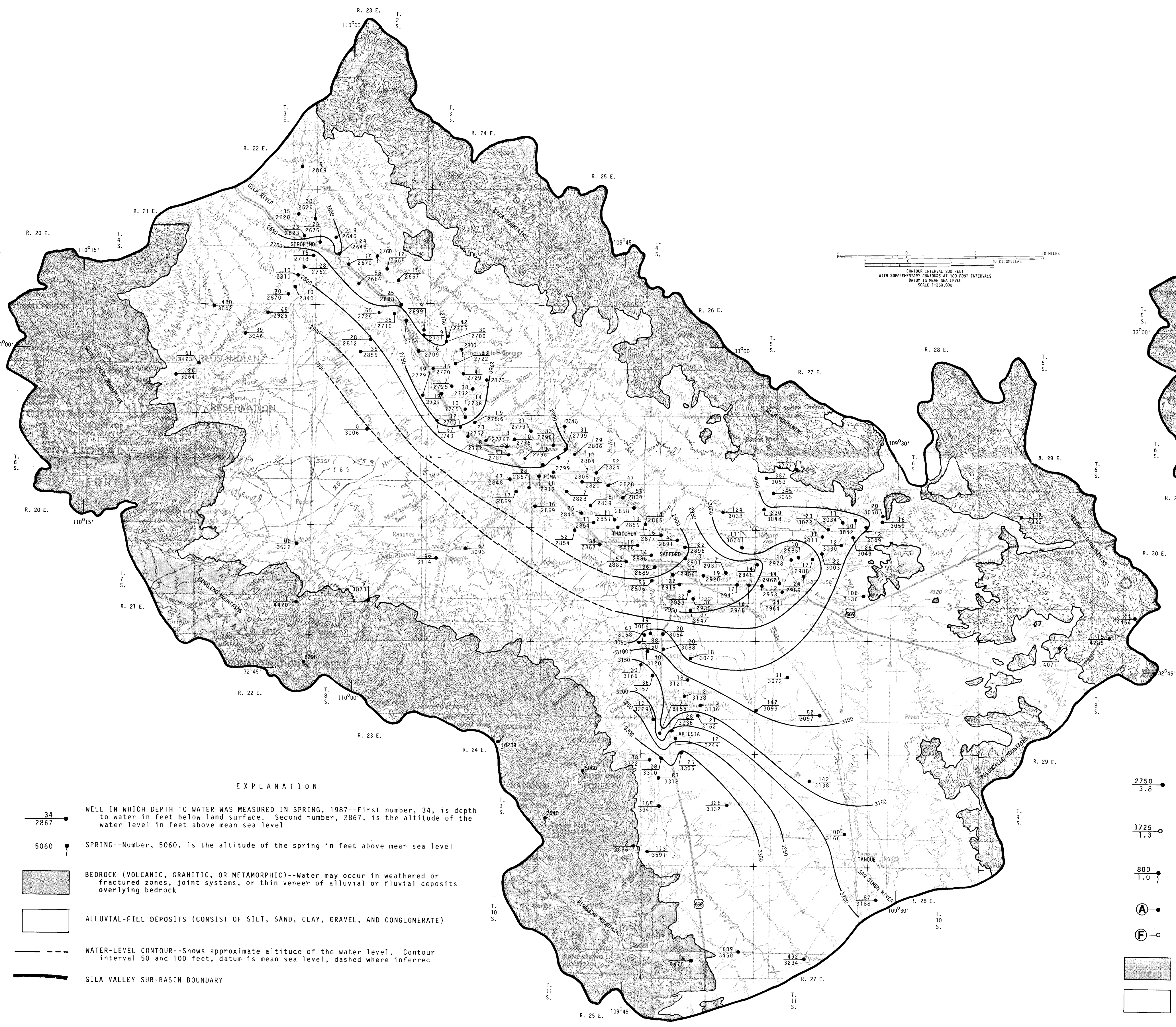
PREPARED IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY



EXPLANATION

WELL IN WHICH DEPTH TO WATER WAS MEASURED IN SPRING, 1987--First number, 34, is depth to water in feet below land surface. Second number, 2867, is the altitude of the water level in feet above mean sea level

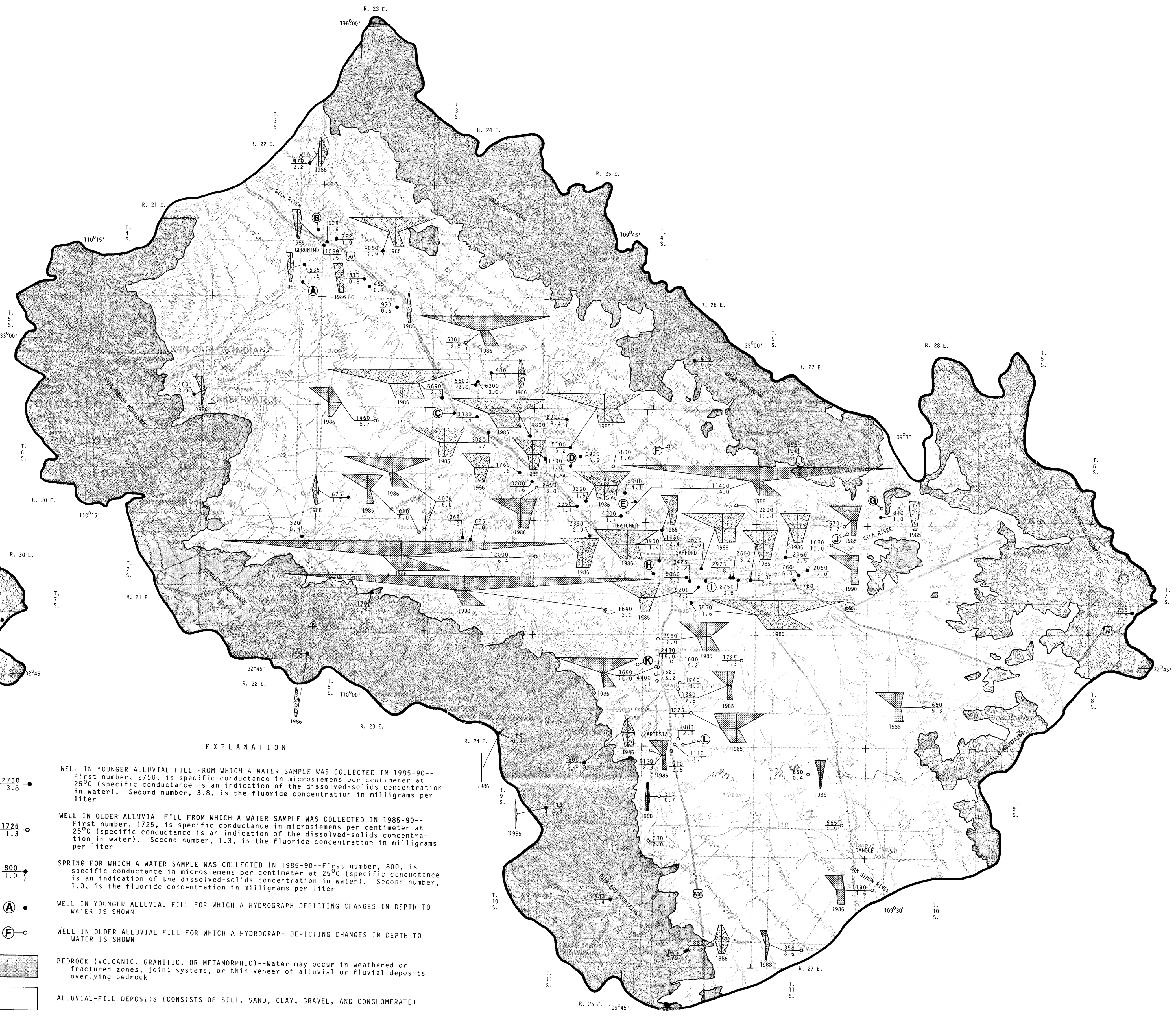
SPRING--Number, 5060, is the altitude of the spring in feet above mean sea level

BEDROCK (VOLCANIC, GRANITIC, OR METAMORPHIC)--Water may occur in weathered or fractured zones, joint systems, or thin veneer of alluvial or fluvial deposits overlying bedrock

ALLUVIAL-FILL DEPOSITS (CONSIST OF SILT, SAND, CLAY, GRAVEL, AND CONGLOMERATE)

WATER-LEVEL CONTOUR--Shows approximate altitude of the water level. Contour interval 50 and 100 feet, datum is mean sea level, dashed where inferred

GILA VALLEY SUB-BASIN BOUNDARY



EXPLANATION

WELL IN YOUNGER ALLUVIAL FILL FROM WHICH A WATER SAMPLE WAS COLLECTED IN 1985-90--First number, 2750, is specific conductance in microsiemens per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Second number, 3.8, is the fluoride concentration in milligrams per liter

WELL IN OLDER ALLUVIAL FILL FROM WHICH A WATER SAMPLE WAS COLLECTED IN 1985-90--First number, 1725, is specific conductance in microsiemens per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Second number, 1.3, is the fluoride concentration in milligrams per liter

SPRING FOR WHICH A WATER SAMPLE WAS COLLECTED IN 1985-90--First number, 800, is specific conductance in microsiemens per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Second number, 1.0, is the fluoride concentration in milligrams per liter

WELL IN YOUNGER ALLUVIAL FILL FOR WHICH A HYDROGRAPH DEPICTING CHANGES IN DEPTH TO WATER IS SHOWN

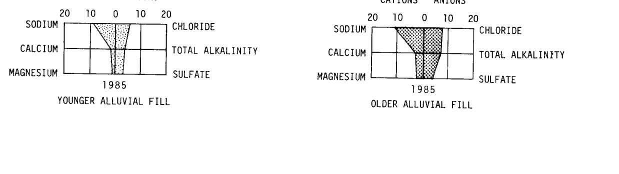
WELL IN OLDER ALLUVIAL FILL FOR WHICH A HYDROGRAPH DEPICTING CHANGES IN DEPTH TO WATER IS SHOWN

BEDROCK (VOLCANIC, GRANITIC, OR METAMORPHIC)--Water may occur in weathered or fractured zones, joint systems, or thin veneer of alluvial or fluvial deposits overlying bedrock

ALLUVIAL-FILL DEPOSITS (CONSISTS OF SILT, SAND, CLAY, GRAVEL, AND CONGLOMERATE)

GILA VALLEY SUB-BASIN BOUNDARY

CHEMICAL QUALITY DIAGRAM--Shows major constituents in milliequivalents per liter. The diagrams are in a variety of shapes and sizes, providing a means of comparing, correlating, and characterizing similar or dissimilar types of water. 1985, below diagram, indicates year in which sample was collected



INTRODUCTION

The Gila Valley sub-basin of the Safford basin is located in southeastern Arizona and encompasses approximately 1,642 square miles. The mountains that bound the sub-basin are the Gila on the northeast, the Peloncillo on the east, and the Pinaleno and Santa Teresa on the southwest. An arbitrary line 5 miles downstream from the town of Geronimo forms the northwest boundary, and a ridge line south of Tanque marks the southeast boundary. The principal drainage for the Gila Valley sub-basin is the Gila River which enters the valley in the east and exits to the northwest. The San Simon River drains the southern part of the sub-basin and then converges with the Gila River. The major communities are Safford, Thatcher, and Pima; at least a dozen smaller communities dot the Gila Valley sub-basin. The major industry is farming and in 1988, about 40,000 acres was irrigated (Norman Norton, Agricultural Stabilization and Conservation Service, oral commun., 1990). The primary crops are cotton and alfalfa.

Climate in the Gila Valley sub-basin is semiarid and warm. Precipitation is about 9 inches per year in the inner valley, greater than 30 inches per year in the surrounding mountains (Witcher, 1982, p. 1), and occurs mostly during July, August, and September. The average maximum daily temperature is about 104°F in July and about 65°F in January, while the average minimum daily temperature is about 69°F in July and about 29°F in January. An extreme high temperature of 116°F in June 1971, and an extreme low temperature of 8°F in January 1910, have been recorded (Sellers and others, 1985, p. 89, 92, 101, 104, 114).

Before 1920 the native vegetation was creosote (a xerophyte) on the slopes; and cottonwood, willow, baccharis, and mesquite (phreatophytes) on the bottom land (Gatewood and others, 1950, p. 9). Saltcedar (a phreatophyte) has now taken over much of the bottom land acreage that is not cleared for irrigation. Early settlers in the sub-basin began irrigation of crops around 1872 by diverting flows of the Gila River (Turner and others, 1946, p. 2). Drought and an increase of cultivated land in the mid 1930's resulted in demands for water in excess of surface-water supplies, and prompted the drilling of water wells to provide a supplemental and more dependable source of water. In 1988, the most recent year for which data are available, approximately 71,000 acre-feet of groundwater was pumped in the Gila Valley sub-basin (Allen Konieczki, U.S. Geological Survey, oral commun., 1990). Diversions of surface water from the main stream of the Gila River in the Gila Valley sub-basin are administered by the Gila Water Commissioner in Safford, Arizona, pursuant to the Globe Equity Number 59 Decree. In 1988, approximately 138,000 acre-feet was diverted.

GEOLOGY

The Gila Valley sub-basin is part of a large, sediment-filled, trough-like depression typical of the geology structures of the Mexican Highland section of the Basin and Range physiographic province. Halpenny and Cushman (1947, p. 3) divided the basin fill into two units--the younger alluvial fill and the older alluvial fill. The deposits of the younger alluvial fill are of fluviatile origin. This unit, rarely wider than 4 miles, consists of clay and unconsolidated silt, sand, and gravel, which all occur in discontinuous lenticular beds. The unit is thickest near Safford and Thatcher where it averages about 85 feet, near Geronimo it thins to about 30 feet. A discontinuous blue clay generally marks the bottom of the unit. The older alluvial fill, which is more or less consolidated, fills the major part of the structural trough which forms the Gila Valley sub-basin. The older alluvial fill can be divided into three facies. In descending order they are a clay-silt facies, evaporite facies, and basal-conglomerate facies (Harbour, 1966, p. 23). The clay-silt facies, believed to be lacustrine in origin, is noted in a driller's log to be as much as 610 feet thick (Knechtel, 1938, p. 202). The evaporite facies, as described by Harbour (1966, p. 33), is composed of salt beds, gypsum, limestone, and gypsiferous clay and shale. This facies is the thickest near the basin axis and interfingers laterally with the clay-silt facies (Harbour, 1966, p. 34). According to Harbour (1966, p. 24), the basal-conglomerate facies extends basin-wide under the clay-silt and evaporite facies. This basal-conglomerate facies is nonindurated to moderately indurated sand and gravel, and is interbedded with the clay-silt facies near the town of Artesia (Witcher, 1982, p. 3). Gravity modeling shows that the older alluvial fill is very thick. In an area a few miles southwest of Safford, sediments may be as much as 11,200 feet thick. In most of the sub-basin sediments are inferred to be thicker than 4,800 feet (Oppenheimer, 1980). At least one well has been drilled to a depth of 3,767 feet without encountering bedrock.

OCCURRENCE AND MOVEMENT OF GROUNDWATER

Groundwater in the Gila Valley sub-basin occurs in both the younger alluvial fill and the underlying older alluvial fill. Water-level data, in conjunction with limited numbers of driller's logs and associated construction data, indicate that both alluvial units likely function as a single aquifer system. Water-level elevation contours on map 1 reflect this assumption. In general, groundwater flows from the basin margins toward the axis of the valley. Then the flow is northwest, parallel to the Gila River. Although the bulk of the retrievable groundwater is in the older alluvial fill, the younger alluvial fill is the unit of principal use. Due to the lenticular character of the younger alluvial fill, groundwater is often encountered at different levels in the same location. Well discharges of up to 2,500 gallons per minute (gal/min) have been reported, but the average seems to be about 1,000 gal/min.

Within the older alluvial fill, the clay-silt facies restricts the vertical movement of groundwater in the underlying basal-conglomerate facies, causing artesian conditions that result in some wells flowing at ground surface. The highly mineralized groundwater recovered from some wells completed in the older alluvial fill is probably a consequence of the deposits in the evaporite facies. Driller's logs of wells near Artesia that penetrate the conglomerate facies show an interbedding of clay and conglomerate. This interbedding creates an aquifer system with the characteristics of fingers that are hydrologically connected. Discharges up to 660 gal/min from irrigation wells near Artesia have been reported by well drillers. Elsewhere in the basin, warm or hot water up to 46°C obtained from some wells and springs may have come from a great depth through fractures in the older alluvial fill caused by faulting (Turner and others, 1946, p. 6).

The Gila River is the primary source of recharge to the Gila Valley sub-basin and rapid water-level rises in response to surface-water flow are observed in wells completed along the Gila River. In addition, mountain-front recharge occurs in stream channels that have cut into caliche-capped gravel zones along the Pinaleno Mountains. This supplies a considerable amount of groundwater to the sub-basin. Witcher (1982, p. 23) suggests that recharge occurs in fractures along basement fault zones in the Pinaleno Mountains. Other recharge sources are seepage from canals and deep percolation from irrigation. Underflow from the adjacent San Simon sub-basin also recharges the Gila Valley sub-basin. Precipitation in the inner valley is not a substantial source of recharge.

WATER QUALITY

Groundwater from the younger alluvial fill in the Gila Valley sub-basin is generally suitable for irrigation, and unsuitable without treatment for public consumption, due to high concentrations of dissolved solids and fluoride. There are two factors that contribute to these high concentrations. The first is groundwater seepage from the older alluvial fill into the younger alluvial fill, as indicated by localized unusually high dissolved-solids concentrations in the younger alluvial fill. Much of the dissolved solids are probably derived from the evaporite facies in the older alluvial fill. The second is seepage from irrigation canals and infiltration of irrigation return water into the younger alluvial fill. The sodium-adsorption ratio values are mostly in the medium to low range in waters derived from the younger alluvial fill, indicating medium to low sodium hazard for irrigation. The sodium-adsorption ratio is an indicator of the potential for irrigation water and soil to enter into cation exchange, with sodium from the water tending to replace adsorbed calcium and magnesium in the soil. Water with a high sodium adsorption ratio may increase the difficulty of cultivating the soil. Water quality in the older alluvial fill is poor in the central part of the basin, but appears to improve along the mountain front near Artesia possibly due to the absence of the evaporite facies there. The sodium-adsorption ratios are in the high range in most of the older alluvial fill, including the Artesia area, due to the lack of sufficient calcium and magnesium ions.

The maximum contaminant level (MCL) for fluoride in public drinking-water supplies, as recommended by the U.S. Environmental Protection Agency and the Arizona Department of Environmental Quality, is 4.0 milligrams per liter (mg/L). There were 108 water samples collected in the sub-basin between 1985 and 1990, and more than a third exceeded the MCL for fluoride. All of the samples exceeding the MCL were from wells completed in the older alluvial fill. The range of fluoride values in the older alluvial fill was 0.4 mg/L to 16.2 mg/L. The range of fluoride values in the younger alluvial fill was 0.6 mg/L to 3.8 mg/L.

Dissolved-solids concentration may be approximated by multiplying specific-conductance values by 0.6, which is the approximate ratio of dissolved solids in mg/L to specific conductance in microsiemens per centimeter (uS/cm). The U.S. Environmental Protection Agency's secondary standards for drinking water has a MCL of 500 mg/L (833 uS/cm) for dissolved solids. The range of specific-conductance values was 65 to 17,700 uS/cm and 82 of the 108 samples exceeded the MCL for dissolved solids. Most of the samples that did not exceed the limit were collected from wells in younger alluvial fill along tributaries of the Gila River and from springs on the southwest side of the basin. Water with a dissolved-solids concentration exceeding 1,000 mg/L (1,667 uS/cm) may have adverse effects on many crops and may cause physiological effects on humans and animals (U.S. Environmental Protection Agency, 1986a). The dissolved-solids concentration of 1,000 mg/L was exceeded in 54 of the 108 wells and springs that were sampled in both the older and younger alluvial fill.

Elevated arsenic levels that exceed the MCL of 50 ug/L for arsenic have been noted in samples obtained from six wells (table 2). Four of the wells are completed in the older alluvial fill. The other two lack construction data, but it is assumed that they are also completed in the older alluvial fill.

SELECTED REFERENCES

Anderson, T. W., Freethey, G. W., and Tucci, P., 1990, Geohydrology and water resources of alluvial basins in south-central Arizona and parts of adjacent states: U.S. Geological Survey Open-File Report 89-378, 99 p., 3 pls., 28 figs., 2 tables.

Arizona Department of Environmental Quality, 1989, Public and semi-public water supply systems rules: Arizona Department of Environmental Quality report, 44 p.

Brown, J. G., 1989, Geology and groundwater resources of the San Carlos Indian Reservation, Gila, Graham, and Pinal Counties, Arizona: U.S. Geological Survey Water-Resources Investigations 89-4152, 39 p., 2 pls.

Davidson, E. S., 1960, Geology of the eastern part of the Safford basin, Graham County, Arizona: Arizona Geological Society Digest, v. 3, p. 123-126.

Fair, C. L., 1961, Geohydrology of the Safford inner valley: Arizona Geological Society Digest, v. 4, p. 125-130.

Gatewood, J. S., Robinson, T. W., Colby, B. R., Hem, J. D., and Halpenny, L. C., 1950, Use of water by bottom-land vegetation in lower Safford Valley, Arizona: U.S. Geological Survey Water Supply Paper 1103, 210 p., 45 figs., 5 pls.

Halpenny, L. C., Cushman, R. L., and Hem, J. D., 1943, Ground-water resources and problems of the Cactus Flat-Artesia area, San Simon basin, Arizona, with a section on Quality of Water: U.S. Geological Survey Open-File Report (unnumbered), 14 p., 3 pls., 2 figs., 6 tables.

Feth, J. H., 1952, Safford basin, Graham County, in Ground water in the Gila River basin and adjacent areas, Arizona--a summary by L. C. Halpenny and others: U.S. Geological Survey Open-File Report (unnumbered), p. 45-57.

Harbour, J., 1960, Sedimentology and stratigraphy of the basin-fill sediments in the Safford Valley: Arizona Geological Society Digest, v. 3, p. 131-132.

_____1966, Stratigraphy and sedimentology of the upper Safford basin sediments: Ph.D. Thesis, University of Arizona, 242 p., 11 pls., 17 figs., 1 table.

Hollander, J. T., 1960, Geology and aquifer characteristics of the inner-valley alluvium in the Safford Valley, Arizona: Arizona Geological Society Digest, v. 3, p. 133-135.

Knechtel, M. M., and Lohr, E. W., 1938, Geology and ground-water resources of the valley of Gila River and San Simon Creek, Graham County, Arizona, with a section on the chemical character of the ground water: U.S. Geological Survey Water-Supply Paper 796-F, 41 p., 9 pls., 6 figs.

Marlowe, J. I., 1960, Late Cenozoic geology of the lower Safford Valley--a preliminary report: Arizona Geological Society Digest, v. 3, p. 127-129.

Oppenheimer, J., 1980, Gravity modeling of the alluvial basins, southern Arizona: unpublished Master's thesis, University of Arizona, Map.

Sellers, W. D., Hill, R. H., and Sanderson-Rae, Margaret, 1985, Arizona climate, the first hundred years, 1885-1985: Institute of Atmospheric Physics, University of Arizona, 143 p., 3 figs., 18 tables.

Turner, S. F., and others, 1941, Water resources of Safford and Duncan-Virden Valleys, Arizona and New Mexico: U.S. Geological Survey Open-File Report (unnumbered), 108 p., 2 pls., 15 figs., 28 tables.

Turner, S. F., and others, 1946, Ground-water resources and problems of the Safford basin, Arizona: U.S. Geological Survey Open-File Report (unnumbered), 28 p., 3 pls., 4 figs., 4 tables.

UOP Div., E. E. Johnson, Inc., 1982, Ground water and wells: St. Paul, Minn., 440 p.

U.S. Environmental Protection Agency, 1986a, Quality criteria for water--1986: EPA-44015/5-86-001, 501 p.

_____1986b, National primary and secondary drinking water regulations; fluoride; final rule: Washington, Federal Register, v. 51, no. 63, p. 11396-11397.

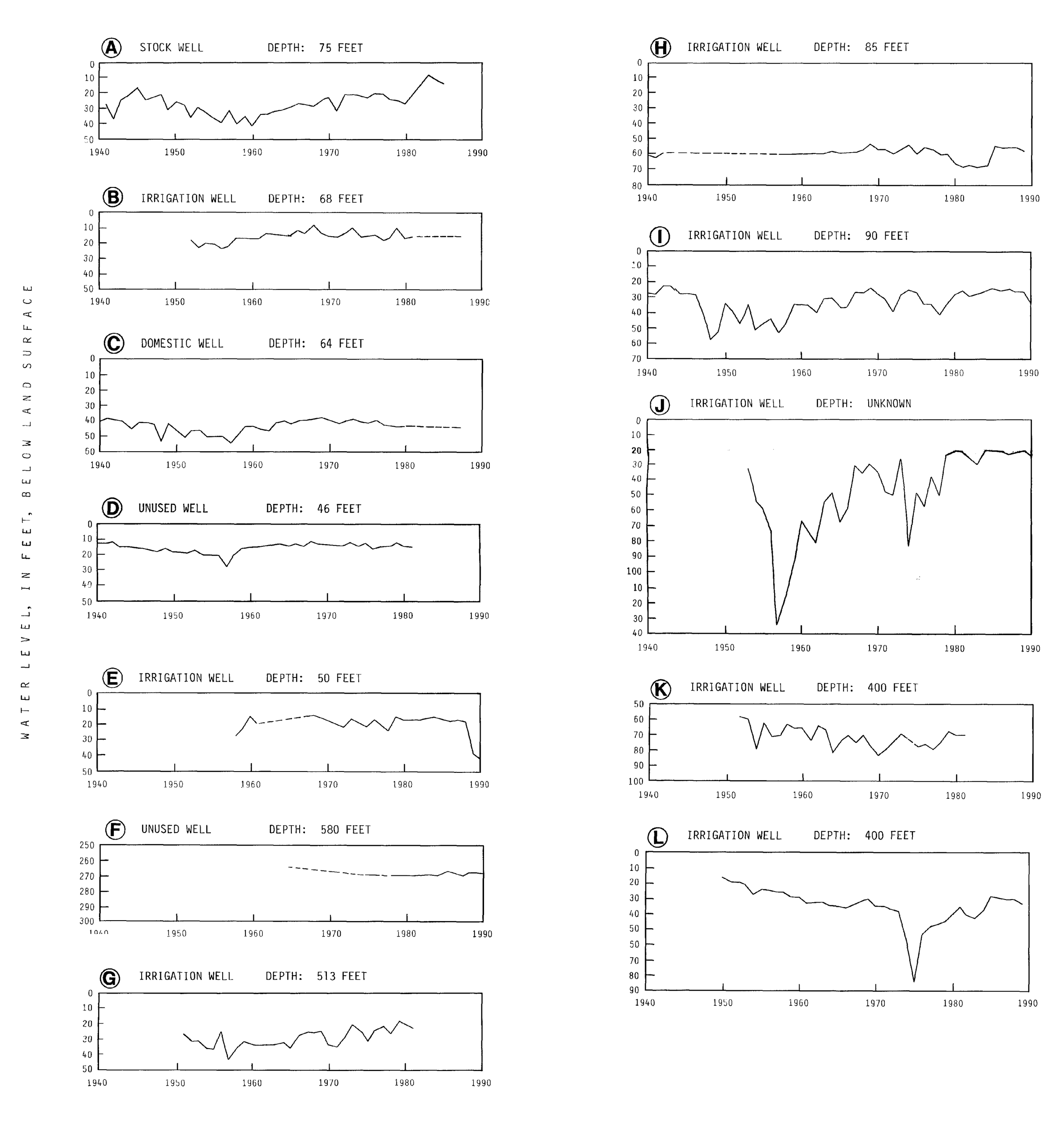
U.S. Geological Survey, 1986, Annual summary of ground-water conditions in Arizona, spring 1984 to spring 1985: U.S. Geological Survey Open-File Report, 86-422W, 2 sheets.

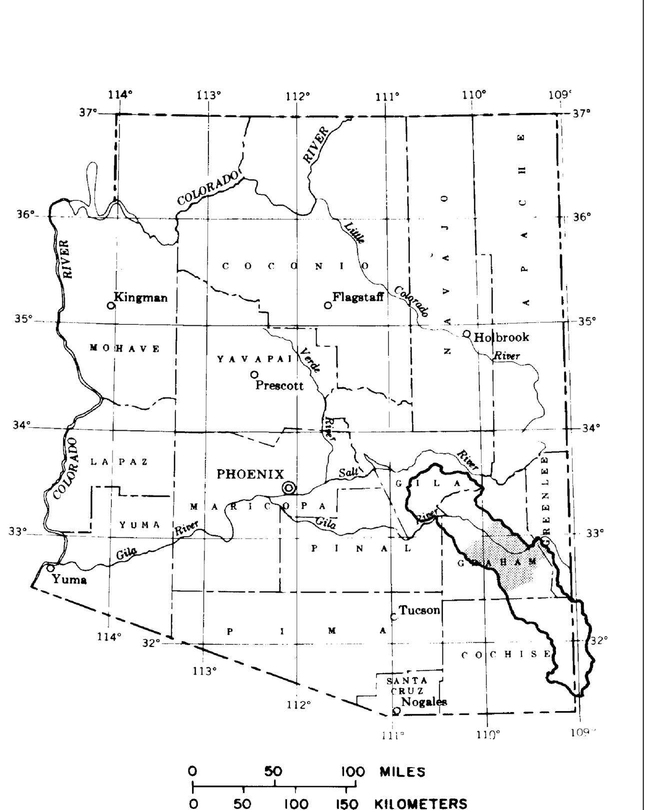
Witcher, J. C., 1982, Exploration for geothermal energy in Arizona basin and range: Arizona Bureau of Geology and Mineral Technology Open-File Report 82-5, 51 p., 10 figs., 3 tables.

TABLE 1 ESTIMATED GROUND-WATER PUMPAGE AND DIVERSION OF THE GILA RIVER IN THE GILA VALLEY SUB-BASIN

YEAR	GROUND-WATER PUMPAGE PUMPAGE IN THOUSANDS OF ACRE-FEET	GILA RIVER DIVERSIONS PUMPAGE IN THOUSANDS OF ACRE-FEET
1935	20	—
1936	20	132
1937	20	161
1938	20	98
1939	20	79
1940	25	100
1941	9	151
1942	19	172
1943	35	122
1944	52	128
1945	35	149
1946	115	70
1947	100	52
1948	110	40
1949	40	168
1950	90	69
1951	125	26
1952	70	129
1953	120	39
1954	90	80
1955	90	86
1956	90	43
1957	100	70
1958	50	147
1959	100	80
1960	90	111
1961	140	36
1962	60	135
1963	80	101
1964	110	70
1965	150	93
1966	90	133
1967	145	90
1968	78	152
1969	140	89
1970	120	96
1971	190	39
1972	130	67
1973	140	125
1974	110	80
1975	145	109
1976	170	94
1977	213	31
1978	132	75
1979	83	106
1980	107	122
1981	140	110
1982	94	118
1983	72	127
1984	70	135
1985	67	134
1986	59	149
1987	70	138
1988	68	138
TOTAL	4828	5394

HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS SHOWN ON THE MAP
(Dashed line indicates inferred water level)





INDEX MAP SHOWING AREA OF REPORT (SHADED)

TABLE 2 WELLS WITH CONCENTRATIONS OF ARSENIC ABOVE THE MAXIMUM CONTAMINANT LEVEL

WELL LOCATION	ARSENIC (mg/L)
NWSWSW S.03, T.6S., R.23E.	0.260
SWNWNW S.30, T.6S., R.25E.	0.077
SWSWSW S.07, T.7S., R.25E.	0.066
SENESE S.27, T.7S., R.25E.	0.110
NWNENE S.02, T.7S., R.27E.	0.100
NWNWNW S.11, T.7S., R.27E.	0.090

U.S. ENVIRONMENTAL PROTECTION AGENCY MAXIMUM CONTAMINANT LEVEL 0.05 (mg/L)

For readers who prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
acre	0 4047	square hectometer
acre-foot	0.001233	cubic hectometer
gallons per minute	0.06309	liters per second

BASE FROM U.S. GEOLOGICAL SURVEY
MESA, ARIZONA 1947-1952, REV. 1978, 1:250,000
CLIFTON, ARIZONA, 1954, REV. 1972, 1:250,000
TUCSON, ARIZONA, 1922-1957, REV. 1974, 1:250,000
SILVER CITY, NEW MEXICO, 1947-1950, REV. 1970, 1:250,000

DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL, SPRING 1987, HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS, AND CHEMICAL QUALITY OF WATER, 1985-1990

MAPS SHOWING GROUNDWATER CONDITIONS IN THE GILA VALLEY SUB-BASIN OF THE SAFFORD BASIN, GRAHAM AND GREENLEE COUNTIES, ARIZONA--1987

BY
K.R. BLACK