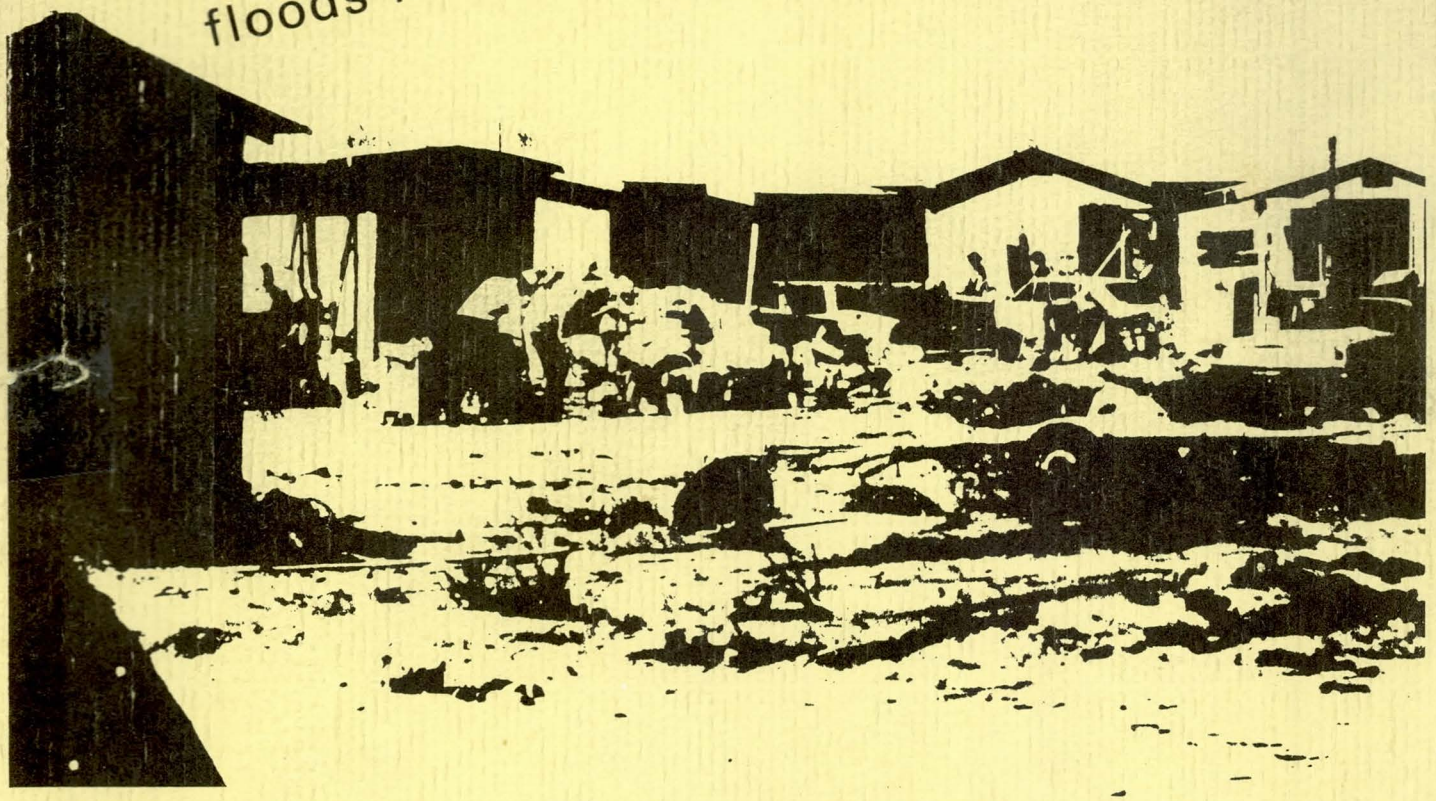
FEBRUARY 1979

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

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I. INTRODUCTION

A. AUTHORITY. This report is submitted under the authority of Public Law 84 - 99, and in accordance with Corps of Engineers regulation ER500-1-1, "Emergency Employment of Army and Other Resources - Natural Disaster Procedures."

B. SCOPE. This report describes the storms and floods in Maricopa County, Arizona, during the period of February 27th through March 6th 1978. The focus of the report is on the effects of flooding in the cities of Phoenix, Glendale, Scottsdale, Tempe, Avondale, Buckeye and adjacent unincorporated areas. The report presents meteorologic and hydrologic data gathered during the storm and floods as well as tabulations of the damages sustained by public and private interests. The flood damages presented in this report include physical damages to structures and crops; emergency costs, costs due to the disruption of normal transportation patterns, and business losses resulting from inundation or erosion by floodwaters and flood-transported debris. They do not include damages caused directly by rainfall or wind.

II. GENERAL DESCRIPTION OF DISASTER AREA

A. DISASTER DECLARATIONS. Mayor Margret Hance declared a state of emergency in the City of Phoenix on March 3rd, 1978. Several smaller municipalities in the area declared states of emergency or issued proclamations requesting disaster aid between March 2nd and March 6th. These included Avondale, Buckeye, Glendale and Scottsdale.

Govenor Wesley Bolin declared a state of emergency on March 2nd. The President declared Arizona a major disaster area on Saturday, March 4th, 1978.

B. LOCATION. Maricopa County (Phoenix SMSA) is situated in south-central Arizona. The flooded areas lie in the Salt River Basin, a tributary of the Gila River Basin, a drainage area of 58,200 square miles encompassing the 9,226 square miles of the study area.

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 elevation portions of the drainage, 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, Agua Fria and Hassayampa 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 Usury Mountains to the east, the South Mountains to the south and the Sierra Estrella to the southwest. Only to the west and southeast do the rolling desert plains typical of the metropolitan area continue uninterrupted (Plate 1). The highest elevation in the County is Four Peaks (7,468 ft.) in the McDowell Mountains which drain into the Salt River. The Salt River flows into the Gila River southeast of Central Phoenix (elevation 925 ft.). The Gila River exits to Maricopa County at an elevation of 430 ft.

E. VEGETATION. Natural vegetation in the drainage area is sparse. Cactus, creosote bush, sagebrush and paloverde are the dominant desert plants. Natural vegetation within the floodplain is mostly composed of tamarisk, mesquite, saltbrush, cattail, desert upland and desert wash plant communities. Irrigation has resulted in the transformation of the desert plain into productive farmland and urban communities. The floodplain of the Gila River from its confluence with the Salt River to Gillespie Dam twenty-five miles to the west is unique in the County in that it contains high quality riparian habitat. Much of this area is encompassed in the Arlington Wildlife Area managed by the Arizona Department of Game and Fish.

Local vegetation is sensitive to flows along the Gila River. A significant reduction in flood flows would lower the groundwater table, causing increased salinity and a reduction of the density of vegetation in the floodplains.

F. RIVERS AND STREAMS. The principal rivers in Maricopa County are the Gila and its major tributary, the Salt. The Hassayampa River and the Agua Fria River join the Gila River below its confluence with the Salt. New River and Skunk Creek are, in turn, tributary to the Agua Fria. The Verde River is the major tributary of the Salt.

Three streams, Trilby Wash, Cave Creek and Indian Bend Wash also carried significant flows as a result of the late February and early March storm. Queen Creek, a small tributary to the Gila located southeast of Metropolitan Phoenix also carried some floodflows. Table 1 displays the 1978 peak flows and drainage areas of these streams as well as other rivers and streams in Arizona. Stream gage locations and measurement points are presented in Plate 2.

G. 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. (See Plate 1).

III. STORMS AND FLOODS OF FEBRUARY 27th - MARCH 6th, 1978

A. METEOROLOGY. The storm of February 28th through March 3rd formed off the coast of Southern California and moved slowly northeastward with a relatively strong southwesterly flow of unusually warm, moist air aloft. This flow, which was more or less perpendicular to the Mogollon Rim in central Arizona, caused the piling and lifting of the air as it crossed the State. The major amount of lifting and precipitation occurred in the areas north and slightly east of metropolitan Phoenix. Maximum amounts of precipitation occurred on February 28th and March 1st in western and central Arizona and on March 1st and 2nd in the eastern portion of the state. A second storm system passed quickly through the state on March 4th and 5th, dropping snow at higher elevations and a small amount of rain elsewhere. Precipitation from this storm system fell mostly in northern Arizona. A detailed meteorological description of the February and March 1978 storms in Arizona can be found in the National Weather Service "Arizona Technical Memorandum AZ8," July 1978, which has been reproduced (with permission of the National Weather Service) as an Appendix to this Flood Damage Report.

B. PRECIPITATION. Two storm systems dropped precipitation, mostly in the form of rain, over cental Arizona during the period February 27th through March 6th. For the combined events, the areas of greatest rainfall were northeast and northwest of the urban portion of Maricopa County in the drainage area of the Salt, Verde, and Agua Fria Rivers. More than 10 inches of rain fell over significant portions of these basins, and a few higher mountain locations received over 15 inches. Precipitation in the Phoenix urban area generally totalled from 2 to 4 inches. Plate 3 is an isohyetal map of the total precipitation in Arizona during the period February 27th - March 6th, 1978.

For the drainage areas of the major rivers in and around metropolitan Phoenix, the period can be characterized as a time of generally increasing rainfall from February 28th through early March 2nd followed by decreasing rainfall through the morning of March 3rd, generally clear skies on the 4th, a period of brief moderate precipitation on the 5th and a few light showers on the 6th. Plate 4 contains mass rainfall curves at two U.S. Geological Survey stations and two U.S. Forest Service stations for the same period. A tabulation of daily precipitation at selected National Weather Service stations in Arizona from February 27th through March 6th can be found in Attachment 1 of the Appendix.

It can be seen on Plate 4 that the rainfall intensities were very high over durations of 12 to 24 hours, especially on March 1st and 2nd. At Rock Springs (lat. 34°03'N, long. 112°09'W, or about 35 miles north of Phoenix) the 5.73 inches which fell between 4 p.m. March 1st and 4 p.m. March 2nd considerably exceeds the 100-year 24-hour precipitation for that location of 4.8 inches, as found in NOAA Atlas 2, Vol. VIII (published by U.S. Dept. of Commerce, NOAA, National Weather Service, 1973).

An extrapolation of intensity-probability data from NOAA Atlas 2 gives this 5.73-inch 24-hour rain at Rock Springs a return period of approximately 400 years.

C. RUNOFF. Runoff from the storms of February 27th - March 6th, 1978 was especially heavy in central Arizona, particularly on streams flowing out of the mountains north and northeast of Phoenix. Very large flows occurred on the Salt and Verde Rivers, the Agua Fria and its tributaries, and the Gila River from the Salt downstream to Painted Rock Dam. Significant flooding was reported along portions of these streams, and some record discharges were observed. Some minor flooding also occurred on the Little Colorado River in Winslow and on the upper Gila River through Duncan and Safford. A detailed account of the flooding in Arizona during February and March 1978, written by the National Weather Service, can be found in the Appendix. A listing of peak discharges (from preliminary U.S. Geological Survey data) can be found in Table 1. The locations of streamgages listed in Table 1 can be found on Plate 2. Selected preliminary U.S. Geological Survey hydrographs of discharges along the Salt and Verde Rivers can be found on Plate 5.

There are a number of reasons for the heavy runoff in Arizona during February and March 1978. First of all, the precipitation prior to late February had been unusually heavy. This provided nearly saturated ground conditions at the lower elevations and an ample snow pack at the higher elevations of the watersheds. During the storm of February 27th - March 6th the snow levels were generally above 7,000 to 8,000 feet, and nearly all of the incident precipitation fell as rain. At the lower elevations the infiltration rates were low because of the antecedent moisture, and a high percentage of the rainfall ran off. At the higher elevations the presence of the snow pack prevented infiltration, and a considerable portion of the snow melted during the rain, adding to the rate of runoff. The high intensities of rain over durations of 12 to 24 hours during the storm were also quite critical in these river basins of central Arizona, most of which have response times of similar duration.

TABLE 1
(Preliminary U.S. Geological Survey Data)

PEAK DISCHARGES FOR FEBRUARY - MARCH 1978 FLOOD*

Plate 2 Conference Number	Station Code	Stream-Gaging Stations	Drainage Area (mi^2)	Date	Time	Ght (ft.)	Discharge (ft^3/s)
1	3945.00	Little Colorado River at Woodruff	8,100	3/2		15.57	3,800
2	4242.00	Cottonwood Wash No. 1 near Kingman	143			4.43	3,000
3	4244.50	Big Sandy River near Wikieup	2,800	3/1	0845	16.23	35,000
4	4244.70	Kirkland Creek near Kirkland	109	3/1	0900	10.53	8,170
5	4249.00	Santa Maria River near Bagdad		2/28	0700	7.49	30,000+
6	4795.00	Gila River near Laveen	20,615	3/6	1845	8.16	1,590
7	4890.00	Santa Cruz River near Laveen	533	3/6		13.94	1,570
8	4891.00	Black River near Maverick	315			4.5	1,900
9	4897.00	Big Bonito Creek near Fort Apache	119	3/3	0015	7.77	2,870
10	4905.00	Black River near Fort Apache	1,232	3/2	0700	22.33	33,200
11	4940.00	White River near Fort Apache	632	3/1	1830	11.05	6,590
12	4965.00	Carrizo Creek near Show Low	439	3/1	1530	12.04	12,700
13	4975.00	Salt River near Chrysotile	2,849	3/1	2215	14.72	43,500
14	4978.00	Cibecue Creek near Chrysotile	295	3/1		9.7	7,400
15	4978.50	Canyon Creek near Globe	316	3/1		15.2	13,500
16	4979.00	Cherry Creek near Young	62.1	3/1		7.2[a]	2,480
17	4979.80	Cherry Creek near Globe	200	3/1	1200	10.9	9,500

TABLE 1 (continued)
(Preliminary U.S. Geological Survey Data)

PEAK DISCHARGES FOR FEBRUARY - MARCH 1978 FLOOD*

Plate 2 Conference Number	Station Code	Stream-Gaging Stations	Drainage Area (mi^2)	Date	Time	Ght (ft.)	Discharge (ft 3/s)
18	4985.00	Salt River near Roosevelt	4,306	3/2	0300	28.55	89,400
19	4988.70	Rye Creek near Gisela	122	3/1	1600	6.85	5,600
20	4990.00	Tonto Creek above Gun Creek, near Roosevelt	675	3/1	0800	16.5	45,800
21	5020.00	Salt River below Stewart Mountain Dam	6,232	3/2	1000	17.15	29,600
22	5055.50	Verde River below Camp Verde	4,670	3/1	1715	19.65	43,000
23	5079.80	East Verde River near Childs	328	3/1	1030	15.0	13,300
24	5080.00	Verde River below east Verde River, near Childs				24.21	69,000
25	5083.00	Wet Beaver Creek near Childs	36.4	3/1	1000[c]	15.66[d]	6,600
26	5085.00	Verde River below Tangle Creek, above horseshoe Dam	5,872	3/1	2230	21.2	91,400
27	5100.00	Verde River below Barlett Dam	6,185	3/2	1200	25.9	101,000
28	5101.00	East Fork Sycamore Creek near Sunflower	4.49	3/2		6.18[a]	550
29	5102.00	Sycamore Creek near Fort McDowell	164	3/1-2		16.0	17,900
30	5113.00	Verde River near Scottsdale	6,600	3/2			95,000±
31	5121.00	Indian Bend Wash at Scottsdale	62	3/2	0300	3.50	3,100
		Salt River at 48th Street, Phoenix		3/2	1900	12.50	138,000

TABLE 1 (continued)
(Preliminary U.S. Geological Survey Data)

PEAK DISCHARGES FOR FEBRUARY - MARCH 1978 FLOOD*

Plate 2 Conference Number	Station Code	Stream-Gaging Stations	Drainage Area (mi^2)	Date	Time	Ght (ft.)	Discharge (ft^3/s)
32	5122.00	Salt River tributary in South Mountain Park, at Phoenix	1.75			2.54[a]	15
33	5124.00	Cave Creek at Phoenix	252	3/2	0200	7.36	2,090
34	5125.00	Agua Fria River near Mayer	588			10.60[a]	9,500
35	5128.00	Agua Fria River near Rock Springs	1,130	3/2	0700	24.48	40,950
36	5137.80	New River near Rock Springs	67.3	3/2		9.74[a]	10,400
37	5138.00	New River at New River	83.3	3/2	0900	12.34[a]	17,900
38	5138.35	New River at Bell Road, near Peoria	187	3/2	0300	9.3±[d]	12,500
39	5138.60	Skunk Creek near Phoenix	64.6	2/28	2000	9.60	13,000±
40	5139.70	Agua Fria River at Avondale	2,013	3/1	1030[c]	5.82	13,100
41	5155.00	Hassayampa River at Box Damsite, near Wickenburg	417	3/1	0430	14.96	27,000
42	5175.00	Centennial Wash near Arlington	1,810	3/2	0930	4.64	10,860
43	5195.00	Gila River below Gillespie Dam	49,650	3/3	1730	16.08	92,900
44	5198.00	Gila River below Painted Rock Dam	50,910				e
45**	4792.00	Queen Creek tributary at Apache Junction	0.51	3/2			∠10
46	5013.00	Tortilla Creek at Tortilla Flat	24.3	3/2		8.67	3,000

TABLE 1 (continued)
(Preliminary U.S. Geological Survey Data)

PEAK DISCHARGES FOR FEBRUARY - MARCH 1978 FLOOD*

Plate 2 Conference Number	Station Code	Stream-Gaging Stations	Drainage Area (mi^2)	Date	Time	Ght (ft.)	Discharge (ft^3/s)
47	5101.70	Camp Creek near Sunflower	2.6	3/2	0100	5.05	402
48	5121.60	Indian Bend Wash (at McDowell Road) at Scottsdale		3/2		9.98	3,400[c]
49	5123.00	Cave Creek near Cave Creek	121	3/2	1000[c]	7.52	8,000
50	5127.00	Agua Fria River tributary No. 2 near Rock Springs	1.11	3/2		14.64	920
51	5136.50	Agua Fria River (at Grand Avenue) at El Mirage		3/6	0200	7.95	9,870
52	5138.20	Deadman Wash (at Black Canyon Highway) near New River	11.1	3/2		5.11	1,400
53	5138.30	New River (at Keefer Hill) near Phoenix					e
54	5139.10	New River near Glendale	323	3/1	0900	9.24[f]	20,000±
55	5142.00	Waterman Wash near Buckeye	403				b
56	5158.00	Hartman Wash near Wickenburg	5.57	3/1		2.99	30±
57	5160.00	Hassayampa River at Wickenburg				10.70	e
58	5165.00	Hassayampa River near Morristown	774	3/1		12.93	28,000±
59	5166.00	Ox Wash near Morristown	6.31	3/1		g	∠100
60	5168.00	Jack Rabbit Wash near Tonopah	137				700±

TABLE 1 (continued)
(Preliminary U.S. Geological Survey Data)

PEAK DISCHARGES FOR FEBRUARY - MARCH 1978 FLOOD*

Plate 2 Conference Number	Station Code	Stream-Gaging Stations	Drainage Area (mi^2)	Date	Time	Ght (ft.)	Discharge (ft^3/s)
61	5170.00	Hassayampa River near Arlington	1,470	3/2	0400	5.6	20,000
62	5172.00	Centennial Wash tributary near Wenden	2.79				0
63	5172.80	Tiger Wash near Aguila	85.2				1,000±
64	5174.00	Winters Wash near Tonopah	47.8	3/1			1,800
65	5196.00	Rainbow Wash tributary near Buckeye	3.45	3/1		3.54	250±
66	5197.50	Bender Wash near Gila Bend	68.8			g	12
67	5197.60	Sauceda Wash near Gila Bend	126			g	48
68	5197.80	Windmill Wash near Gila Bend	12.9			5.82	20
69	5201.00	Military Wash near Sentinel	8.70	2/28		3.44[f]	250
70	5202.00	Black Gap Wash near Ajo	12.1			4.95	270
71	5202.30	Crater Range Wash near Ajo	1.49			g	12

* Data provided by USGS, Phoenix, AZ.
** Reference numbers 45 and above pertain to partial-record stations.

a ISHWM
b To be determined (no longer in alphabetical order)
c About
d Need IS and OSHWM's at gage
e Not determined
f No. 2 gage
g Below csg pin

IV. FEDERAL, STATE AND LOCAL EMERGENCY PROGRAMS

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

A. FEDERAL PROGRAMS. The principal Federal agencies offering direct post flood emergency assistance were: the Federal Disaster Assistance Administration (FDAA) of the Department of Housing and Urban Development (HUD); the Small Business Administration of the Department of Commerce; the Farmers Home Administration and the Agricultural Stabilization and Conservation Service of the Department of Agriculture.

The FDAA administered two programs: a program 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 program under Sections 402 and 419 of the same act to repair or restore public facilities damaged by the flood. A summary of public assistance by type of program is presented in Table 2.

B. STATE AND LOCAL PROGRAMS. The State of Arizona, through the Department of Economic Security (DES), provided individual and family grants for housing and food (food stamp program). In addition to the grant programs (See Table 2), unemployment insurance claims increased because the flooding put people out of work. The American Red Cross and numerous other volunteeer organizations spent time and offered direct financial aid to flood disaster victims.

In addition to the public funding and loan programs presented in Table 2, the Internal Revenue Service will be crediting business and personal loss at the end of the 1978 tax year. Estimates of these credited amounts may not be available.

TABLE 2

PUBLIC ASSISTANCE AND EMERGENCY LOAN PROGRAMS
(Preliminary)

Agency and Type of Program	Amount	Comments
FEDERAL		
Farmers Home Administration (FHA) Loand to Repair Form Homes	$500,000	Should exceed preliminary estimate.
Small Business Administration (SBA) Loans to Homes and Businesses	$7,451,000	Approved: Home Loans $2,307,700; Business Loans $4,643,000 still to process.
Agricultural Stabilization and Conservation Service (ASCS) Food Stamps and Farm Loans	$2,400,000	Should exceed preliminary estimate.
Housing and Urban Development (HUD) Loans and Grants to Flood Victims	$1,145,000	Administrative cost: $45,000.
FDAA	$8,534,000	Aid to public agencies.
STATE OF ARIZONA		
Department of Economic Security (DES) Individual and Family Grants Unemployment Insurance	$353,000	Grant Amount: $325,025 Unemployment: 27,892
LOCAL AGENCIES		
American Red Cross Direct aid to Flood Victims	$177,000	Food and Clothing $121,095, Medical $3,614, Mass Care $18,969, Building $629, Furnishings $32,399, and Occupational Supplies $622.
SUBTOTAL DIRECT AID	$9,064,000	
SUBTOTAL LOAN PROGRAM	$11,496,000	
TOTAL ALL AID	$20,560,000	

Source: FDAA (Federal Disaster Assistance Administration, Maricopa County), SBA, HUD, Red Cross and State of Arizona

V. DESCRIPTION OF FLOOD DAMAGES

A. SUMMARY OF FLOOD DAMAGES. Total damages, estimated to be $36.7 million exclusive of public assistance programs, are presented by location and by type in Tables 3 and 6. This flood was not the most severe hydrologic event recorded in Maricopa County: the flood of 1891 flowed at 300,000 cfs. Nevertheless, rapid urbanization resulted in making the 1978 flood (at 138,000 cfs) was the most damaging ever experienced locally. Three deaths were directly attributable to the flood. In addition, a woman was asphyxiated by her auto's exhaust while she was waiting at a flooded crossing.

The greatest losses to any development type were to northern and southern arterials linking Metropolitan Phoenix. A list of these roads/highways and bridges with damage estimates is presented in Table 4. Plates 6 through 16 indicate their locations. Other major public damages included main irrigation and drainage systems and $3.2 million at Sky Harbor Airport. Total public damages exceeded $16 million.

Residential damages, totaling $3.1 million, occurred throughout the County. Two areas, Allenville and Holly Acres, both on the Gila River, experienced the most extensive damage. More than fifty percent of the total value of contents and structures was lost in each area. Level terrain, allowing floodflows to disperse, generally prevented intensive flooding elsewhere. The City of Glendale, where flows within the municipal streets disbursed the areas of damage, is typical of residential damages outside the Salt-Gila River floodplain.

Table 3 presents total damages in Maricopa County from the February - March flood. Traffic delay costs, estimated by the Arizona Department of Transportation are based upon a $2.81 per hour value of travelers' time and an additional average vehicle operation cost of $0.17 per hour. The total loss of almost $.4 million is included in total roads and bridges damages. With only three crossings open to traffic from throughout the County (Mill Avenue, Central Avenue, and the approach to the Hohokam Freeway), a breakdown of additional costs by location was not made. Therefore, traffic delay costs are not incorporated in the figures presented in Table 6.

TABLE 3

SUMMARY OF ALL FLOOD DAMAGES
(1,000's)

Location	Physical Damages	Business and Emergency Losses	Total
Agricultural	$3,909	$122	$ 4,031
Residential	2,806	312	3,118
Commercial	686	59	745
Industrial:			
Sand and Gravel	2,254	240	2,494
Other Industrial	5,148	188	5,336
Public:			
Roads and Bridges			12,899
Other Public	3,412	11	3,423
Other	1,085	7	1,092
TOTAL ALL DAMAGES			$33,138

Industrial damages were concentrated in the Salt River overflow areas. Sand and gravel operations have historically experienced the greatest industrial losses from flooding in Maricopa County. In order to access their raw materials, they are situated near the riverbeds. Damages to sand and gravel firms totaled $2.5 million of the $7.8 million industrial damages.

The Gila River was the site of the heaviest commercial losses. $365,000 of the $745,000 in total commercial damages were inflicted along the Gila River. The establishments affected were varied in type, but over $200,000 of the damages were incurred by metallic recycling centers.

The February-March flood damaged a significant portion of Maricopa County's agricultural industry. Major losses occurred along the Salt and Gila Rivers. Damage resulted from erosion and siltation of prime farmland adjacent to the two rivers. Total damage to land and erosion is estimated to be $.4 million on 6,600 acres.

The heavy silting caused by the flood has resulted in a one to two year loss in production depending upon the amount of damage. The principal crop grown along the Salt and Gila Rivers is cotton, planted in rotation with barley and wheat. Sandy soil deposited in place of rich topsoil

TABLE 4

MAJOR HIGHWAY AND BRIDGE DAMAGES

Plate Key Code*	Name of Highway/ Bridge Location	Date Closed	Date Open	Total Days Closed	$ Damage to Structure**	Agency Affected	Bridge or Road
Not on Plates	Verde River Bridge (7)	March 1	March 15	14	$275,000	State	Bridge
Not on Plates	State Route 87 and Sycamore Cr. (7)	March 2	March 7	5	25,000	State	Road
Not on Plates	State Route 87 and Sycamore Cr. (7)	March 2	March 7	5	23,000	State	Road
1	Gilbert Rd. (1)	March 2	March 24	22	22,500	County	Road
2	Country Club Dr. (1)	March 1	March 15	14	325,000	State	Bridge
3	McKellips (1)	March 1	April 26	57	138,000	County	Road
4	Alma School Rd. (1)	March 1	April 15	46	140,000	County	Road
5	McClintock/Hayden (1)	March 2	March 7	6	333,750	County	Bridge
6	Rural Road (1)	March 2	March 6	5	63,750	County	Bridge
7	Mill Avenue (1)	March 2	March 2	--	60,000	City-Tempe	Road
8	Approach to Hohokam Freeway (1)	March 2	Under construction at time of flooding	--	425,000	State	Road
9	48th Street (1)	March 2	May 19	79	223,000	City	Road
10	40th Street (2)	March 2	March 12	79	227,000	City	Road
11	24th Street (2)	March 2	March 12	79	377,000	City	Road

* See Plates 6 - 14.

** Includes emergency costs to open road or highway.

TABLE 4 (continued)

MAJOR HIGHWAY AND BRIDGE DAMAGES

Plate Key Code*	Name of Highway/ Bridge Location	Date Closed	Date Open	Total Days Closed	$ Damage to Structure**	Agency Affected	Bridge or Road
12	16th street (2)	March 2	September 1 (on detour - 2 yrs. before bridge rebuilt and opened)	183	$4,995,000	City	Bridge
13	7th Street (2)	March 2	March 15	14	417,000	City	Bridge
14	Central Avenue (2)	March 2	March 2	--	190,000	City	Bridge
15	7th Avenue (2)	March 2	March 12	10	1,500,000	City	Bridge
16	19th Avenue (2)	March 2	August 25 (on detour - 2 yrs. before bridge rebuilt and opened)	177	1,850,000	City	Bridge
17	35th Avenue (2)	March 2	March 12	10	184,000	City	Bridge
18	51st Avenue (3)	March 2 March 23	March 13 March 27	11 24	123,750	County	Bridge
19	67th Avenue (3)	March 2	May 9	69	46,250	County	Road
20	91st Avenue (3)	March 2	May 12	72	100,000	County	Road
21	115th Ave. (Avondale) (3)	March 2	March 12	10	68,500	County	Road
22	Gila River Bridge Highway 85 (Buckeye) (4)	March 3	March 9	6	76,000	State	Bridge

* See Plates 6 - 14.

** Includes emergency costs to open road or highway.

TABLE 4 (continued)

MAJOR HIGHWAY AND BRIDGE DAMAGES

Plate Key Code*	Name of Highway/ Bridge Location	Date Closed	Date Open	Total Days Closed	$ Damage to Structure**	Agency Affected	Bridge or Road
Not on Plates	Hassayampa Cross. & Old Highway 80 (4)	March 2	March 7	5	264,000	County	Road
Not on Plates	New River Dips I-17 - U.S. 60 (7)	February 28	March 10	12	35,000	State	Road
					12,507,500		

* See Plates 6 - 14.
** Includes emergency costs to open road or highway.

resulted in at least a one year land preparation period. A silage crop will be planted to eliminate germination of weeds. Silage can be sold on the market, but at below the per acre yield of the cotton it will replace. Crop losses totaling $1.6 million have been reported.

Several wells and drainage channels along the Salt and Gila Rivers required rectified due to silting. Flood depths along the Salt and Gila Rivers ranged from 3 to 4 feet at storm peak. The loss to dairy production included the following: livestock loss, feed loss, physical damage to pasture, damage to equipment, barns and homes, and estimated loss to production. Several major dairy farms were not up to pre-flood production levels, as of December 1978.

The final damages to dairies, farms and ranches will not be fully realized until pre-flood production is achieved. Meanwhile, flood effects such as poor soil and livestock disease continue to increase agricultural damages from the disaster.

The major damages to farms and ranches occurred along the Gila and Salt Rivers from 115th Avenue west to Painted Rock Dam. This area experienced over $3 million in agricultural damages.

The damage figures presented in this report are based upon discussions and samplings of the major farms and ranches. Smaller family operations of less than 20 acres may have been excluded. A summary of damages to farms and ranches is presented in Table 5.

TABLE 5

Summary of Agricultural Damages
March Flood 1978 (1,000's Dollars)

Description of Loss	Salt River 35th Ave. to 115th Ave.	Gila River 115th Ave. to Painted Rock	All Others*	Totals
Land (Reshaping & Clearing)	$265	$ 916	$207	$1,388
Crop	35	1,331	209	1,575
Equipment	59	686	154	899
Livestock	-	32	15	47
Business & Emergency	19	102	1	122
TOTAL	$378	$3,067	$586	$4,031
Acres Damaged	500	4,400	1,700	6,600
Crop Acreage Damaged	200	3,800	1,200	5,200

* Includes: Agua Fria, New River, Hassayampa, Skunk Creek, Queen Creek and Trilby Wash.

B. LOCATION 1 - SALT RIVER - GRANITE REEF DAM TO 48th STREET. This area east of Phoenix is principally agricultural. The Salt River Indian Reservation, Mesa, Tempe and Scottsdale border the Salt River between the City of Phoenix and Granite Reef Dam below the confluence of the Salt and Verde Rivers.

The volume of flood flows along the Verde River into the Salt River was undetermined, but the maximum discharge is estimated to have approached 100,000 cfs. The peak flow below Stewart Mountain Dam, 10 miles east of the Verde confluence on the Salt River, was 29,600 cfs on March 2nd. Upstream of Phoenix, Indian Bend Wash contributed a peak of 3,100 cfs to the flood flow on the Salt River. On March 2nd, the Salt River peaked at 122,000 cfs as it entered Phoenix -- an event which is estimated to be equalled or exceeded only once, on the average, in approximately 30-35 years.

Flooding on the Salt River isolated some members of the Salt River Pima-Maricopa Community. Tribal personnel evacuated three families from the south side of the Salt River as a result of isolation.

Residential damage to yards and lots throughout this location totaled $31,000, mostly from erosion. The major private sector losses were suffered by industry, principally sand and gravel mining firms that operate within the river bed along the Salt River. They suffered lossses to mined stockpiles and equipment. These firms' losses totaled almost $1 million in the Tempe-Mesa area as a result of this flood. An industrial park at the western edge of Tempe, near 48th Street, was the site of most of the additional $1.5 million of industrial damages.

Damages to agricultural operations in Location 1 were minimal, confined principally to service roads and irrigation systems. These damages are presented in the public damage summary (Table 6).

C. LOCATION 2 - SALT RIVER - PHOENIX. The central metropolitan floodplain is dominated by industry and the Sky Harbor Airport. Extension of the airport is awaiting implementation of flood control measures. Gravel mining operations comprise most of the industrial base in this area, while metallic recycling centers constitute what little commerce operates within the floodplain.

Although residences were not damaged in south Phoenix, the population was affected. Officers of the Phoenix Police Department evacuated over 200 families for the evening of March 2nd when rising waters threatended their homes. The flood virtually isolated most workers from their jobs in central Phoenix.

The largest industrial casualty was a loss of $2 million, most of which was copper wiring. Commercial losses of $279,000 accrued to junkyards scattered in south Phoenix. There were no agricultural damages reported along this segment of the river. Sky Harbor Airport sustained $3.2 million of physical damages, and experienced aircraft traffic delays and disruption.

D. LOCATION 3 - SALT RIVER - 35th AVENUE TO 115th AVENUE. Rural housing and agriculture, both crop and dairy farming, are the most prevalent forms of land use in this area. The 91st Avenue effluent treatment plant, the central processing facility for Phoenix, is located within the floodplain.

Flows along the Salt River first affected large areas of residential property in this reach. Over 30 homes and 1 apartment building experienced a total of $298,000 in damages. Railroad loss was $13,000 and industrial losses totaled $109,000.

Approximately 500 acres of agricultural land was damaged (requiring re-leveling or debris removal) along this section of the Salt River. A total of $378,000 in damages were reported, of which $265,000 represented damages to the land (cost for re-leveling and clearing); $35,000 was crop loss; equipment damages were $59,000; and $19,000 were business and emergency losses.

E. LOCATION 4 - GILA RIVER. The Gila River floodplain is a rural area with some commerce and gravel mining. There are two residential areas within this floodplain: Holly Acres and Allenville. The major commercial use within this section is related to cock gaming. The Arlington Wildlife Area, administered by the Arizona Game and Fish Department, lies to the north of Gillespie Dam.

There were two major tributaries other than the Salt River which added to the flow on the Gila River during the flood. The Agua Fria River enters the Gila below the Agua Fria's confluence with the New River. The peak inflow from the Agua Fria was approximately ~~41,000~~ cfs. The Hassayampa River added 20,000 cfs at its peak on March 2nd. The flow went almost directly into the Arlington Wildlife Area. A ranch, located at the confluence of the Agua Fria River and the Gila River, suffered the largest commercial loss, $250,000. Metallic recycling centers suffered most of the remaining $115,000 in commercial damages. Industrial damage was limited to two sand and gravel mining operations.

This section of the Gila River suffered extensive agricultural damage. Damages to farms totaled over $3 million: $1,331,000 in crops; $916,000 to land; equipment losses of $686,000; $32,000 in livestock; and business losses of $102,000. Approximately 4,400 acres of farm and ranch land were damaged, of which 3,800 acres were planted.

Residential damages exceeded $2 million. Nearly all of this damage occurred in Holly Acres and Allenville. Holly Acres is located at the intersection of El Mirage Road and Southern Avenue. During the flooding of the Gila River, the water rose to about 5 feet above ground level throughout this 70 acre community. All 55 of the homes were affected. Most filled to about 4 feet with mud and debris. Many had walls torn apart by the river. Most of the residents stayed with relatives in the

Phoenix area during the flood, while others were given shelter by the Red Cross and the FDAA.

The residents of Holly Acres are planning to remain there. About 96 percent have received SBA loans to rebuild and clear their homes and property. One resident is completely rebuilding his home. Others (about 9) are repairing existing structures damaged by the flood. Many are planning to rebuild, but are waiting for financial aid. Those who have not qualified for SBA loans have received federal grants, and others had flood insurance.

The residents are aware that they live in a floodplain, and have been given waiver permits by the County to rebuild. The permit states that the County will not be responsible for any future flood damages.

About 60 homes are located in Allenville, about 1½ miles south of Buckeye. During the evening (6:30 to 7:00 p.m.) of March 2nd, the Maricopa County Sheriff's Department alerted residents to watch for floodwaters. A short time later (about 11:00 p.m.), Allenville was flooded. Watermarks and mud lines were left on the outside of homes 6 feet above ground level. The residents of Allenville escaped the flood with what they could carry away.

Some of the residents stayed with relatives in the Buckeye area; others were given motel rooms in Buckeye by HUD. Others stayed at emergency shelters set up by the Red Cross. The Red Cross also supplied the residents with food and clothing. On April 22nd, HUD brought 38 mobile homes for the displaced to a vacant lot owned by the City of Buckeye. HUD has given each family a mobile home to occupy for a maximum of 14 months, by which time the families must locate their own housing. HUD is also making grants available for those wishing to buy the mobile homes they are now living in, but will not allow them to be moved back into Allenville. Maricopa County paid residents $3.00/hour for general clean-up work, and families have begun re-settling into their homes.

Allenville was a very low income community. Most of the residents were owner occupied. The value of these homes before the flood was typically under $3,000. The majority of the houses were demolished by floodflows.

F. LOCATION 5 - CAVE CREEK. Cave Creek flows south into Phoenix from the Tonto National Forest. Cave Creek Dam, located in the Union Hills, is a flood control structure built by local interests in 1923. Construction is underway on Cave Buttes Dam one mile to the south by the Corps. Although Cave Creek historically flows into the Salt River, its natural channel south of the Arizona Canal is urbanized with no defined channel remaining. Much of the urban area below Cave Creek Dam is middle class.

The peak flow on Cave Creek occurred on March 2nd. Near the City of Cave Creek, north of Phoenix and Cave Creek Dam, the maximum flow was 8,000 cfs. Water within Cave Creek Reservoir rose to within 6 inches of its top. Inside Phoenix, the peak flow was 2,100 cfs at 2:00 a.m. One death occurred within the City of Cave Creek. A Maricopa County Sheriff's Deputy drowned while attempting a rescue of stranded residents.

The Cave Creek flow, when combined with the local inflow in the Arizona canal, overflowed the canal bank spillway at this location and several locations downstream. The resultant overflow affected homes bounded by Dunlap Avenue and Glendale Avenue to the north and south respectively, and Seventh Avenue eastward to Nineteenth Avenue. Residential damage totaled $245,000, 96 percent of the loss being attributable to Cave Creek. Outside depth of flooding was generally less than 1 foot, and most of the structures within the overflow area were untouched as waters encroached upon their lawns or remained within the local drainage system. Some residents avoided significant damages with wooden slats prepared to fit doorway and carport slots constructed after past flood experience. The local flat terrain keeps flood levels low enough for such measures to be effective.

G. LOCATION 6 - GLENDALE. All of the flood damages within the City of Glendale were due to the over toppage and erosion of the bank of the Arizona Canal, a dirt canal which flows along the northern boundaries of the cities of Glendale and Peoria. The Arizona Canal, fed from both Cave Creek and local canal inflows, was running at capacity during the peak of the flood. This canal overtopped at 59th Avenue and spilled at the 43rd Avenue spillway. The Salt River Project performed silt dredging and bank reinforcement along the canal during the flood.

The floodwaters flowing out of the spillway at 43rd Avenue continued mainly along the east side of the street until they reached Grand Avenue. The flow from the 59th Avenue overflow caused $56,000 in public damages to Glendale Samaritan Hospital at 60th Avenue and Northern, $30,000 of which is estimated business losses. This same flow then continued down 61st Avenue between Northern Avenue and Grand Avenue. The majority of the $157,000 in residential flood damage within the City of Glendale was found in this area.

Industrial damage was isolated to one firm, a cotton gin, with $241,000 in damage. The commercial damage of $63,000 was found along Grand Avenue between 43rd Avenue and 67th Avenue. Various motels and small businesses received considerable flood damage on the north side of Grand Avenue. Traffic was delayed for approximately 4 days along 43rd Avenue and 59th Avenue at various intersections between the Arizona Canal and Gand Avenue because of the water overflow in these streets. Generally, the majority of the Glendale area was not affected by the overflow of the Arizona Canal, since most of the floodwater flowed down 43rd and 59th Avenues until it reached Grand Avenue, where it collected in ponds on the south side of the street.

H. LOCATION 7 - OTHER AREAS. The storms of February 27th through March 6th caused flooding conditions throughout Maricopa County on such streams as the Verde River, Indian Bend Wash, Skunk Creek, the New River, the Hassayampa River, Trilby Wash and Queen Creek. The damage outside of the areas enumerated above amounted to $2,765,000. Of this figure, $2,154,000 was damage to public facilities, mostly roads, bridges and flood control structures. Limited private development minimized the possibility of additional losses along many of these streams.

Indian Bend Wash is the site of a nearly completed Corps project. The peak flow of 3,100 cfs at its confluence with the Salt River was below the projects' designed maximum of 30,000 cfs. Although the inlet structure for Indian Bend Wash was not complete, it is upstream of the intruding flows which entered via side channels from the Arizona Canal and did not affect protection. The project's performance limited damages to $30,000. One death occurred at the McKellips Road crossing, when one of two young men attempting to jump the collapsed bridge in a four wheel drive vehicle drowned.

There were several areas that suffered agricultural damages. These included farms and ranches located adjacent to the Agua Fria, Hassayampa, and New Rivers in addition to Queen Creek, Trilby Wash, and Skunk Creek. Damages to farms and ranches in these areas were estimated at $586,000, which included: $209,000 crop loss, $207,000 land reshaping, $154,000 equipment loss, $15,000 livestock loss and $1,000 business loss. Approximately 1,700 acres of land require reshaping; 12,000 acres were planted.

586
30

TABLE 6

FLOOD DAMAGES BY LOCATION AND TYPE
(1,000's)

Location	Physical Damages	Business and Emergency Losses	Total
1. Salt River Granite Reef to 48th Street			
Agricultural	$ 0	$ 0	$ 0
Residential	27	4	31
Commercial	2	24	26
Industrial:			
Sand and Gravel	988	10	998
Other Industrial	1,443	17	1,460
Public:			
Roads and Bridges			1,731
Other Public	136	4	140
Other	796	6	802
Total - Location 1			$5,188
2. Salt River 48th Street to 35th Avenue			
Agricultural	$ 0	$ 0	$ 0
Residential	0	0	0
Commercial	256	23	279
Industrial:			
Sand and Gravel	666	150	816
Other Industrial	3,370	156	3,526
Public:			
Roads and Bridges	8,761	979	9,740
Other Public	3,200	0	3,200
Other	200	0	200
Total - Location 2			$17,761
3. Salt River 35th Avenue to 115th Avenue			
Agricultural	$ 359	$ 19	$ 378
Residential	285	13	298
Commercial	1	4	5
Industrial:			
Sand and Gravel	0	0	0
Other Industrial	95	14	109
Public:			
Roads and Bridges			338
Other Public	0	0	0
Other	13	1	14
Total - Location 3			$1,142

TABLE 6

FLOOD DAMAGES BY LOCATION AND TYPE
(1,000's)

Location	Physical Damages	Business and Emergency Losses	Total
4. Gila River			
Agricultural	$2,965	$102	$3,067
Residential	2,189	175	2,364
Commercial	362	3	365
Industrial:			
Sand and Gravel	600	80	680
Other Industrial	0	0	0
Public:			
Roads and Bridges			340
Other Public	53	4	57
Other	44	0	44
Total - Location 4			$6,917
5. Cave Creek			
Agricultural	$ 0	$ 0	$ 0
Residential	189	56	245
Commercial	1	4	5
Industrial:			
Sand and Gravel	0	0	0
Other Industrial	0	0	0
Public:			
Roads and Bridges	0	0	0
Other Public	2	1	3
Other	1	0	1
Total - Location 5			$ 254
6. Arizona Canal Glendale			
Agricultural	$ 0	$ 0	$ 0
Residential	93	64	157
Commercial	62	1	63
Industrial:			
Sand and Gravel	0	0	0
Other Industrial	240	1	241
Public:			
Roads and Bridges	0	0	0
Other Public	21	2	23
Other	31	0	31
Total - Location 6			$ 515

12507

TABLE 6

FLOOD DAMAGES BY LOCATION AND TYPE
(1,000's)

Location	Physical Damages	Business and Emergency Losses	Total
7. All Other Areas			
Agricultural	$ 585	$ 1	$ 586
Residential	23	0	23
Commercial	2	0	2
Industrial:			
Sand and Gravel	0	0	0
Other Industrial	0	0	0
Public:			
Roads and Bridges			358
Other Public	0	0	0
Other	0	0	0
Total - Location 7			$969

VI. DAMAGES THAT WOULD HAVE BEEN PREVENTED BY PROJECTS AUTHORIZED BUT NOT YET CONSTRUCTED

Expected to be completed in September 1979, Cave Buttes Dam, with 3 dikes is under construction about 0.7 miles downstream (south) from the existing Cave Creek Dam. It is to be a compacted-earthfill structure with a maximum height of about 109 feet above streambed. The unlined spillway in conjunction with the outlet works will pass a peak discharge of 100,600 cfs. The detention basin will reduce a standard project flood with a peak inflow of 54,000 cfs to an outflow of 486 cfs. The detention basin would have been more than sufficient to reduce the inflow experienced during the March flood (a peak discharge of 8,000 cfs occurred 5 miles upstream on Cave Creek near Cave Creek) to a non-damaging flow. Had Cave Buttes Dam been completed during this flood, the $.25 million in damages experienced in the Cave Creek location would have been prevented.

The Arizona Canal diversion channel is a feature of the authorized New River and Phoenix City Streams, Arizona, flood control project. The diversion channel will be located just upstream of the existing Arizona Canal and, as reformulated in 1976, will extend from 40th Street downstream (westerly) about 17.3 miles to its confluence with Skunk Creek. It would consist of concrete rectangular, concrete trapezoidal, and unlined sections designed to intercept and convey from 6,800 cfs to 36,000 cfs. As presently scheduled, construction of the diversion channel would be completed in 1991. When fully operational, the project will provide protection against flood flows expected to occur with a frequency of once in every 100 years. Inasmuch as the recent flood was of a lesser frequency and damages south of the Arizona Canal were a result of flows emanating from the watershed upstream of the canal, the diversion channel, had it been fully operational, would have prevented all of the $515,000 in damages reported to have occurred south of the canal.

VII. GROUND WATER EFFECTS

A. GROUND WATER QUALITY. The water pumped from both irrigation and drainage wells in the area between Buckeye and Gillespie Dam is of poor quality; unsuitable for human consumption because of its high salt content. This is especially true of the ground water pumped by the drainage pumps. Much of this ground water is not suitable for farming purposes either and is used only when no other water is available.

The quality of water between Gillespie Dam and Painted Rock Dam is good and generally free from salt due to its greater surface depth.

B. WATER LEVELS. The area along the Gila River between Buckeye and Gillespie Dam has always been plagued with a high underground water table. Ground water levels in the root zone deteriorate crops. Underground water level estimates between El Mirage Road and Gillespie Dam are shown below:

TABLE 7

GOUND WATER DEPTHS
1978

Site	Depth From Ground Surface
El Mirage Road	20'
Sarival Road	68'
Buckeye	8'
Palo Verde	5'
Arlington	2½ - 6'

Farmers in the Arlington area have reported a rise in the ground water level by approximately two feet since the March flood, with the present water level being about 4 feet below ground. None of the farmers in this area own drainage pumps to remove excess ground water from their land. The only drainage pumps operating between Buckeye and Gillespie Dam are owned by the Buckeye Irrigation District (BID) which presently has 7 in operation. Five pumps are located around Buckeye and 2 are south of Palo Verde. The ground water level varies in this area, but is normally between 5 and 10 feet from the ground surface. BID reported that their drainage pumps have been operating continuously since January 1978 at the flow rates shown below:

TABLE 8

BID'S GROUND WATER PUMPING RATES

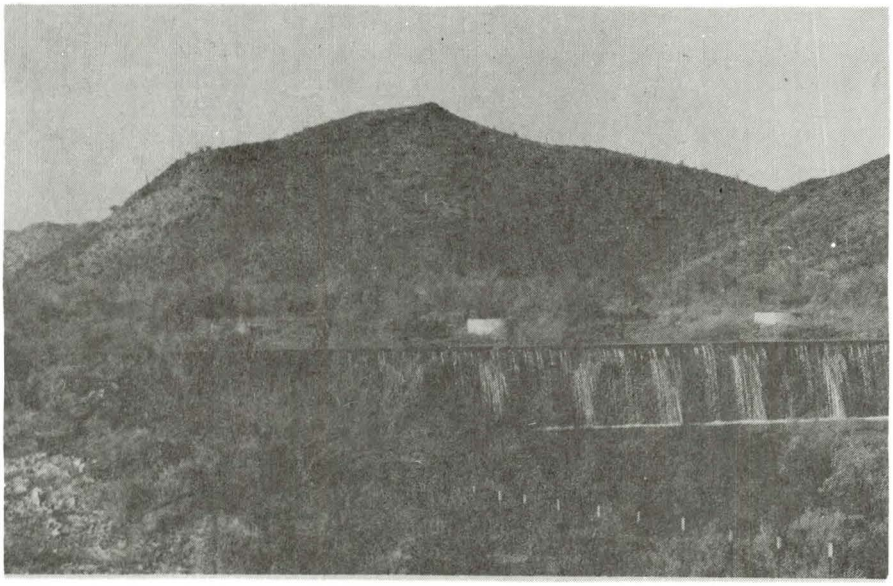
Drainage Pump Number	Flow Rate (gallons/minute)
1	3,100
2	2,800
3	2,800
4	1,060
5	1,683
6	1,290
7	1,964

33 #3/s

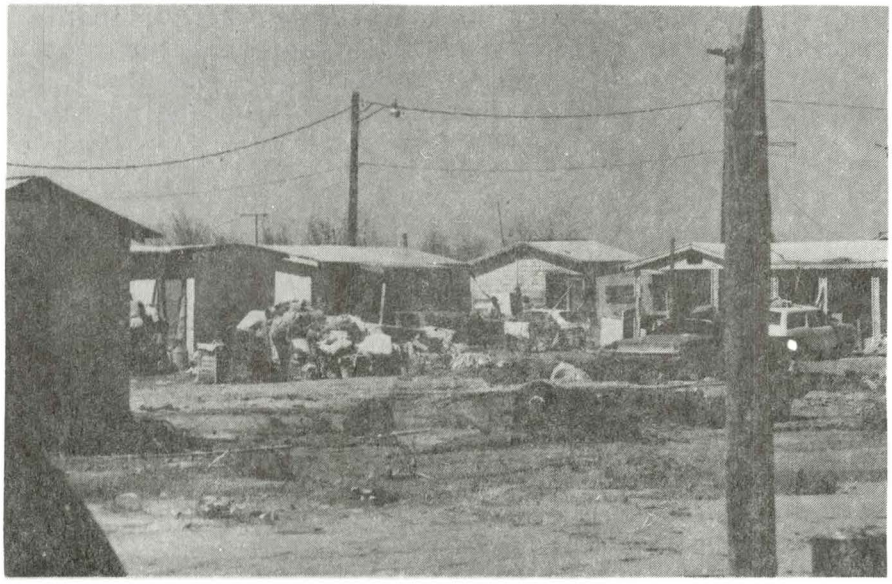
BID also stated that there has not been much change in the ground water level since the flood because: 1) the duration of the March flood was short (2-3 days); and 2) the flood water was very muddy, and tended to spread over a large area and evaporate rather than soak into the ground. None of the farmers in the area have reported an increase in the ground water level since the February-March flood.

BID pumps excess ground water into a system of waste ditches which send the water into the Arlington Canal. The farmers between Arlington and Gillespie Dam can use it for irrigation. Any water not used for irrigation is sent into the Gila River via the Arlington Canal at Gillespie Dam.

No problem with ground water exists in the area between Gillespie Dam and Painted Rock Dam. The Arizona Land Department reported the average rise of the water table in this area at 8 feet since the flood, with an average distance from ground surface to water level being about 96 feet.

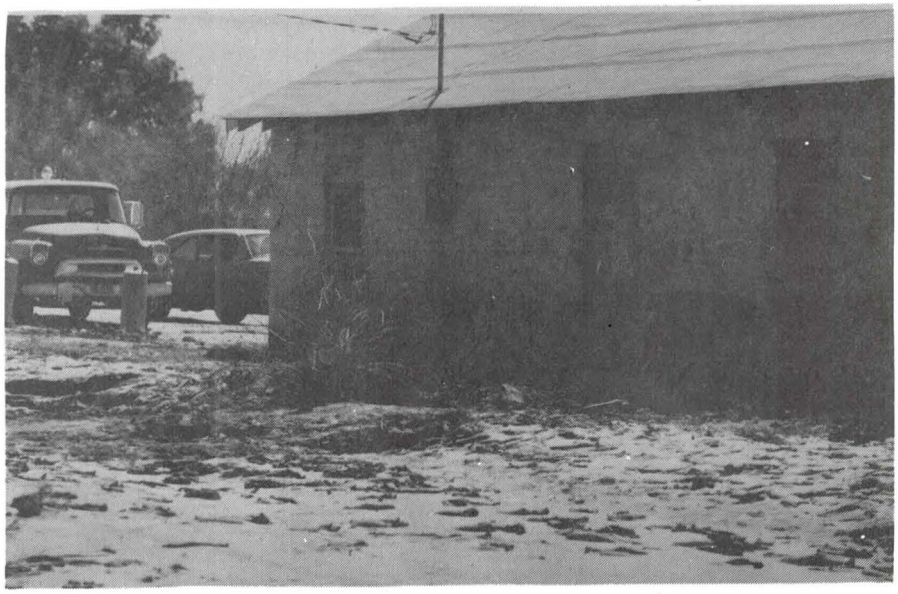


1. Flood flows overtopping Gillespie Dam on the Gila River south of Arlington.

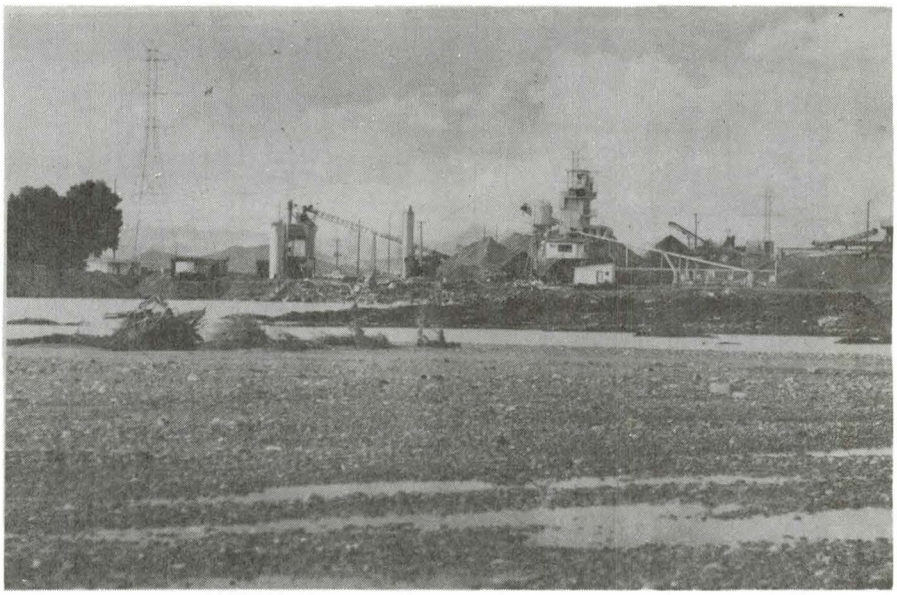


2. Residents of Allenville assess water damage to their personal belongings.

3. Yards in Allenville were cluttered with debris carried by the Gila River.

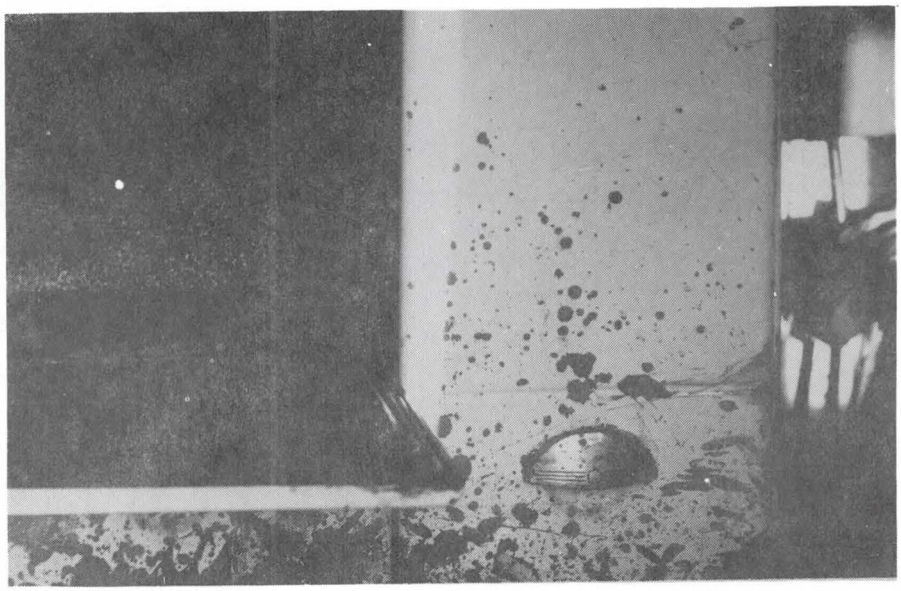


4. The waterline from the February-March 1978 flood is 3 feet above the drying clay ground in Allenville on the Gila River.

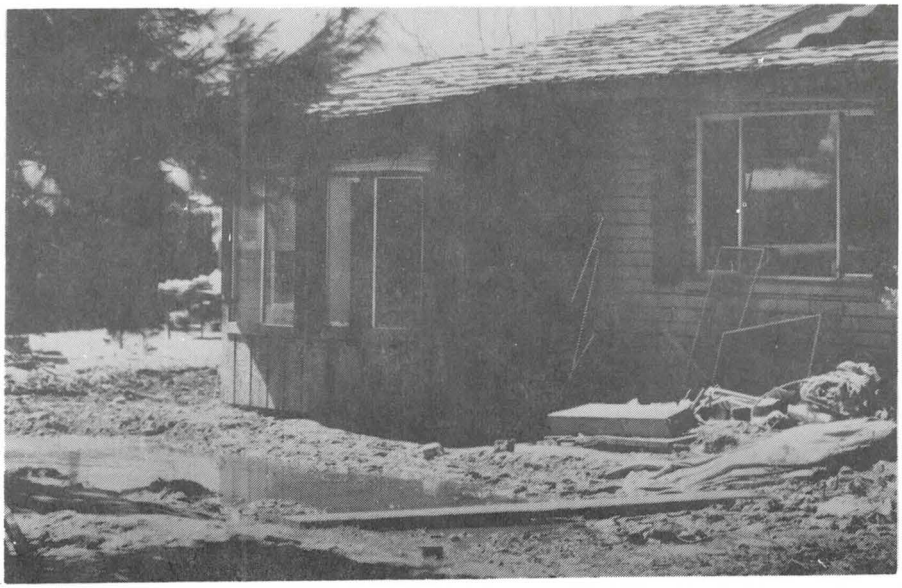


5. This flooded sand and gravel mining company south of Buckeye is typical of others throughout the Salt and Gila Rivers that sustained a total of $2.5 million in damages.

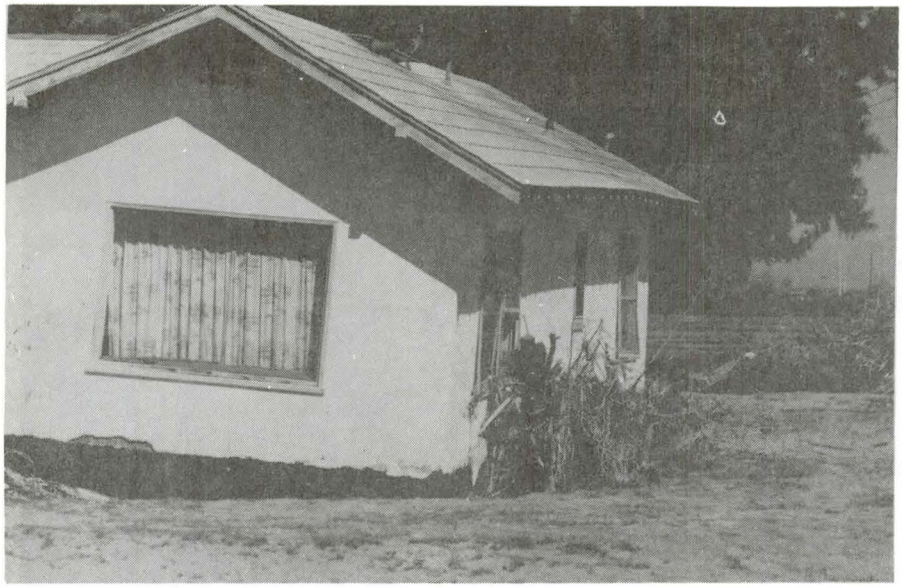
6. Broken and debris strewn fences lined ruined yards in Holly Acres, south of Tolleson, after being flooded by the Gila River.



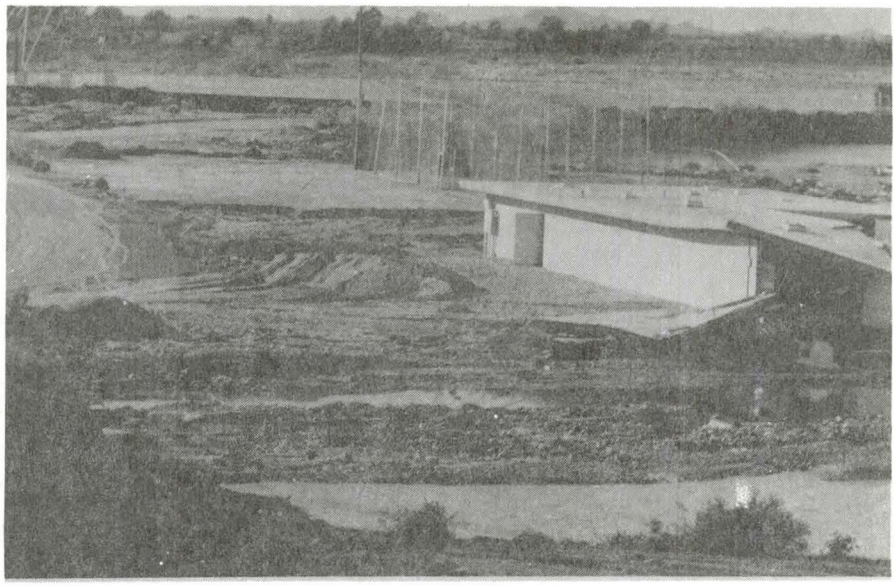
7. Mud stains on an oven in Holly Acres, where damages to personal belongings within homes totalled $.5 million.



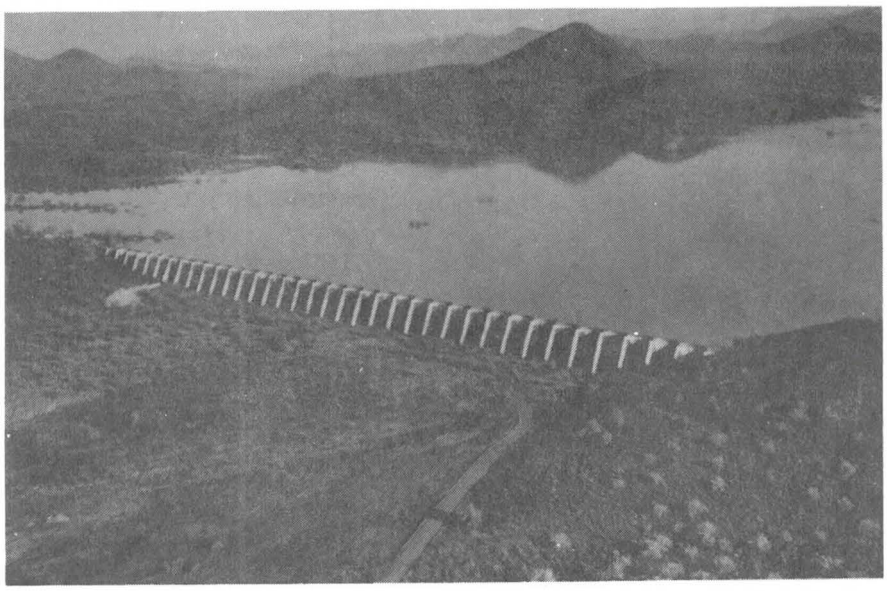
8. Watermarks stain the bay windows almost to the shutters on this home in Holly Acres. A waterline that can be seen on the wood and bricks indicates the level at which water stood for a prolonged period of time.



9. The Gila River flood flows undermined the foundation of this house at the southern end of Holly Acres, nearest the river.

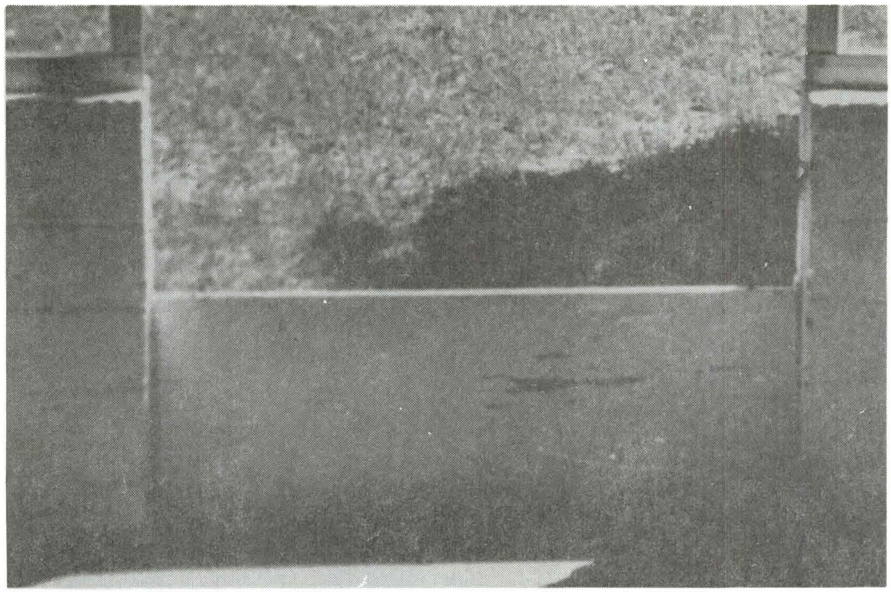


10. The preseason training site for a major league baseball club, the Milwaukee Brewers, was destroyed by flood flows of the Salt River. The club relocated from this South Phoenix location in order to complete spring training.



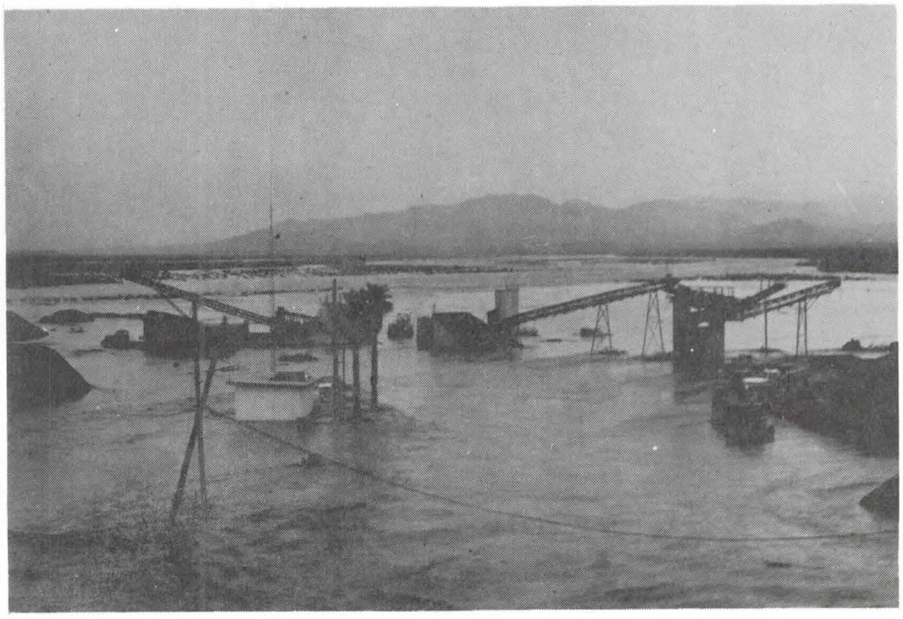
11. Cave Creek Dam held 7,000 acre-feet and filled within 6 inches of its brim during March 1978.

12. Looking northeast, Cave Creek Dam releases enter the Arizona Canal from the left and spill into northern Phoenix on the right. See Plate 15 for details of the overflow area.



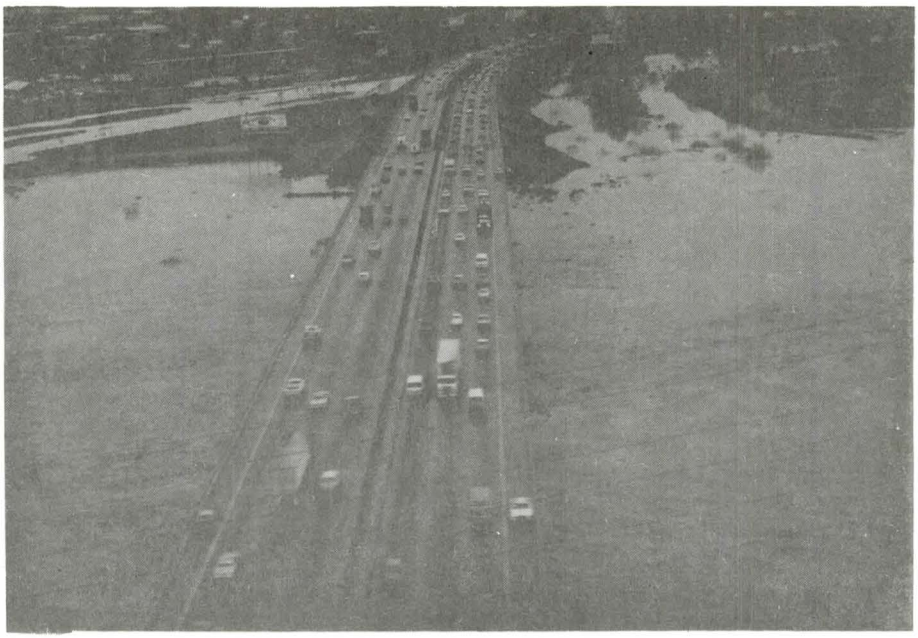
13. A wooden slat is used for flood protection from Cave Creek in northern Phoenix.

14. McDowell Exhibit Plaza is on the left and Eldorado Park on the right in this photo looking westward along the Corps' Indian Bend Wash.

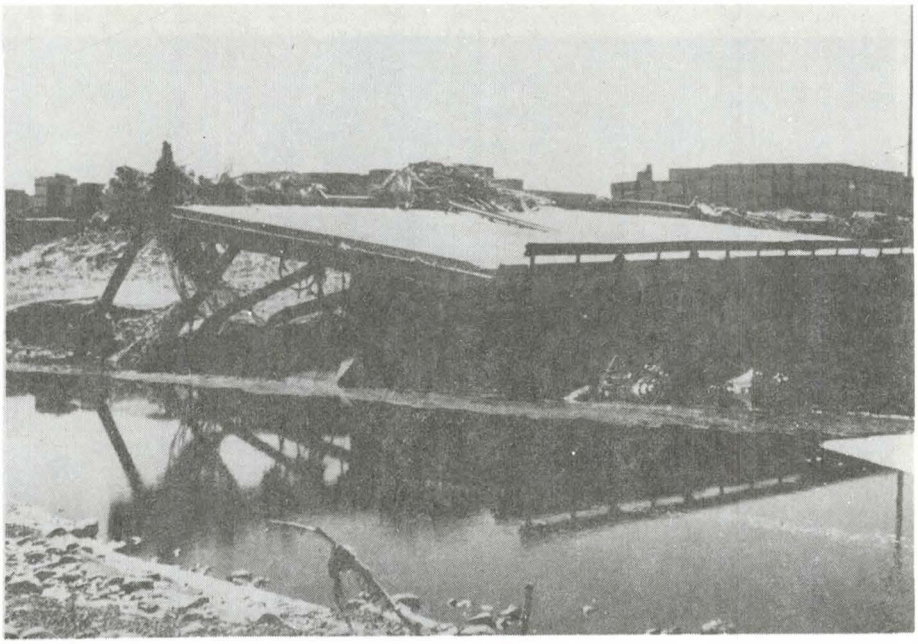


15. A sand and gravel operation near Mesa is completely inundated by the flood waters of the Salt River.

16. Approximately 2,500 feet of runway at Sky Harbor International Airport is washed away as the flow in the Salt River approaches 122,000 cubic feet per second.



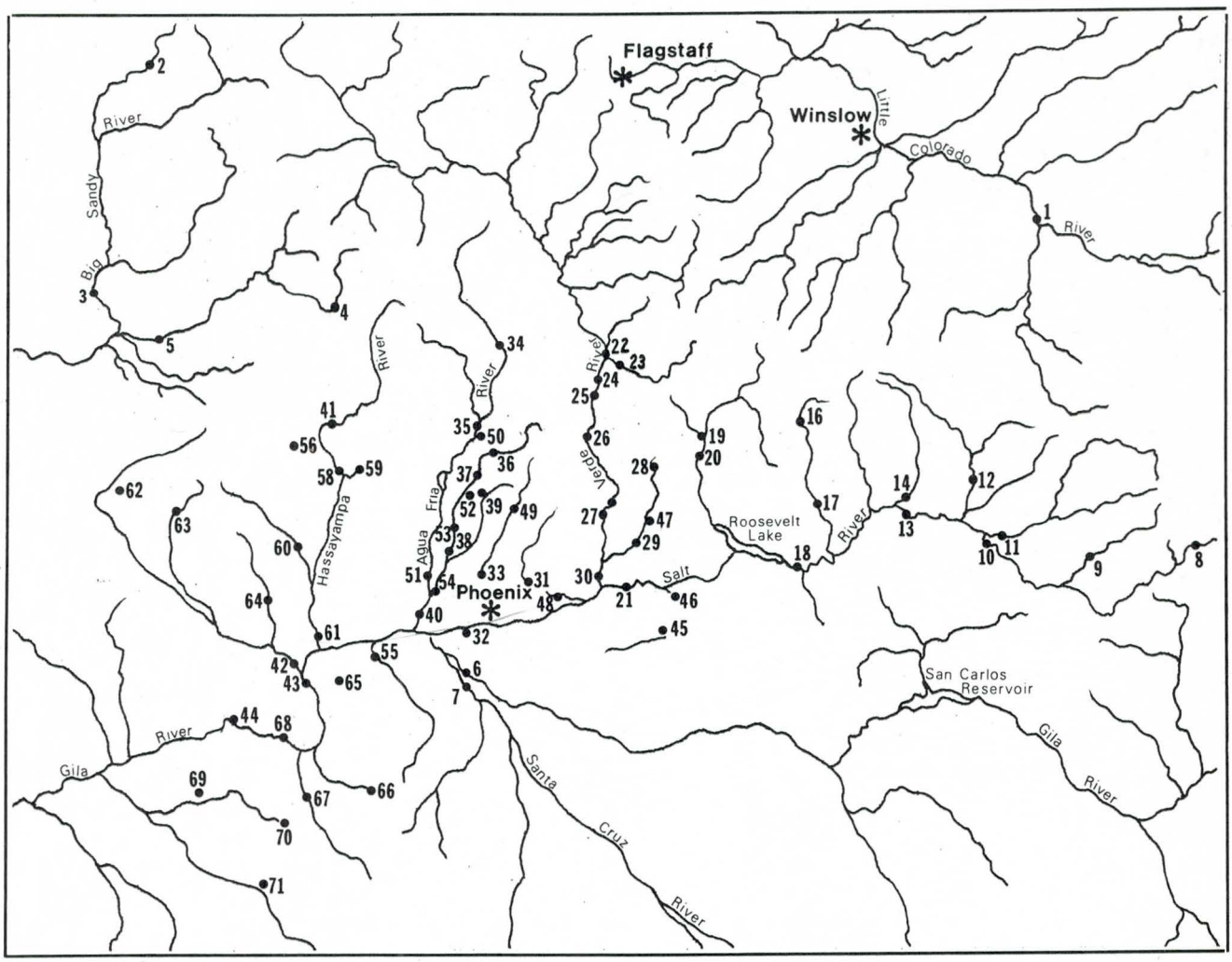
17. Long lines of traffic and delays of many hours were caused by the March 1978 flood as only three bridges remained open on the Salt River. Shown here is the Interstate 10 (Maricopa Freeway) Bridge.



18. Shown here is the 19th Avenue Bridge completely destroyed by flood waters of the Salt River.

INDEX MAP
PHOENIX, ARIZONA AND VICINITY
SCALE 2 0 2 4 MILES

PLATE 1



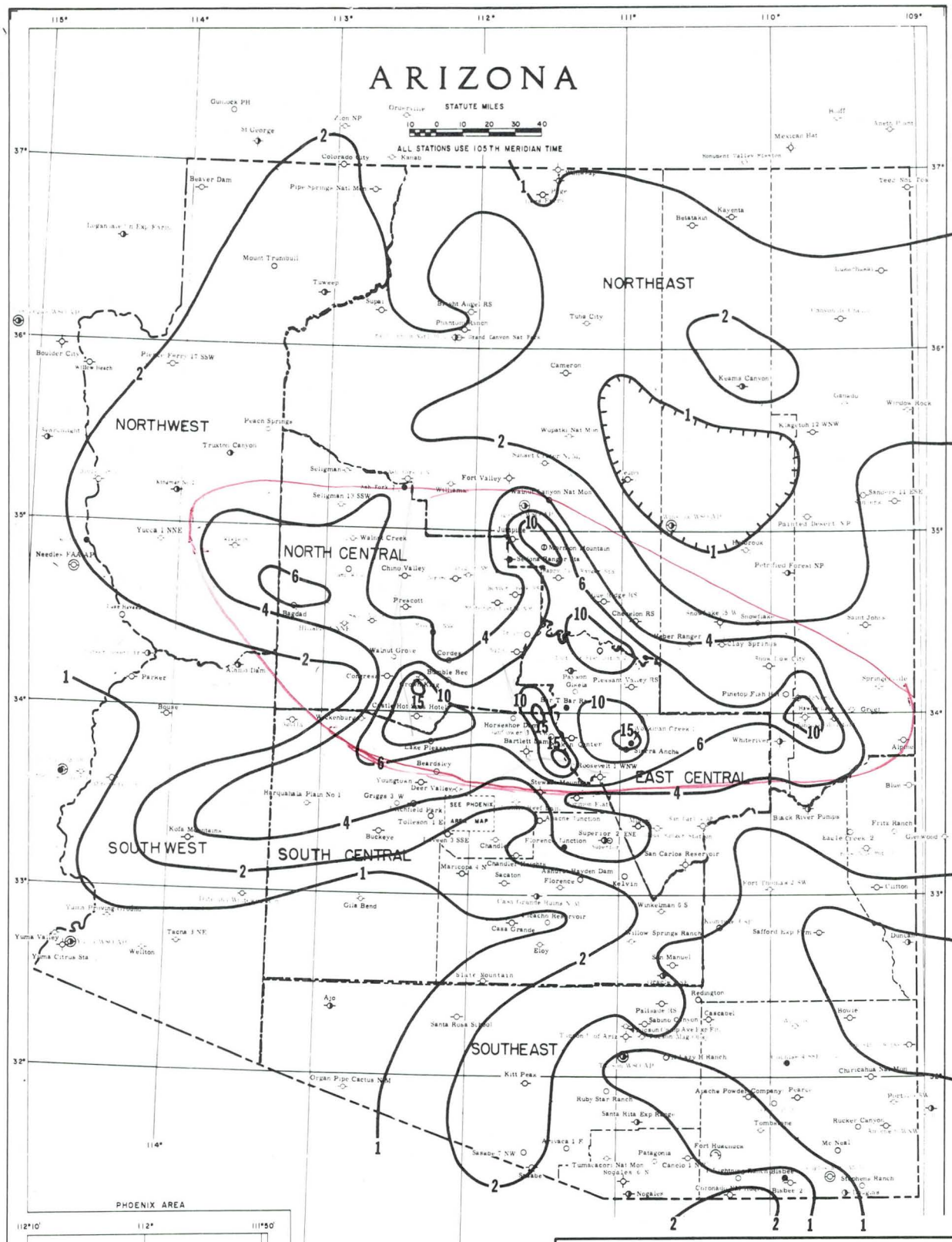
*Central Arizona Gaging Stations

*Refer to Table 1 for specific gaging station numbers and discharge information.

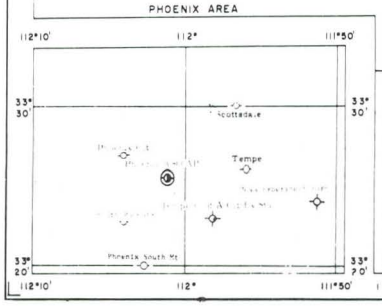
STREAM GAGE LOCATIONS

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

PLATE 2



PHOENIX AREA



STATION LEGEND

- Precipitation only
- Precipitation, storage
- Precipitation and Temperature
- Precipitation, Temperature and Evaporation

Type of gage: ○ Non-recording, ● Recording, ◑ Both types

◎ Double circle combinations indicate the availability of more detailed meteorological data.

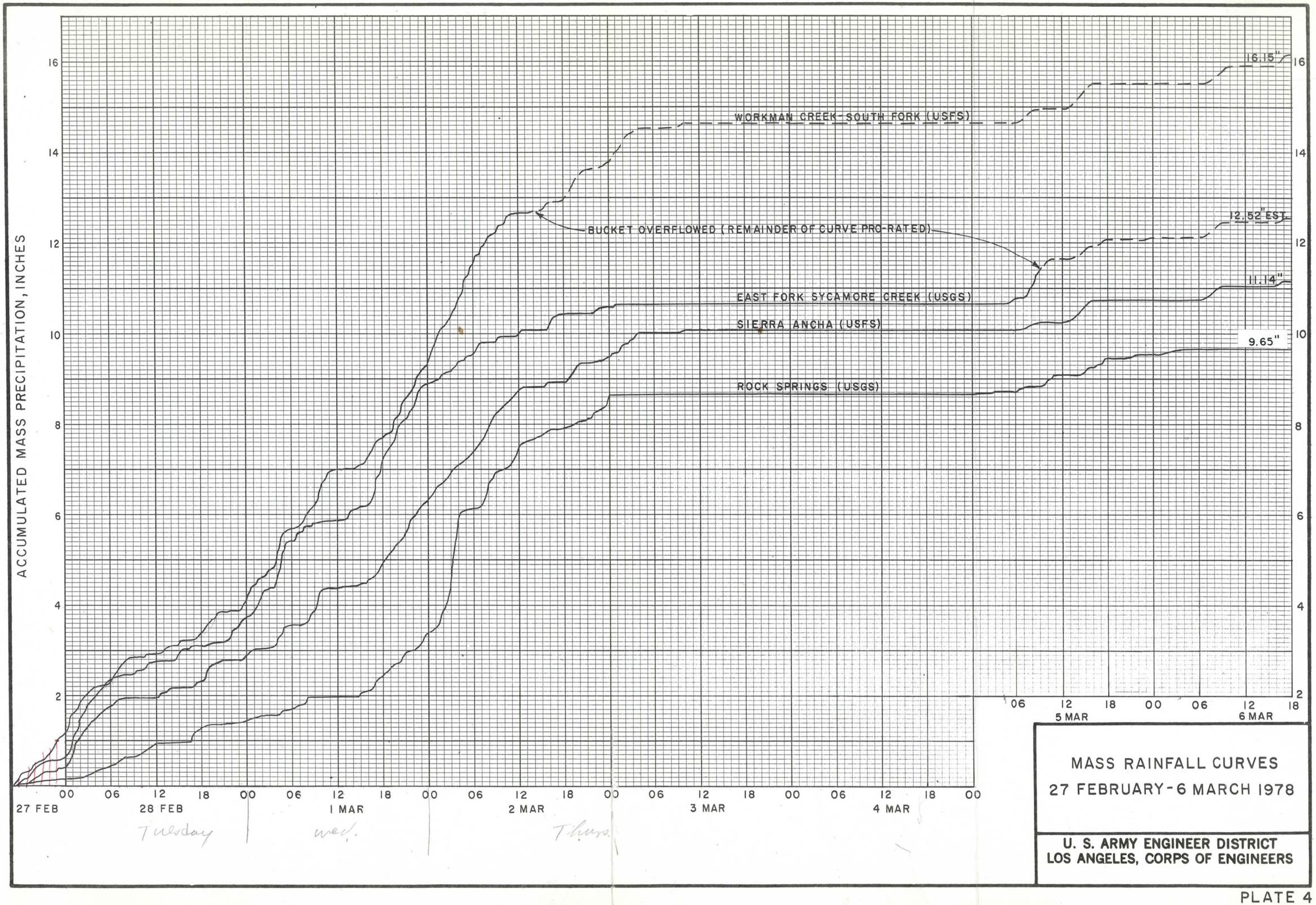
ISOHYETAL MAP

STORM TOTALS

February 27 - March 6, 1978

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

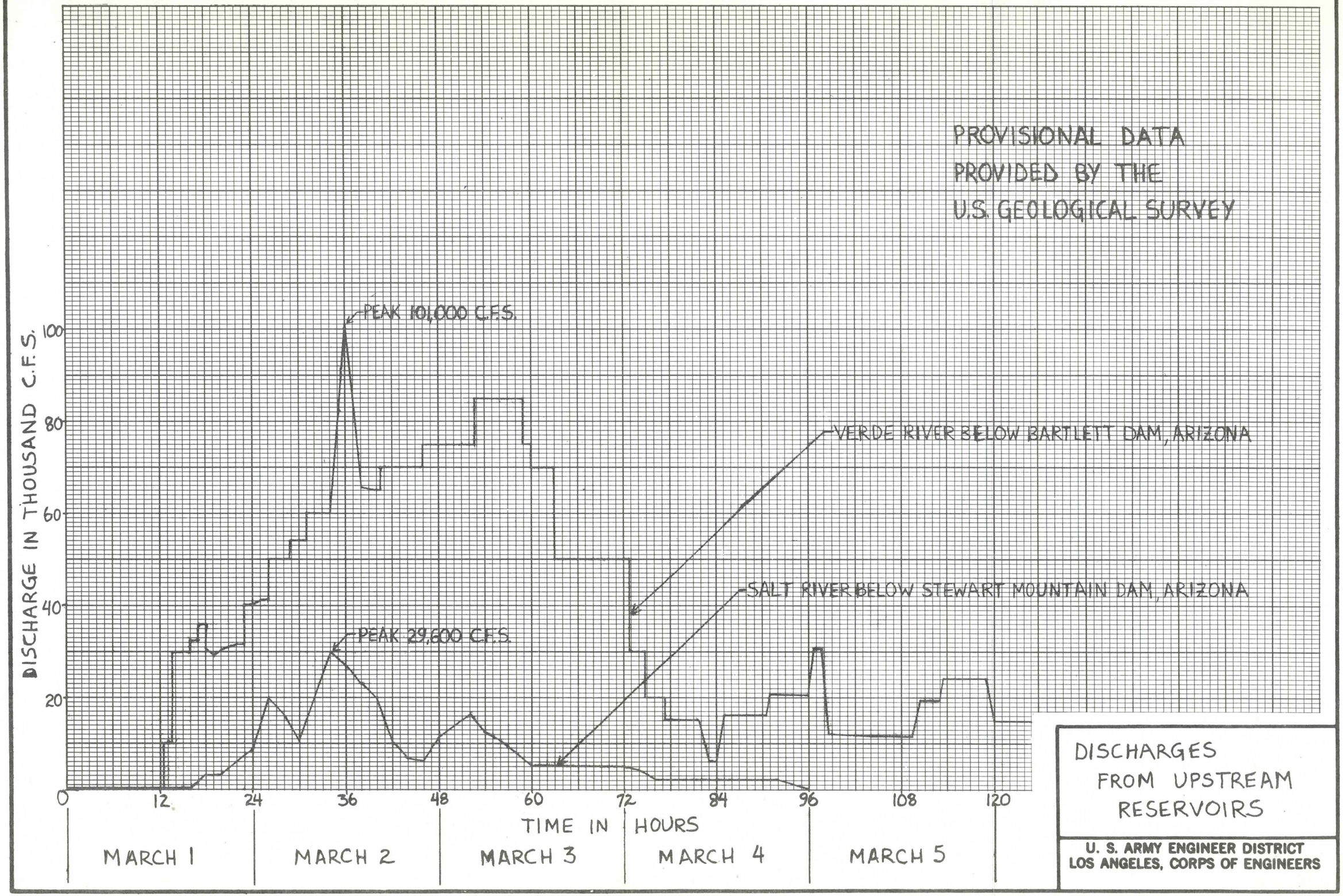
PLATE 3



MASS RAINFALL CURVES
27 FEBRUARY-6 MARCH 1978

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

PROVISIONAL DATA
PROVIDED BY THE
U.S. GEOLOGICAL SURVEY



DISCHARGES
FROM UPSTREAM
RESERVOIRS

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

PLATE 5

MARICOPA COUNTY, ARIZONA

SALT RIVER

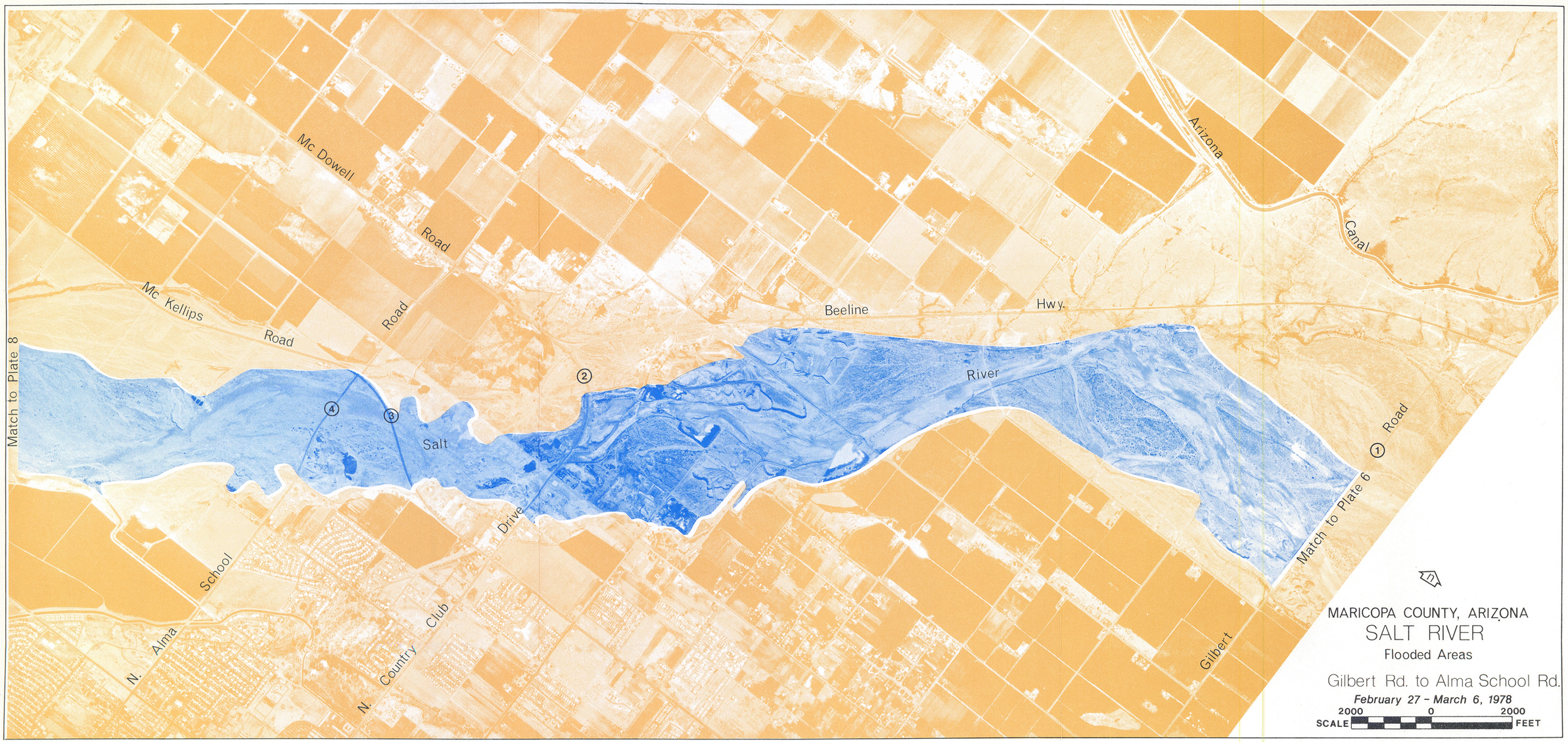
Flooded Areas

Granite Reef Dam to Gilbert Rd.

February 27 – March 6, 1978

SCALE 2000 0 2000 FEET

PLATE 6



MARICOPA COUNTY, ARIZONA

SALT RIVER

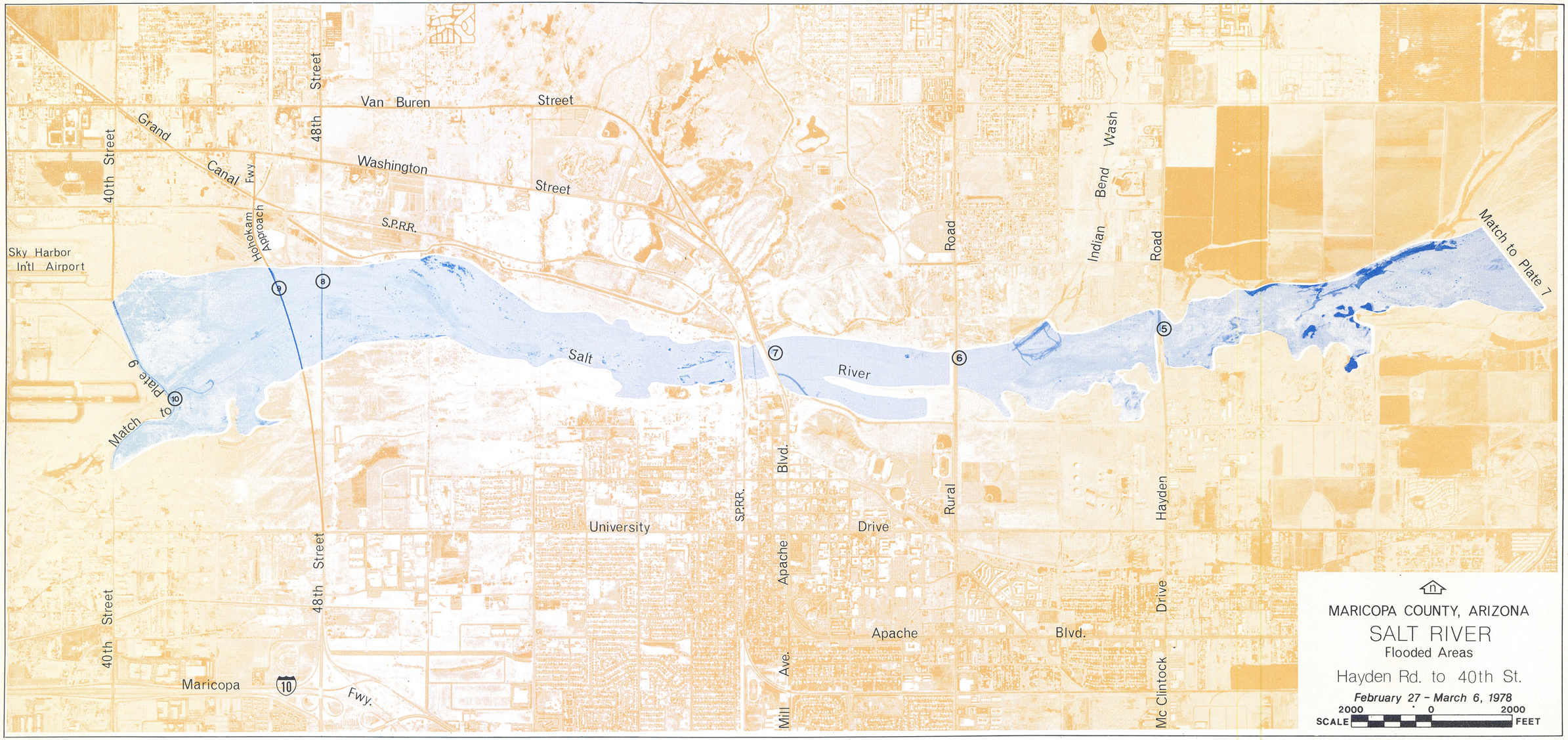
Flooded Areas

Gilbert Rd. to Alma School Rd.

February 27 - March 6, 1978

SCALE 2000 0 2000 FEET

PLATE 7



MARICOPA COUNTY, ARIZONA

SALT RIVER

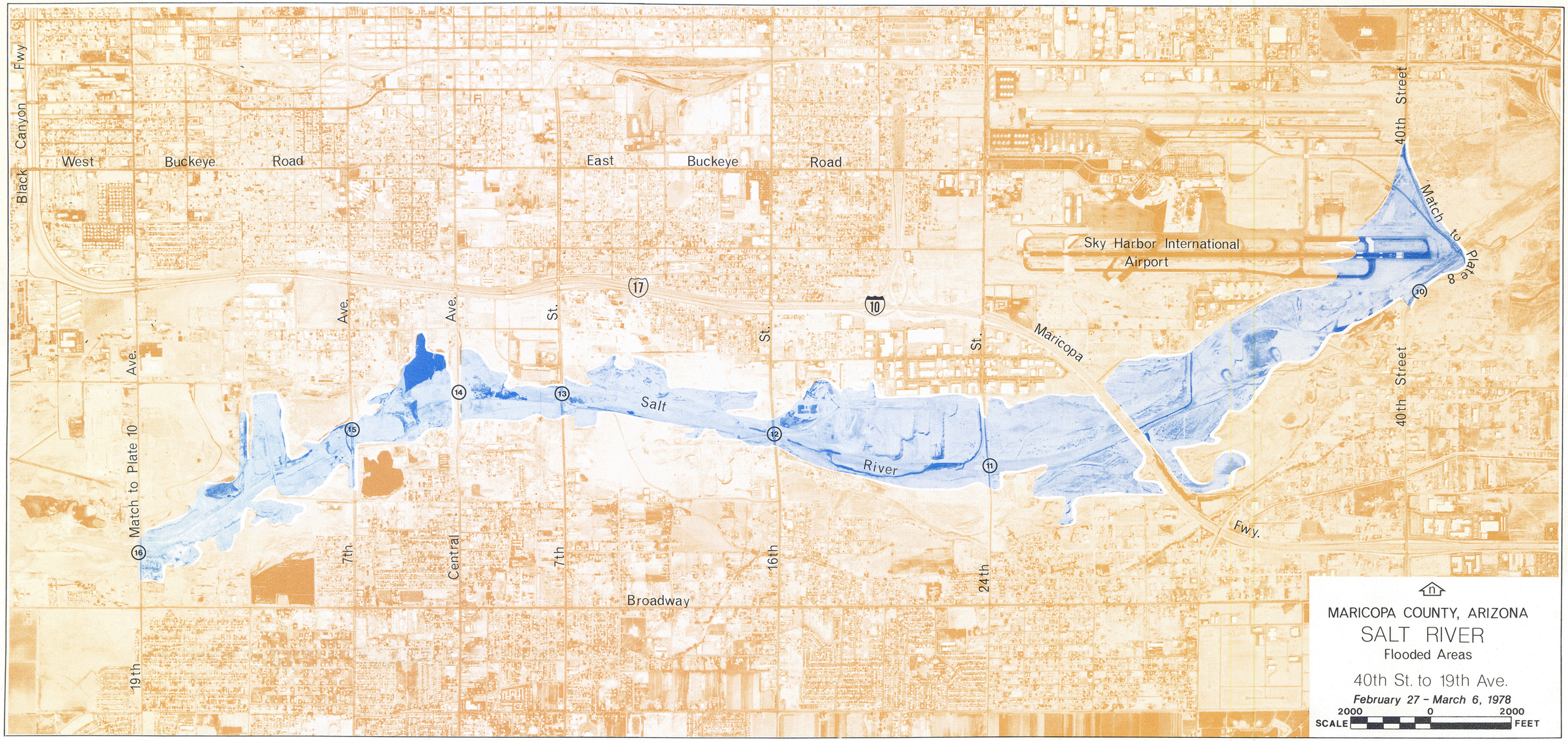
Flooded Areas

Hayden Rd. to 40th St.

February 27 - March 6, 1978

SCALE 2000 · 0 2000 FEET

PLATE 8



MARICOPA COUNTY, ARIZONA

SALT RIVER

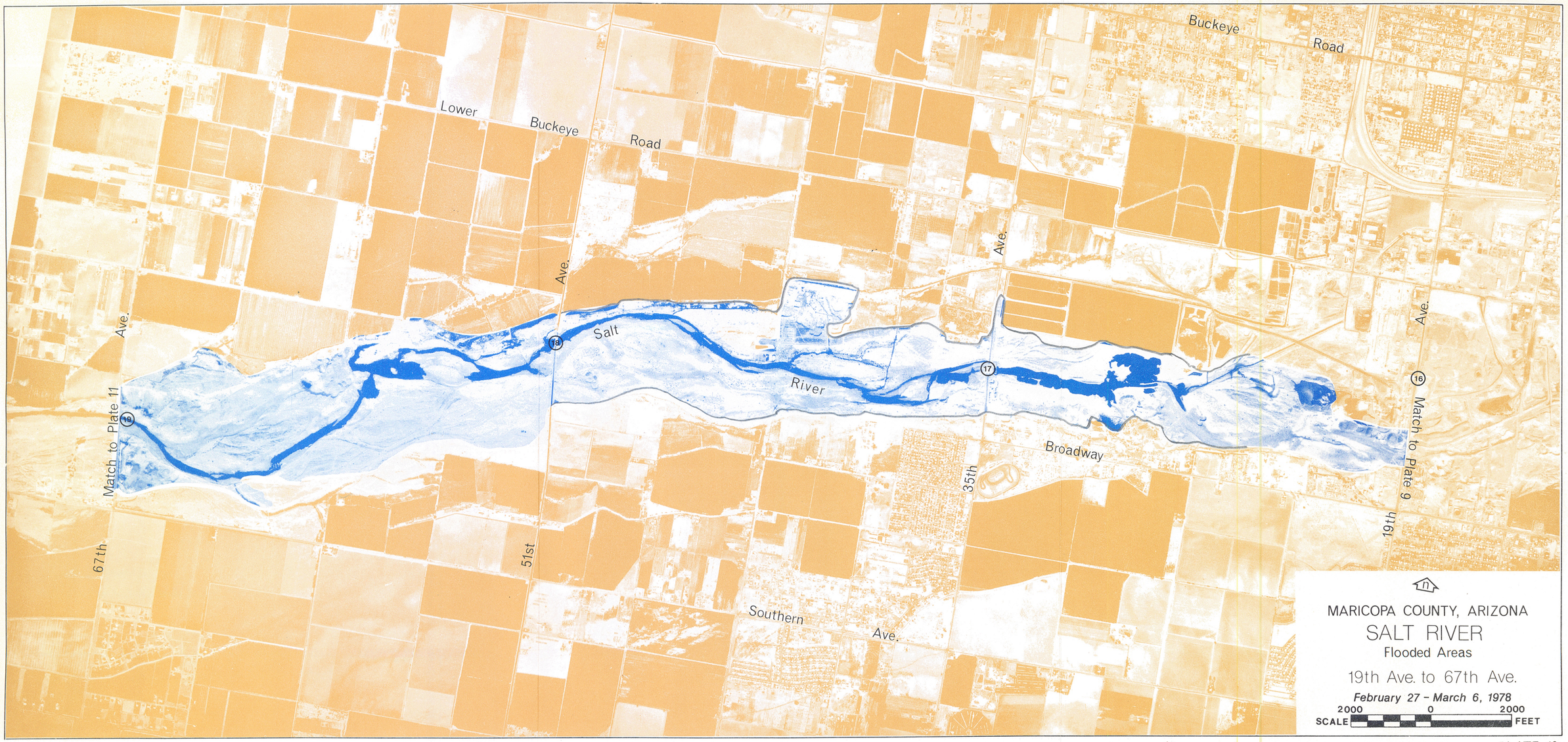
Flooded Areas

40th St. to 19th Ave.

February 27 – March 6, 1978

SCALE 2000 0 2000 FEET

PLATE 9



MARICOPA COUNTY, ARIZONA

SALT RIVER

Flooded Areas

19th Ave. to 67th Ave.

February 27 – March 6, 1978

SCALE 2000 0 2000 FEET

PLATE 10

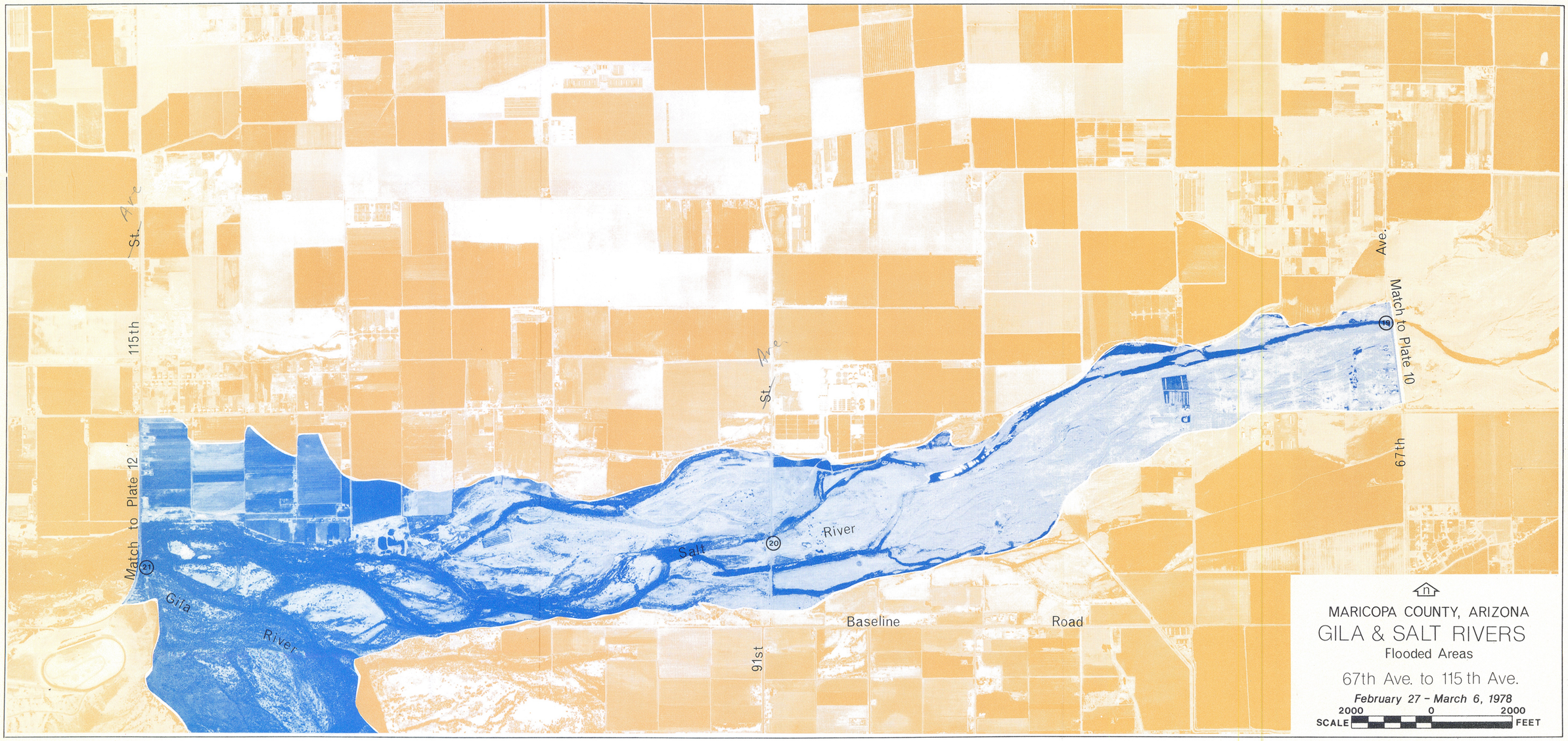

St. Ave
115th
Match to Plate 12
21
Gila
River
Salt
River
20
St. Ave
91st
Baseline
Road
Ave.
Match to Plate 10
19
67th
11
MARICOPA COUNTY, ARIZONA
GILA & SALT RIVERS
Flooded Areas
67th Ave. to 115 th Ave.
February 27 - March 6, 1978
2000 0 2000
SCALE
FEET

PLATE 11

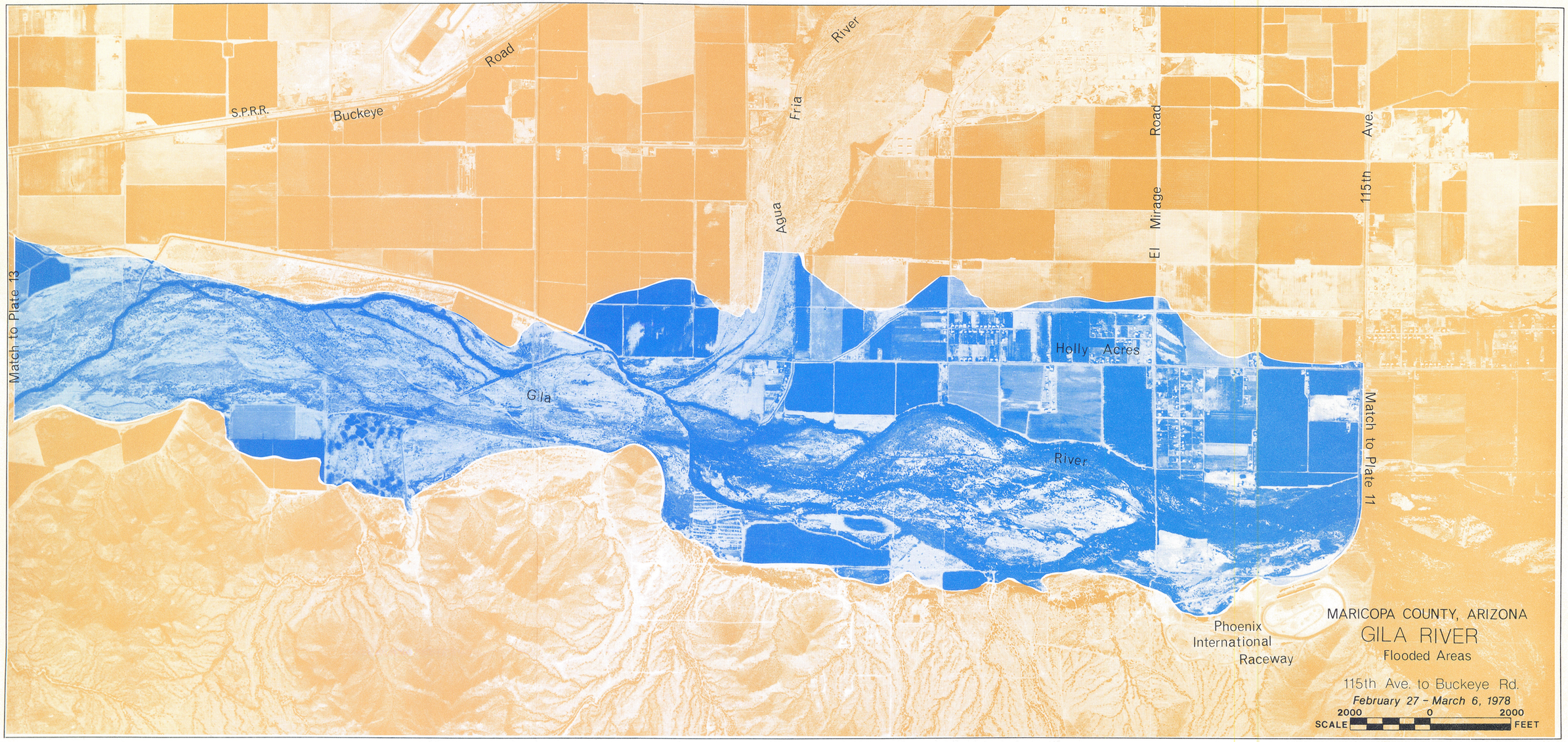

S.P.R.R.
Buckeye Road
Agua Fria River
El Mirage Road
115th Ave.
Match to Plate 13
Gila River
Holly Acres
Match to Plate 11
Phoenix International Raceway
MARICOPA COUNTY, ARIZONA
GILA RIVER
Flooded Areas
115th Ave. to Buckeye Rd.
February 27 - March 6, 1978
SCALE 2000 0 2000 FEET

PLATE 12

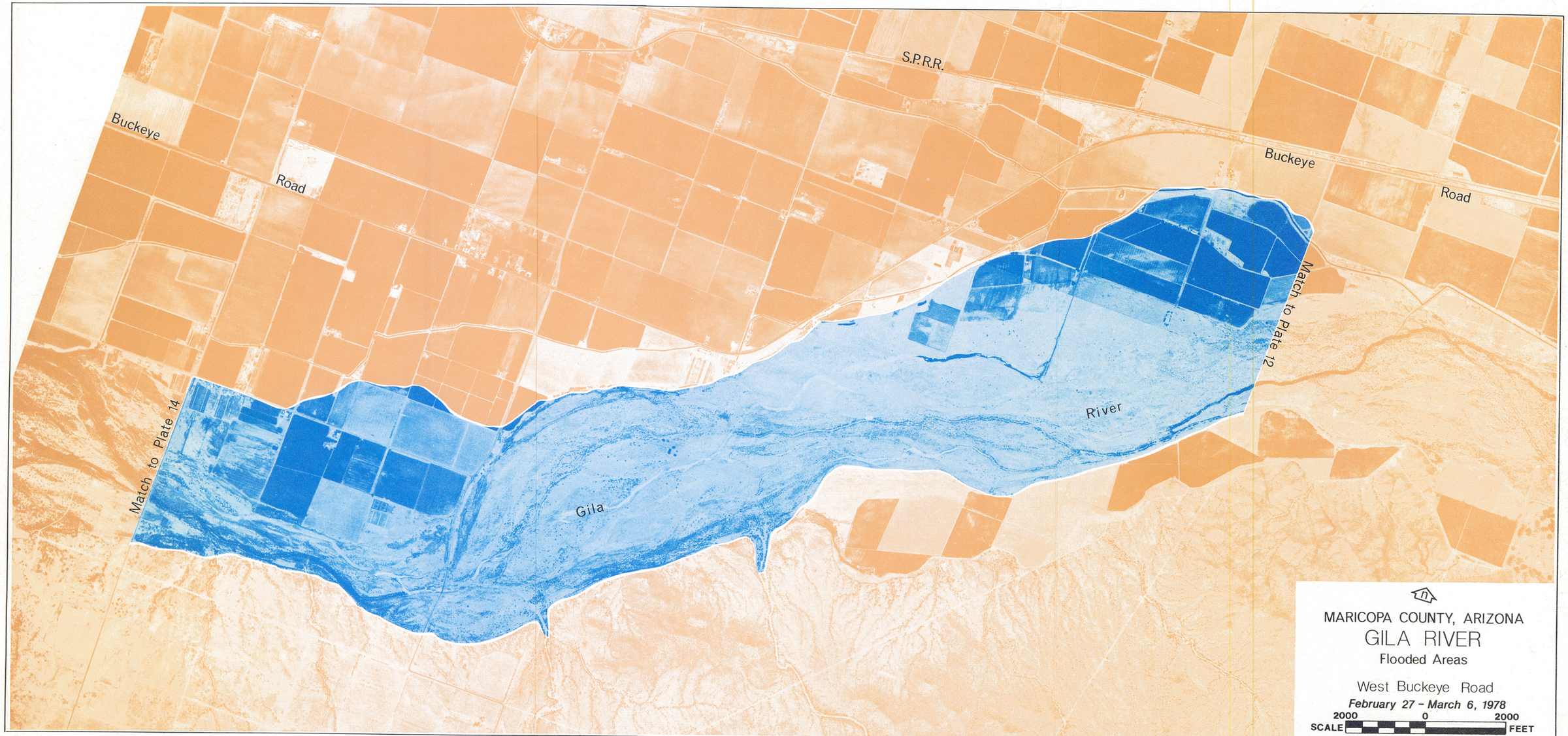
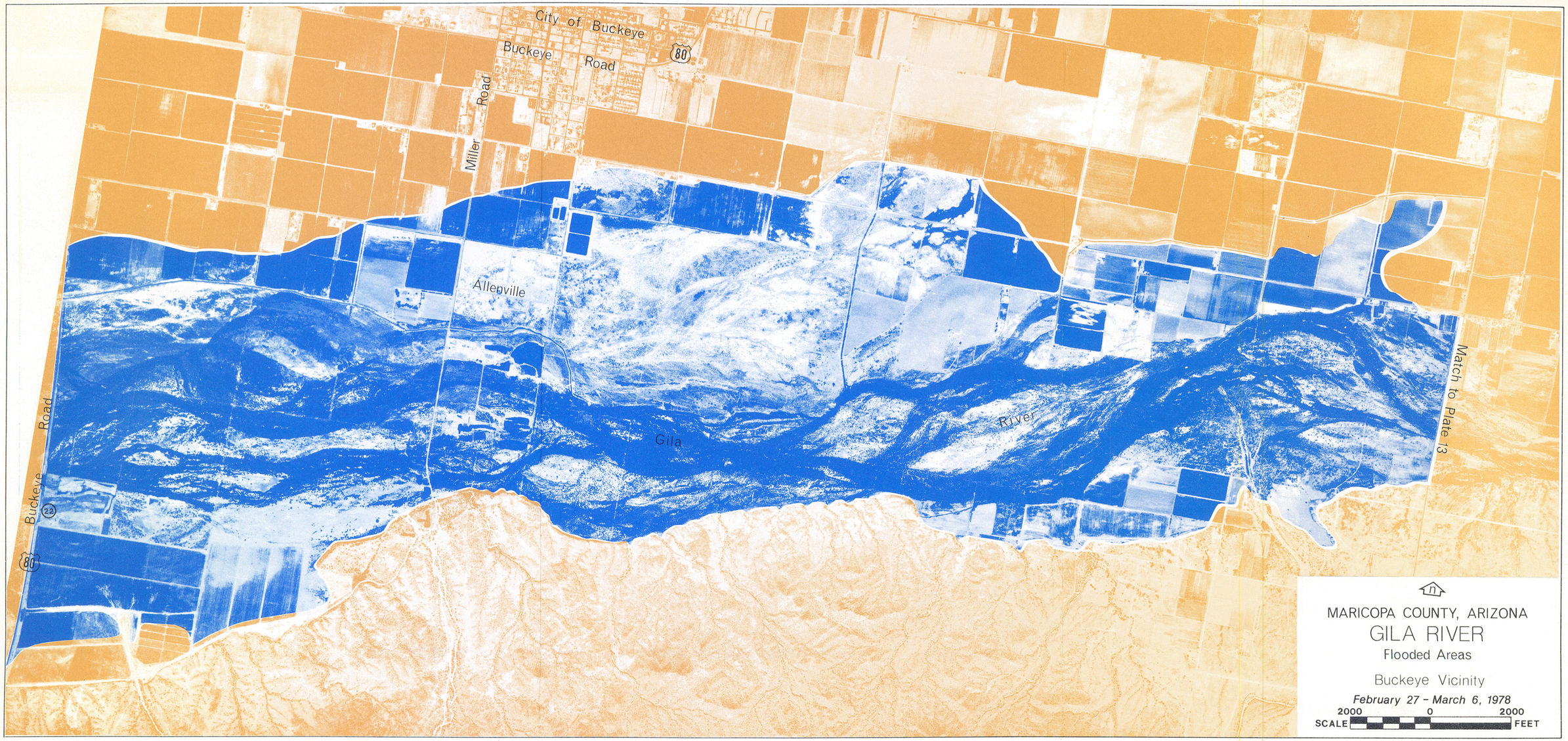

S.P.R.R.
Buckeye
Road
Buckeye
Road
Match to Plate 14
Gila
River
Match to Plate 12
MARICOPA COUNTY, ARIZONA
GILA RIVER
Flooded Areas
West Buckeye Road
February 27 - March 6, 1978
SCALE
2000
0
2000
FEET

PLATE 13



MARICOPA COUNTY, ARIZONA

GILA RIVER

Flooded Areas

Buckeye Vicinity

February 27 - March 6, 1978

SCALE 2000 0 2000 FEET

PLATE 14

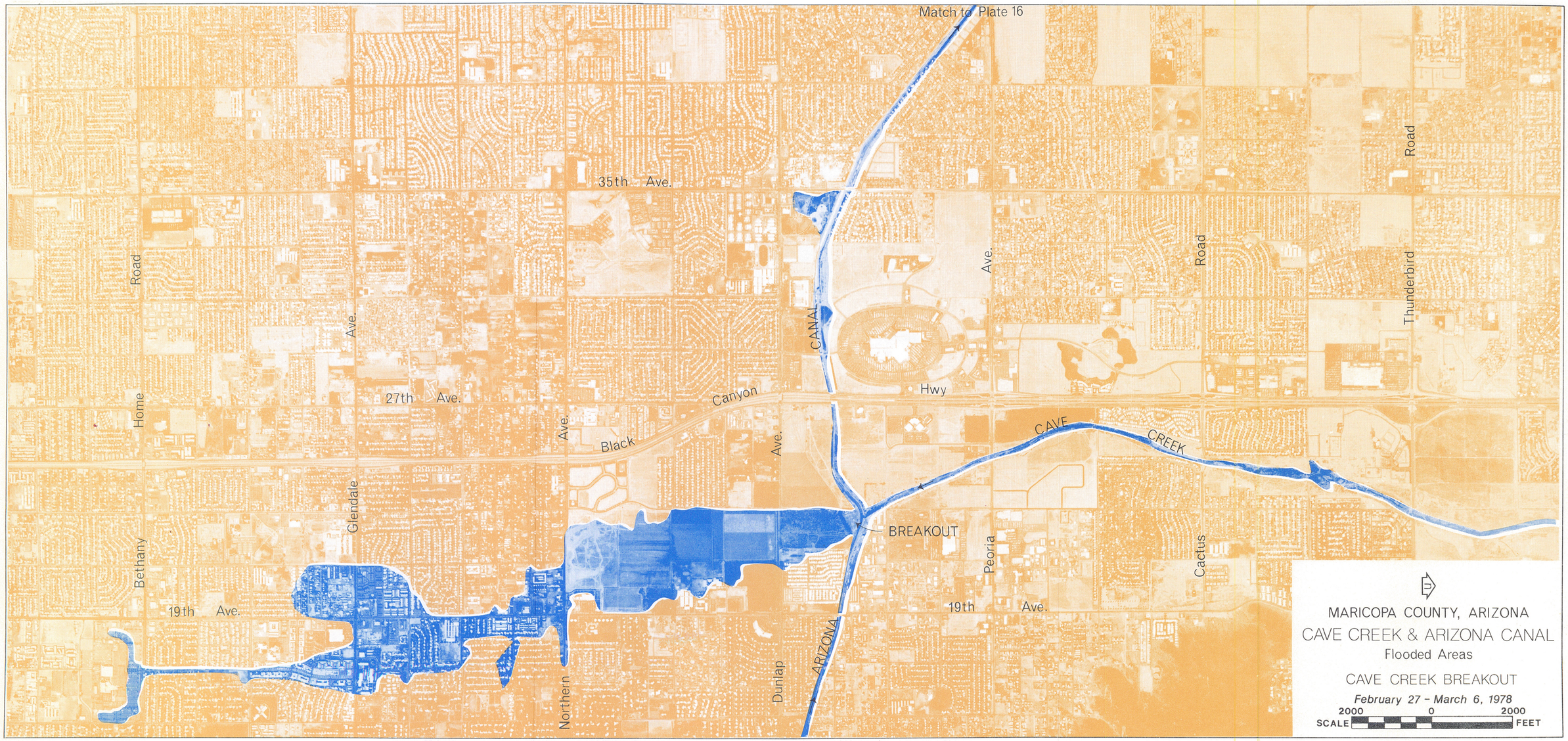
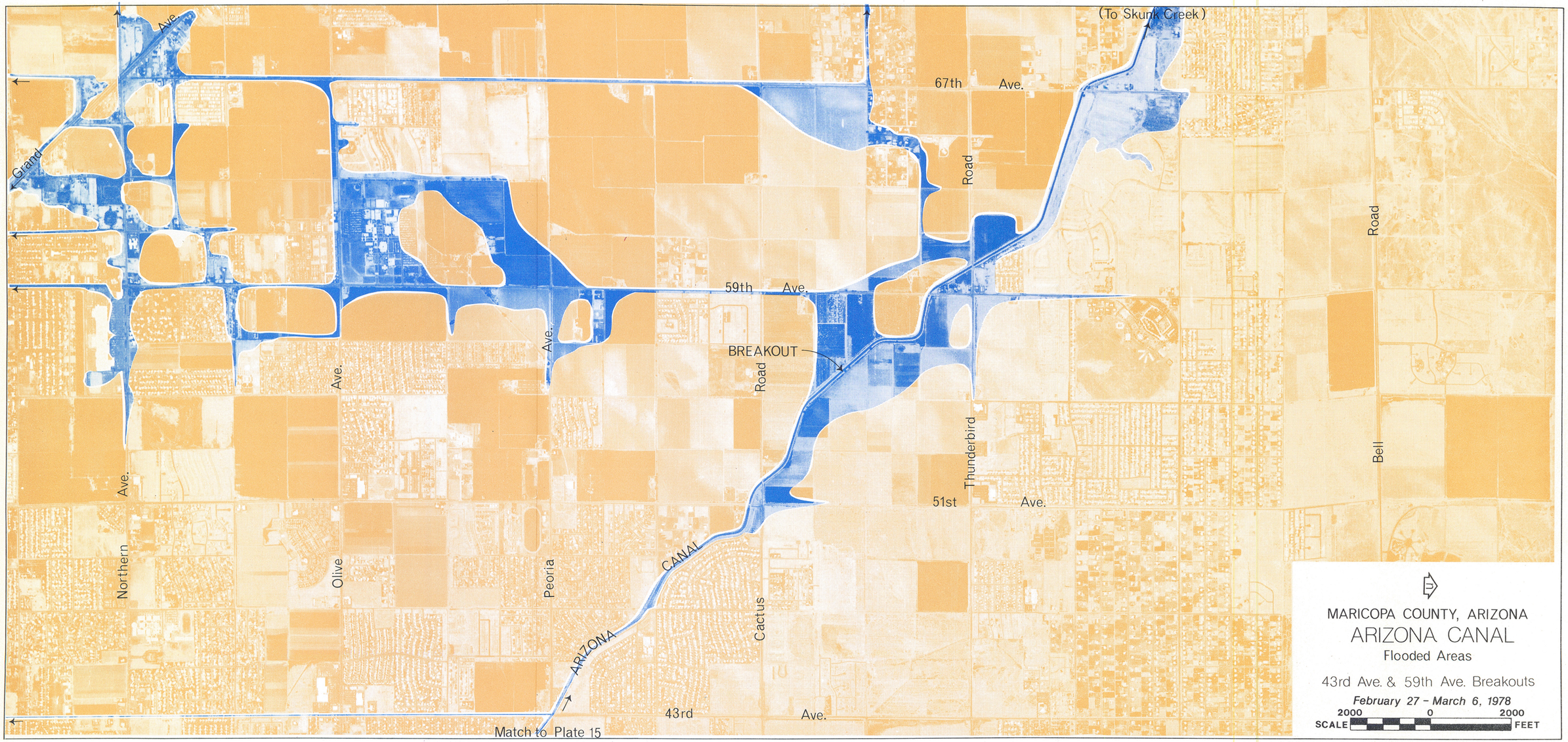

Match to Plate 16
35th Ave.
Road
Ave.
27th Ave.
Home
Canyon
Black
Ave.
Ave.
CANAL
Ave.
Road
Thunderbird
Road
Hwy
CAVE
CREEK
BREAKOUT
Glendale
Bethany
19th Ave.
Northern
Dunlap
ARIZONA
Peoria
19th Ave.
Cactus
MARICOPA COUNTY, ARIZONA
CAVE CREEK & ARIZONA CANAL
Flooded Areas
CAVE CREEK BREAKOUT
February 27 - March 6, 1978
2000 0 2000
SCALE FEET

PLATE 15



MARICOPA COUNTY, ARIZONA

ARIZONA CANAL

Flooded Areas

43rd Ave. & 59th Ave. Breakouts

February 27 – March 6, 1978

SCALE 2000 0 2000 FEET

PLATE 16

Appendix

Arizona Flooding, February-March 1978

The National Weather Service published ARIZONA FLOODING, FEBRUARY-MARCH 1978 as a timely document to assist all parties interested in the disaster. The Corps appreciates the cooperation extended by the NWS in providing its report and allowing the following updates and minor revision.

	Page	Location on Page and Nature of Revision
1.	1	Item 11: Asterisk added after the date: "March 20, 1978*"
2.	1	Bottom of page: Asterisk and footnote added: "*Figures have subsequently been revised upward"
3.	2	Paragraph 4, line 17, end of line: the words "storm over" are changed to "storm track over"
4.	13	Paragraph 1, line 3: The name "Cove Creek" -- a typographical error in the original
5.	13	Paragraph 3, line 1: The name "Roosevelt Lake" changed to the words "the lakes"
6.	18	Top of page: Symbol added after "Attachment 2"
7.	18	Near top of page, on line of "Horseshoe Lake" (439,238 AF)* changed to (139,238 AF)* -- a typographical error in the original and not a revision of data
8.	18	Bottom of page: Symbol and footnote added: "A NUMBER OF THE VALUES LISTED IN ATTACHMENT 2 HAVE SUBSEQUENTLY BEEN REVISED."
9.	23	Top of page (as one reads): Symbol added after "TANGLE CREEK"
10.	23	Second line: "Courtesy of Salt River Project" changed to "Courtesy of U.S. Geological Survey"
11.	23	Bottom of page: Symbol and footnote added: "NOTE: HYDROGRAPH HAS SUBSEQUENTLY BEEN REVISED."
12.	23	Bottom of page: Asterisk and second footnote added: "*Subsequently revised to 94,000 cfs"

ARIZONA TECHNICAL MEMORANDUM AZ8

ARIZONA FLOODING
FEBRUARY - MARCH
1978

PHOENIX, ARIZONA
JULY 1978

ARIZONA FLOODING, FEBRUARY-MARCH 1978

Weather Service Forecast Office Staff
Phoenix, Arizona

I. SUMMARY

On Saturday, March 4, 1978, and on subsequent days as damage assessments were made, President Jimmy Carter, at the request of Arizona's Governor, declared nine counties of Arizona as disaster areas. During the period from February 27 through March 3, heavy rain fell over most of the state. Heavy rains fell on and below the Mogollon Rim with lesser amounts over the White Mountains. Although some snow melt occurred between 6500 and 7200 feet, most of the runoff resulted from rain below the 6500 ft. level.

Extensive flooding occurred in the Salt and Verde River drainages which supply water for Maricopa County including the Greater Phoenix area. Flooding also occurred in the city of Winslow from runoff into Clear and Chevelon Creeks, while minor overflows occurred in the Safford Valley from the Gila River.

Rains over the Northeast Plateau area made dirt roads in the Navajo and Hopi reservations impassable, effectively isolating many people.

II. DAMAGE ASSESSMENT

Source: Federal Disaster Assistance Administration as of March 20, 1978*- Francis Tobin

Apache County	unknown
Gila County	$ 2,720,000
Graham County	449,000
Greenlee County	89,000
Maricopa County	11,362,000
Mohave County	1,500,000
Navajo County	250,000
Pima County	500,000
Yavapai	1,600,000
	$18,470,000

Deaths: 1 in Maricopa County.

Note: Although Apache County was designated a disaster area, the apparent damage was mainly impassable roads.

*Figures have subsequently been revised upward.

III. METEOROLOGY

An unusually wet winter was climaxed by an extremely heavy rain episode between February 27 and March 3. Up to 12 inches of rain fell over the partially snow-covered central basins of Arizona during this period. Serious flooding throughout northern and central Arizona resulted in nine counties being declared disaster areas (Figures 1 and 2).

The most obvious meteorological questions are: "Why were the rains and runoff so heavy?" and "What is the likelihood or probability of a similar event occurring in the future?"

Several factors, some of which are closely related, contributed to the flood-producing heavy rains and snow melt. Three factors considered are: 1) the synoptic meteorology dealing with the movement and development of the storms, 2) the physics dealing with snow melt and moisture availability for precipitation, and 3) the influence of recent storm events.

In dealing with synoptic meteorology a little background is needed. Winter storms (or low-pressure systems) are steered across the Pacific and North America along the belt of the strongest westerly winds, often called the "jet stream" or "storm track". The storm track normally migrates from its summer position across Canada south to the middle of the United States in midwinter. The track is normally north of Arizona even in midwinter; consequently, most storms have only a minor effect on the state. Major storms occur in Ariozna when the storm track dips south of this normal position. This happens primarily in two ways. In the first case a low-pressure system cut off from the main storm track (cut-off low) forms in the Southwest or just off the coast of southern California. The storm track briefly buckles, and one individual low-pressure system plunges south, becoming isolated as the belt of westerly winds returns to its normal position. Such a system may persist for many days and cause prolonged rain and snow. A prime example is the great snow storm of December 1967. The flow of this type is characterized in Figure 3a. In the second case a split occurs in the storm track over the Pacific Ocean. One branch flows through western Canada and the other through the southwestern United States (Figure 3b). This brings a series of abnormally warm, wet, low-pressure systems into Arizona. Both of these flow types are infrequent with only a few days each winter characterized by these synoptic conditions. The winter of 1977-78, however, was quite unusual in that the flow depicted in Figure 3b was a relatively frequent occurrence.

The flow pattern of late February 1978 was characterized by the flow represented in Figure 3b. These storms, picking up warm, moist subtropical air, progressed eastward from the central Pacific into the Southwest. This subtropical air, often with a very high water content can be a very important factor in producing heavy rain during a winter storm.

On February 27, a very weak trough moved across Arizona bringing only a few showers. However, the trough was not followed by the usual ridge accompanied by drier air, but with essentially saturated air moving through the ridge.

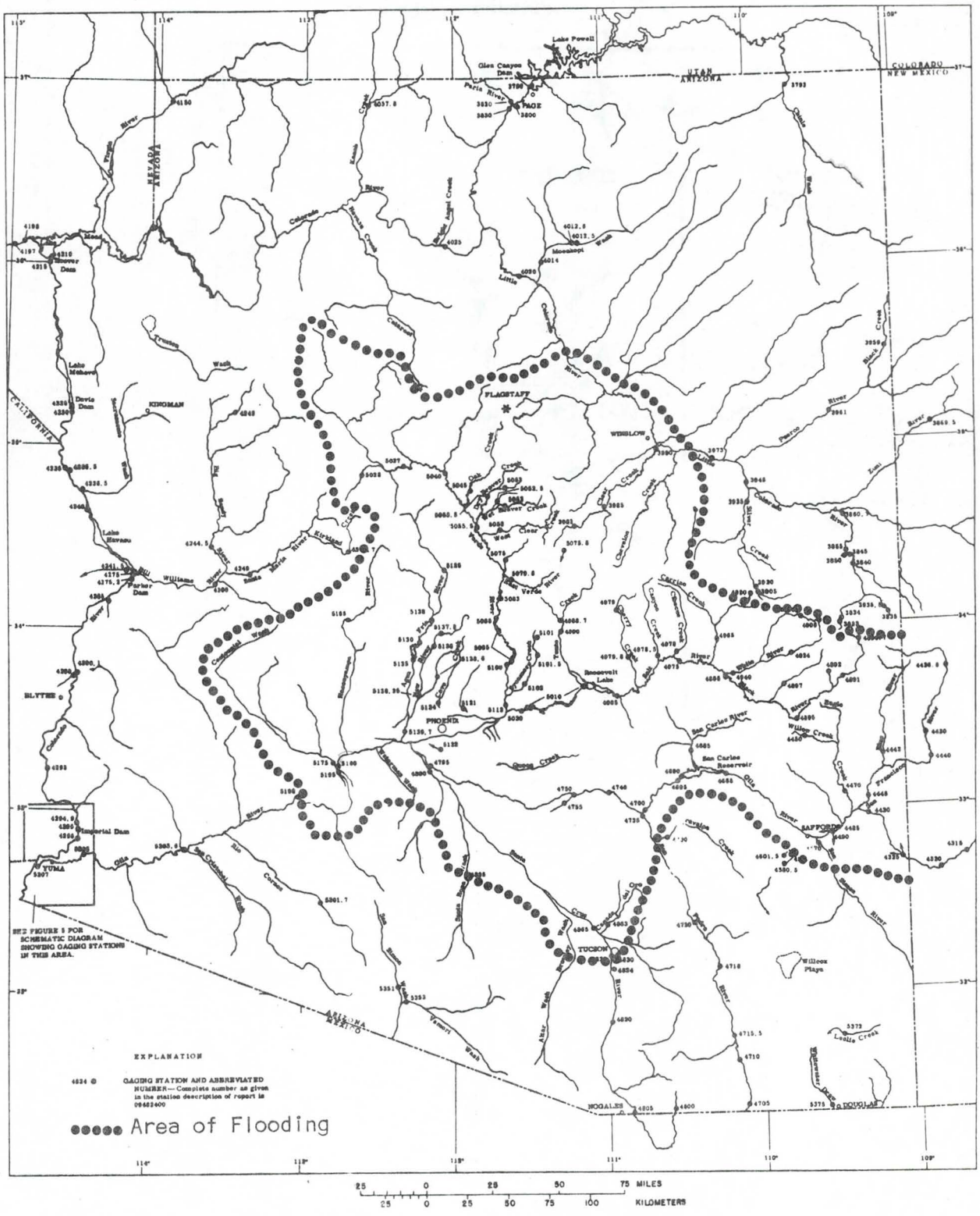
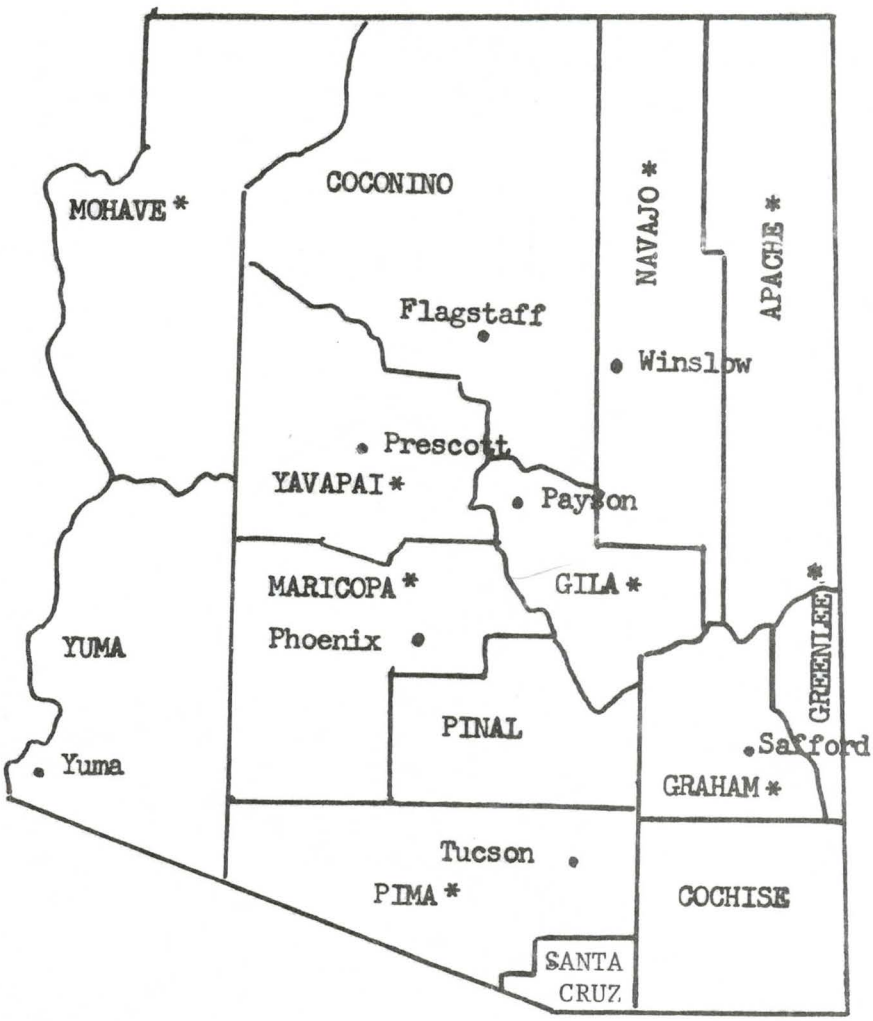


FIGURE 1.--MAP OF ARIZONA SHOWING LOCATION OF GAGING STATIONS



ARIZONA'S COUNTIES
* Disaster designated

FIGURE 2

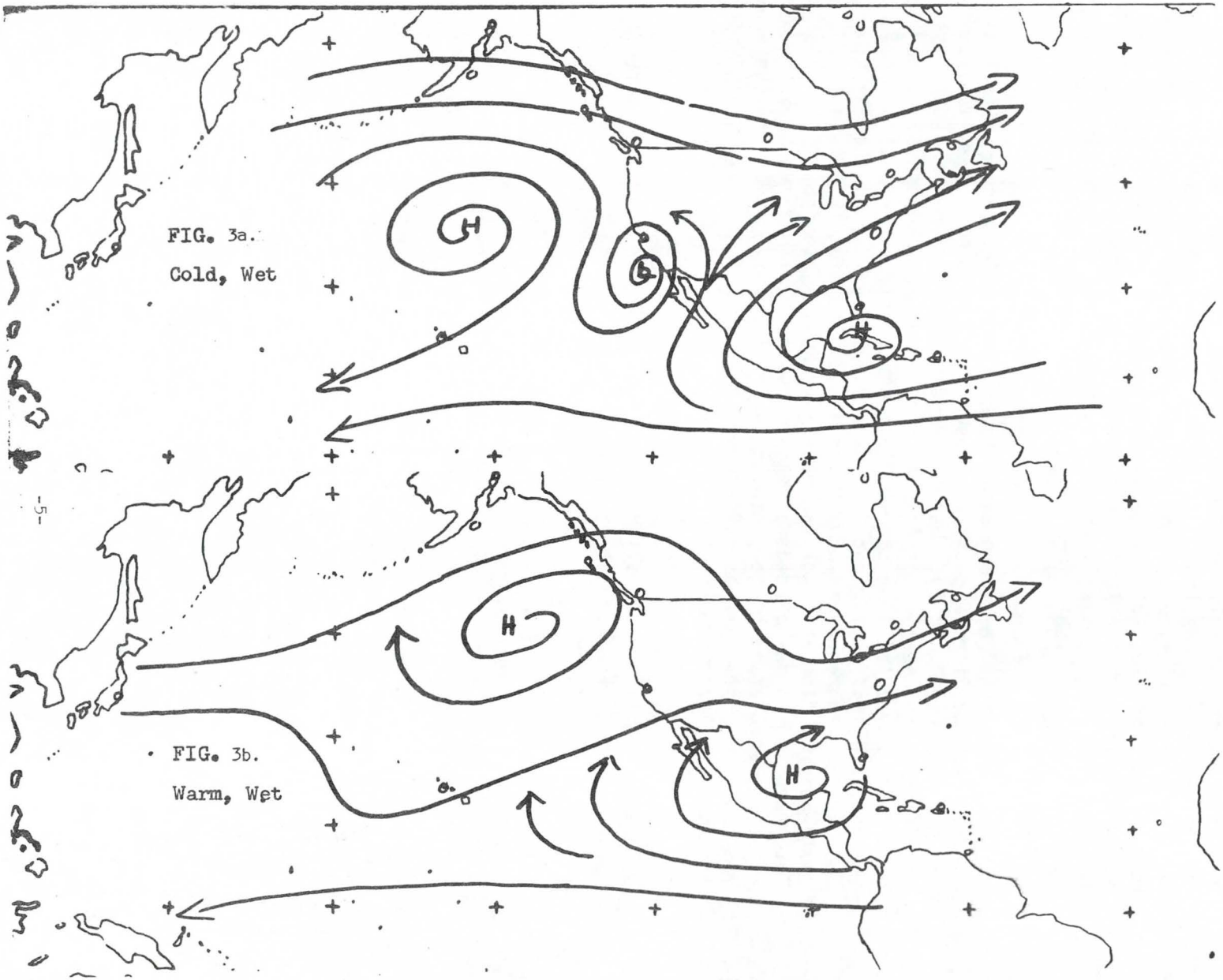


FIG. 3a.
Cold, Wet

FIG. 3b.
Warm, Wet

As a result of upward vertical motion over a wide area, causing the air to cool, the capacity of the air to hold water was reduced. Widespread heavy rains resulted. It is unusual, but storms can occur which result in precipitation outside of a low-pressure system. The rain on Monday, February 27, was a good example. Upward vertical motion was occurring throughout Arizona as a result of the physics associated with the advection (horizontal transport by the winds) of warm air. Consequently, even as a weak ridge moved into the state, moderately heavy rains began.

At the same time, a strong storm moved into the eastern Pacific near the southern California coast on Tuesday, and into Arizona on Wednesday, March 1 (Figures 4 and 5). Between Monday evening, when the moist air moved across the weak ridge into Arizona, and early Wednesday, when the main storm moved into the state, there was nearly continuous moderate to heavy rainfall. (Figures 6, 7, and 8.) Moreover, on Tuesday night, February 28, there was an area of relatively cold air aloft in the southwesterly flow ahead of the main storm moving in from California. This resulted in large areas of deep convection with very heavy showers. As these large areas of deep convective showers moved into Arizona from the southwest, the air was lifted over the central mountains resulting in greatly enhanced rainfall.

As the main storm center weakened and moved across Arizona on Wednesday, March 1, the terrain effect was obscured as the flow became more westerly. However, the deep convective showers continued almost without interruption.

There was a slight break late Wednesday night and Thursday morning, March 2, as the weak ridge that followed was drier. However, in this fast-moving sequence of weather disturbances, another weak trough pushed into the state Thursday afternoon and the heavy rains resumed.

Finally, on Thursday night, March 2, and Friday, March 3, a somewhat stronger and drier ridge moved into Arizona to bring relief from the rains for a couple of days.

With regard to the rainfall-producing mechanisms, the presence of the moist tropical air is very important for increased rain potential. Another important item is the effect of warm saturated air on snow. There was a significant decrease in the snow pack during the course of these storms, which served to enhance and prolong the runoff. During the storm, the snow pack on the Verde watershed decreased by 40% and on the Salt watershed by about 28%.

Finally, another contributing factor to the severity of the flooding was the antecedent conditions. The winter season, from late December to late February, had been characterized by several storm periods with heavy rains. Though the earlier storms were lacking in significant tropical moisture and were not quite as heavy, they did serve, in some cases, to saturate the ground and lessen its ability to absorb subsequent rains.

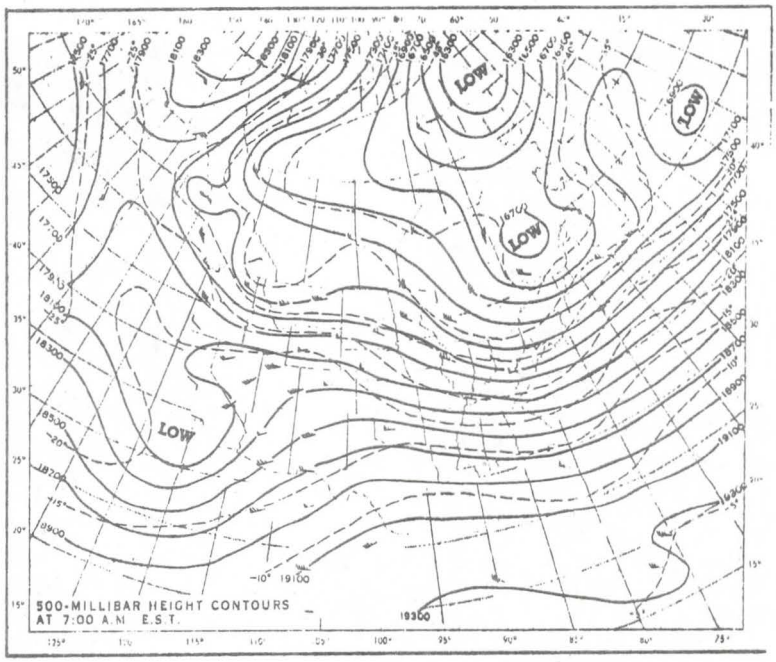


FIGURE 4

WEDNESDAY, MARCH 1, 1978

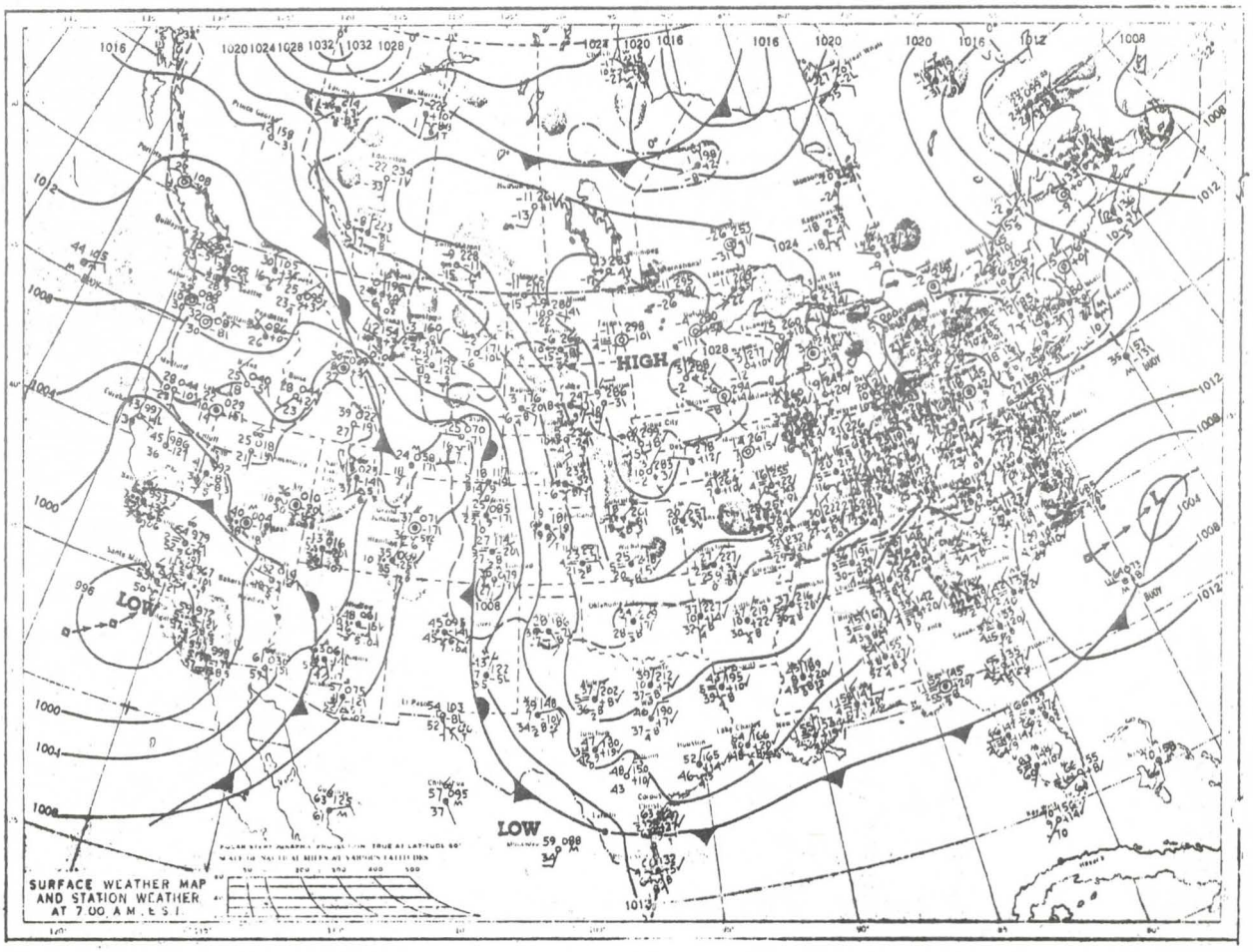
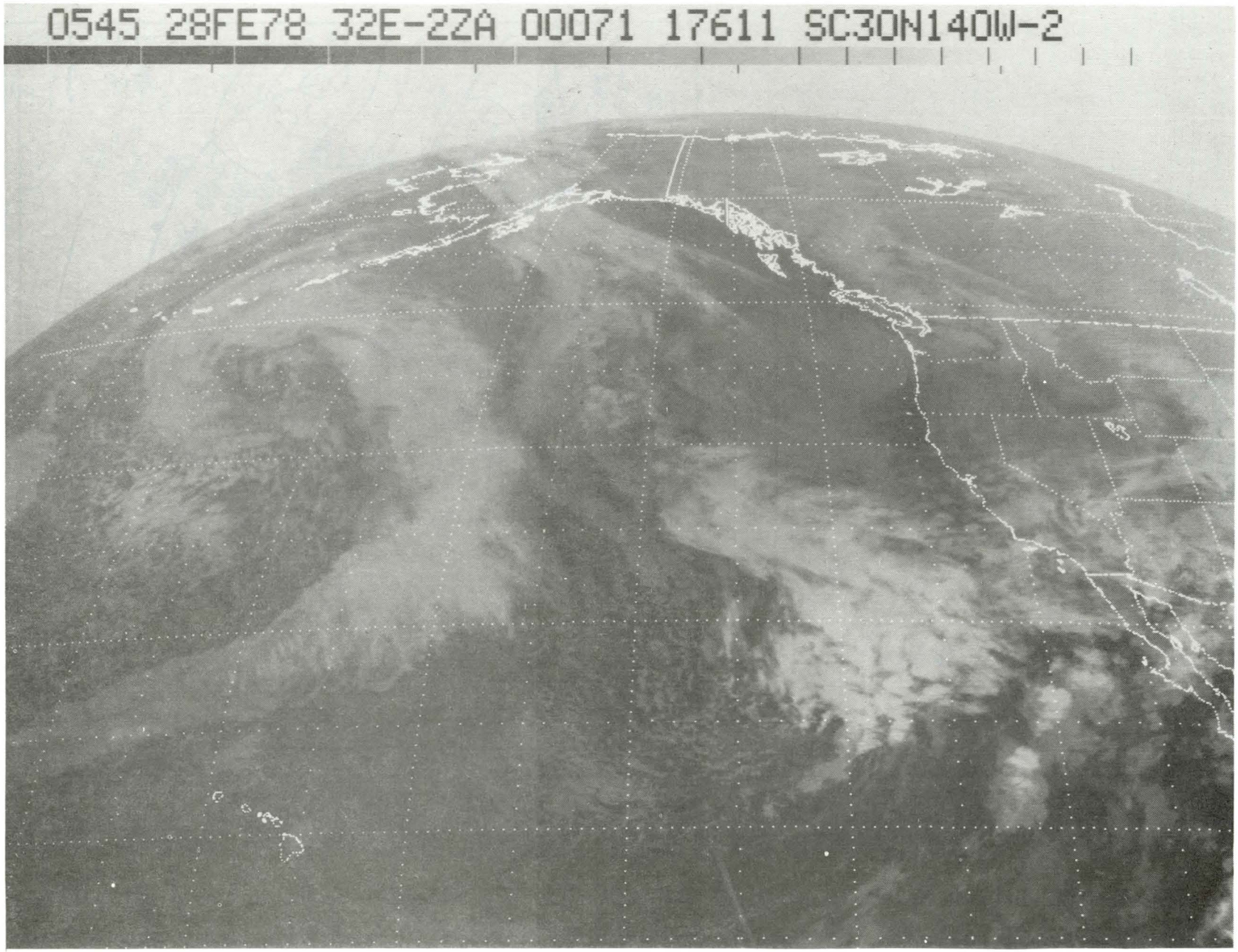
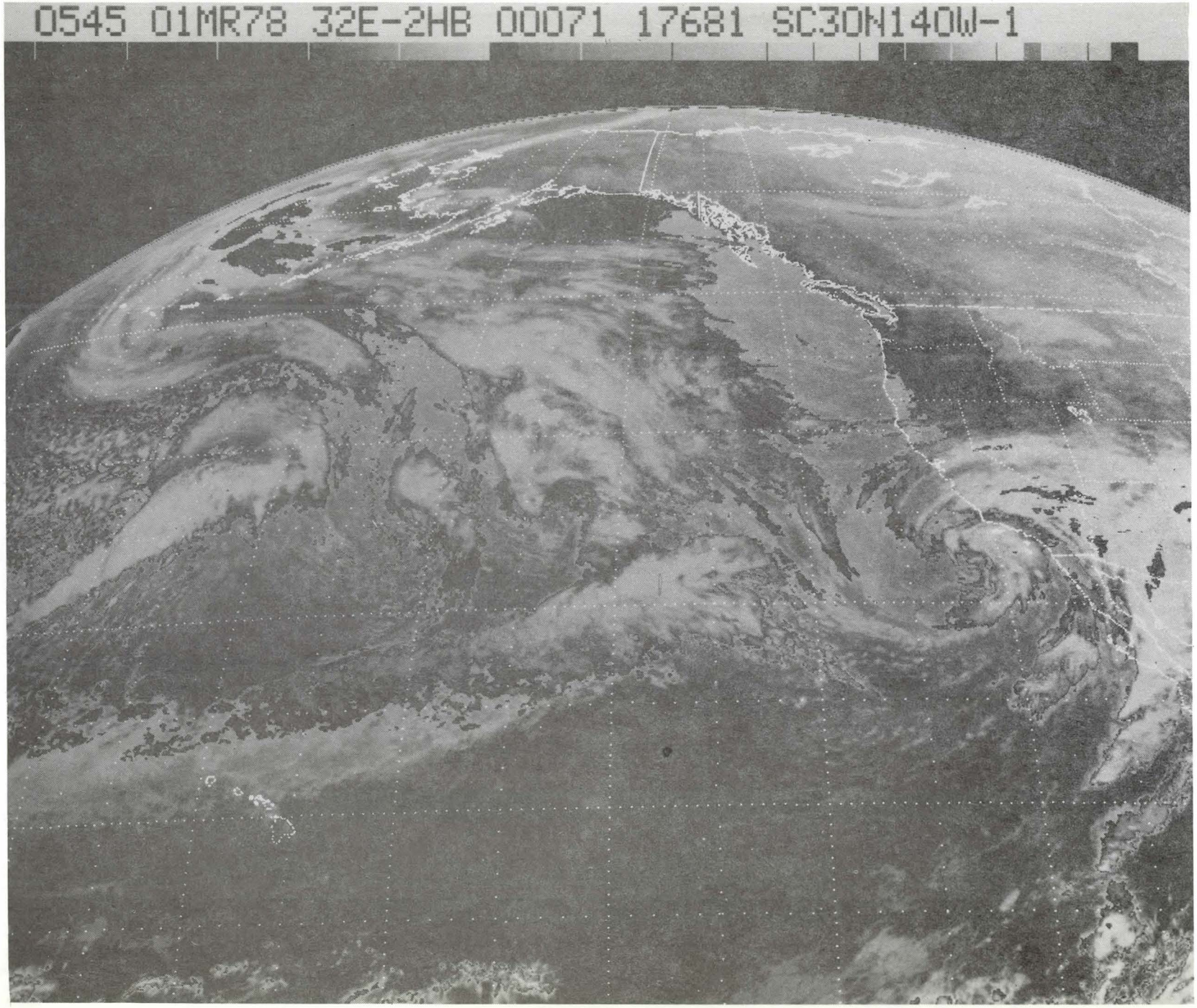


FIGURE 5


0545 28FE78 32E-2ZA 00071 17611 SC30N140W-2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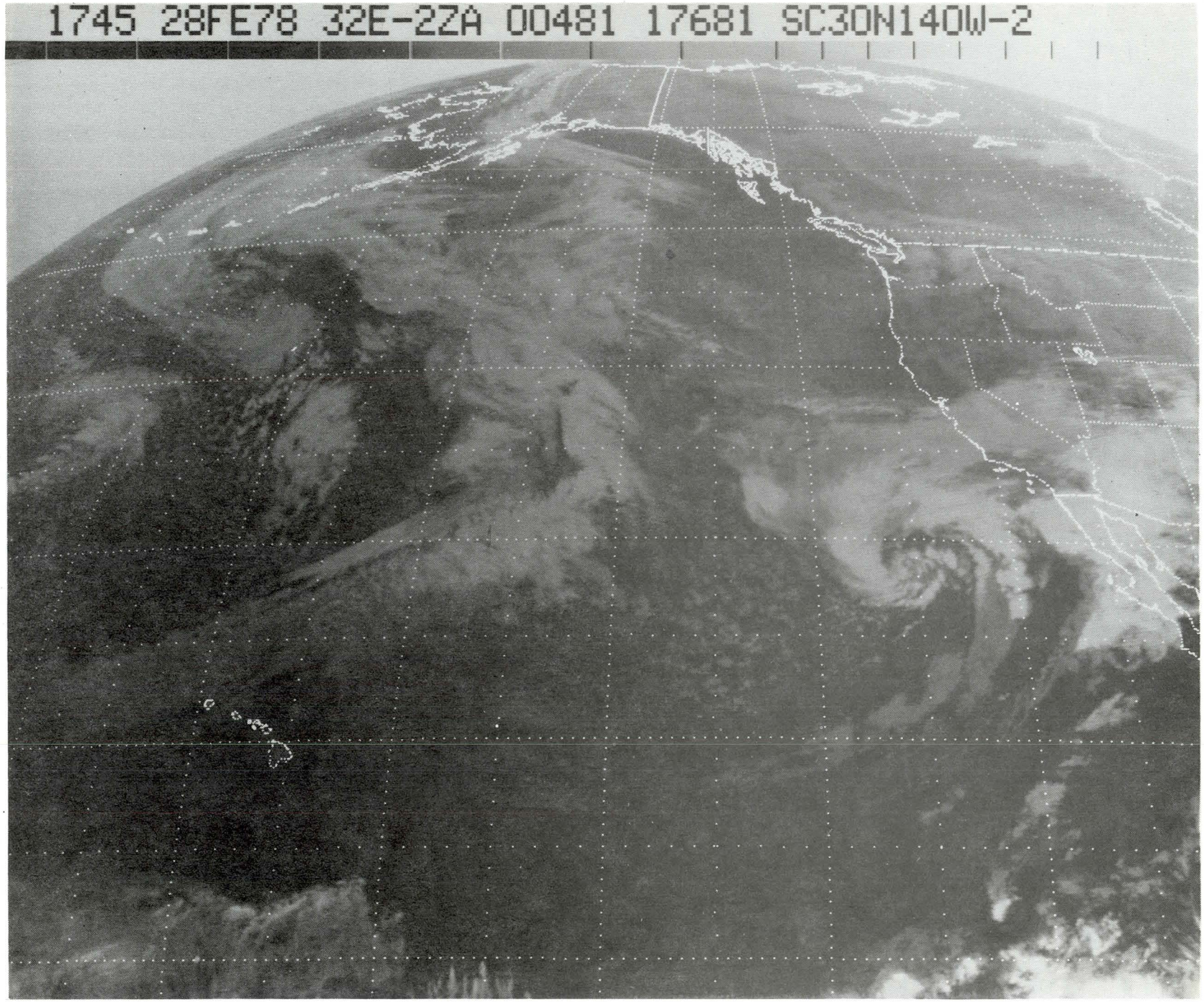

1745 28FE78 32E-2ZA 00481 17681 SC30N140W-2

The three greatest flood episodes on the Salt River system since the beginning of climatological records in Arizona were in 1905, 1941, and 1978. All were similar in that they were a combination of heavy rain and snow melt. They were also the three wettest winters on record at Phoenix at least. Fortunately, the probability of floods of this magnitude is small, with similar events having a return period of approximately 35 years. This doesn't mean there won't be similar storm events and flooding again next year or the following year, but the probability is very small.

In summary, there are several factors necessary to produce floods of the magnitude that occurred this year. These factors are: (1) the low probability of an anomalous storm track across the central and eastern Pacific at low latitudes, (2) the low probability that a sequence of troughs would not be separated by dry ridges, and (3) high soil moisture conditions from previous storm events.

IV. HYDROLOGY

The major flooding in Arizona occurred in the Verde River Basin with a drainage area of about 6600 square miles and in the Salt River Basin with a drainage area of 6232 square miles. Runoff from these river basins was partially contained in the following reservoirs:

VERDE RIVER	- Horseshoe Lake	
	Capacity:	139,238 Acre Ft. (AF)
	02/28/78:	67,924 AF
	Percent Capacity:	49
	Bartlett Lake	
	Capacity:	178,477 AF
	02/28/78:	78,244 AF
	Percent Capacity:	44
SALT RIVER	- Roosevelt Lake	
	Capacity:	1,381,580 AF
	02/28/78:	289,110 AF
	Percent Capacity:	21
	Apache Lake	
	Capacity:	245,138 AF
	02/28/78:	234,482 AF
	Percent Capacity:	96
	Canyon Lake	
	Capacity:	57,852 AF
	02/28/78:	54,609 AF
	Percent Capacity:	94
	Saguaro Lake	
	Capacity:	69,765 AF
	02/28/78:	67,264 AF
	Percent Capacity:	96

For subsequent inflows and discharges for these reservoirs operated by the Salt River Project, see Attachment 2.

I. Verde, Salt and Hassayampa Rivers

February 28: Tonto Creek above Gun Creek first began to rise significantly about 4 a.m., reaching a peak flow of about 16,800 cubic feet per second (CFS) at 11 a.m.

The automatic rain gage at Junipine on Oak Creek recorded over 1.50 inches during the night with snow-melt runoff occurring from the headwaters of Oak Creek. A small dam under repair near Mundt's Park on a tributary to Oak Creek was of concern to the Arizona Dam Commission, but fortunately the dam was not breached.

March 1: By early morning, water was reported over the bridge at Indian Gardens on Oak Creek and some mobile homes at Sycamore Cove below Sedona were isolated. During the night 28 people had to be evacuated. In the Tonto and East Verde basins flooding isolated additional people. Three feet of water was flowing in the normally dry Hassayampa River at Wickenburg, although no flooding was reported.

In the upper Verde near Prescott, there was concern over the safety of seven small dams with a capacity of 25 acre-feet. Flows from Butte, Miller, Aspen, Manzanita, and Granite Creeks resulted in local flooding. Williamson Valley Wash near Paulden had a record crest of approximately 6000 CFS at noon on the 1st. The previous record at this short period (1965) gaging station was 3910 CFS on February 9, 1976. Flow from Sycamore Creek and the Upper Verde resulted in evacuations at Bridgeport.

The Verde near Paulden crested at 8000 CFS on March 1 at 2 p.m. Downstream, Wet Beaver Creek near Rim Rock crested at 9 a.m. on the 1st at 4500 CFS, while West Clear Creek crested at 1 p.m. on the 1st at 13,500 CFS. Wet Beaver Creek and West Clear Creek are tributaries to the Verde.

In the East Verde River basin, Pine Creek was over the bridge at Pine by midafternoon on March 1. Floodwaters in Tonto Creek destroyed several small trailers and isolated the town of Punkin Center.

Listed below are flows for the lower Verde River and Tonto Creek:

	DISCHARGE	TENDENCY	CREST
At 1 p.m.: (March 1st):			
Tonto Creek above Gun Creek	33,000 CFS	Falling	--
Verde River below Camp Verde	32,000 CFS	Rising	--
Verde Rim at East Verde	60,400 CFS	Falling	67,600 CFS (11 a.m.)
Verde below Tangle Creek	76,400 CFS	Rising	82,400 CFS* (11 p.m.)

*Subsequently revised to 94,000 CFS

As a result of significant inflow to Bartlett Dam on the Verde River, the Salt River Project began releasing 30,000 CFS on March 1. At the flood control dam on Cave Creek north of Phoenix, the water was at the 28 ft. level (top of dam 40 ft.) at 12:45 p.m. Since February 28th, Lake Pleasant on the Agua Fria rose 6 feet.

By early morning on March 2nd, most of the rivers and creeks had crested. Listed in Attachment 2 are crest flows at several stream gaging stations.

By 5:45 a.m., the outflow from the lakes on the Salt River had passed 27th Avenue in Phoenix. Discharge information for Bartlett Dam and Stewart Mountain Dam is listed in Attachment 2.

At 11 a.m., the Salt River at Tempe was discharging a combined flow of the Salt and Verde at 115,000 CFS. Tempe is below the confluence of the Salt and Verde Rivers.

March 3 - Inflow into the flood control dam on Cave Creek brought the lake level to within 10 inches of the top of the dam. Releases from the dam of 1500 CFS caused considerable flooding in the western sections of metropolitan Phoenix.

Flow from the New and Agua Fria Rivers combined with the floodwaters in the Salt River to cause extensive flooding downstream from Phoenix to Painted Rock Dam. From March 4th through March 13th, the storage in Painted Rock Reservoir increased from 53,850 AF to 384,870 AF. Attachment 2 contains the Granite Reef discharge data.

2. Little Colorado River

On the morning of March 1, flooding began in the Bushman Acres section of Winslow at about 3:45 a.m. The flooding resulted from a break in the dike system protecting the area from the Little Colorado River. Early that morning, the Woodruff gaging station on the upper reaches of the Little Colorado reported only 1034 CFS while Chambers on the Rio Puerco had negligible flow. The principal inflow to the Little Colorado was from Clear and Chevelon Creeks.

At noon on March 1st East Clear Creek below Willow Creek crested at 10,600 CFS. By early afternoon flooding was reported along Chevelon Creek, while Clear Creek was receding.

On March 2nd, flooding was still occurring in both Bushman Acres and Ames Acres in Winslow. The Little Colorado at Woodruff rose 5 feet, adding about 3000 CFS to the downstream flow. Flooding continued to be a problem in Winslow until about 6 p.m. on March 2nd.

3. Gila River below Coolidge Dam

Snow melt and local inflow caused the Gila at Kelvin to crest at about 2300 CFS on March 1st and again on March 3rd at about midnight with a flow of 6600 CFS.

4. Gila River above Coolidge Dam

On the Gila River in eastern Arizona and western New Mexico, heavy rains, and rain on snow caused significant rises in both the Gila and its major tributary, the San Francisco.

By midmorning on March 2nd, some minor overbank flooding was reported at Duncan, Arizona, on the Gila.

Eagle Creek probably contributed a significant amount of local inflow. There was some minor flooding of the Little Hollywood section of Safford at this time.

During the night of March 2nd, the flow from the San Francisco remained over 8000 CFS. By the morning of March 3rd, minor flooding was reported at Red Rock, New Mexico, and overbank flooding was continuing at Duncan, Arizona. The Gila River began rising again in the Safford Valley about 11 a.m., MST on March 3rd from the headwater contribution. In addition to the Little Hollywood area of Safford, about 1000-2000 acres of farmland were inundated by the Gila River in the Safford Valley during this flood episode.

During the period from March 1 through March 10, inflow to San Carlos Reservoir was 161,900 AF. See Attachment 2 for Gila River and tributaries' discharge data.

5. Santa Cruz River

No major flooding occurred on this river. However, Rillito Creek, the Santa Cruz River north of Tucson, and both the Pantano and Tanque Verde Washes were near bankful during the period March 1-3. Because of high water, there was considerable bank erosion on both the Tanque Verde Wash and the Rillito Creek.

From February 27 - March 3, precipitation at Tucson International Airport totaled 0.51 inch. However, 1 to 2 inches fell north and east of downtown Tucson, while 9.53 inches was recorded at the Palisades Ranger Station at 8000 feet on Mt. Lemmon. On March 1, the snow depth decreased nearly a foot at Palisades where near- to above-freezing temperatures were reported from February 28 - March 2 and 7.69 inches of rain fell during a 48-hour period. During the period considerable snow also melted below the 8000 ft. level contributing to the runoff. See Attachment 2 for discharge data.

ACKNOWLEDGMENTS

Preparation of this report could not have been accomplished without the whole-hearted cooperation of the National Weather Service Offices in Flagstaff, Tucson, and Winslow; the U.S. Geological Survey Offices in Flagstaff, Phoenix, Safford, and Tucson; the Salt River Project; and the Arizona State Division of Emergency Services. Special acknowledgment should be given to Messrs. C. D. Jensen, D. L. Bjorem, and W. F. Johnson of the Phoenix Weather Service Forecast Office whose contributions were especially valuable.

Attachment 1

PROVISIONAL RAINFALL DATA

Salt-Verde Basins

	Feb		March					
	27	28	1	2	3	4	5	6
Apache Jct (5p)	T	.05	.06	.49	--	--	.05	.31
Ash Fork 5N (8a)	--	.78	1.52	.41	.35	.03	.57	.07
Bar-T-Bar (8a)	.70	1.10	2.05	2.95	--	--	.88	--
Beardsley (PM)	.03	.77	.28	1.87	.06	--	.15	.05
Beaver Creek RS (5p)	.06	.37	1.03	.10	.29	--	--	.64
Bumble Bee (4p)	.10	.72	--	2.43	--	--	.31	1.10
Carefree (5p)	T	1.45	1.73	2.42	1.18	.39	--	.40
Childs	--	1.35	2.20	.76	.70	--	.36	.95
Chino Valley (8a)	--	1.22	.65	1.13	.17	T	.51	.15
Congress (6p)	.13	.45	1.53	.43	1.10	.07	.08	.30
Cordes (6p)	T	.37	1.21	.68	.41	--	.21	.12
Crown King RS (1p)	.23	1.50	4.87	3.38	2.03	1.43	--	.37
Deer Valley (1p)	.80	.72	2.23	.49	--	--	--	T
Flagstaff (5a)	--	.43	1.48	.99	1.02	--	.65	.52
Griggs (8a)	--	--	2.67	.14	--	--	.50	--
Happy Jack RS (1p)	--	1.30	1.41	1.16	1.17	--	--	1.60
Hawley Lake (8a)	.02	1.49	2.32	5.81	1.41	--	.02	.52
Horse Mesa Dam (8a)	--	.80	.70	2.16	.47	--	.06	.26
Horseshoe Dam (8a)	--	1.95	1.35	4.12	.50	--	.06	.25
Irving (10a)	--	.48	1.73	.76	1.04	--	.55	.72
Jerome (9a)	.19	.89	1.10	.55	--	--	1.05	.09
Junipine (5p)	.56	2.51	2.74	2.15	1.20	--	1.90	1.70
Litchfield Park (5p)	1.34	--	.35	1.81	--	--	.26	.01
McNary (8a)	--	1.17	1.85	2.05	.80	.04	.06	.31

Attachment 1 (continued)

	Feb			March				
	27	28	1	2	3	4	5	6
Mesa Exp Sta (8a)	--	.25	1.10	.25	.03	.37	--	
Montezuma Castle (5p)	T	.39	.56	.04	.04	T	.35	
Mormon Flat Dam (8a)	--	.58	.64	1.78	.54	--	.04	.33
Phoenix NWS (5a)	--		.39	.66	.05	--	T	.44
Phoenix City (5p)	T	.71	.38	.82	.01	--	.36	--
Phoenix So. Mtn.	T	.71	.90	.21	.04	--	.50	.10
Pinetop FH (5p)	--	1.16	1.49	1.25	.64	--	--	1.32
Pleasant Valley RS (5p)	T	1.22	1.37	2.10	.61	.63	.40	--
Prescott Airport (5a)	--	.41	.74	.81	.33	T	.25	.20
Prescott (8a)	--	.41	1.01	1.09	.50	T	.46	.28
Payson (8a)	--		1.91	1.75	1.99	--	.06	.62
Roosevelt Dam (8a)	--	.99	1.10	4.14	.62	--	.07	.40
Sedona RS (4p)	.17	1.39	1.13	.61	.39	--	.58	.32
Seligman (5p)	.80	--	1.27	.12	.20	.05	.35	.06
Seligman 13 (4p)	1.17	--	1.33	.30	.25	.26	.50	--
South Phoenix (5p)	.03	.60	.66	.27	.05	--	.53	--
Stewart Mtn Dam (8a)	--	.35	.95	2.00	.32	--	.08	.52
Tempe (8a)	--	.53	.56	.39	.04	--	T	.38
Tempe Citrus (8a)	.31	.57	.31	.10	--	.02	.28	--
Tolleson (4p)	.40	1.02	1.50	.02	.47	--	--	--
Tuzigoot NM (7p)	.04	.44	.03	.21	.19	.01	.10	.11
Walnut Creek (6p)	T	1.59	1.93	.29	.35	.05	.59	.14
White River (8a)	--	.81	.85	2.11	.82	--	.01	.50
Wickenburg (6p)	.38	1.69	1.90	.54	--	.34	--	.35
Youngtown (4p)	.01	1.28	.35	2.22	--	--	.28	--

Attachment 2††

SALT RIVER PROJECT DATA

	2/28/78	3/1/78	3/2/78	3/3/78	3/4/78	3/5/78
VERDE RIVER	0800M	1600M	1100M	1100M	1100M	1100M
Horseshoe Lake	(139,238 AF)*					
Storage	67,924	115,799	126,540	117,687	120,631	114,660
Bartlett Lake	(178,477 AF)*					
Storage	78,244	126,542	176,845	162,301	159,126	159,750
Inflow-CFS	1,680	72,400	65,400	67,400	16,700	7,630
Outflow-CFS	199	30,000	98,380	75,000	1,660#	10,000
SALT RIVER						
Roosevelt Lake	(1,381,580 AF)*					
Storage	289,110	397,897	592,563	797,505	887,786	919,333
Apache Lake	(245,138 AF)*					
Storage	234,482	241,172	243,947	239,466	234,510	234,897
Canyon Lake	(57,852 AF)*					
Storage	54,609	56,724	54,248	53,081	54,748	54,007
Saguaro Lake	(69,756 AF)*					
Storage	67,264	68,256	68,886	62,898	62,541	62,779
Inflow-CFS	1,976	91,840	118,700	69,720	20,907	12,402
Outflow-CFS	190	0	26,372	5,400	1,800	0
Tributary Inflow-CFS	--	3,920	6,000	--	--	--
Granite Reef Dam (Discharge)	191	6,800	80,000	100,000	25,000	12,000

Temp for dam inspection
* Capacity in Acre feet

††NOTE: A NUMBER OF THE VALUES LISTED IN ATTACHMENT 2 HAVE SUBSEQUENTLY BEEN REVISED.

Reservoir releases for Bartlett Dam on March 2, 1978.

Time	Discharge (CFS)
8 a.m.	60,000
11 a.m.	98,380
1 p.m.	65,000
4:30 p.m.	70,000
10 p.m.	75,000

Reservoir releases for Stewart Mountain Dam on March 2, 1978.

Time	Discharge (CFS)
8 a.m.	20,000
Late afternoon	10,000

Reservoir storage for Lake Pleasant (capacity 157,000 AF).

Date	Storage (AF)
February 27	Negligible
March 4	90,000
March 5	135,000

- Discharge during the rise 4800-6000 CFS.

March 2nd Flow Data.

	Crest Discharge	Time
New River at New River	45,000 CFS*	10 a.m.
Oak Creek near Cornville	15,000 CFS	9 a.m.
Tonto Creek above Gun Creek	40,000 CFS	8 a.m.
Verde River at Clarkdale	25,000 CFS	11 a.m.
Verde River at Camp Verde	45,000 CFS**	Noon
Salt River at Roosevelt	125,000 CFS	8 a.m.
Salt River at 48th Street, Pheonix	138,000 CFS	11 p.m.

* Previous record 19,500 CFS, September 5, 1970
** Previous record 43,000 CFS, September 5-6, 1970

March 3rd Flow Data.

	Crest Discharge	Time
Verde River below Tangle Creek	71,400 CFS	7 a.m.

Granite Reef Reservoir Data.

Date	Time	Inflow (CFS)	Discharge (CFS)
March 2-3	(Night)	100,000 Total 85,000 Verde 15,000 Salt	100,000
March 3	3 p.m.	55,400 Total 50,000 Verde 5,400 Salt	--
March 4	(Early Morning)	16,800 Total 15,000 Verde 1,800 Salt	55,000
March 5	--	--	12,000

Gila River and Tributaries Discharge Data.

	Date	Discharge
San Francisco River at Glenwood, NM	3/1	2000 CFS
Gila River at Red Rock, NM		Near B.F.
San Francisco River at Glenwood, NM	3/2	3200 CFS
San Francisco River at Clifton, AZ		9000 CFS (nr. F.S.)
Blue River above Clifton, AZ		Approx. 4000 CFS
Gila River near Safford, AZ		1st crest 21,600 CFS (7:30 p.m.)
Gila River near Safford, AZ	3/3	2nd crest 18,940 CFS (2:00 p.m.)

Santa Cruz River and Tributaries Discharge Data.

	Date	Crest
Rillito Creek at Tucson	3/2 (11 a.m.)	Approx. 6000 CFS
Tanque Verde at Tucson	3/2	Approx. 1000 CFS
Rincon Creek at Tucson	3/2	Approx. 2400 CFS

WARNINGS, WATCHES & STATEMENTS ISSUED

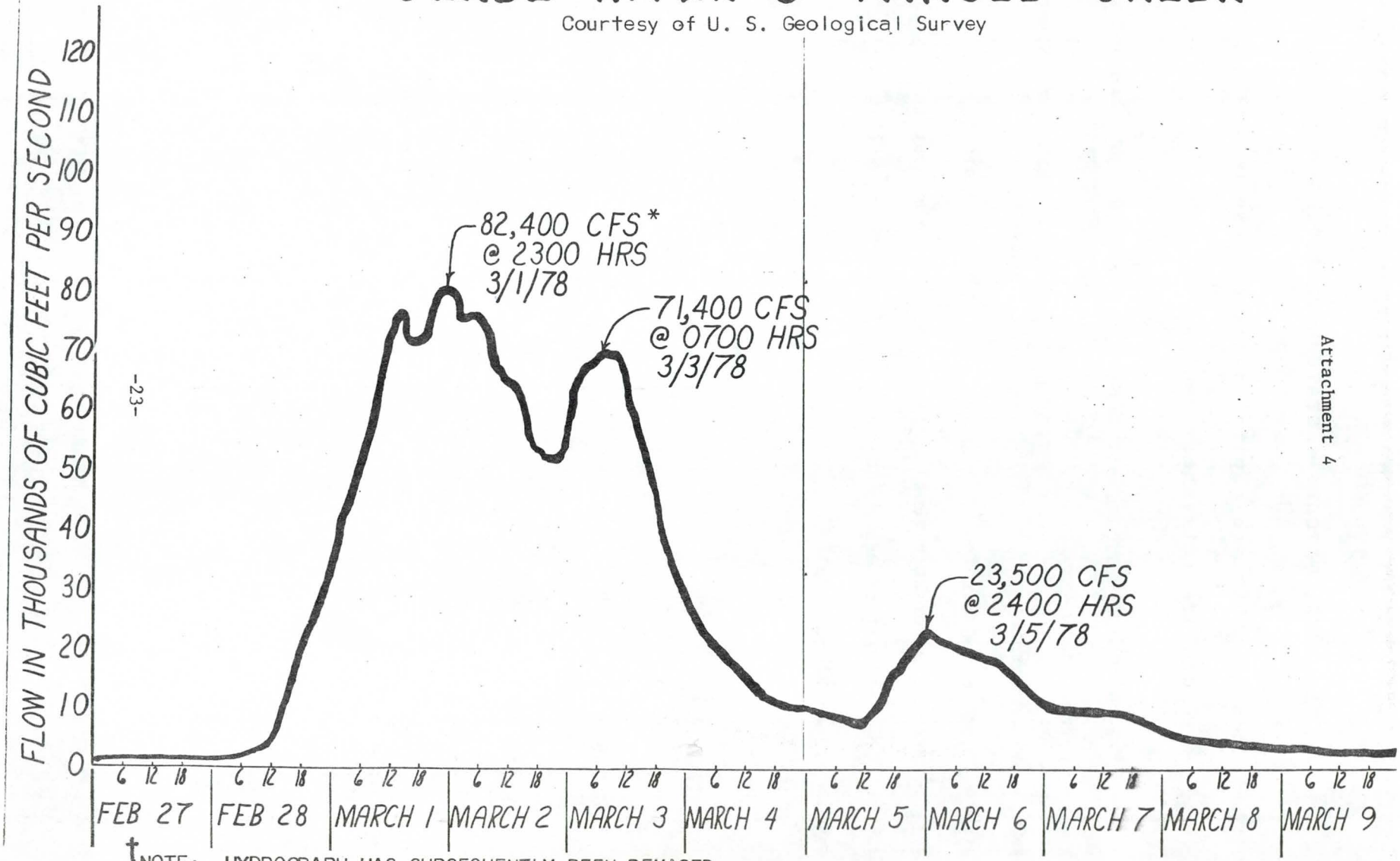
Date	Time MST	APACHE	COCHISE	COCONINO	GILA	GRAHAM	GREENLEE	MARICOPA	MOHAVE	NAVAJO	PIMA	PINAL	SANTA CRUZ	YAVAPAI	YUMA
28	0015	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS
	0530				SWS			SWS				SWS		SWS	
	0900		FFW					FFW			FFW	FFW	FFW		FFW
	1100		FFW	FFW	FFW	FFW	FFW	FFW			FFW	FFW	FFW		FFW
	1530	X	X	SWS	SWS	X	X	X		SWS	X	X	X	SWS	SWS
	1530	HS		HS	HS	HS				HS				HS	
	1715	HS		HS	HS	HS		FFW		HS				HS	
	2030	SWS		SWS	SWS	SWS		SWS		SWS				SWS	
1	0530	X		X	SWS	X		SWS		X				SWS	
	0700				FFW*										
	0720				SWRS										
	1130				SWRSX			SWRS						SWRS	
	1300										SWS				
	1500				SWRS			SWRS				SWRS		SWRS	
	1500										FFW*				
	1700										SWS				
	1800				SFFRS			SFFRS						SFFRS	

Attachment 3 (continued)

Date	Time MST	APACHE	COCHISE	COCONINO	GILA	GRAHAM	GREENLEE	MARICOPA	MOHAVE	NAVAJO	PIMA	PINAL	SANTA CRUZ	YAVAPAI	YUMA
1	2315				SWS			SWS				SWS		SWS	SWS
2	0000			SRS	SRS			SRS			SRS			SRS	
	0530	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS	SWRS
	0730									FW					
	1330									FS					
	1500			FFW	FFW			FFW						FFW	FFW
	1600					FW	FW								
	1830									FS					
	1900			FFW	FFW			X						FFW	X
	2030					FW	FW								
	2300			FFW	FFW									FFW	
3	0030					FW	FW			X					
	0530			*	*	FW	FW							*	
	1030					FS	FS								
	1100					SRS	SRS								
	1500					FS	FS								
	2300					FS	FS								

VERDE RIVER @ TANGLE CREEK†

Courtesy of U. S. Geological Survey



†NOTE: HYDROGRAPH HAS SUBSEQUENTLY BEEN REVISED.

*Subsequently revised to 94,000 CFS

Attachment 4

WARNINGS, WATCHES & STATEMENTS ISSUED

NOTE: Counties that are capitalized are those counties which were declared disaster areas.

*	=	Expiration	SFFRS	=	Special Flash Flood and River Statement
X	=	Cancellation	SWRS	=	Special Weather and River Statement
FW	=	Flood Warning			
FFW*	=	Flash Flood Warning	FS	=	Flood Statement
SRS	=	Special River Statement	HS	=	Heavy Snow Warning
SWS	=	Special Weather Statement			
FFW	=	Flash Flood Watch			