, after personnel at Lake Pleasant announced that major water releases of 60,000 cfs would be necessary. The total volume of water released from Lake Pleasant was 52,500 acre feet, or one third of the capacity of the reservoir.

Hatfield Acres is a small community with approximately 32 dwelling units, 19 of which are mobile homes. Rose Garden Lanes, south of Hatfield Acres, contains about 20 units, 5 of which are mobile homes. Flood damages reported in Hatfield Acres were much greater than those in Rose Garden Lanes. Damages such as cracked house foundations, yard and fence damages, buckled floorboards, water soaked walls, and destroyed contents were not uncommon for Hatfield Acre residents. While in Rose Garden Lanes, damages were mainly silt deposits or land erosion. Individual property damages ranged from \$1,500 to \$109,000 in Hatfield Acres and from \$500 to \$36,000 in Rose Garden Lanes.

Private sand and gravel operations and a sewage treatment facility have been accused of partially blocking the river channel, thereby re-directing the water flow to the nearby communities. Whatever the case, sand and gravel operations lost \$600,000 in this area from the December flood. Physical damages totaled \$200,000, a third of the losses to the sand and gravel industry in Location 3.

Damage to public roads and bridges of \$270,000 was the third largest damage category, followed by commercial damages of \$148,000. Three commercial establishments including a western movie town, a worm farm, and a privately owned water company were affected.



In El Mirage flood waters on the Aqua Fria River shifted the house, shown on the right, off of its foundation.



Sand and gravel operations locate within the flood plain. The operation above is south of Buckeye, inside the Gila River channel which is in the foreground.

#### 4. LOCATION 4 - GILA RIVER - U.S. 80 TO WATSON ROAD.

This reach has extensive agricultural development, one small community, and few commercial and industrial enterprises. Agricultural damages in Location 4 totaled \$419,000, or 68% of all damages reported for this location. Most damage was to land used for cotton production. In many instances, the cotton crops had been harvested once, but the second pick and rood (ground cotton pick-up) had not been completed. In part, these agricultural damages are attributable to the cutting of a new channel by the Gila River, thereby affecting farm land which had been untouched in the past by floodwaters. Extensive damage to land, crops, and structural property improvements resulted from the December flood.

Damages to the residential sector totaled \$152,000. Seventy-nine percent of the residential sector damages occurred in Allenville. Allenville is primarily a community of farm laborers, and many of the residents are of retirement age. Before the March 1978 flood, Allenville contained approximately 60 dwelling units. The March 1978 flood devastated the community, leaving only 40 dwelling units. Residents were provided with temporary HUD housing near Buckeye until they could repair their own homes. Throughout the summer and fall of 1978, Allenville residents were involved in an effort to rebuild their community. CETA funds were awarded for community restoration work. Residents hoped to have 100% of the clean-up completed by Christmas. At the time of flooding in December, 30 to 40 families had returned to their homes. The flood of December, 1978, again devastated Allenville. Total damage is estimated at \$120,000. Residents no longer want to move back, and are currently involved with the State of Arizona and the U.S. Army Corps of Engineers in a possible relocation program (see Section VI).

Damages to the one sand and gravel operation in this area totaled \$45,000. Public road and bridge damages were reported at \$3,000. No commercial establishments are located in this area. Total damages reported in Location 4 were \$619,000.

#### 5. LOCATION 5 - GILA RIVER - WATSON ROAD TO PERRYVILLE ROAD.

Total damages for this location were estimated at almost \$2 million, of which \$1.8 million or 90% were residential and agricultural losses. Residential development consists mainly of low density, single family dwelling units. Residential damages totaled \$155,000, or 8% of the losses in Location 5. Eighty-two percent of all the damages were agricultural. Location 5 contains a large number of dairy and feedlot operations. Losses to dairy/feedlot operations ranged from structural damage to emergency costs which were incurred when moving livestock to dry ground. Often, additional losses occurred because of sickness and physical harm inflicted upon livestock during the process of moving or because farmers were forced to sell their animals prematurely for lack of adequate food or shelter.



Damages totaled \$120,000 at Allenville. Here, water still surrounds the community on December 21, 1979, one day after the peak flow occurred.



This twisted wall is the remains of a house at the confluence of the Salt and Gila Rivers. At the right, the rear wheels of the heavy truck are stuck in the mud.

Location 5 contains no commercial, industrial, or public facilities, other than roads and bridges. Physical damages to roads and bridges totaled at \$189,000.

6. LOCATION 6 - GILA RIVER - PERRYVILLE ROAD TO 115th AVENUE.

This area contains the confluence of the Salt and Gila Rivers at 115th Avenue and the confluence of the Gila and Agua Fria Rivers at Litchfield Road. Damages totaled \$3.7 million.

Agricultural damages totaled \$1.8 million, nearly half of all the damages reported. Most agricultural damage was from land erosion, damaged irrigation structures, and crop losses.

Residential damages exceeded \$1.2 million. Most of this loss was in the Holly Acres subdivision and other residential units located between 115th and 122nd Avenues. Holly Acres is a 5 to 10 year old subdivision with an average home value of \$55,000. Local residents had just completed repair work from the February-March flood. They planned to spend the holiday season in their homes after many families had spent nine months in other housing. The December, 1978 flood occurred shortly before Christmas, and largely destroyed the repair work completed after the February-March, 1978 flood. Floodproofing and construction of flood control structures are alternatives under consideration to reduce the flood hazard in Holly Acres. Physical damage and revenues foregone at the Phoenix International Raceway and a cock gaming establishment represent all of the \$326,000 in commercial losses reported. There are no sand and gravel operations in this location.

7. LOCATION 7 - SALT RIVER - 115th AVENUE TO 35th AVENUE.

This area experienced the most extensive agricultural damage on the Salt River. Agricultural losses were \$938,000, 34% of the total \$2.8 million in damages reported for this location. Ninety-eight percent of the damages to agricultural acreage on the Salt River occurred in Location 7. The primary crop in this area is upland cotton, followed by alfalfa and barley. Losses to the single sand and gravel operation in this reach totaled \$232,000. Conveyor belt damage, pit flooding, and revenues foregone were the major losses. Damages to commercial establishments were \$514,000. A tire recycling establishment had the most commercial losses. Emergency costs and physical damages to public roads and bridges totaled \$434,000. Most of the other public losses were to three sites: the 91st Avenue Sewage Treatment Plant, where a culvert and an effluent channel were damaged; a Bureau of Reclamation transmission tower where original footings were shifted by rushing water; and the water pipeline feeding into the Palo Verde Nuclear Power Plant now under construction. Residences, generally consisting of 5 acre ranchettes, had losses of \$182,000. These residential units sustained the only residential damage which occurred on the Salt River.

8. LOCATION 8 - SALT RIVER - 35th AVENUE TO 48th STREET.

This area is the most heavily urbanized portion of the Salt River and sustained more than \$13 million dollars in flood damage. Physical damages to roads and bridges totaled \$5.7 million. Key elements of the regional transportation system crossing the Salt River were affected. The damage estimates for roads and bridges were reported by the City of Phoenix, Engineering Inspections Department and the Maricopa County Transportation Planning Office. It is estimated, however, that an additional \$12 million in traffic delay costs were incurred by motorists crossing the entire Salt River between the December, 1978 flood and January 6, 1979. This estimate considers the value of drivers' time attributable to transportation delay, and additional vehicle operation expenses which occur when bridge wash-outs require re-routing of traffic and otherwise disrupt the normal traffic patterns.

Public damages to facilities other than roads and bridges accounted for nearly \$5 million. These included the sanitary landfill operations at 18th Street and 19th Avenue, a sewage interceptor line, and Sky Harbor International Airport. Sky Harbor suffered \$4.6 million in runway and radar system damage. Although flooding occurred during the busy Christmas season, operations continued to run close to normal. Due to the reduced runway length, however, some planes were forced to take off with less than full fuel tanks in order to reduce the weight of the aircraft. The City of Phoenix is considering excavation of the river channel at 40th Street and construction of a dike to reduce future flood damages to the airport.

Five of the 17 Salt River sand and gravel operations are in this reach and they sustained a total of \$1 million in losses. Most losses resulted from conveyor damage and forgone revenues. Damage to individual operations ranged from a low \$300 to a high of \$300,000. Other industrial establishments located near the river had over \$1 million in losses. Commercial damages of \$808,000 were reported for this reach. Location 8 has the highest concentration of commercial establishments, most of which are located close to the seven main river crossings.

No agricultural or residential damage was reported at this location.

9. LOCATION 9 - SALT RIVER - 48th STREET TO COUNTRY CLUB DRIVE.

The seven sand and gravel operations along this reach accounted for \$1.5 million in damages, 45% of the \$3.3 million total losses in Location 9.

The public sector received the second greatest dollar loss. Road and bridge washouts accounted for \$1.1 million of the \$1.7 million in public damages and were second only to damages of this type on Location 8. Roads and bridges in this location include the primary transportation routes into the Phoenix urban area for residents of Tempe and Mesa.



Designed to withstand flows of 15,000 cfs, the 7th St. Bridge washed out during the flood that peaked at 140,000 cfs. Until the bridge was repaired, 16,000 daily users were directly affected.



The east end of the Sky Harbor International Airport main runway is covered by flood flows. The airport had damage totalling \$4.6 million, but operations were not seriously affected.

The Arizona State University parking lot in Tempe was the largest single element in "other" public damages. ASU sustained damage to traffic control lights, fire lanes, water lines, and light poles. Agricultural and commercial losses were minor and no damages were reported in the residential sector.

The Salt River-Pima-Maricopa Indian Community Reservaton borders Location 9. Tribal officials indicated that damages on the reservation were similar to those sustained during the February-March, 1978 flood. The largest losses due to the December flood were to the five sand and gravel operations under permit or lease on reservation land. Community members, living on the south side of the river, also faced problems as normal transportation routes were impassable. The nearest crossings available to motorists were at Hayden Road, Scottsdale Road, or the Mill Avenue bridge in Tempe.

10. LOCATION 10 - SALT RIVER - COUNTRY CLUB DRIVE TO GRANITE REEF DAM.

Granite Reef Dam represents the northeastern boundary of Location 10, and the Salt River study limit for this report. The dam is located at the confluence of the Verde and Salt Rivers. Damages in Location 10 totaled \$1.3 million. The total reflects the relatively limited amount of development in this area. Nearly 92% of all damages were to four sand and gravel operations, one of which operates on land leased from the Salt River-Pima-Maricopa Indian Community. Public damages to roads and bridges account for \$48,000 in losses. A road on the reservation was also damaged.

Damages to the remaining sectors were minimal. Agricultural damages of \$5,000 were incurred as corrals on graze land were destroyed. No damages were reported in the commercial and residential sectors.

Table 10 summarizes all flood damages by location.



The Tempe Bridge on Mill Ave. was one of the three crossings over the Salt River that did not close. Normally a one-way crossing, two-way traffic used the bridge while the adjacent dip crossing was closed.



Looking south toward ASU, the edge of the Mill Ave. dip crossing is shown next to the Tempe Bridge. Flood flows washed out the crossing and diverted traffic, mostly to the Tempe Bridge.

Table 10

FLOOD DAMAGES BY LOCATION  
(1,000)

<u>Location/Type</u>	<u>Physical Damages</u>	<u>Income Losses</u>	<u>Emergency Costs</u>	<u>Total</u>
1. Agua Fria River Confluence with Gila River to Indian School Road				
Agricultural	\$ 191	\$ 109	\$ -	\$ 300
Commercial	2	-	-	2
Industrial:				
Sand and Gravel	429	28	8	465
Other	-	-	-	-
Public:				
Roads and Bridges	79	-	17	96
Other	114	-	-	114
Residential	3	-	-	3
Total-Location 1	<u>          </u>	<u>          </u>	<u>          </u>	<u>\$ 980</u>
2. Agua Fria River Indian School Rd. to Bell Rd.				
Agricultural	\$ 39	\$ 16	\$ -	\$ 55
Commercial	206	78	1	285
Industrial:				
Sand and Gravel	176	36	-	212
Other	-	-	-	-
Public:				
Roads and Bridges	275	-	69	344
Other	1	-	-	1
Residential	57	-	-	57
Total-Location 2	<u>          </u>	<u>          </u>	<u>          </u>	<u>\$ 954</u>
3. Agua Fria River Bell Rd. to Waddell Dam				
Agricultural	\$ -	\$ -	\$ -	\$ -
Commercial	68	72	8	148
Industrial:				
Sand and Gravel	200	400	-	600
Other	-	-	-	-
Public:				
Roads and Bridges	255	-	15	270
Other	58	90	-	148
Residential	736	76	8	820
Total-Location 3	<u>          </u>	<u>          </u>	<u>          </u>	<u>\$ 1,986</u>

- Less Than \$500

Table 10

FLOOD DAMAGES BY LOCATION (Cont'd)  
(1,000)

<u>Location/Type</u>	<u>Physical Damages</u>	<u>Income Losses</u>	<u>Emergency Costs</u>	<u>Total</u>
4. Gila River US 80 to Watson Rd.				
Agricultural	\$ 246	\$ 173	\$ -	\$ 419
Commercial	-	-	-	-
Industrial:				
Sand and Gravel	45	-	-	45
Other	-	-	-	-
Public:				
Roads and Bridges	3	-	-	3
Other	-	-	-	-
Residential	152	-	-	152
Total-Location 4	<u>246</u>	<u>173</u>	<u>-</u>	<u>\$ 619</u>
5. Gila River Watson Rd. to Perryville Rd.				
Agricultural	\$ 830	\$ 735	\$ 46	\$ 1,611
Commercial	-	-	-	-
Industrial:				
Sand and Gravel	-	-	-	-
Other	-	-	-	-
Public:				
Roads and Bridges	163	-	26	189
Other	-	-	-	-
Residential	155	-	-	155
Total-Location 5	<u>830</u>	<u>735</u>	<u>46</u>	<u>\$ 1,955</u>
6. Gila River Perryville Rd. to 115th Ave.				
Agricultural	\$1,271	\$ 472	\$ 9	\$ 1,752
Commercial	192	129	5	326
Industrial:				
Sand and Gravel	-	-	-	-
Other	3	-	-	3
Public:				
Roads and Bridges	188	-	146	334
Other	13	60	-	73
Residential	1,210	-	18	1,228
Total-Location 6	<u>1,271</u>	<u>472</u>	<u>9</u>	<u>\$ 3,716</u>

- Less than \$500

Table 10

FLOOD DAMAGES BY LOCATION (Cont'd)  
(1,000)

<u>Location/Type</u>	<u>Physical Damages</u>	<u>Income Losses</u>	<u>Emergency Costs</u>	<u>Total</u>
7. Salt River 115th Ave. to 35th Ave.				
Agricultural	\$ 637	\$ 300	\$ 1	\$ 938
Commercial	502	12	-	514
Industrial:				
Sand and Gravel	29	120	83	232
Other	63	25	5	93
Public:				
Roads and Bridges	365	-	69	434
Other	356	-	44	400
Residential	173	5	4	182
Total-Location 7				<u>\$ 2,793</u>
8. Salt River 35th Ave. to 48th St.				
Agricultural	\$ -	\$ -	\$ -	\$ -
Commercial	419	377	12	808
Industrial:				
Sand and Gravel	440	503	50	993
Other	731	275	5	1,011
Public:				
Roads and Bridges	5,689	-	-	5,689
Other	4,367	306	300	4,973
Residential	-	-	-	-
Total-Location 8				<u>\$13,747</u>
9. Salt River 48th St. to Country Club Dr.				
Agricultural	\$ 18	\$ 3	\$ -	\$ 21
Commercial	7	35	-	41
Industrial:				
Sand and Gravel	868	542	67	1,477
Other	-	59	-	59
Public:				
Roads and Bridges	962	-	125	1,087
Other	600	-	-	600
Residential	-	-	-	-
Total-Location 9				<u>\$ 3,286</u>

- Less than \$500

Table 10

FLOOD DAMAGES BY LOCATION (Cont'd)  
(1,000)

<u>Location/Type</u>	<u>Physical Damages</u>	<u>Income Losses</u>	<u>Emergency Costs</u>	<u>Total</u>
10. Salt River				
Country Club Dr. to Granite Reef Dam				
Agricultural	\$ 5	\$ -	\$ -	\$ 5
Commercial	-	-	-	-
Industrial:				
Sand and Gravel	911	301	7	1,219
Other	-	-	-	-
Public:				
Roads and Bridges	30	-	18	48
Other	-	-	-	-
Residential	-	-	-	-
Total-Location 10	<u>          </u>	<u>          </u>	<u>          </u>	<u>\$ 1,272</u>

- Less Than \$500

Certain damages reported by several entities could not be identified by location. These damages are not in Table 10, although total damages reported for each river elsewhere in this report include these damages:

Agua Fria River

Mountain Bell	\$62,000
APS	218,000
Traffic delay	1,289,000

Gila River

Buckeye Irrigation District	\$592,000
Mountain Bell	180,000
APS	249,000

Salt River

Mountain Bell	369,000
APS	1,554,000
Traffic Delay	10,727,000
SRP, including the Verde River	5,481,000

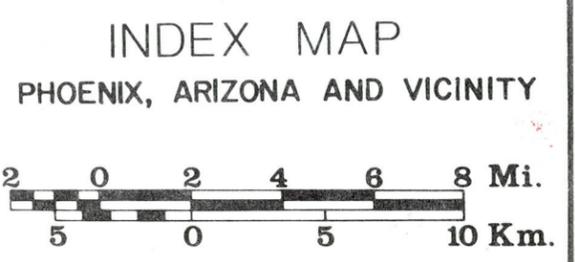
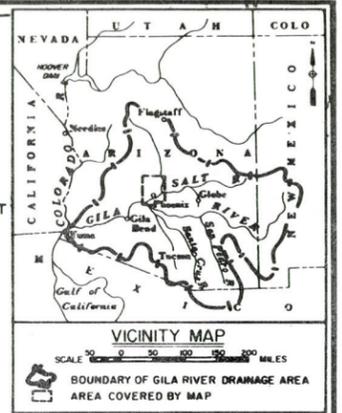
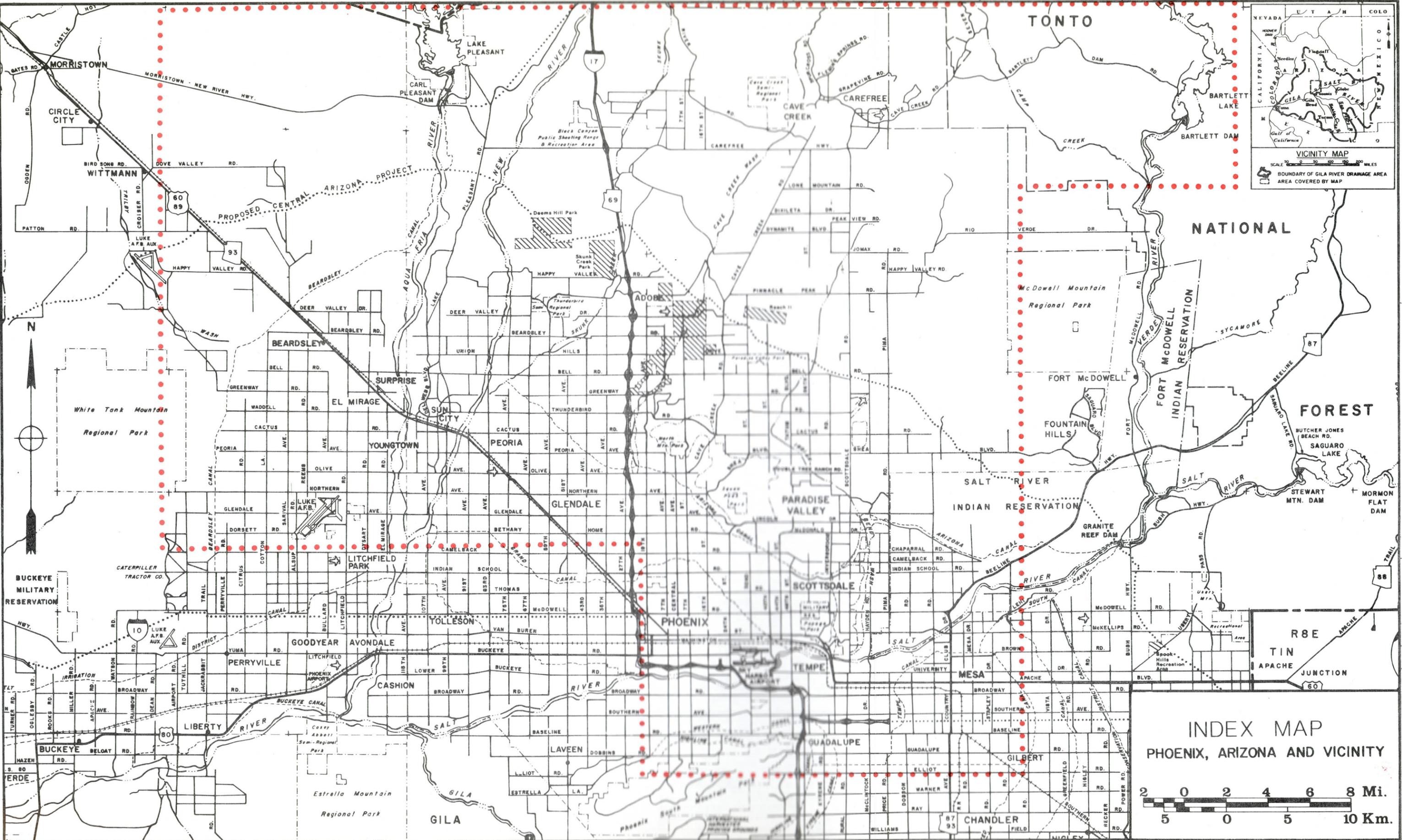
Flood damages totaled \$51.756 million.

## VI. DAMAGES THAT WOULD HAVE BEEN PREVENTED BY CORPS PROJECTS

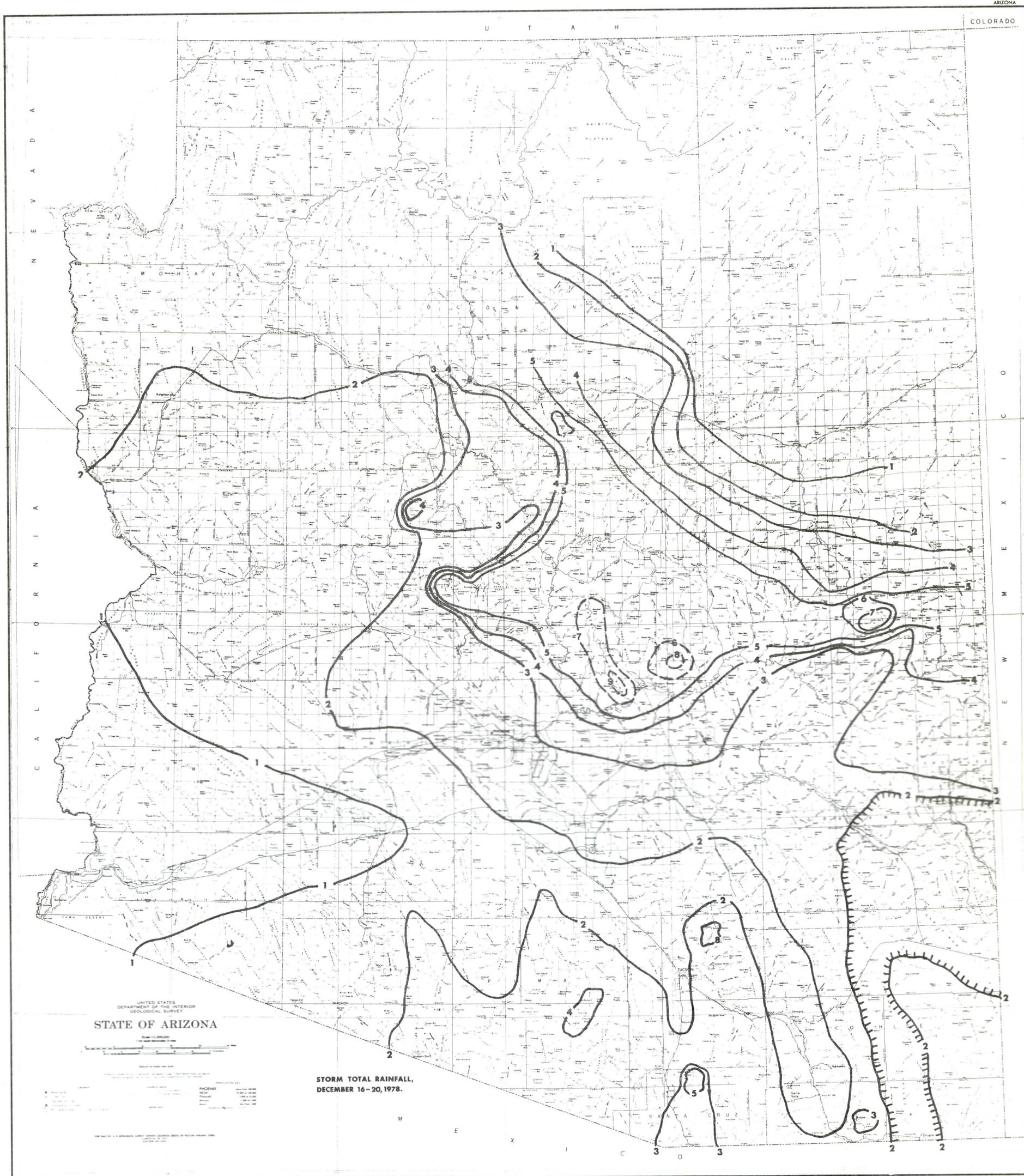
A. NEW RIVER AND PHOENIX CITY STREAMS. The Phoenix and Vicinity project, including the New River, is primarily designed to protect against flooding on Cave Creek, Skunk Creek, and the New River. However, included in the selected plan is the development of floodproofing measures along the Agua Fria River, which stretches about 10 miles between its confluences with the New River on the north and the Gila River to the south. This area is essentially Location 1. Such measures will include construction or modification of bridges by local interests, relocation, diking, and some channel clearing. Had this construction provided a point disposal for New River floodflow, \$215,000 of the damages in Location 1 would have been prevented. Damages to agricultural operations and to sand and gravel mining firms would not be reduced.

B. CENTRAL ARIZONA WATER CONTROL STUDY. The Corps and the Bureau of Reclamation are examining alternatives for flood control along the Salt and Gila Rivers in the Central Arizona Water Control Study (CAWCS). Many alternatives of varying types and levels of protection are being considered. The scope of project alternatives range from enlarged bridges crossing the Salt River (intended to reduce traffic delay) to upstream control on the Salt and/or Verde Rivers. If upstream control had reduced the peak flow on the Salt River at Tempe Bridge to 50,000 cfs, some damages would still have occurred. Along the Salt River, 10 crossings would still have been closed. Sand and gravel operations would have been affected. Prolonged releases would have increased sand and gravel income losses. On the Gila River, the Agua Fria inflow would have increased the flood flow to about 80,000 cfs. Damages would have been reduced on the Gila River, but not eliminated. Damages along the Agua Fria would not have been affected by any of the CAWCS alternatives.

C. ALLENVILLE FLOOD CONTROL STUDY. The Arizona Division of Emergency Services has asked the Corps to help relocate Allenville out of the flood hazard area. In response, the Corps is studying relocation and other alternative flood control measures in the Allenville Flood Study. The Corps plans to complete evaluation, planning, and design by April, 1980. Had relocation or another measure been completed, the \$120,000 in residential damages would not have occurred. In addition, \$400,000 in public assistance to Allenville residents would not have been needed.

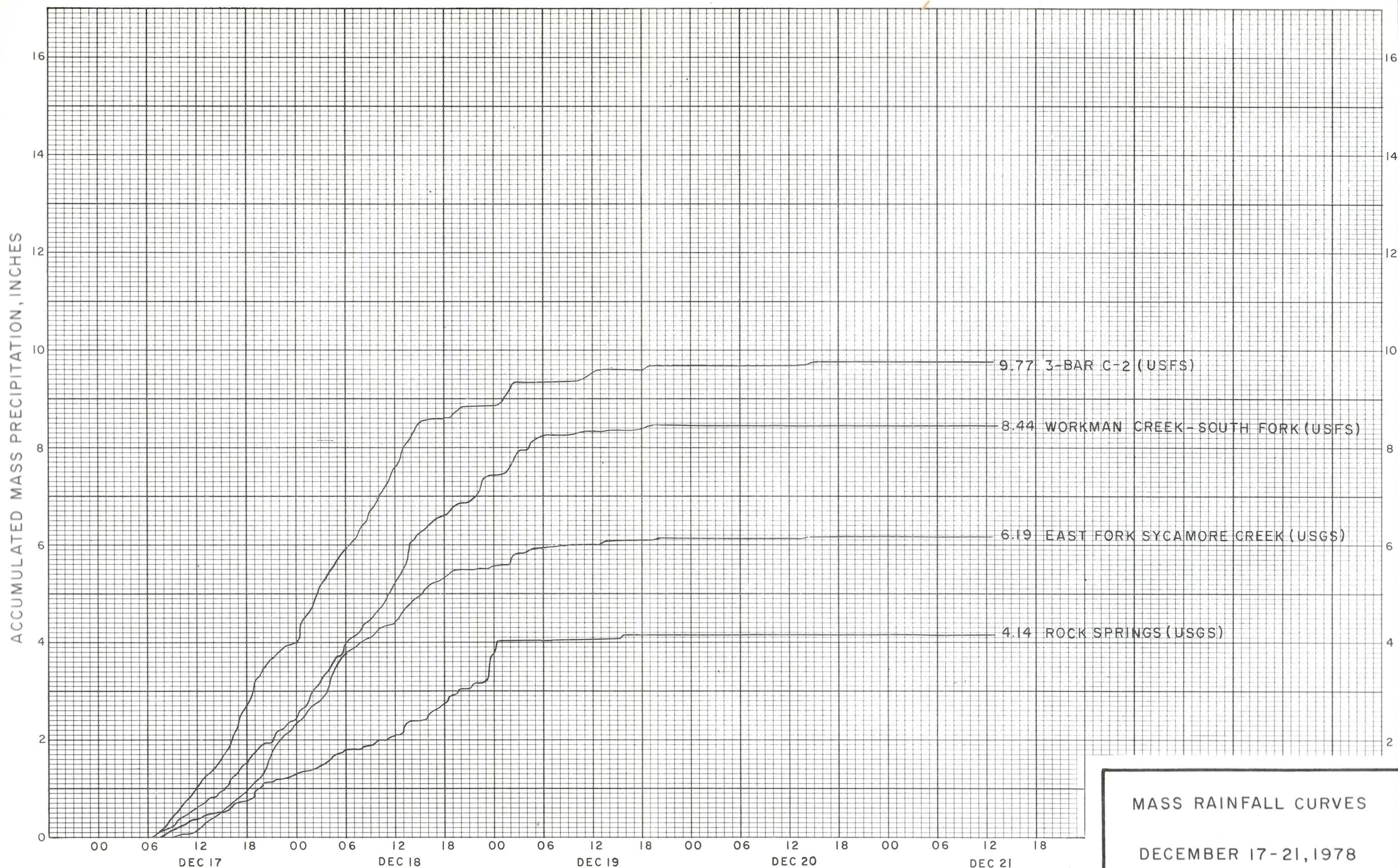


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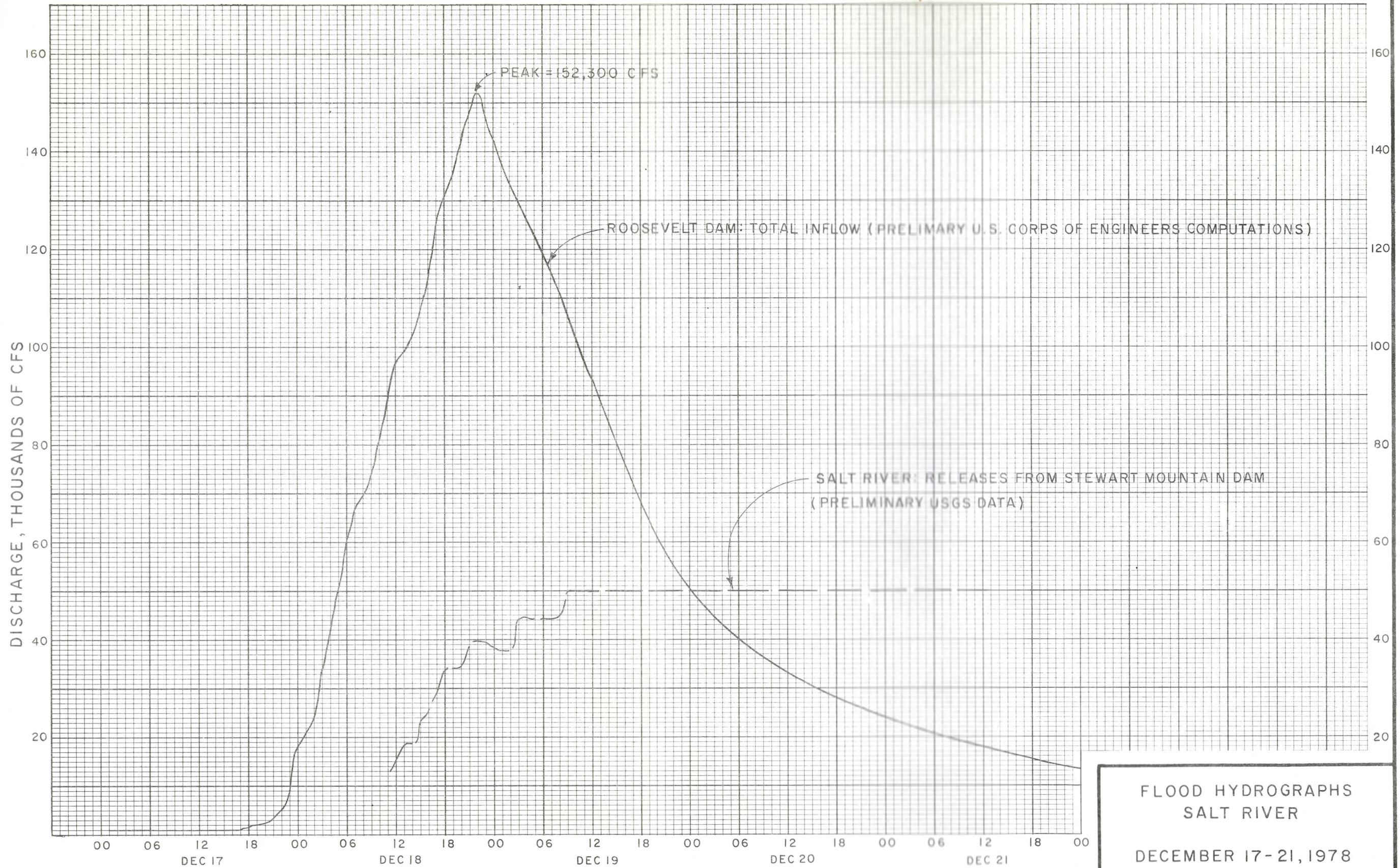


This plate was reproduced and modified, with permission of the National Weather Service, from Figure 2 of the "Report on the Arizona Floods of December 16-20, 1978," by U. S. Dept. of Commerce, NOAA, National Weather Service, May 18, 1979. The modifications are denoted here as dashed isohyets which have been added in the Mazatzal and Sierra Ancha Mountains northeast of Phoenix on the basis of unpublished U. S. Forest Service and U. S. Geological Survey precipitation data which were not available at the time that the original National Weather Service map was prepared.

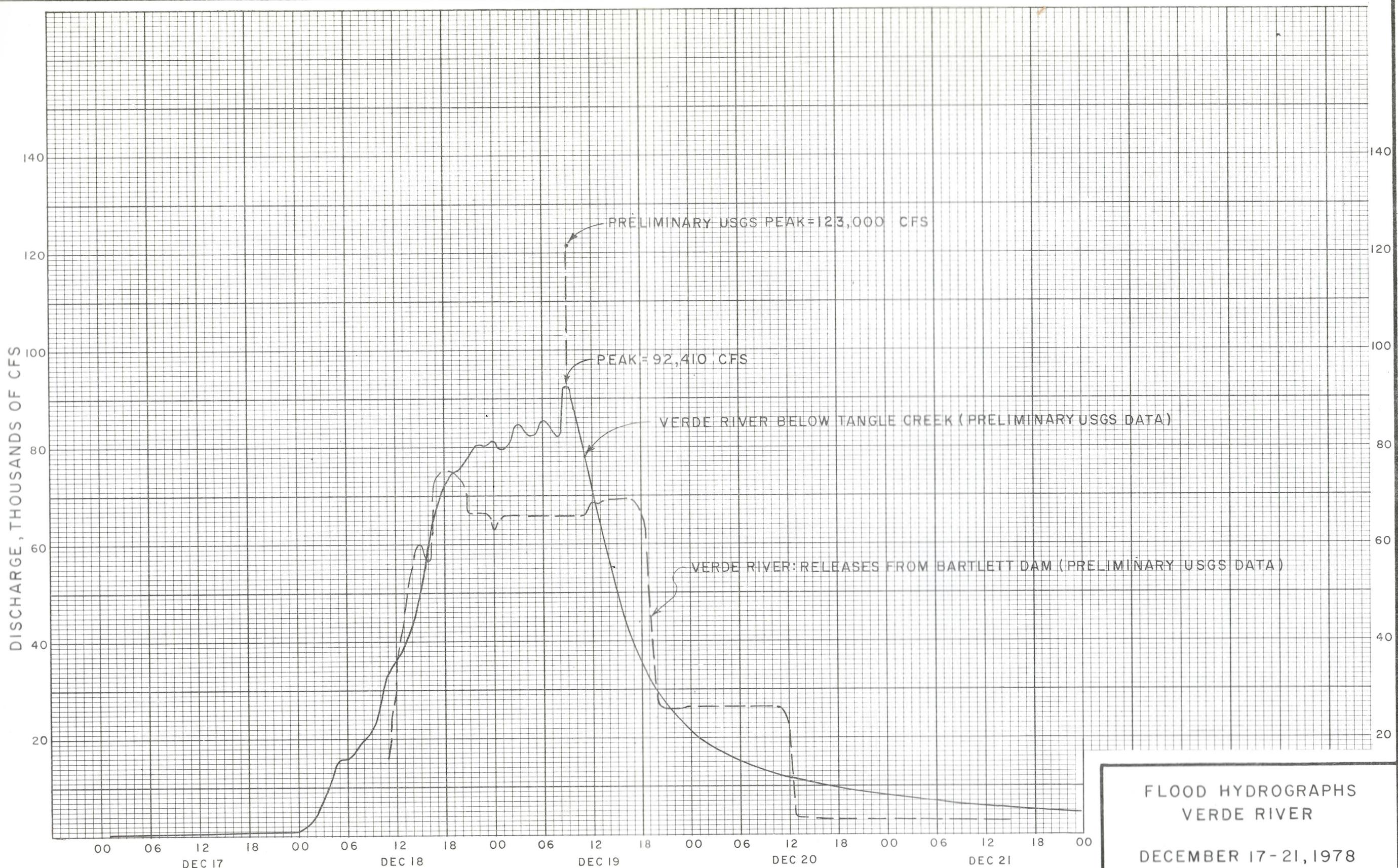
**ISOHYETAL MAP**  
STORM TOTAL RAINFALL  
DECEMBER 16-20, 1978



MASS RAINFALL CURVES  
DECEMBER 17-21, 1978  
U. S. ARMY ENGINEER DISTRICT  
LOS ANGELES, CORPS OF ENGINEERS



FLOOD HYDROGRAPHS  
SALT RIVER  
DECEMBER 17-21, 1978  
U. S. ARMY ENGINEER DISTRICT  
LOS ANGELES, CORPS OF ENGINEERS



FLOOD HYDROGRAPHS  
VERDE RIVER  
DECEMBER 17-21, 1978  
U. S. ARMY ENGINEER DISTRICT  
LOS ANGELES, CORPS OF ENGINEERS

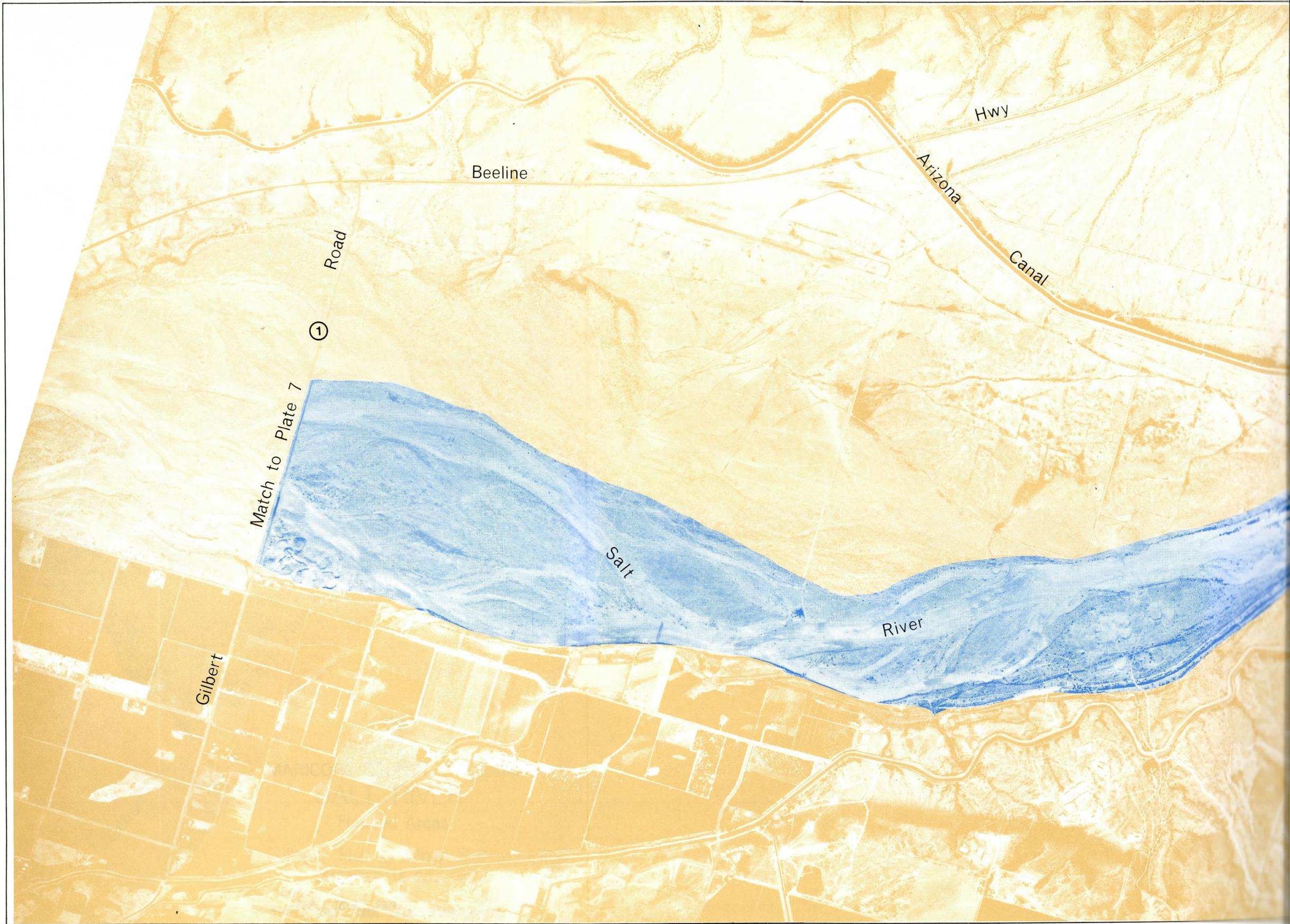




Plate 7

①  
Road

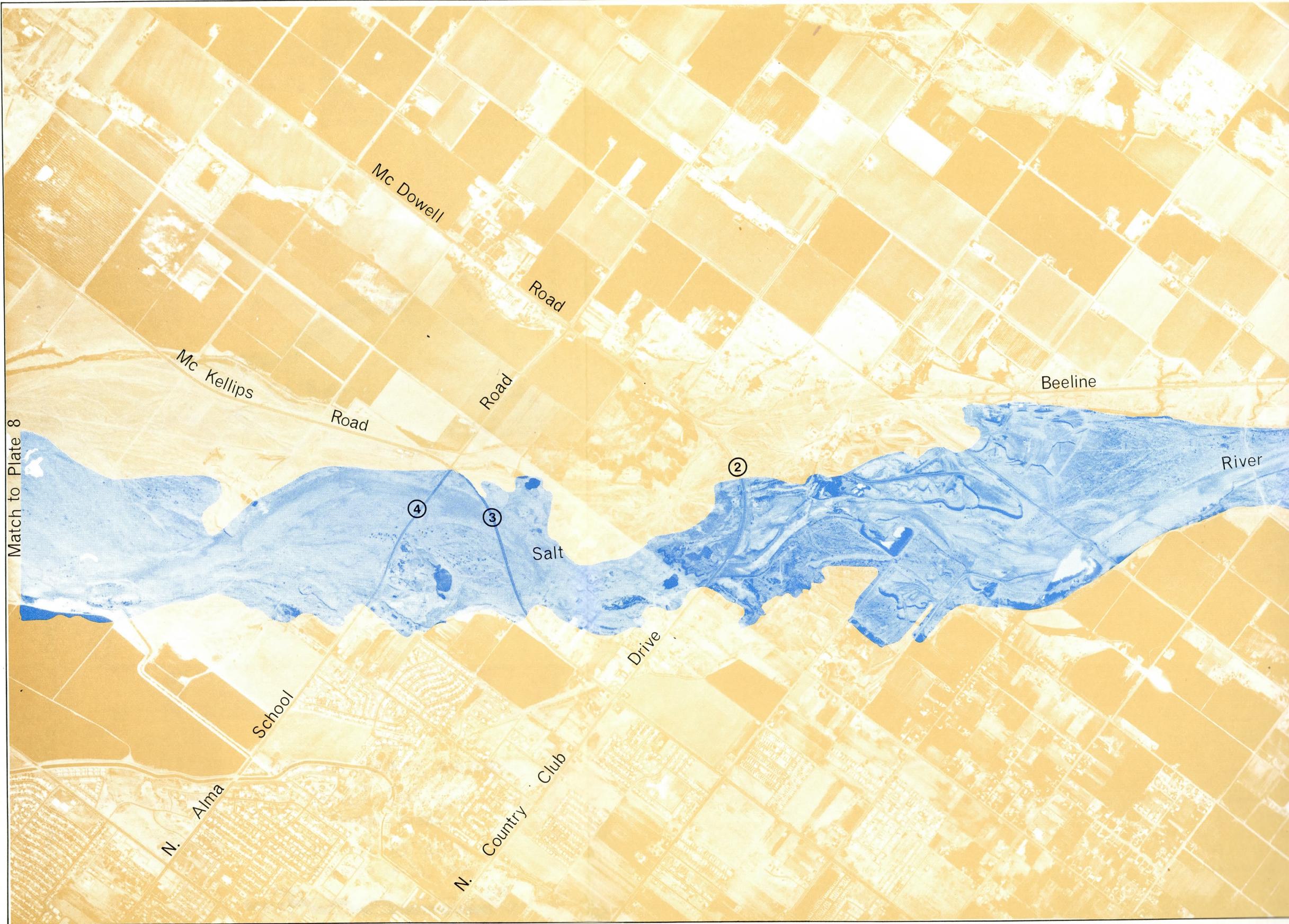
Beeline

Hwy  
Arizona  
Canal

Granite Reef Dam

Salt  
River

  
 MARICOPA COUNTY, ARIZONA  
**SALT RIVER**  
 Flooded Areas  
 Granite Reef Dam to Gilbert Rd.  
 DECEMBER 16-20, 1979  
 SCALE  FEET



Match to Plate 8

Mc Dowell

Road

Mc Kellips

Road

Road

Beeline

River

4

3

Salt

2

Drive

School

N. Alma

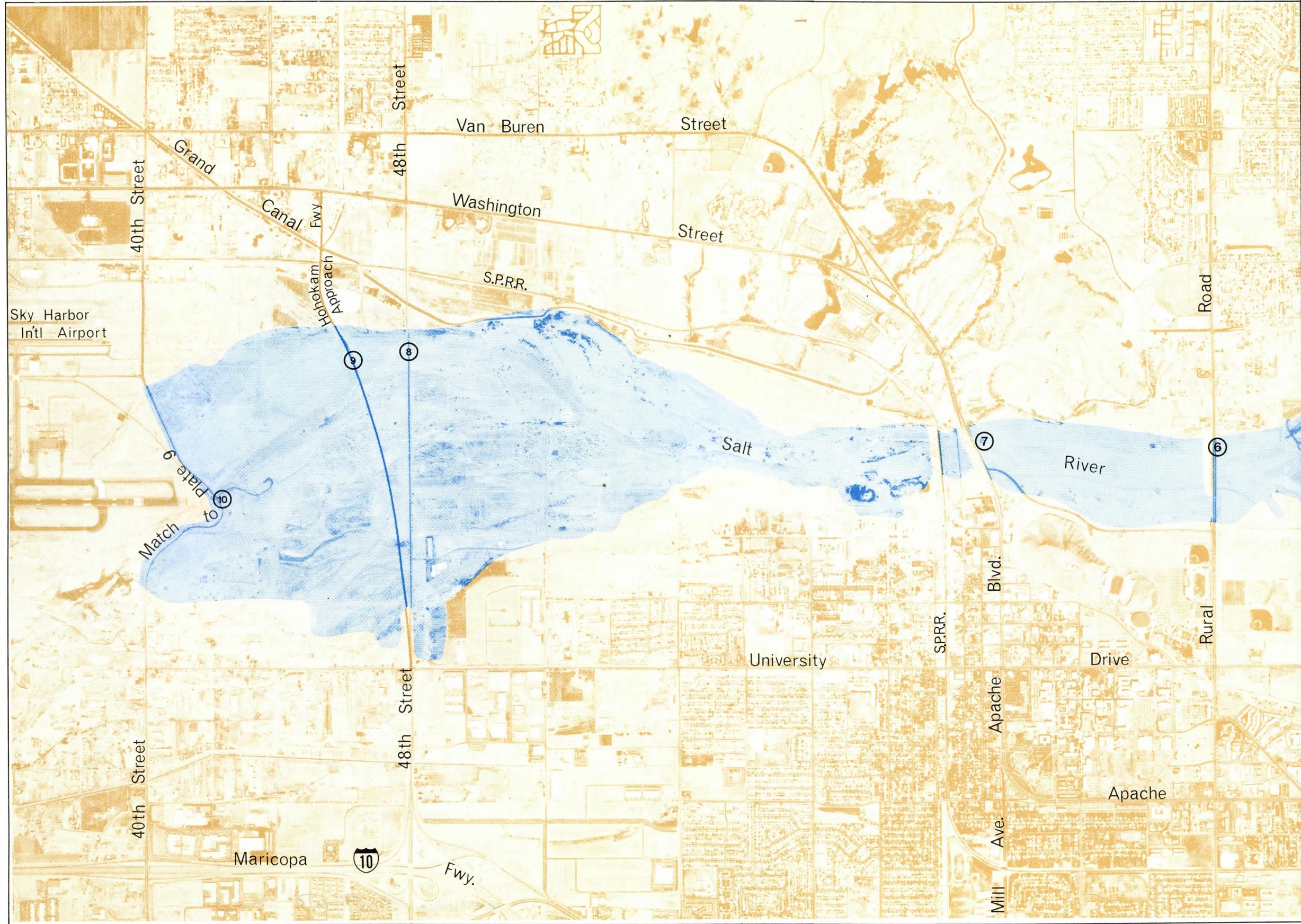
N. Country Club

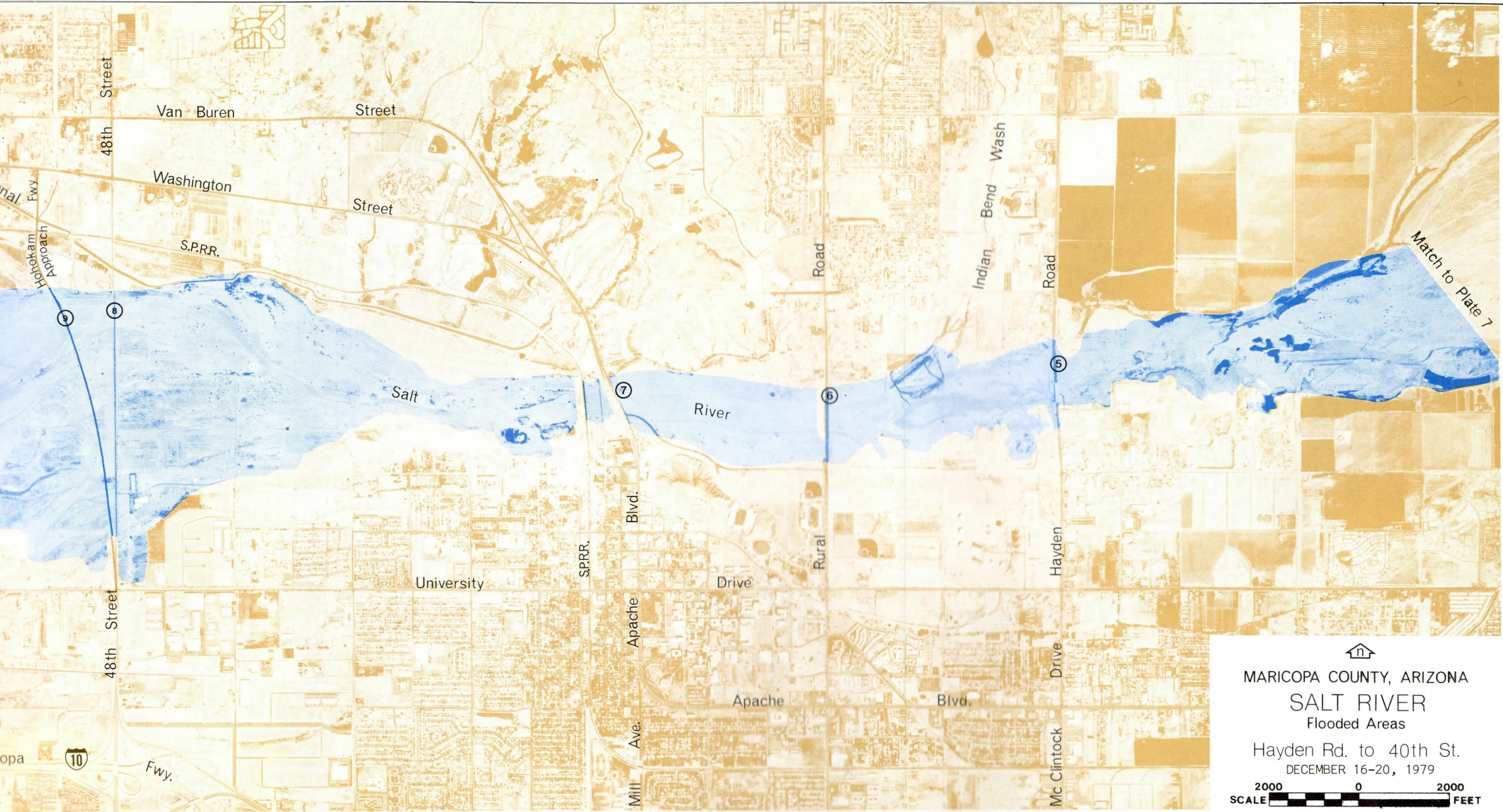


MARICOPA COUNTY, ARIZONA  
SALT RIVER  
Flooded Areas

Gilbert Rd. to Alma School Rd.  
DECEMBER 16-20, 1979

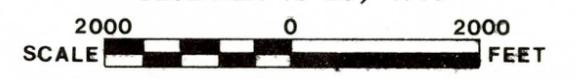




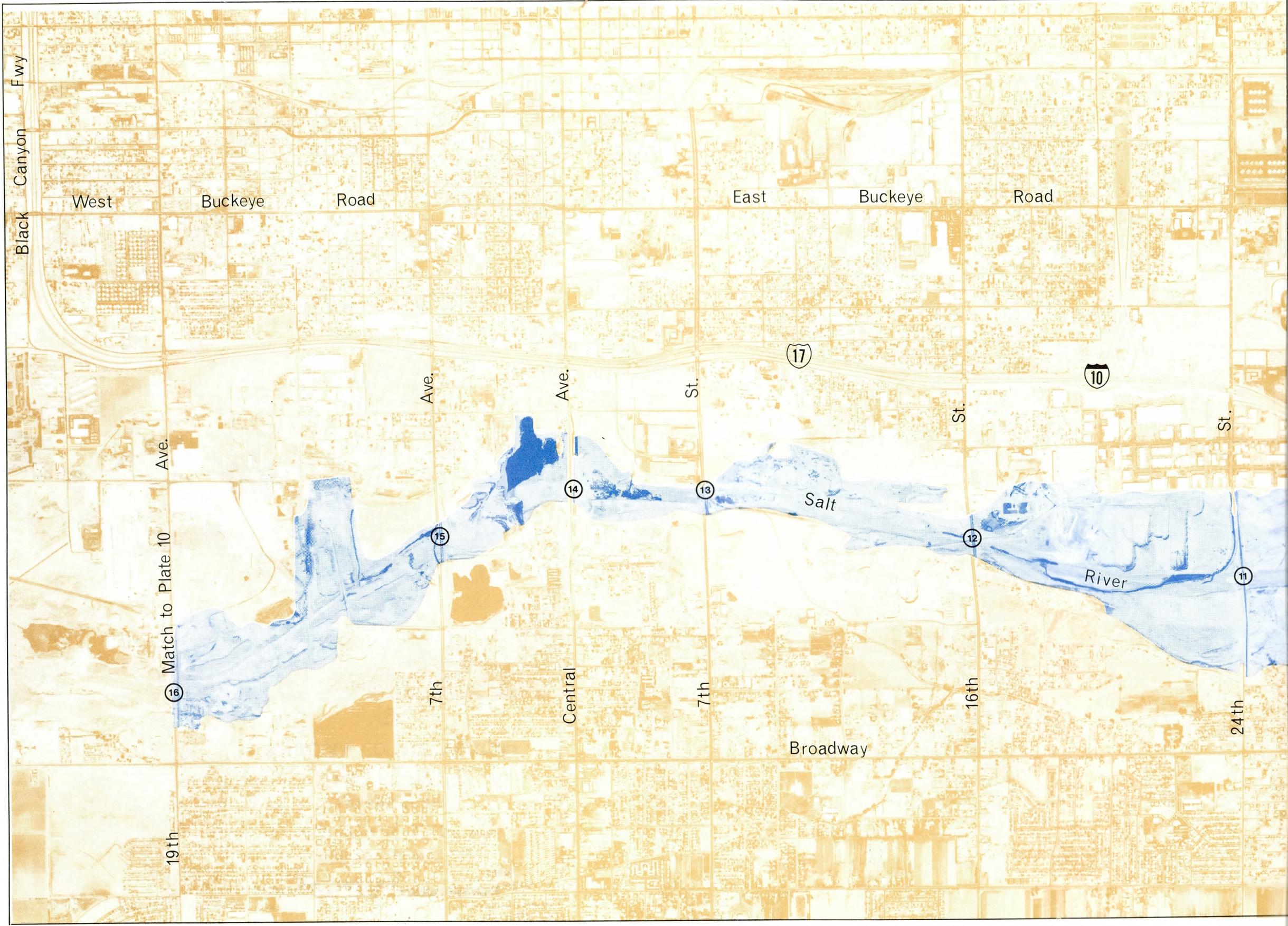


MARICOPA COUNTY, ARIZONA  
SALT RIVER  
Flooded Areas

Hayden Rd. to 40th St.  
DECEMBER 16-20, 1979



Match to Plate 7



Black Canyon Fwy

West Buckeye Road

East Buckeye Road

Ave.

Ave.

Ave.

St.

St.

St.

⑫ Match to Plate 10

7th

Central

7th

Broadway

16th

24th

19th

17

10

14

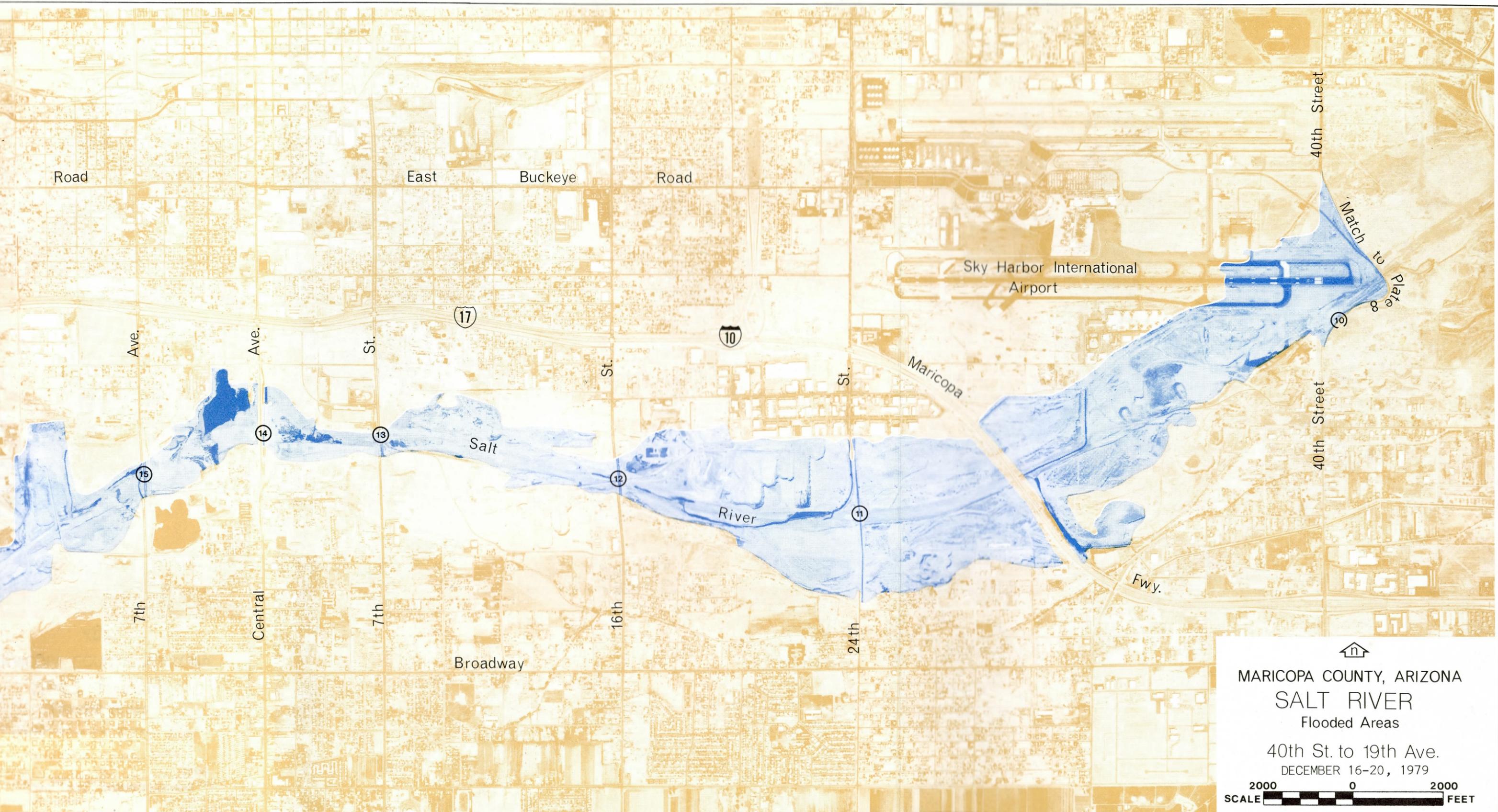
13

12

11

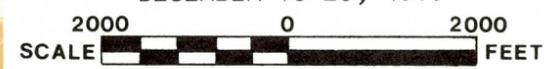
Salt

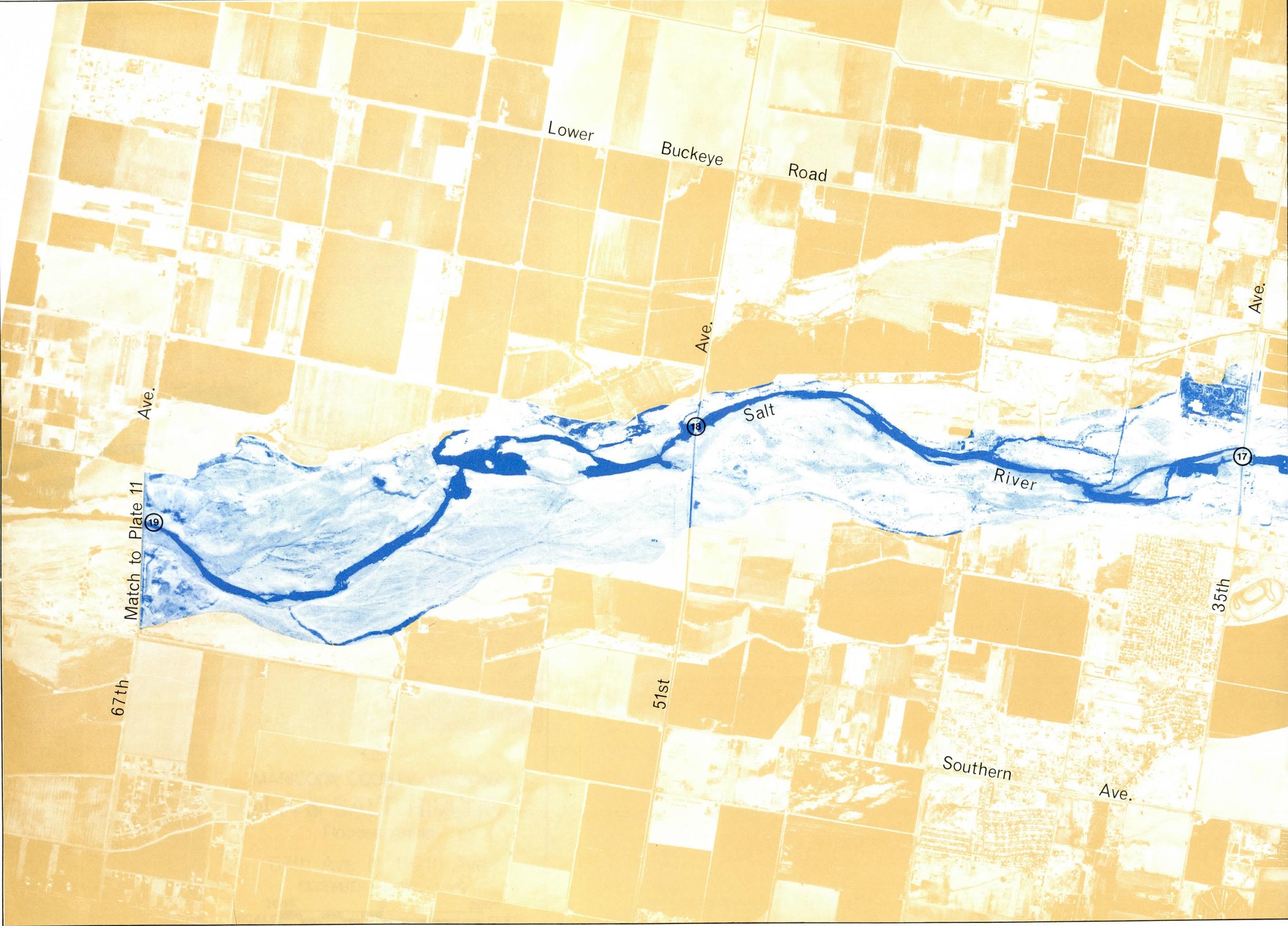
River



MARICOPA COUNTY, ARIZONA  
SALT RIVER  
Flooded Areas

40th St. to 19th Ave.  
DECEMBER 16-20, 1979





Lower

Buckeye

Road

Ave.

Match to Plate 11

67th

Ave.

51st

Salt

River

Southern

Ave.

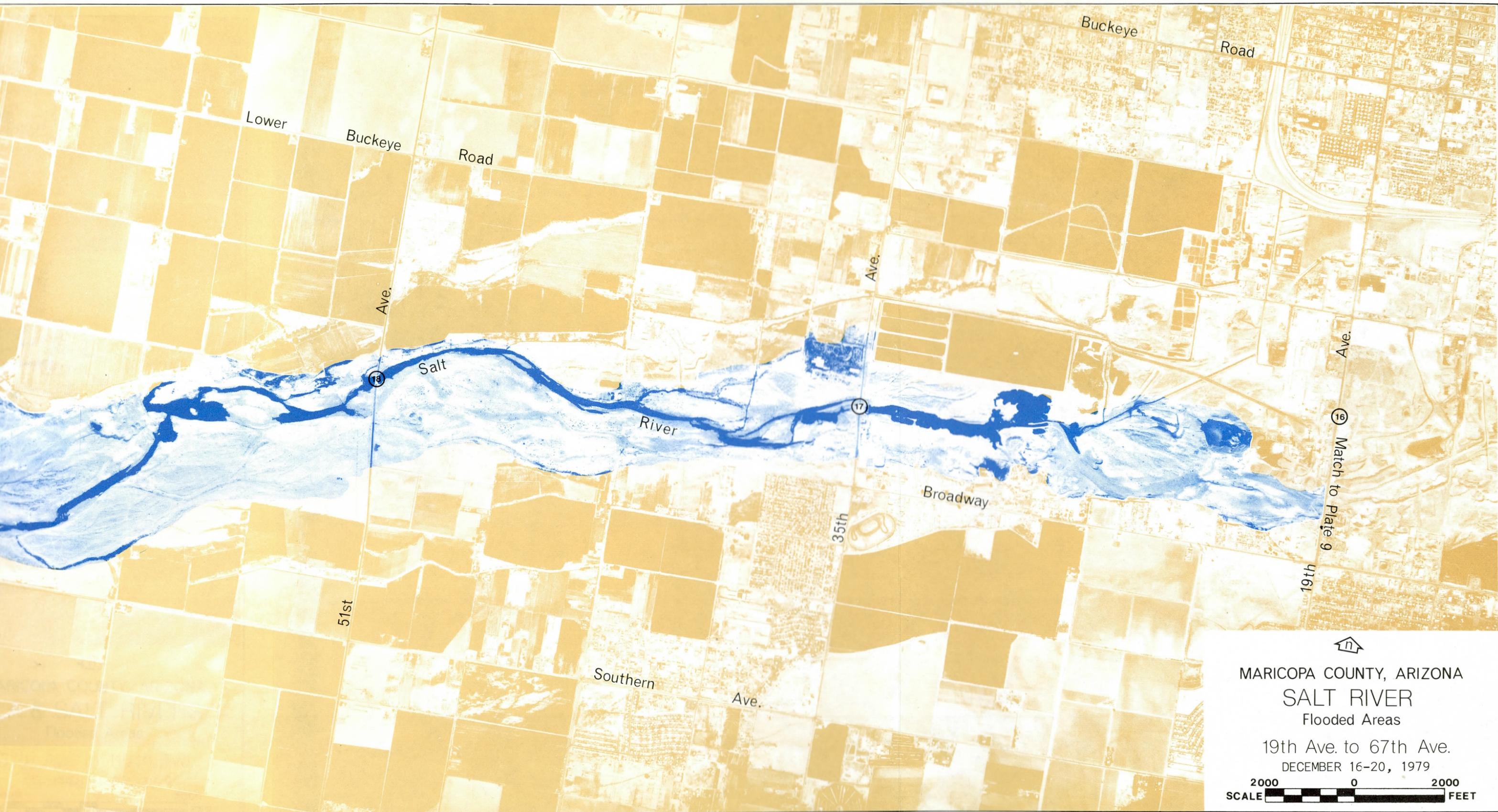
Ave.

35th

16

18

17



MARICOPA COUNTY, ARIZONA  
SALT RIVER  
Flooded Areas

19th Ave. to 67th Ave.  
DECEMBER 16-20, 1979





Ave.

115th

Match to Plate 12

20

Gila River

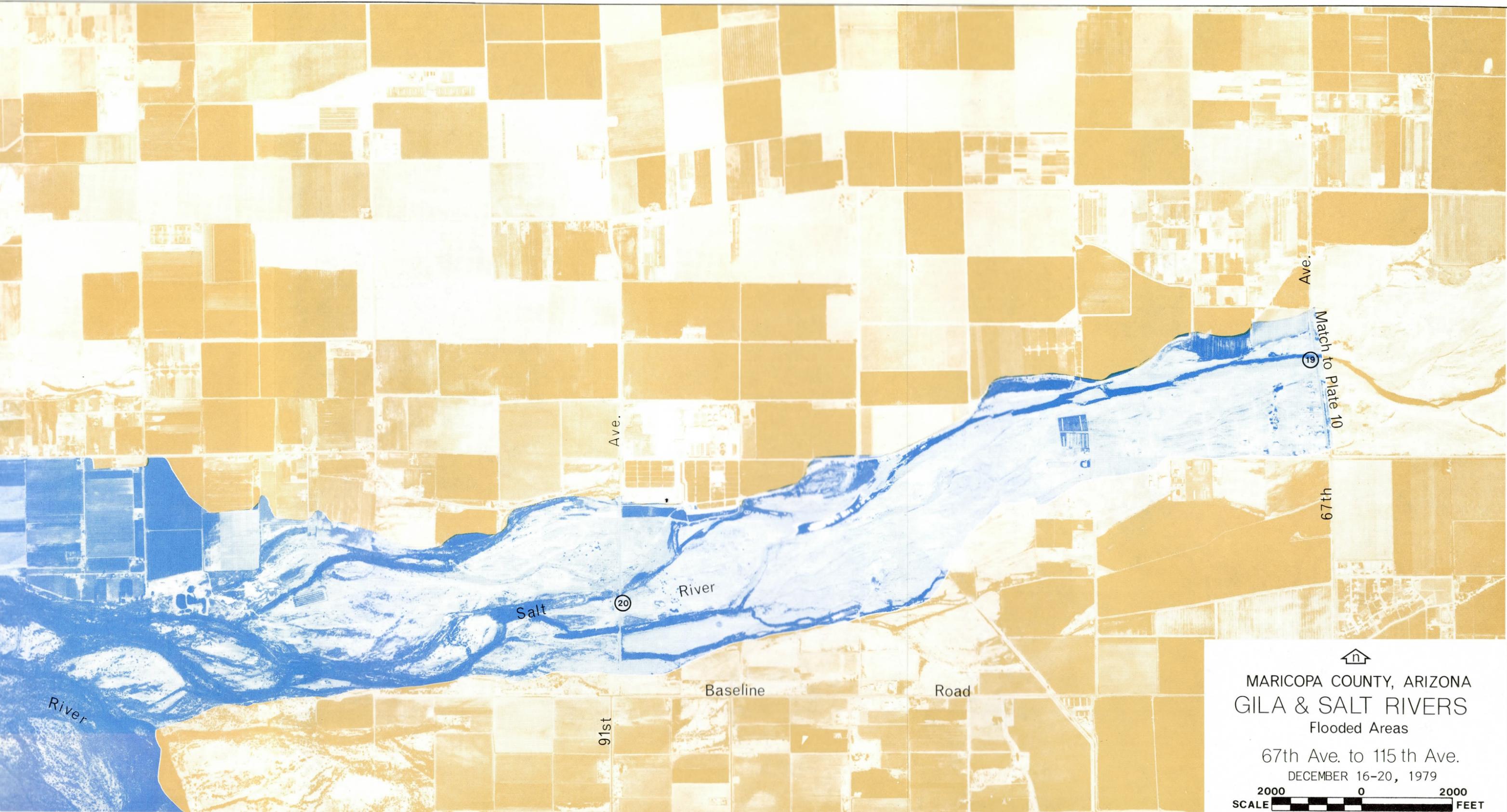
Ave.

91st

Salt

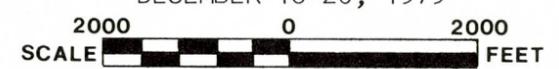
River

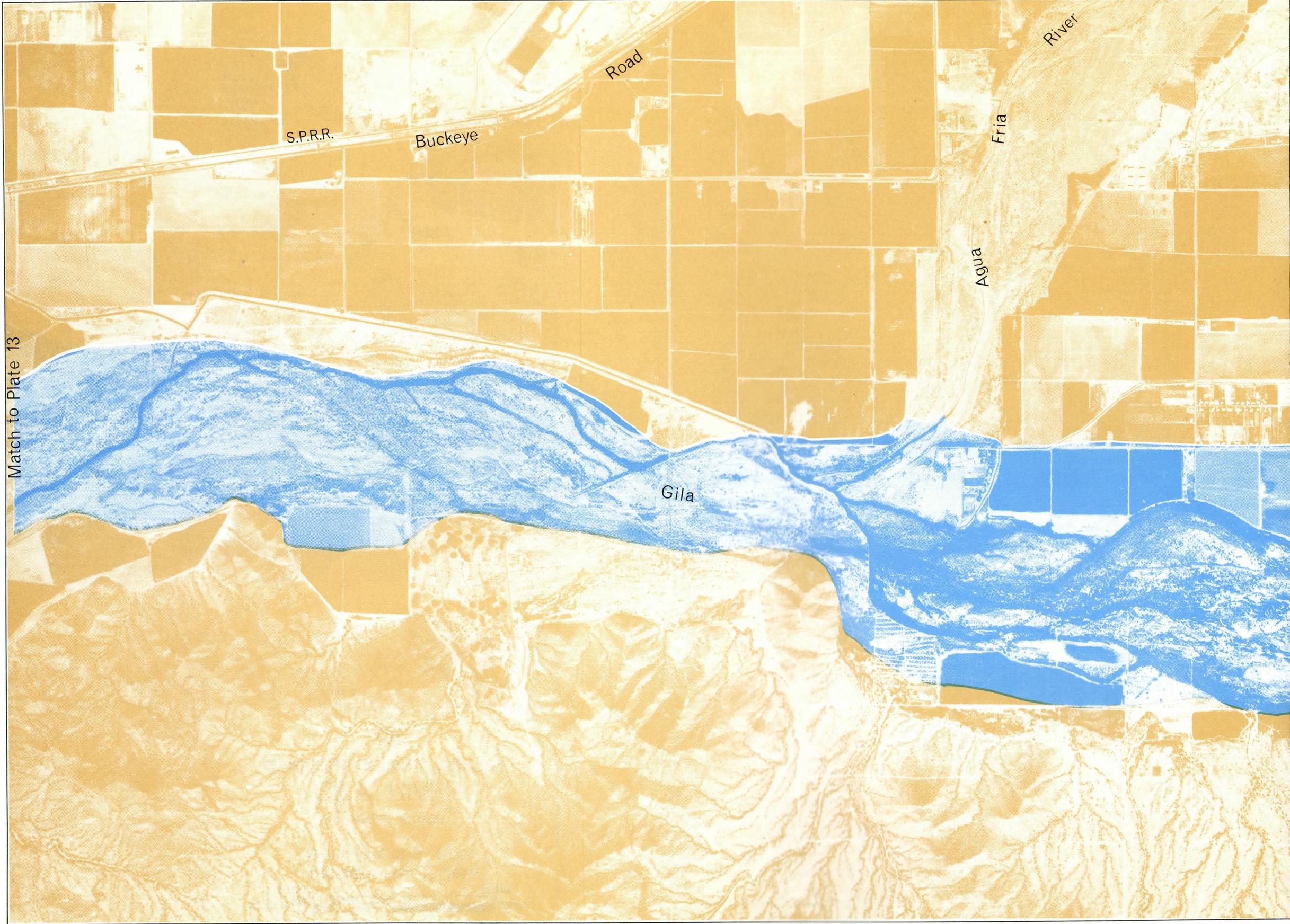
Baseline



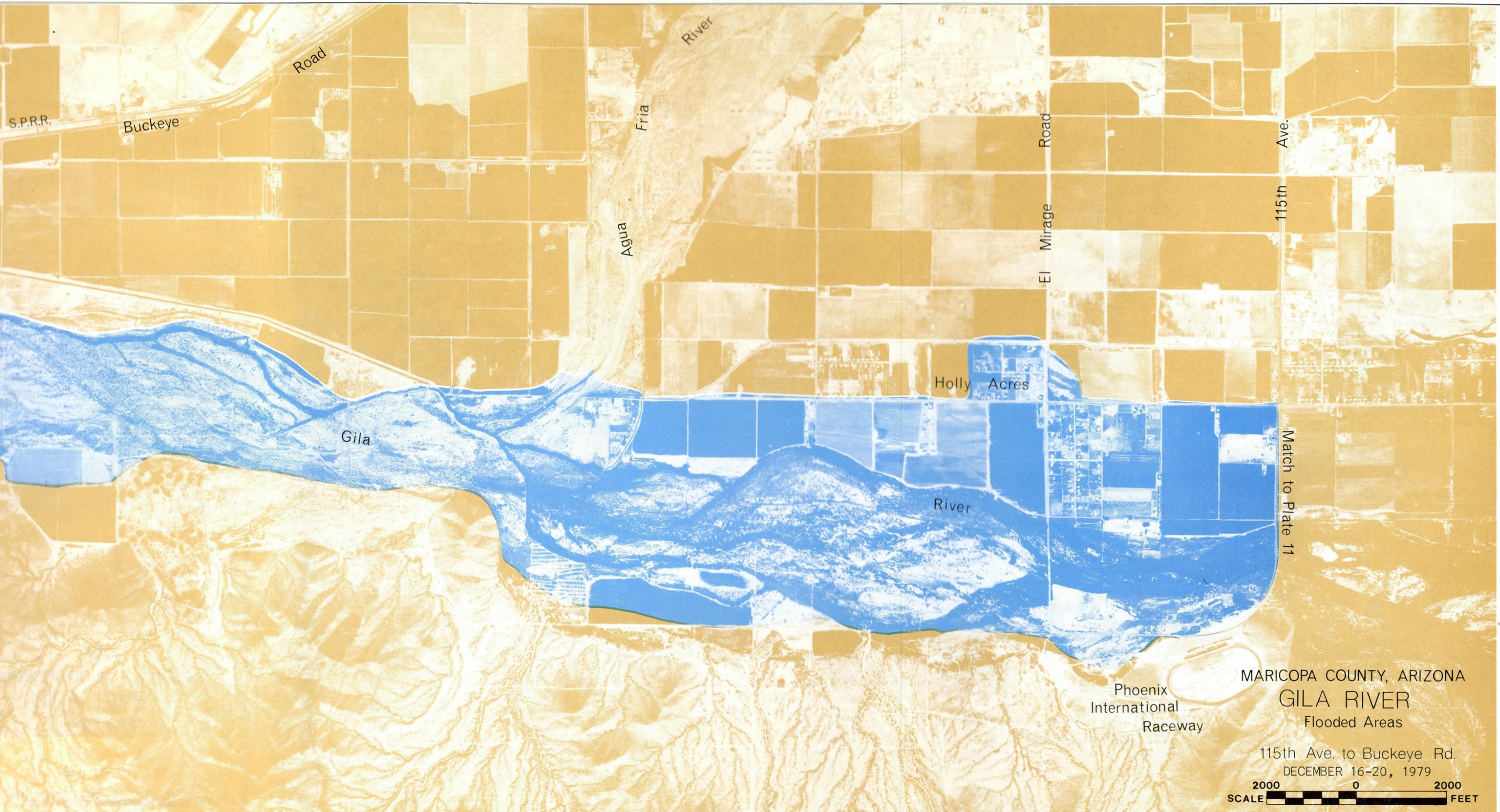
🏠  
MARICOPA COUNTY, ARIZONA  
GILA & SALT RIVERS  
Flooded Areas

67th Ave. to 115th Ave.  
DECEMBER 16-20, 1979



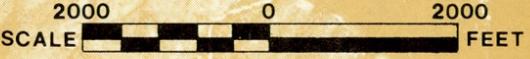


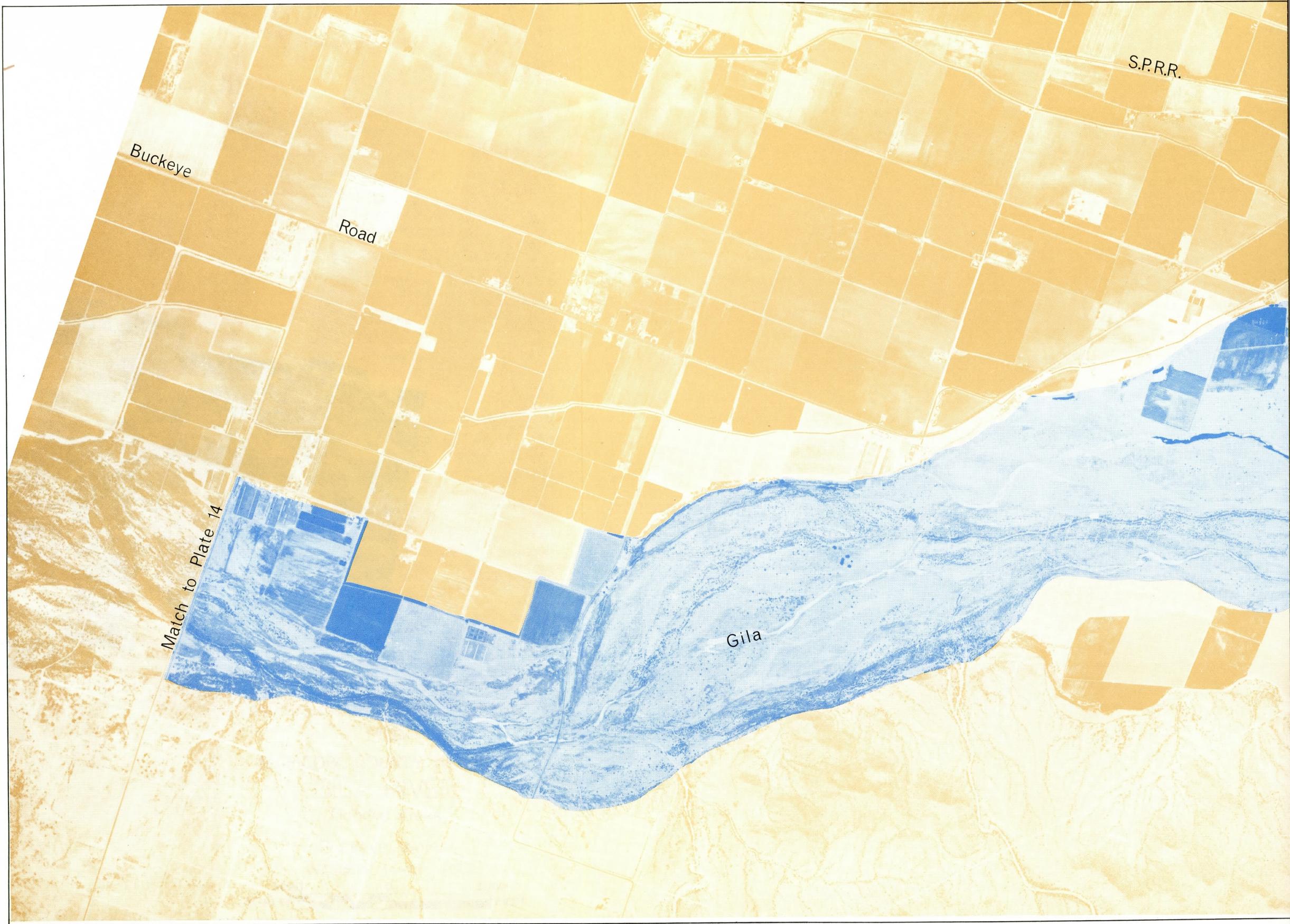
Match to Plate 13



MARICOPA COUNTY, ARIZONA  
GILA RIVER  
Flooded Areas

115th Ave. to Buckeye Rd.  
DECEMBER 16-20, 1979





Buckeye

Road

S.P.R.R.

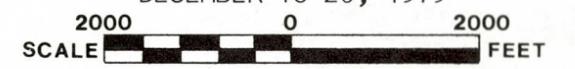
Match to Plate 14

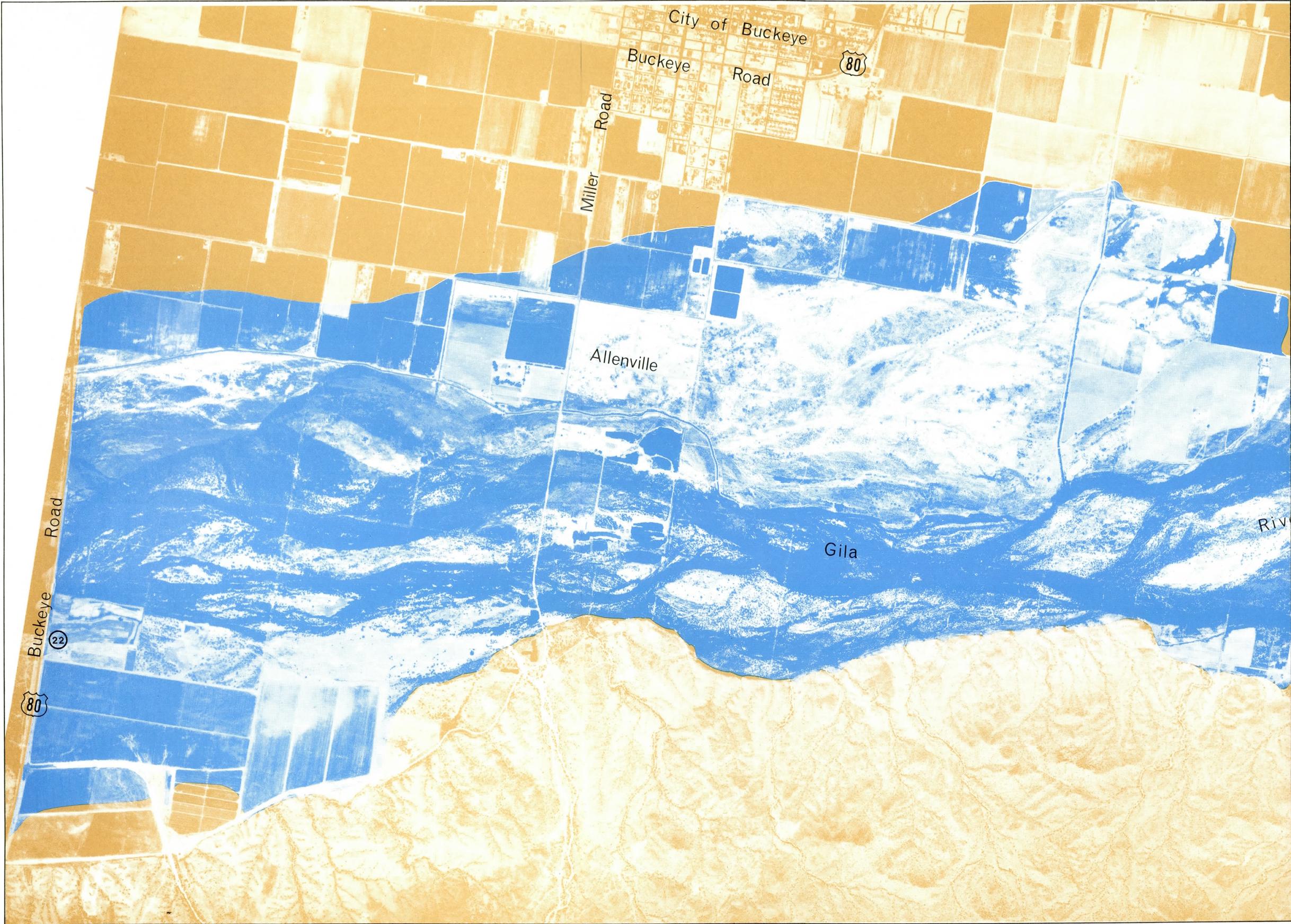
Gila



↑  
MARICOPA COUNTY, ARIZONA  
GILA RIVER  
Flooded Areas

West Buckeye Road  
DECEMBER 16-20, 1979





City of Buckeye

Buckeye Road



Miller Road

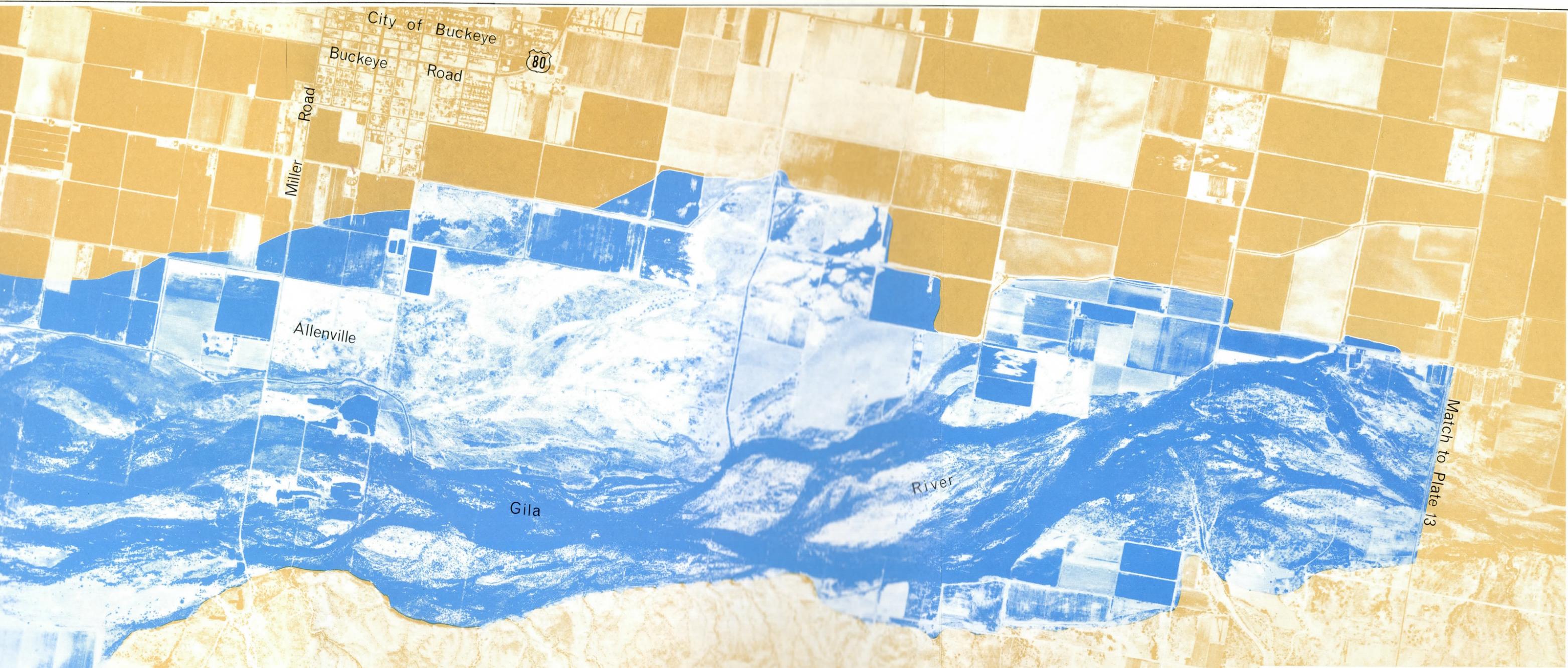
Allenville

Gila

River

Buckeye Road





MARICOPA COUNTY, ARIZONA  
GILA RIVER  
Flooded Areas

Buckeye Vicinity  
DECEMBER 16-20, 1979

