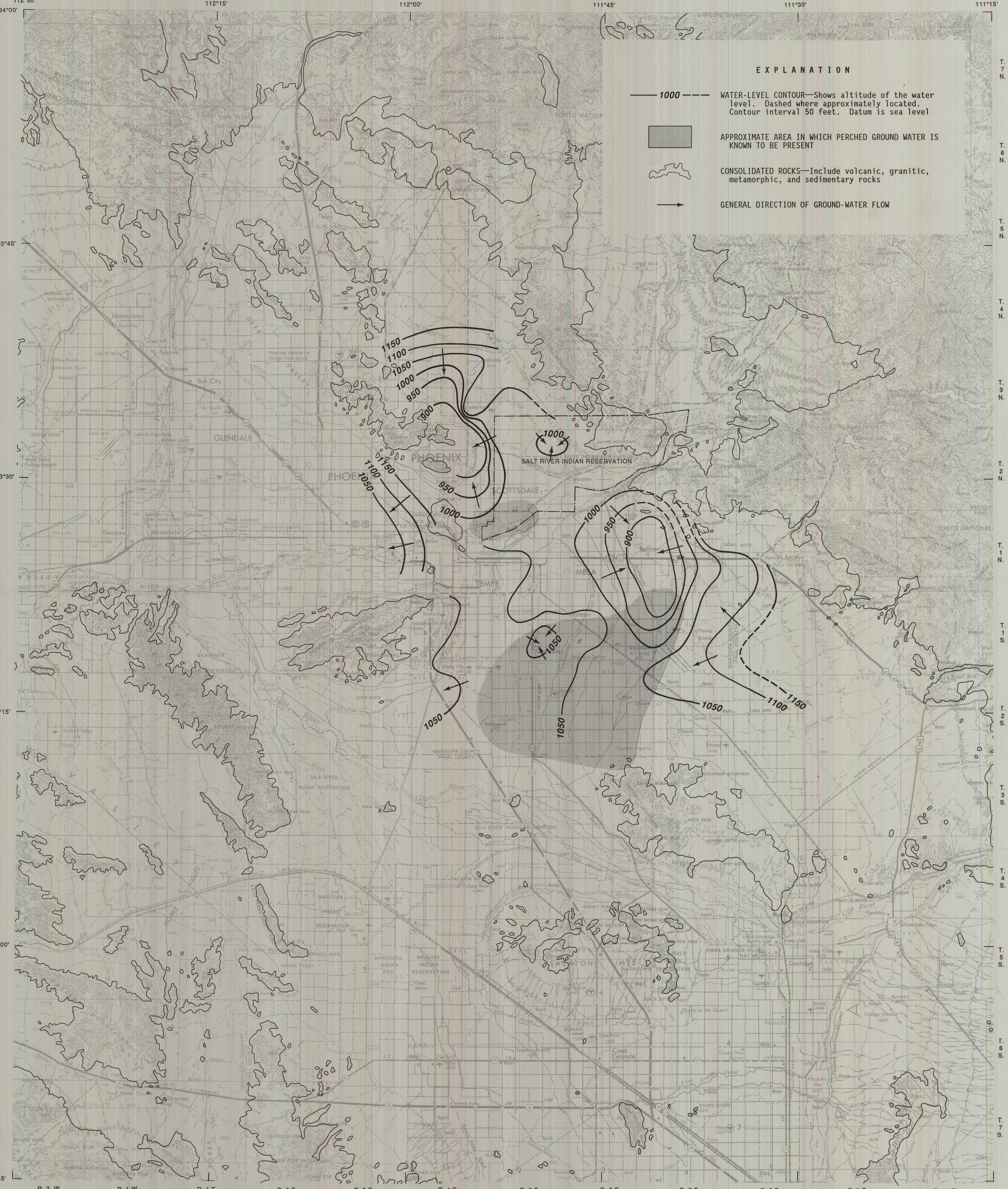
Base from U.S. Geological Survey 1:250,000
Mesa, 1954-69 and Poenix, 1954-69

ALTITUDE OF THE WATER LEVEL, ABOUT 1900



Geology from M.E. Cooley, 1973

ALTITUDE OF THE WATER LEVEL, 1986

5 0 5 10 MILES
5 0 5 10 KILOMETERS
TOPOGRAPHIC CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

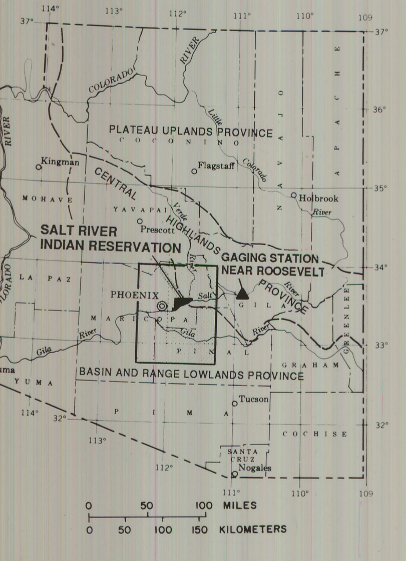


Figure 1.--Location of study area (shaded).

INTRODUCTION

The Salt River Indian Reservation covers about 77 mi² in the eastern part of Salt River Valley in south-central Arizona, which is one of the major agricultural areas in the State. Increased water use since 1900 has resulted in major changes in the ground-water system in and near the reservation. The purpose of this study was to evaluate those changes. About 800 mi² of the regional ground-water area was included in the study in order to evaluate the ground-water resources of the reservation (fig. 1).

The study area is in the Basin and Range physiographic province (Fenneman, 1931) and consists of broad alluvial valleys surrounded by mountain ranges that rise abruptly above the generally flat valley floors. The mountains are composed of consolidated rocks, which include crystalline, extrusive, and sedimentary rocks. The crystalline and extrusive rocks are virtually impermeable and form physical boundaries for surface-water and ground-water flow. The valleys are underlain by thousands of feet of permeable sediments that contain large quantities of ground water. The oldest sediments were deposited before high-angle block faulting occurred. These sediments consist mostly of reddish-colored, well-cemented breccia, conglomerate, sandstone, and siltstone and are exposed mainly north of the Salt River along the east and west boundaries of the study area (Laney and Hahn, 1986). Other sediments were deposited during and after block faulting and consist of unconsolidated clay, silt, sand, and gravel and variably consolidated caliche, mudstone, siltstone, sandstone, conglomerate, and evaporites. The degree of sorting and cementation and the distribution of the materials differ areally and with depth. Interbedding and lensing are common, and lateral discontinuities caused by high-angle faults may be present in some lower units (Laney and Hahn, 1986).

The valley floor ranges in altitude from about 1,100 ft above sea level in the southwest to about 2,000 ft in the north. The Phoenix and South Mountains have peaks as high as 2,500 ft above sea level. The McDowell and Superstition Mountains are about 4,000 and 5,000 ft in altitude, respectively. The western two-thirds of the Salt River Indian Reservation is in the valley and the eastern one-third is in the McDowell Mountains. The principal water resources of the area include streamflow of the Salt River and ground water stored in the underlying sediments. The average annual precipitation ranges from about 8 in. on the valley floor to about 16 in. in the Superstition Mountains, and the average annual lake evaporation is about 75 in. (Sellers and Hill, 1974). The flow of the Salt River is controlled, except during extremely wet years, by reservoirs that were constructed to store excess runoff and regulate the flow of the river. The first structure, Theodore Roosevelt Dam, on the Salt River was completed in 1911, followed by Mormon Flat Dam in 1925, Horse Mesa Dam in 1927, and Stewart Mountain Dam in 1930. On the Verde River, Bartlett Dam was completed in 1939 and Horseshoe Dam in 1946. The six reservoirs have a combined storage capacity of more than 2 million acre-ft of water. Irrigated agriculture, which became a prominent industry in the 1940's, together with other industries and municipalities, uses the available surface water from the reservoirs and about 1 million acre-ft of ground water each year in the Salt River Valley (U.S. Geological Survey, 1986).

The hydrologic data on which these maps are based are available, for the most part, in computer-printout form for consultation at the Arizona Department of Water Resources, 99 East Virginia, Phoenix, and at U.S. Geological Survey offices in: 375 South Euclid Avenue, Tucson, and 1545 West University, Tempe. Material from which copies can be made at private expense is available at the Tucson and Tempe offices of the U.S. Geological Survey.

This investigation was done in cooperation with the U.S. Bureau of Indian Affairs. The authors gratefully acknowledge the cooperation and assistance of the personnel of the Salt River Pima-Maricopa Indian Community, City of Scottsdale Water Department, City of Mesa Utility Operations Division, and Salt River Project. The authors particularly wish to thank Arnold Makil of the U.S. Bureau of Indian Affairs for his help with the data collection.

AQUIFER CHARACTERISTICS

The main water-bearing unit consists of sediments that are several thousand feet thick in places. The sediments have been divided into four units—upper, middle, lower, and red (Laney and Hahn, 1986) on the basis of geologic and hydrologic properties. The upper unit consists of gravel, sand, and silt and is as much as 300 ft thick south and southwest of Mesa and 200 ft thick in Paradise Valley. The unit has excellent water-bearing characteristics and, where saturated, may yield as much as 4,500 gal/min of water to wells (Laney and Hahn, 1986). Ground water is perched in the upper unit in the south-central part of the area where most of the deposits are silt. Near Scottsdale, where most of the deposits are sand and gravel, perched water also occurs and may be caused by buried caliche-cemented terraces (Péwé, 1978). The middle unit consists mostly of silt, siltstone, and silty sand and gravel. The unit is as much as 1,000 ft thick and generally will yield about 1,000 gal/min of water to wells. North of Mesa, the unit yields about 4,000 gal/min of water locally to wells (Laney and Hahn, 1986). The lower unit consists mainly of mudstone, clay, silt, and evaporites with locally interbedded sand and gravel, conglomerate, and basalt and may be as much as 10,000 ft thick. In many areas, the lower unit yields 50 gal/min or less of water to wells; however, the conglomerate and the sand and gravel units may yield as much as 3,500 gal/min to wells (Laney and Hahn, 1986). The red unit, which consists of well-cemented coarse-grained materials, has been subjected to faulting. Although the thickness of the red unit is not known, it is as much as 500 ft thick near Scottsdale and yields about 1,000 gal/min of water to wells (Laney and Hahn, 1986). The crystalline rocks that are exposed along the margins of the study area may yield as much as 10 gal/min of water to wells from fractures.

The hydraulic characteristics of the water-bearing units have a wide range of values because of the extreme heterogeneity of the units. The hydraulic conductivity of the upper unit, which has been dewatered in much of the area, ranges from about 50 to 500 ft/d (Laney and Hahn, 1986); specific yield ranges from 15 to 25 percent (Freethey and others, 1986). The middle unit contains the most recoverable ground water and is the major source of ground water in the study area. Aquifer-test data show that the hydraulic conductivity of the middle unit ranges from about 20 to 100 ft/d (Niccoli and Long, 1981); specific yield is estimated to range from 5 to 20 percent. Ross (1980) used a uniform specific-yield value of 12 percent in his model. Little is known about the hydraulic characteristics of the lower units because of the lack of data from wells perforated only in the individual units. Laney and Hahn (1986) estimated that hydraulic conductivity of the lower and red units may range from 0.001 to 100 ft/d.

GROUND-WATER CONDITIONS, ABOUT 1900

An arbitrary date of about 1900 was used for the water-level contours because the first records on wells and depths to water were compiled between 1897 and 1905. Water-level data for about 1900 for the Phoenix-Mesa area were compiled by Lee (1905). The earliest available water-level data for Paradise Valley were compiled by Meinzer and Ellis (1916). Water-level contours are substantiated by water-level data collected before large quantities of ground water were withdrawn in the area southeast of Mesa (Babcock and Halpenny, 1942) and in the north end of Paradise Valley (McDonald and others, 1947).

Records indicate that non-Indian settlers started diverting water from the Salt River for irrigation in 1868. By 1889, water was diverted for the irrigation of more than 35,000 acres (Davis, 1897). The Arizona Canal was constructed in 1883 and 1884 and first used in 1885. Pumping of ground water for irrigation began in the late 1890's (Davis, 1897); however, only small quantities of ground water were withdrawn until the 1940's (Anderson, 1968). When the non-Indian settlers arrived, water levels were shallow—less than 10 ft to about 70 ft below the land surface in the Phoenix-Mesa-Chandler area. The gradient of the ground water sloped generally with the gradient of the Salt River (Lee, 1905). Water-level contours indicate that the hydraulic gradient averaged about 0.001 and ranged from 0.0006 to 0.004. Near the Arizona Canal, water levels were about 60 to 70 ft below the land surface. In Paradise Valley, 10 mi northwest of the Arizona Canal, water levels were about 270 ft below the land surface (Meinzer and Ellis, 1916). Along the Salt River and in the area south of the river, the direction of ground-water movement was from east to west. In Paradise Valley, the ground water moved from north to south. Water-level contours indicate that water moved from the Salt River to the aquifer in the first 10 mi downstream from Granite Reef Dam; however, about 3 mi farther downstream, in the area north of Tempe, water moved from the aquifer to the Salt River. The diversion of surface water for irrigation reduced recharge along the river, created new areas of recharge along unlined irrigation canals and under irrigated fields, and caused minor changes in ground-water flow patterns. For example, in Paradise Valley, water-level measurements indicated the development of a ground-water ridge under the Arizona Canal (Meinzer and Ellis, 1916). Water levels were more than 20 ft above the natural water table near the Arizona Canal. Effects of the ridge extended 2 mi or more northward from the canal. In general, however, the areas and amounts of artificial recharge were small and probably had little impact on the hydrologic system as a whole. Before 1923, the hydrologic system in central Arizona was considered to be in equilibrium; that is, inflow was equal to outflow (Anderson, 1968).

The volume of recoverable ground water in storage beneath the Salt River Indian Reservation to a depth of 1,200 ft below the land surface was about 4 million acre-ft in 1900. This volume was estimated using specific-yield values ranging from 0.10 to 0.20 and estimated aquifer volumes.

GROUND-WATER CONDITIONS, 1986

Between 1900 and 1986, water levels declined and the direction of ground-water movement changed significantly because millions of acre-feet of water were pumped from the ground-water reservoir (U.S. Geological Survey, 1986) and because recharge decreased. In 1900, the general direction of ground-water flow was from north to south in Paradise Valley and east to west along and south of the river. By 1986, ground water flowed toward the center of cones of depression east of Mesa and west of the reservation. In most of the area, water-level contours indicate that the hydraulic gradient ranges from about 0.002 to 0.03.

In 1986, depth to water below the land surface was less than 100 ft near the Salt River, more than 500 ft east of Mesa, and 400 ft west of the Salt River Indian Reservation. As water levels declined, areas of perched ground water that are apparently supported by fine-grained or cemented material within the upper unit remained. Perched ground water may result, in part, from irrigation-return flow. Water levels were measured in winter when pumping for irrigation was minimal. Agricultural pumping seldom ceases, however, and continuous pumping occurs at many public-supply wells. Hence, static water levels are uncommon. Water-level contours represent the regional water table as interpreted from a complex water-level data set. Withdrawal of ground water and resulting water-level declines caused land subsidence in Paradise Valley and the Mesa-Chandler areas (Schumann, 1974). About 3 million acre-ft of recoverable ground water is in storage to a depth of 1,200 ft beneath the Salt River Indian Reservation.

CONVERSION FACTORS

For readers who prefer to use the metric (International System) units, the conversion factors for the inch-pound units used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
square mile (mi²)	2.590	square kilometer (km²)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm³)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
degree Fahrenheit (°F)	°C = 5/9(°F-32)	degree Celsius (°C)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929."

GROUND-WATER CONDITIONS IN AND NEAR THE SALT RIVER INDIAN RESERVATION, SOUTH-CENTRAL ARIZONA

By
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1991