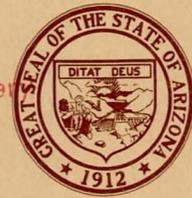


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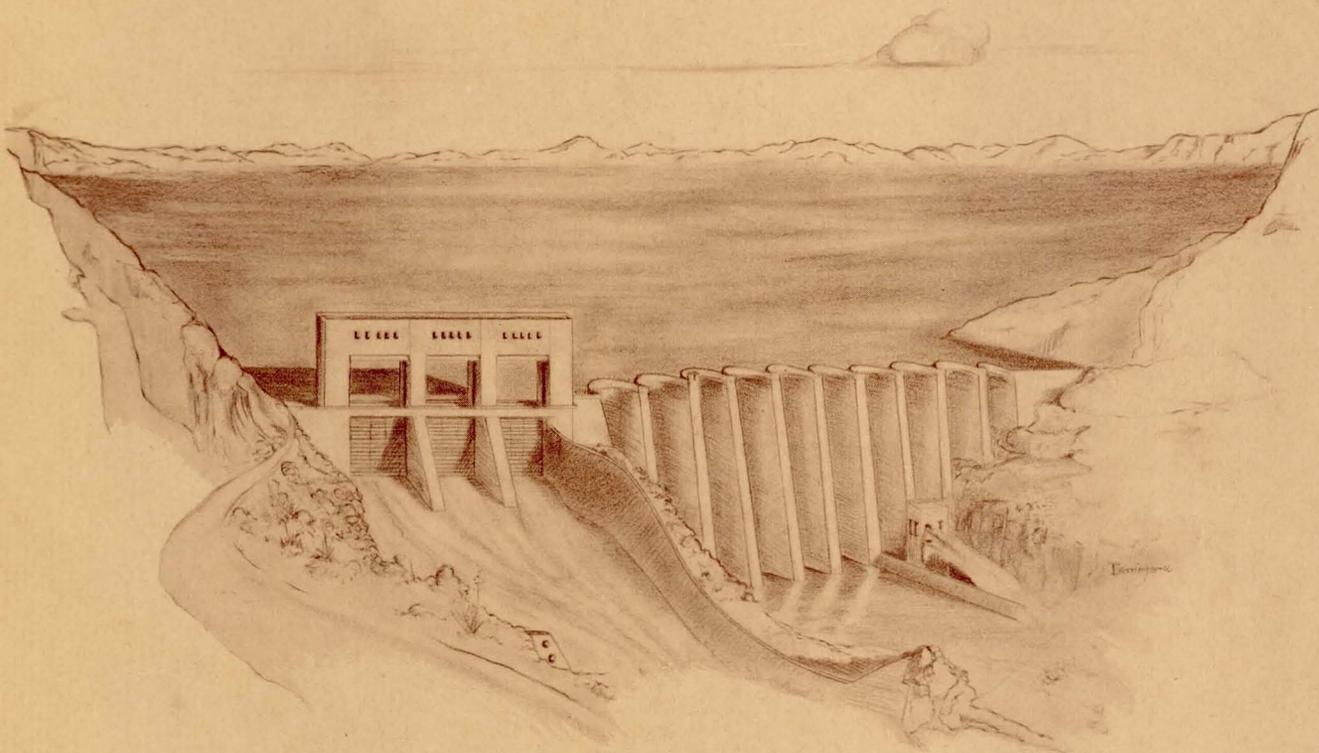
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INFILTRATION AND RECHARGE FROM THE FLOW OF APRIL 1965 IN THE SALT RIVER NEAR PHOENIX, ARIZONA

BY P. C. BRIGGS
AND L. L. WERHO



PREPARED BY THE GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR

PHOENIX, ARIZONA
NOVEMBER 1966

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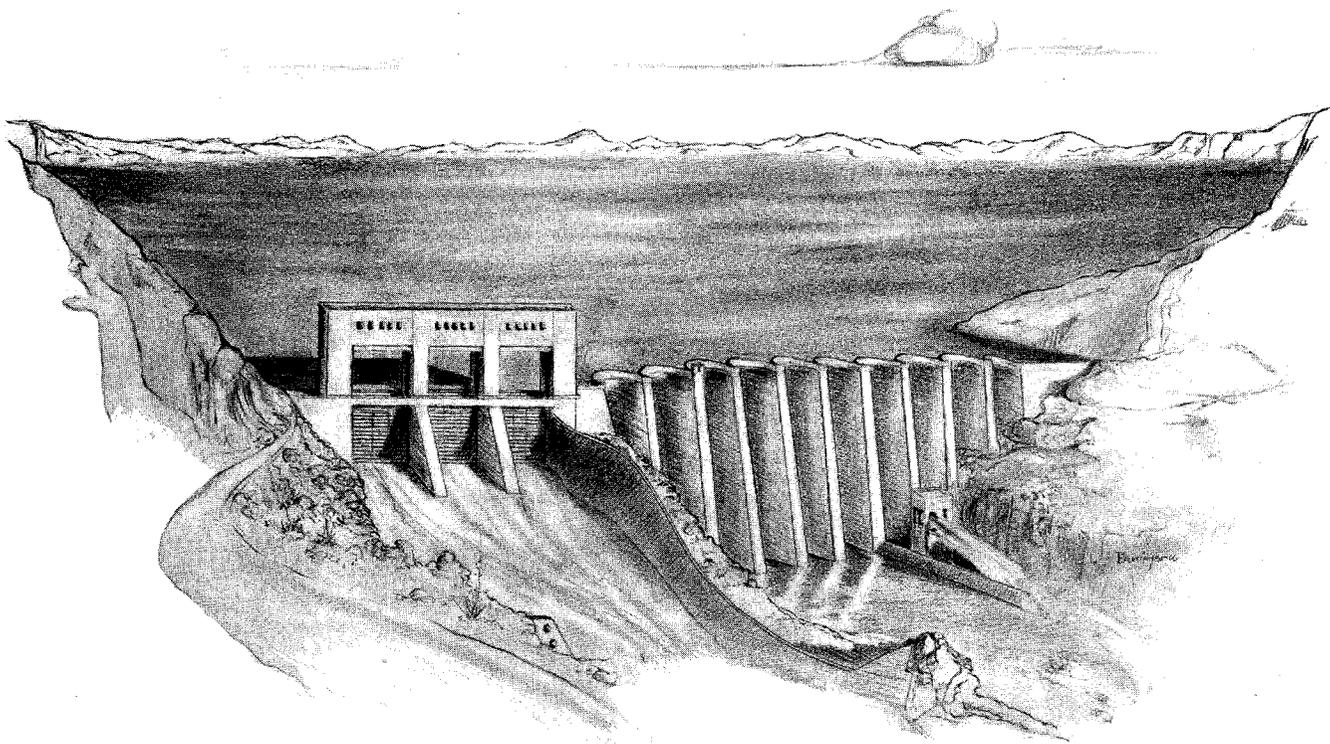
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By

P. C. Briggs and L. L. Werho

INTRODUCTION

An unusual flow event occurred in the Salt River below Granite Reef Dam on April 19-25, 1965—unusual in the sense that it was a relatively large flow of water in a stream channel that is normally dry. The flow was the result of a controlled release of water from Bartlett Reservoir upstream from Granite Reef Dam. When the release of water from Bartlett Reservoir was anticipated, sites were selected along the normally dry Salt River channel below Granite Reef Dam at which to measure streamflow and water-table fluctuations. The purpose of these measurements was to investigate the flow characteristics in the channel and infiltration and recharge to the ground water from the channel.

The Salt River flows westward from its headwaters in the White Mountains in eastern Arizona. Its major tributary is the Verde River. A series of dams provides storage on each river. Below the confluence of the Verde and Salt Rivers, Granite Reef Dam diverts water into two canals for agricultural, industrial, and municipal use in the Salt River Valley; the Salt River channel below Granite Reef Dam is dry most of the time.

In this study, the 25 miles of channel through the flat alluvial Salt River Valley between Granite Reef Dam and 7th Avenue in Phoenix was divided into three reaches. Each reach has different physical characteristics, which are representative of the present condition of the channel. In the 19-mile reach from Granite Reef Dam to 48th Street, the channel is poorly defined and meanders across a wide flood plain that has an average gradient of 9 feet per mile (fig. 1). In the lower 10 miles of this reach, from Oak Street to 48th Street, a few gravel pits have been dug into the natural channel. The 4-mile reach from 48th to 16th Street has been modified by man and has an average width of about 350 feet from 48th to 40th Street and about 100 feet from 40th to 16th Street. In the lower 2-mile reach from 16th Street to 7th Avenue the channel has been obliterated by several large gravel pits (fig. 2).



Figure 1. --The Salt River channel 6 miles downstream from Granite Reef Dam.



Figure 2. --Gravel pits along the Salt River between 7th Street and 7th Avenue, April 28, 1965.

STREAMFLOW

Streamflow data collected at six selected sites (fig. 3) were used to calculate peak rates and volumes of flow, which showed the attenuation of flow as the water moved downstream. Streamflow volumes at four sites and data collected from gravel pits between 48th Street and 7th Avenue were used to calculate infiltration rates.

About 39,000 acre-feet of water was released during the 82 hours when the spillway gates and river outlets of Bartlett Dam were open. The maximum rate of discharge from the dam was 9,390 cfs (cubic feet per second). The water traveled the 27-mile length of the channel to Granite Reef Dam with no appreciable loss. At Granite Reef Dam, 19,000 acre-feet was diverted into the Arizona and Consolidated Canals. The water that the canals were unable to carry—20,000 acre-feet—was released at a maximum rate of 6,100 cfs into the Salt River.

The progress of the flow below Granite Reef Dam is shown by the four discharge hydrographs in figure 4. About three-fourths of the total flow at Granite Reef was lost from the surface as the flood traveled the 19-mile reach to 48th Street. The shape of the flow hydrograph changed considerably from that at Granite Reef Dam—the maximum discharge was reduced by about two-thirds and occurred on the second peak instead of on the first peak (fig. 4). Between 48th and 16th Streets the discharge hydrographs show little change, and total volume and maximum rate of flow were reduced only about 10 percent. However, the speed of travel of the front of the floodwave was more than twice that in the previous reach. The gravel pits between 16th Street and 7th Avenue stopped most of the remaining flow, and less than 100 acre-feet crossed 7th Avenue.

Figure 5 shows the effects of the physical features of the river channel on the volume of flow and the speed of the front of the floodwave. A marked decrease in the speed of the front of the flood and an increase in the rate of loss of surface flow occurred in the reaches having gravel pits (fig. 5).

INFILTRATION AND RECHARGE

The attenuation of the flow downstream from Granite Reef Dam is the result of infiltration into the permeable alluvium that underlies the inundated area, retention in gravel pits, and evapotranspiration. Evapotranspiration was probably negligible, but infiltration rates were high.

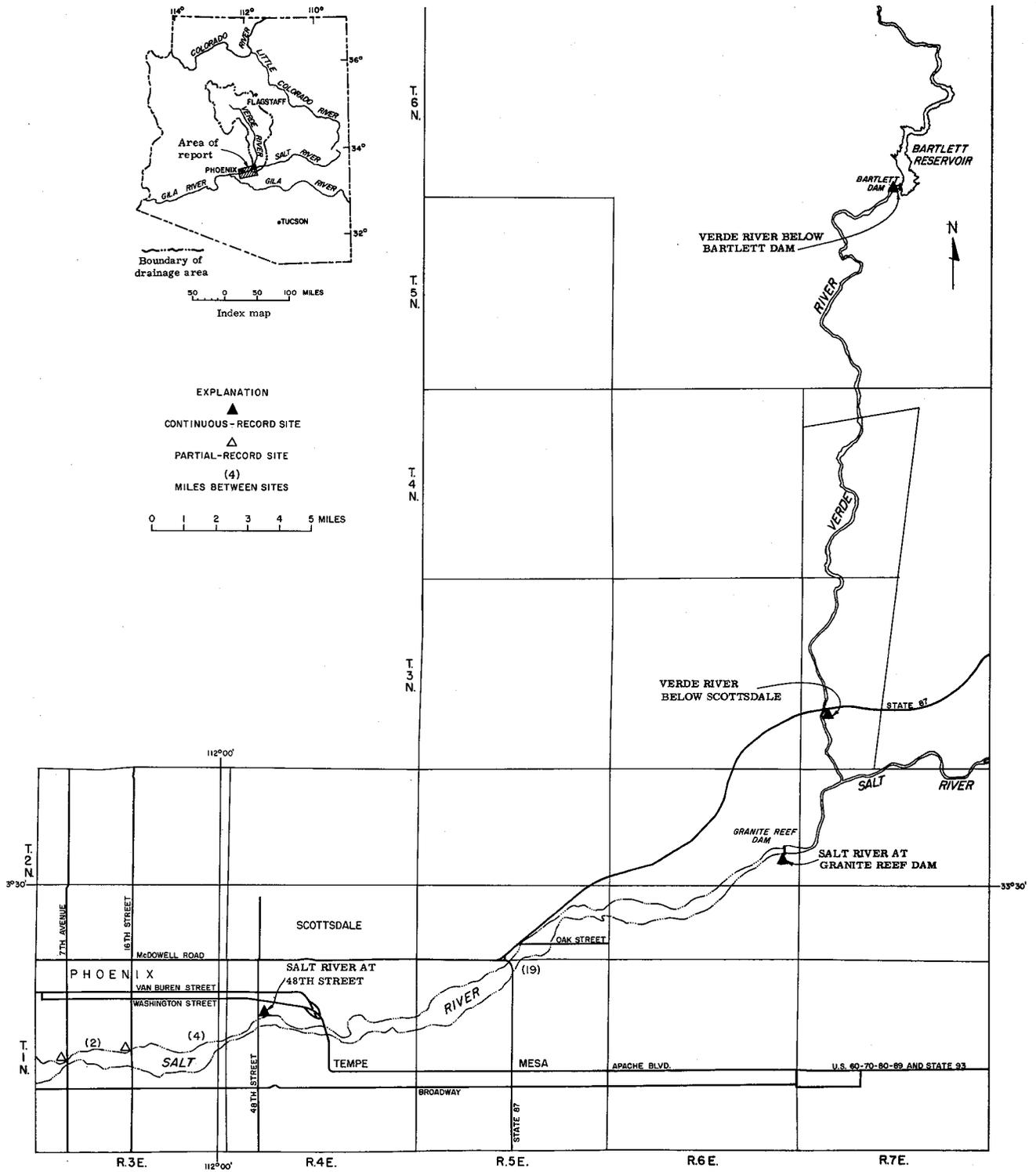


Figure 3. --Location of streamflow measuring sites.

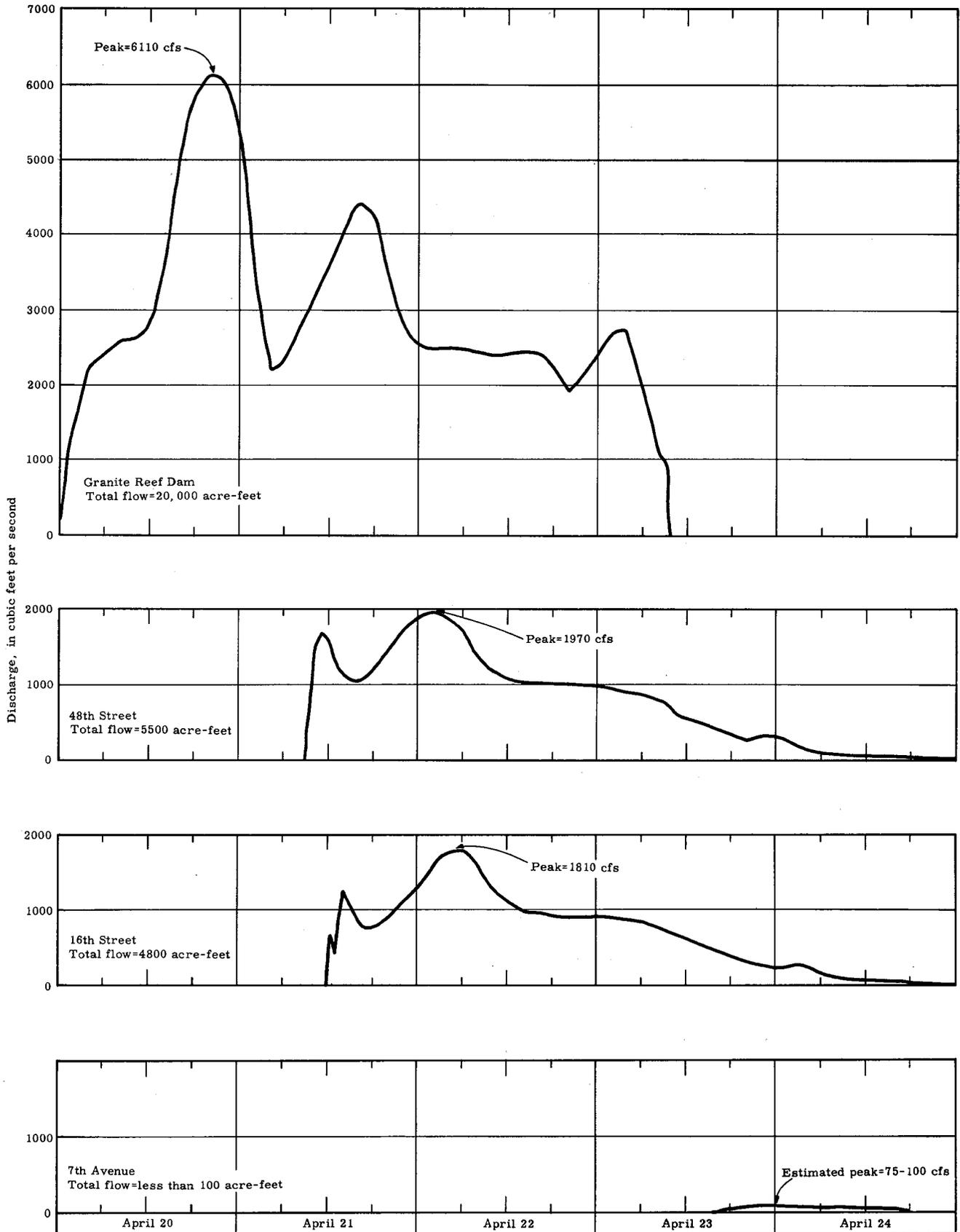


Figure 4. -- Discharge at four sites on the Salt River below Granite Reef Dam.

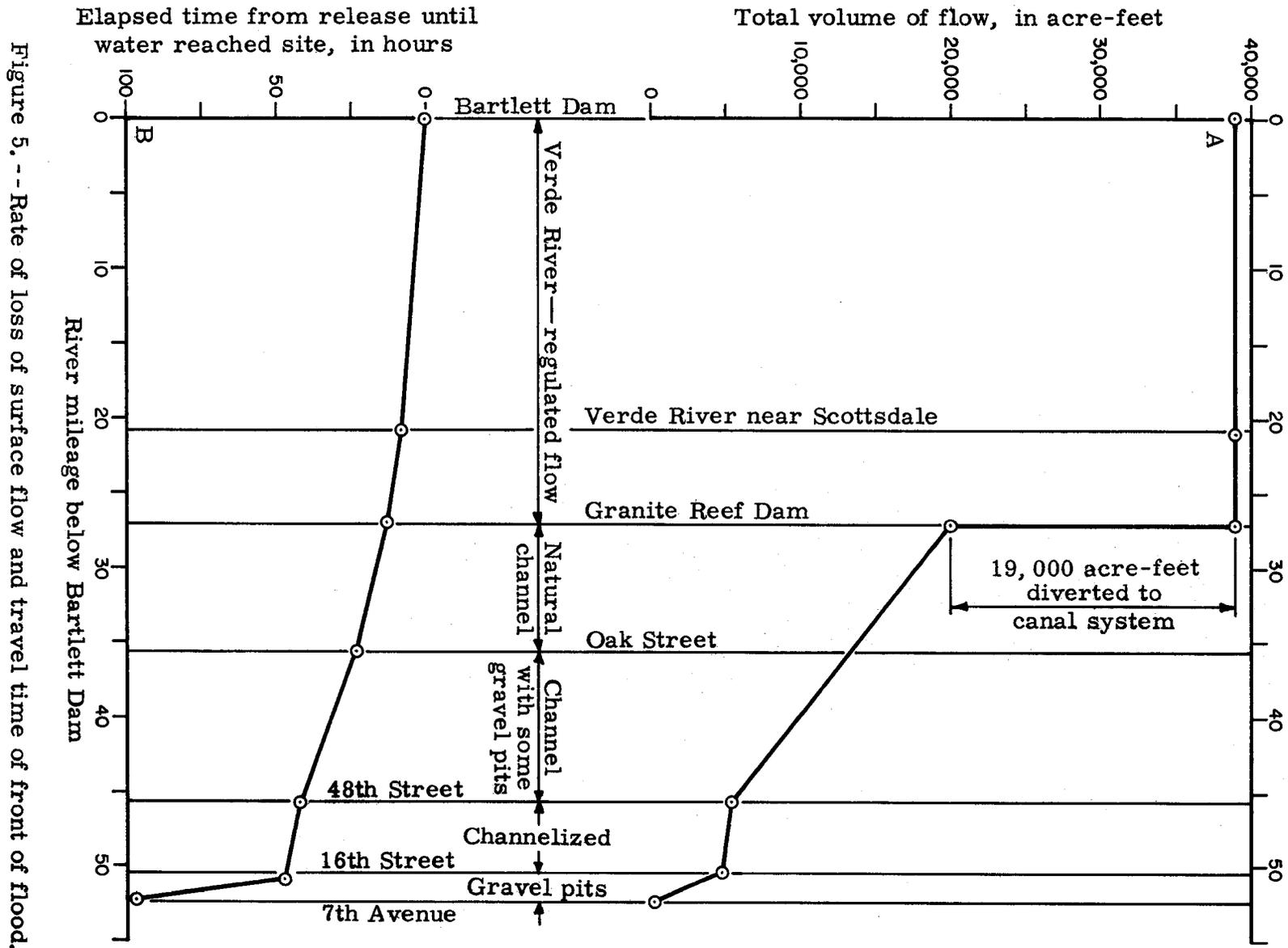


Figure 5. -- Rate of loss of surface flow and travel time of front of flood.

The infiltration rates in the three reaches for the period of flow were calculated as follows:

Reach: Granite Reef Dam to 48th Street

Inundated area from aerial photographs (partially estimated)

Channel	1, 140	acres
Gravel pits	<u>120</u>	acres
Total	1, 260	acres
Surface flow into reach	20, 000	ac-ft
Surface flow out of reach	<u>5, 500</u>	ac-ft
Loss of surface flow	14, 500	ac-ft
Volume of pits (120 acres x 20 feet estimated depth)	2, 400	ac-ft
Loss due to infiltration during period of surface flow	12, 100	ac-ft
Flow duration	3. 8	days
Infiltration rate	$\frac{12, 100 \text{ ac-ft}}{1, 260 \text{ acres} \times 3. 8 \text{ days}}$	= 2.5+ ft/day (0.25 in/hr)

Reach: 48th to 16th Streets

Inundated area from aerial photographs

Channel	85	acres
Gravel pits	<u>8</u>	acres
Total	93	acres
Surface flow into reach	5, 500	ac-ft
Surface flow out of reach	<u>4, 800</u>	ac-ft
Loss of surface flow	700	ac-ft
Volume of pits (8 acres x 20 feet estimated depth)	160	ac-ft
Loss due to infiltration during period of surface flow	540	ac-ft
Flow duration	4	days
Infiltration rate	$\frac{540 \text{ ac-ft}}{93 \text{ acres} \times 4 \text{ days}}$	= 1.4 ft/day (0.7 in/hr)

Reach: 16th Street to 7th Avenue

Inundated area from aerial photographs

Gravel pits		180 acres
Surface flow into reach		4,800 ac-ft
Surface flow out of reach		<u>100 ac-ft</u>
Loss of surface flow		4,700 ac-ft
Volume of pits (180 acres x 20 feet estimated depth)		3,600 ac-ft
Loss due to infiltration during period of surface flow		1,100 ac-ft
Flow duration		4 days
Infiltration rate	$\frac{1,100 \text{ ac-ft}}{180 \text{ acres} \times 4 \text{ days}}$	= 1.5 ft/day (0.75 in/hr)

The water retained by the gravel pits is depleted by infiltration and evaporation. Evaporation is assumed to be negligible, and infiltration rates from the gravel pits were determined from data obtained during periodic measurements of surface outflow from the pits and changes in water level in the pits (fig. 6). The measured and calculated infiltration rates for water in the pits are as follows:

April 21 - 25	1.5 feet per day	calculated
April 24 - 26	1.3 feet per day	measured
April 26 - May 6	1.1 feet per day	measured

These rates are in agreement with those found in previous studies made on Queen Creek (Babcock and Cushing, 1942) and the Santa Cruz River (Turner and others, 1943).

Most of the infiltrating water probably percolates down to recharge the ground-water reservoir, as indicated by water-table rises in observation wells (fig. 7). The data for all but one observation well are insufficient to distinguish the rise in water level due to recharge from the rises due to other causes, such as a reduction in pumping or increased loading on an artesian aquifer.

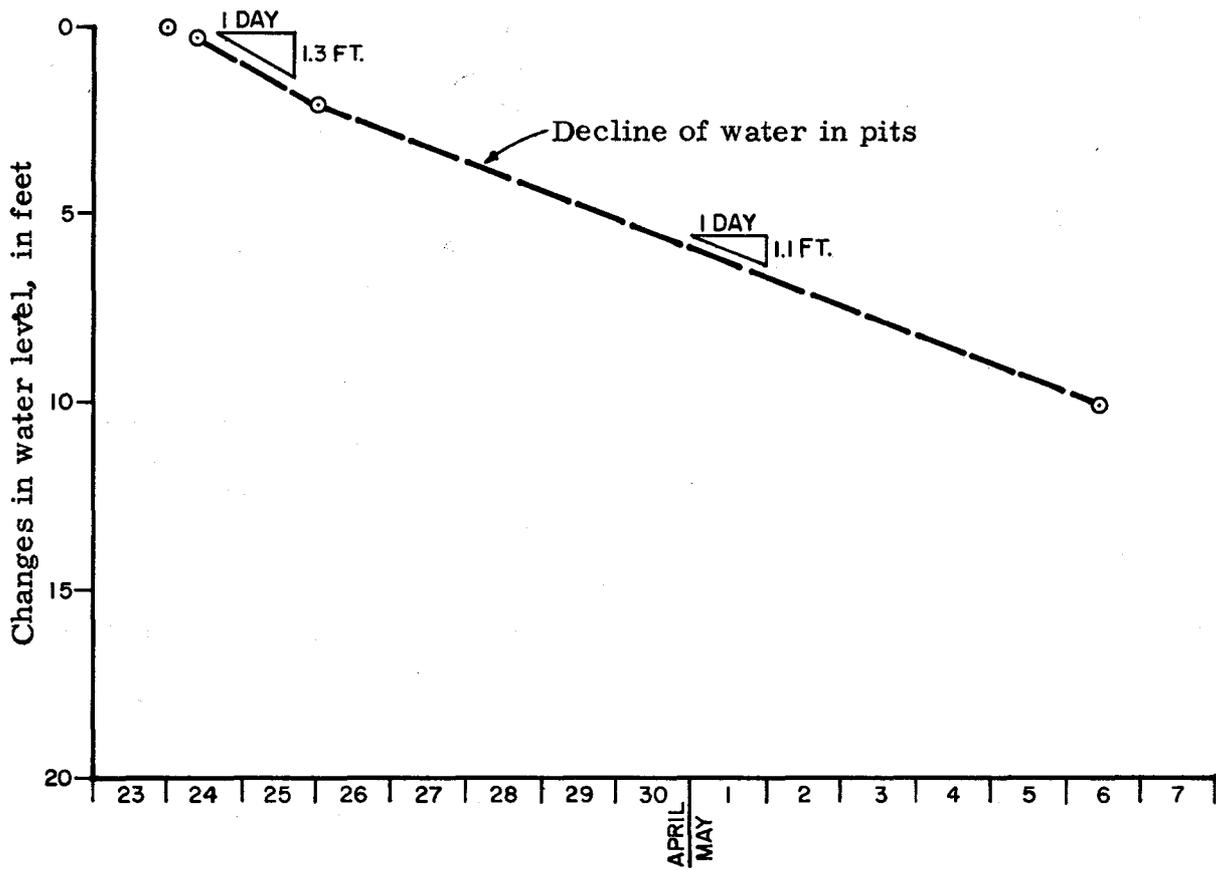


Figure 6. -- Rates of water-level decline in the gravel pits between 16th Street and 7th Avenue.

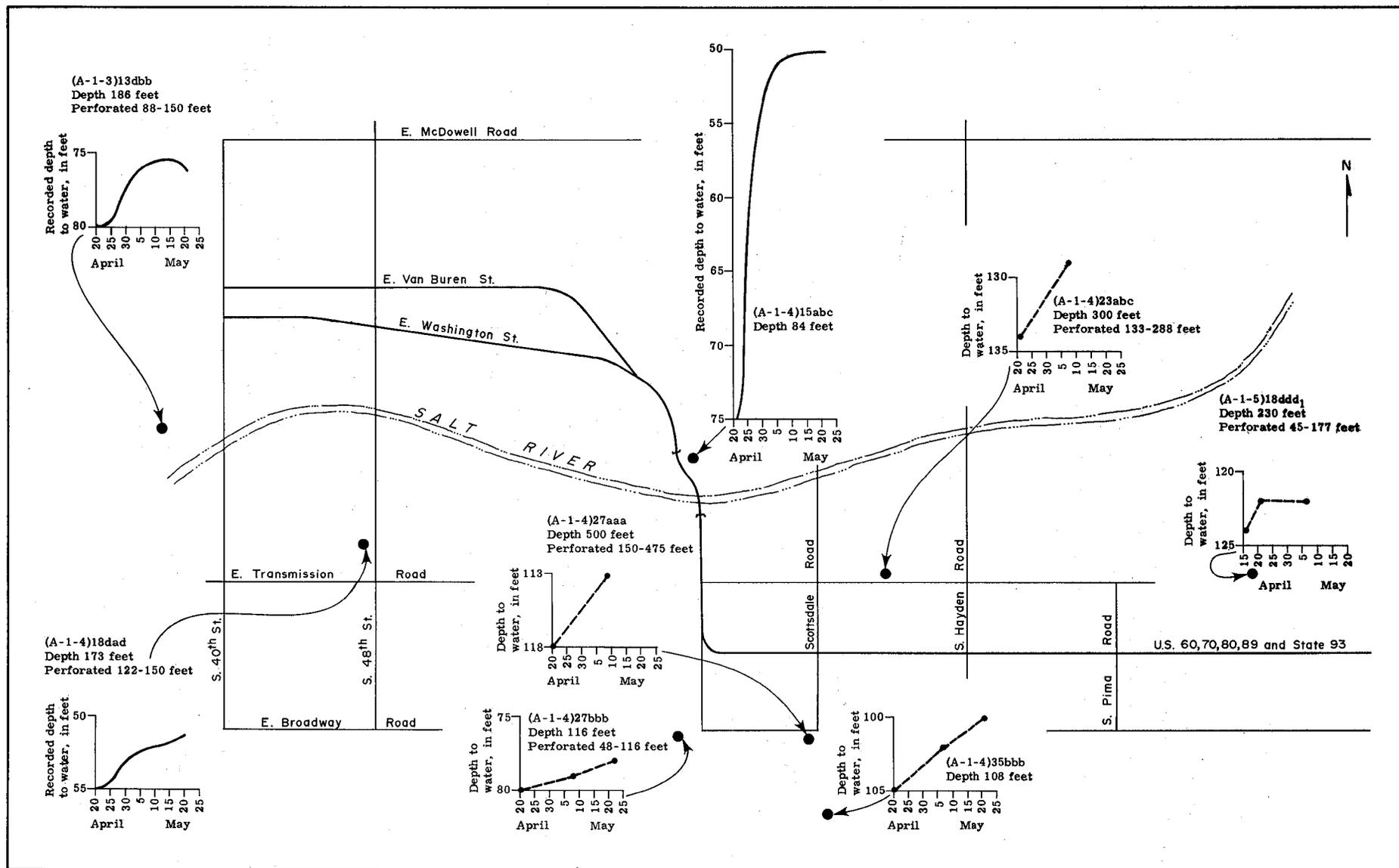


Figure 7. --Changes in water levels in observation wells.

Observation well (A-1-3)13dbb near 36th Street is about 500 feet from the river. The time lag from the beginning of surface flow near the well to the corresponding water-level rise was 1-1/2 days, which shows a percolation rate of 330 feet per day. The total rise in water level was about 4-1/2 feet. A rate of 400 feet per day was calculated by standard methods, which agrees with the measured rate of 330 feet per day. The close agreement between the calculated and measured figures suggests that recharge did occur near this well and that other measured rises in water levels reflect an increase in ground-water storage.

SUMMARY

During an 82-hour period in April 1965, 39,000 acre-feet of water was released from Bartlett Reservoir at a maximum rate of 9,390 cfs. The water traveled the 27-mile reach to Granite Reef Dam with no measurable loss. At Granite Reef about half of the flow was diverted into the Arizona and Consolidated Canals. The 20,000 acre-feet that was released into the normally dry Salt River below Granite Reef Dam diminished to less than 100 acre-feet 25 miles downstream at 7th Avenue. Calculated infiltration rates were 2.5 feet per day in the reach from Granite Reef Dam to 48th Street and 1.4 feet per day from 48th Street to 16th Street. In the gravel pits immediately upstream from 7th Avenue, an initial infiltration rate of 1.5 feet per day was calculated, and an average of 1.1 feet per day was measured for the 10-day period following the end of flow into the pits. Rising water levels in observation wells—as much as a 25-foot rise next to the river—show that recharge occurred in the alluvium under the river. Most of the water lost in the river channel probably was recharged to the ground-water reservoir.

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