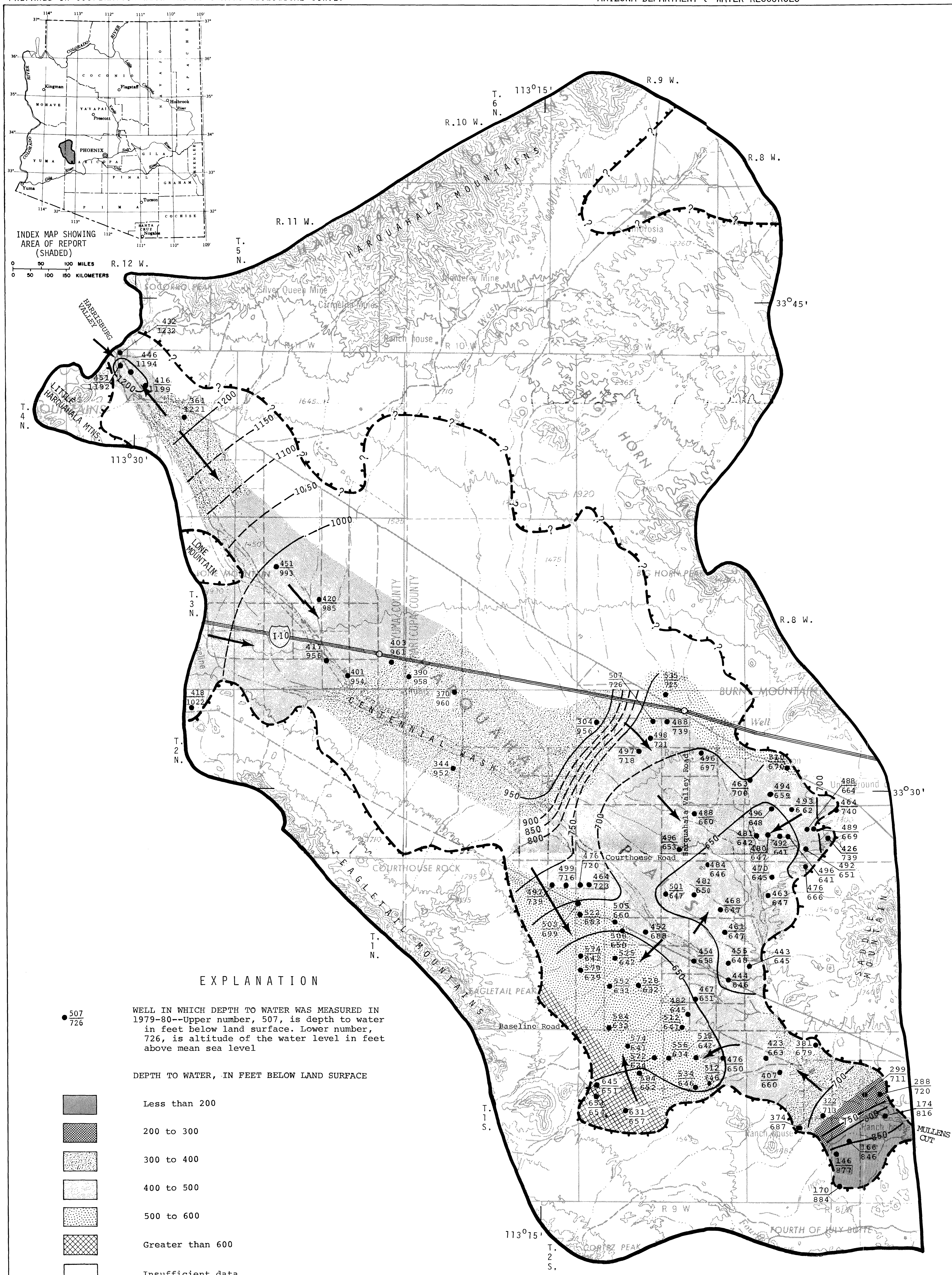
PREPARED IN COOPERATION WITH UNITED STATES GEOLOGICAL SURVEY

ARIZONA DEPARTMENT OF WATER RESOURCES



INDEX MAP SHOWING AREA OF REPORT (SHADED)

0 50 100 MILES
0 50 100 150 KILOMETERS

EXPLANATION

507/726 WELL IN WHICH DEPTH TO WATER WAS MEASURED IN 1979-80--Upper number, 507, is depth to water in feet below land surface. Lower number, 726, is altitude of the water level in feet above mean sea level

DEPTH TO WATER, IN FEET BELOW LAND SURFACE

- Less than 200
- 200 to 300
- 300 to 400
- 400 to 500
- 500 to 600
- Greater than 600
- Insufficient data

650 WATER-LEVEL CONTOUR--Shows altitude of the water level in the main water-bearing unit. Dashed where approximate. Contour interval 50 feet. Datum is mean sea level

GENERALIZED DIRECTION OF GROUND-WATER FLOW

? APPROXIMATE BOUNDARY OF THE MAIN WATER-BEARING UNIT--The main water-bearing unit is principally alluvium, which consists of clay, silt, sand, and gravel. In part of the area the permeable beds of sand and gravel are overlain by thick fine-grained beds; the fine-grained beds, principally clay, probably contribute only small amounts of water to irrigation wells. Outside the boundary of the main water-bearing unit, faulted or fractured consolidated rocks and thin alluvial deposits in narrow valleys may yield small amounts of water to wells. Boundary queried where uncertain

ARBITRARY BOUNDARY OF GROUND-WATER AREA

INTRODUCTION

The Harquahala Plains area includes about 760 square miles in southwestern Arizona. The area is drained by Centennial Wash, which enters on the northwest through the Harrisburg Valley "Narrows" and exits 42 miles southeast through a similar constriction at Mullens Cut. All streams in the area are intermittent; washes and arroyos flow only after heavy rains. The ground-water reservoir, therefore, is the only dependable source of water. The principal use of ground water is for agriculture; nearly all of the ground water pumped is used to irrigate crops.

The hydrologic data on which these maps are based are available, for the most part, in computer-printout form for consultation at the Department of Water Resources, 222 North Central Avenue, Suite 850, Phoenix, and at the U.S. Geological Survey offices at the Federal Building, Box FB-44, 301 West Congress Street, Tucson or Valley Center, Suite 1880, Phoenix. Material from which copies can be made at private expense is available at the Tucson and Phoenix offices of the U.S. Geological Survey.

GROUND WATER

The main water-bearing unit in the Harquahala Plains area is the alluvium, which consists of various deposits of clay, silt, sand, and gravel. The deposits are from less than 300 feet thick near the mountains to more than 2,000 feet thick in the central part of the area. Most of the water yielded to wells comes from coarse deposits described as sand and gravel by Cooley (Denis, 1971, pl. 2) and as conglomerate by the Bureau of Reclamation (1977, p. 77). These deposits yield as much as 2,500 gallons per minute of water to wells.

South of Baseline Road, the alluvium consists mainly of sand and gravel. North of baseline Road, however, the coarse deposits are overlain by fine-grained beds, principally clay. The generalized extent of the fine-grained beds as mapped by Cooley (Denis, 1971, pl. 2) is shown on Sheets 2 and 3. The thickness of the fine-grained beds increases to the northwest, and the beds are more than 1,000 feet thick in the western part of T. 2 N., R. 9 W. Although the fine-grained beds are included with the main water-bearing unit, they probably contribute little water to wells. In this part of the Harquahala Plains area, most wells obtain water from the coarse material underlying the fine-grained beds; locally, however, interbedded sand and gravel lenses may contribute moderate to large quantities of water to some wells.

In the newly developed agricultural acreage in the west-central part of the area (sections 34 and 36, T. 3 N., R. 11 W., and adjoining acreage), wells penetrate a sequence of alternating fine and coarse layers, and bottom in conglomerate at about 900 feet below the land surface. The alternating fine and coarse layers probably grade laterally to the southeast into the fine-grained beds but well logs for the intervening area are not available to confirm this. In the north, northwest, and northeast parts of the Harquahala Plains area the characteristics of the main water-bearing unit are generally unknown.

Outside the boundary of the main water-bearing unit a few wells obtain small amounts of water from faulted or fractured consolidated rocks or from thin alluvium overlying the consolidated rocks. These wells supply water for domestic, stock, and mining uses.

In the early 1950's, prior to significant ground-water development in the Harquahala Plains area, the slope of the ground-water surface was from northwest to southeast at a low gradient, and ground water discharged from the area at Mullens Cut. The depth to water ranged from 17 feet at the southeastern outlet to more than 240 feet along the mountain fronts.

Recharge to the ground-water reservoir from precipitation or runoff in the Harquahala Plains area is small. Metzger (1957, p. 32) believed recharge to "be of the order of a few thousand acre-feet annually." Underflow into the Harquahala Plains area through the Harrisburg Valley "Narrows" was originally thought to be inappreciable because the cover of alluvium is narrow and thin within the "Narrows". In August 1958, a series of flash floods filled a reservoir constructed on Centennial Wash at the "Narrows" (Sec. 5, T. 4 N., R. 12 W.). Sinkholes soon formed in the bottom of the reservoir, and rapidly drained the reservoir of water. Consequently, a water-level rise was observed in a downstream well (see Hydrograph E, Sheet 2), suggesting that recharge through the "Narrows" area might be greater than originally believed. (See Kam, 1964, p. 55-58, for details of these events.) At the location of the reservoir, the bedrock consists of complexly faulted, fractured, and folded sandstone and limestone (Varga, 1977, p. 17, and written communication, 1978), and probably provides numerous conduits for the movement of water into the alluvium of the upper part of the Harquahala Plains area.

As indicated by static water-level measurements, ground water beneath the Hubbard Plain, which borders the Harquahala Plains area west of Lone Mountain between the Little Harquahala Mountains and the Eagletail Mountains, probably moves eastward into the Harquahala Plains area. In the Hubbard Plain area, surface water flows west in Bouse Wash, a tributary of the mainstem of the Colorado River.

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
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
gallon per minute	0.06309	liter per second

5 0 5 MILES
5 0 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL

DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL, 1980

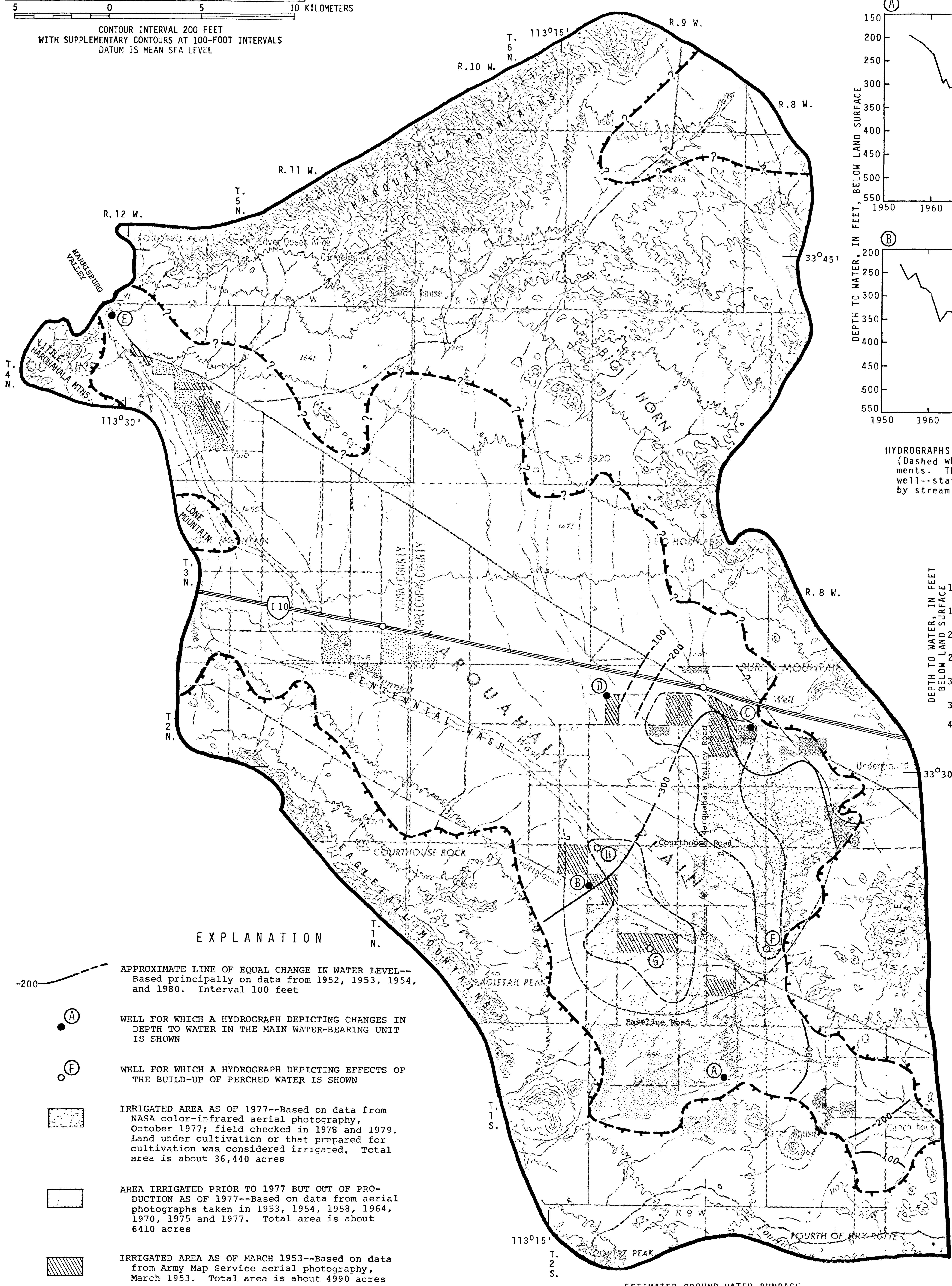
MAPS SHOWING GROUND-WATER CONDITIONS IN THE HARQUAHALA PLAINS AREA MARICOPA AND YUMA COUNTIES, ARIZONA--1980

by

C. G. Graf

5 0 5 MILES
5 0 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL



EXPLANATION

-200 APPROXIMATE LINE OF EQUAL CHANGE IN WATER LEVEL--Based principally on data from 1952, 1953, 1954, and 1980. Interval 100 feet

Ⓐ WELL FOR WHICH A HYDROGRAPH DEPICTING CHANGES IN DEPTH TO WATER IN THE MAIN WATER-BEARING UNIT IS SHOWN

Ⓕ WELL FOR WHICH A HYDROGRAPH DEPICTING EFFECTS OF THE BUILD-UP OF PERCHED WATER IS SHOWN

IRRIGATED AREA AS OF 1977--Based on data from NASA color-infrared aerial photography, October 1977; field checked in 1978 and 1979. Land under cultivation or that prepared for cultivation was considered irrigated. Total area is about 36,440 acres

AREA IRRIGATED PRIOR TO 1977 BUT OUT OF PRODUCTION AS OF 1977--Based on data from aerial photographs taken in 1953, 1954, 1958, 1964, 1970, 1975 and 1977. Total area is about 6410 acres

IRRIGATED AREA AS OF MARCH 1953--Based on data from Army Map Service aerial photography, March 1953. Total area is about 4990 acres

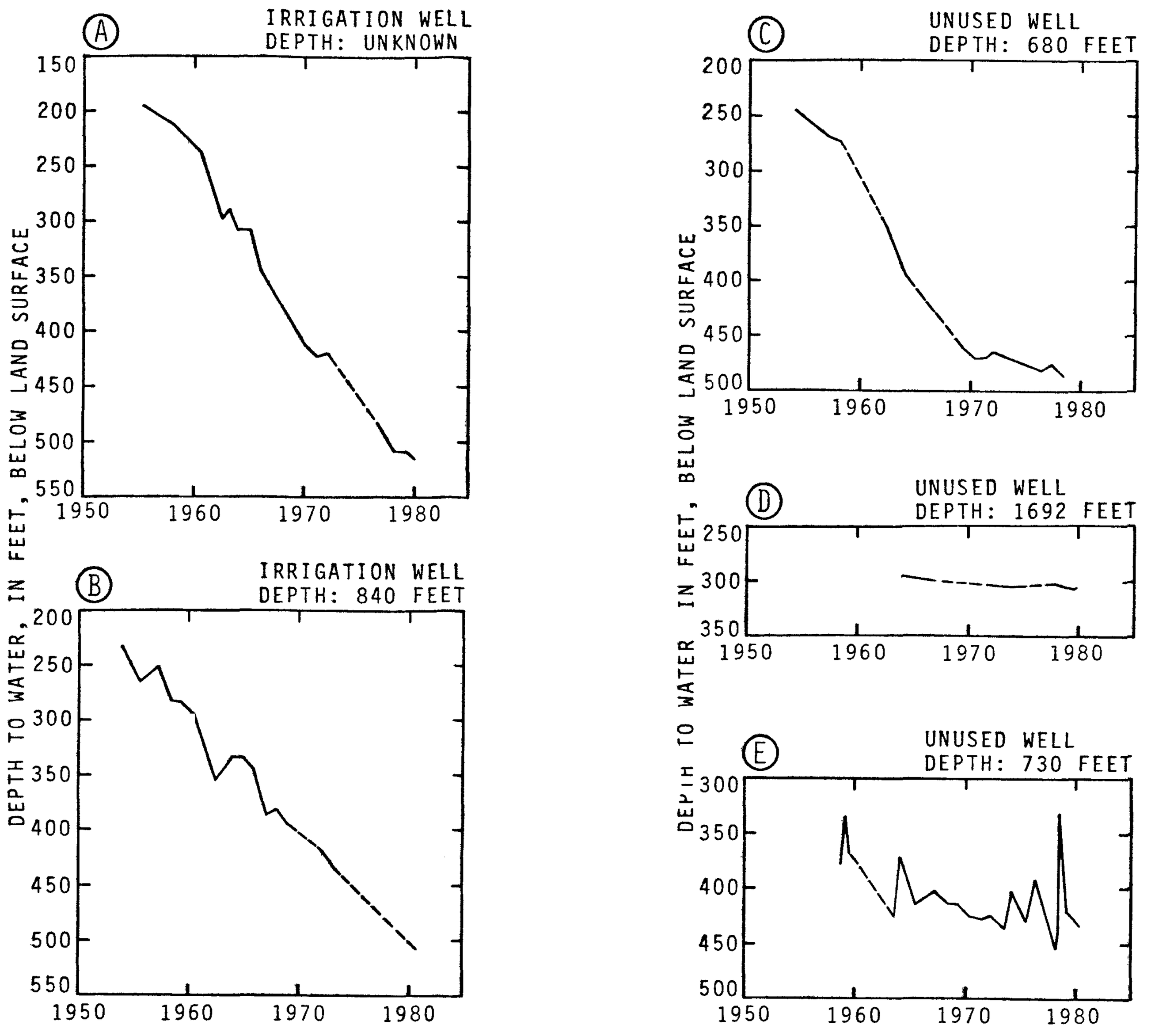
APPROXIMATE AREA IN WHICH PERCHED GROUND WATER IS KNOWN TO BE PRESENT

GENERALIZED LIMIT OF FINE-GRAINED BEDS--Slightly modified from Cooley (Denis, 1971, pl.2). Queried where uncertain

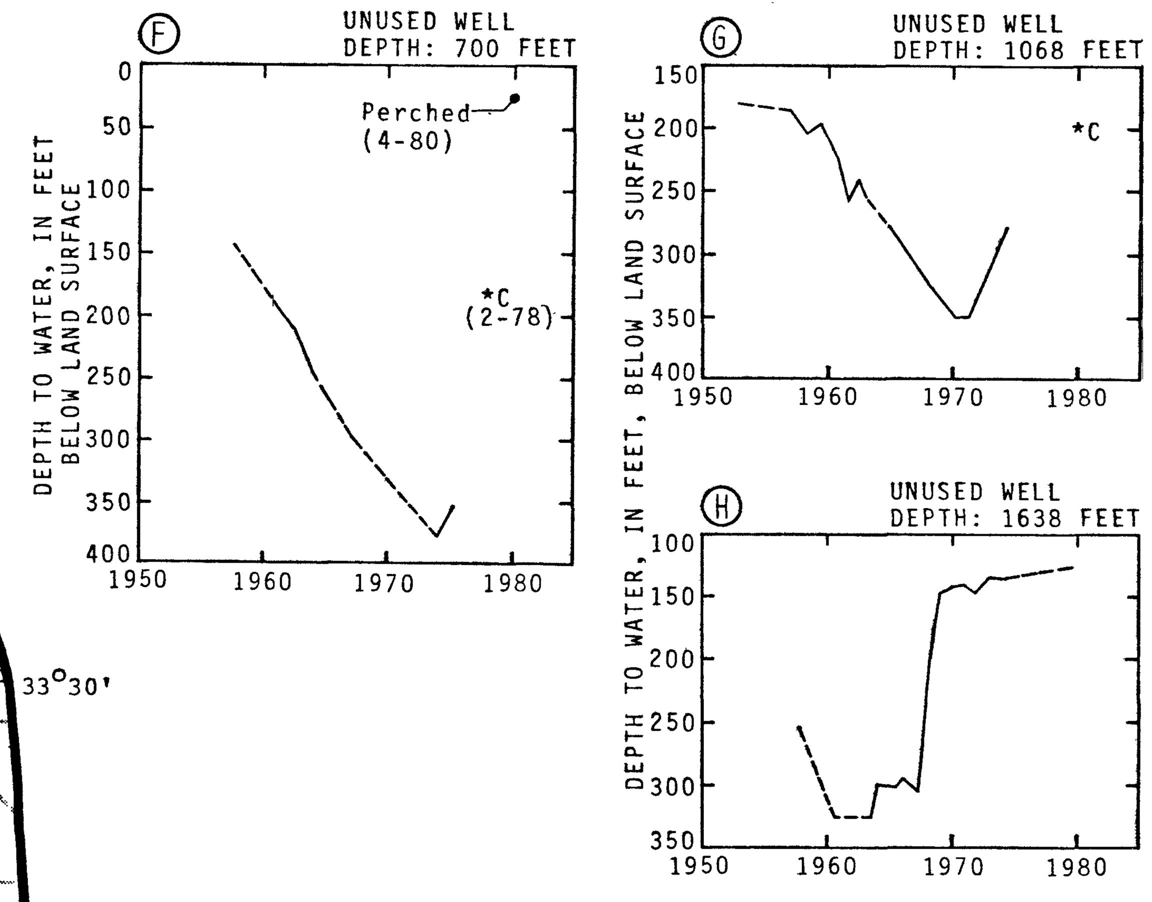
APPROXIMATE BOUNDARY OF THE MAIN WATER-BEARING UNIT--The main water-bearing unit is principally alluvium, which consists of clay, silt, sand, and gravel. In part of the area the permeable beds of sand and gravel are overlain by thick fine-grained beds; the fine-grained beds, principally clay, probably contribute only small amounts of water to irrigation wells. Outside the boundary of the main water-bearing unit, faulted or fractured consolidated rocks and thin alluvial deposits in narrow valleys may yield small amounts of water to wells. Boundary queried where uncertain

ARBITRARY BOUNDARY OF GROUND-WATER AREA

HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS THAT TAP THE MAIN WATER-BEARING UNIT
(Dashed where more than one pumping season intervened between measurements)



HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS AFFECTED BY PERCHED WATER
(Dashed where more than one pumping season intervened between measurements. The symbol, *C, represents level at which cascading water entered well--static water level could not be obtained because of interference by stream of cascading water.)



GROUND WATER DEVELOPMENT AND THE FORMATION OF ZONES OF PERCHED WATER

In 1953, about 5,000 acres of land was cultivated in the Harquahala Plains area using ground water for the irrigation of crops; about 20,000 acre-feet of ground water was withdrawn in 1953. By 1957, the withdrawal of ground water had caused changes in the ground-water flow system, and a cone of depression had begun to develop in the irrigated area. Extensive development continued and in 1962-65, the annual withdrawal of ground water was about 200,000 acre-feet, which resulted in water-level declines of more than 20 feet annually. Beginning in the late 1960's annual ground-water pumpage decreased as some farmland was abandoned due to the large declines in water level. In 1978 and 1979, ground-water pumpage was about 100,000 and 87,000 acre-feet, respectively. As of 1980, water levels have declined more than 300 feet in much of the southeastern portion of the Harquahala Plains area; abandoned farmland and wells are common, particularly near the boundary of the main water-bearing unit.

Large-scale withdrawal of ground water has caused several cones of depression to develop beneath the irrigated farmland. Two large depressions have formed in the southeast part of the area and ground water now moves into these depressions from all directions. Little if any ground water now moves out of the area at Mullens Cut. A smaller cone of depression underlies farmlands southeast of Harrisburg Valley; another cone is beginning to develop in T. 3 N., R. 11 W., in the west-central part of the area.

In parts of the Harquahala Plains area, downward percolation of irrigation water has caused a buildup of perched water over the fine-grained beds. The extent of the perched water zones, as well as the configuration of the perched water level, is irregular and may reflect differences in the permeability of the fine-grained beds. Generally, the altitude of the perched water level is higher than the altitude of the water level in the main water-bearing unit in the early 1950's At least 27 wells exhibit effects of the buildup of perched water. In some wells, perched water issues into the well through an opening in the casing and cascades down the well to the static water level below (Hydrograph G). The cascading water mixes with the water standing in the well and discharges through casing perforations into the main water-bearing unit. In other wells, the water level has risen in contrast to the general trend of water-level decline, often to stabilize in apparent hydrostatic equilibrium with the perched zone (Hydrograph H). Sometimes, a stream of cascading water is engulfed as the water level rises in the well (Hydrograph E). The reason for the rise in water levels in wells penetrating the fine-grained beds and bottoming in the underlying coarser materials is unclear, but could be the result of casing failure and collapse, encrustation of the perforations, plugging of the perforations with clay, or clogging of the aquifer by entrapped air and clay in the cascading water.

ESTIMATED GROUND-WATER PUMPAGE IN THE HARQUAHALA PLAINS AREA
(Numbers rounded to nearest thousand acre-feet)

Year	Pumpage, in thousands of acre-feet	Year	Pumpage, in thousands of acre-feet	Year	Pumpage, in thousands of acre-feet
1940	1	1955	30	1970	111
1941	1	1956	40	1971	99
1942	1	1957	50	1972	108
1943	1	1958	60	1973	109
1944	1	1959	95	1974	137
1945	1	1960	125	1975	130
1946	1	1961	100	1976	129
1947	1	1962	200	1977	123
1948	1	1963	200	1978	100
1949	1	1964	200	1979	87
1950	5	1965	200		
1951	7	1966	160		
1952	10	1967	170		
1953	20	1968	165		
1954	33	1969	145	TOTAL:	3158

EARTH FISSURING AND LAND SUBSIDENCE

In southern Arizona, water-level declines of 300 feet are often accompanied by earth-fissuring and large-scale land subsidence. In the Harquahala Plains area, however, evidence is limited to two small earth fissures, one in section 9, T. 2 N., R. 9 W. and one in section 36, T. 2 N., R. 9 W. The fissure in section 9, first visible on a 1958 aerial photo appeared to have been dormant for many years when examined in the field in 1978. The fissure in section 36 opened up in an irrigated field in 1961, was soon filled by the farmer, and has not reappeared since. The antiquity of fissuring and the proximity of fissures to irrigated fields suggest that the fissuring was caused by near-surface subsidence due to application of irrigation water to dry soil rather than to large-scale land subsidence caused by ground-water withdrawal. In June 1980, a line of benchmarks, anchored in bedrock outcrops at each end, was established across the area along Harquahala Valley Road to detect future land subsidence.

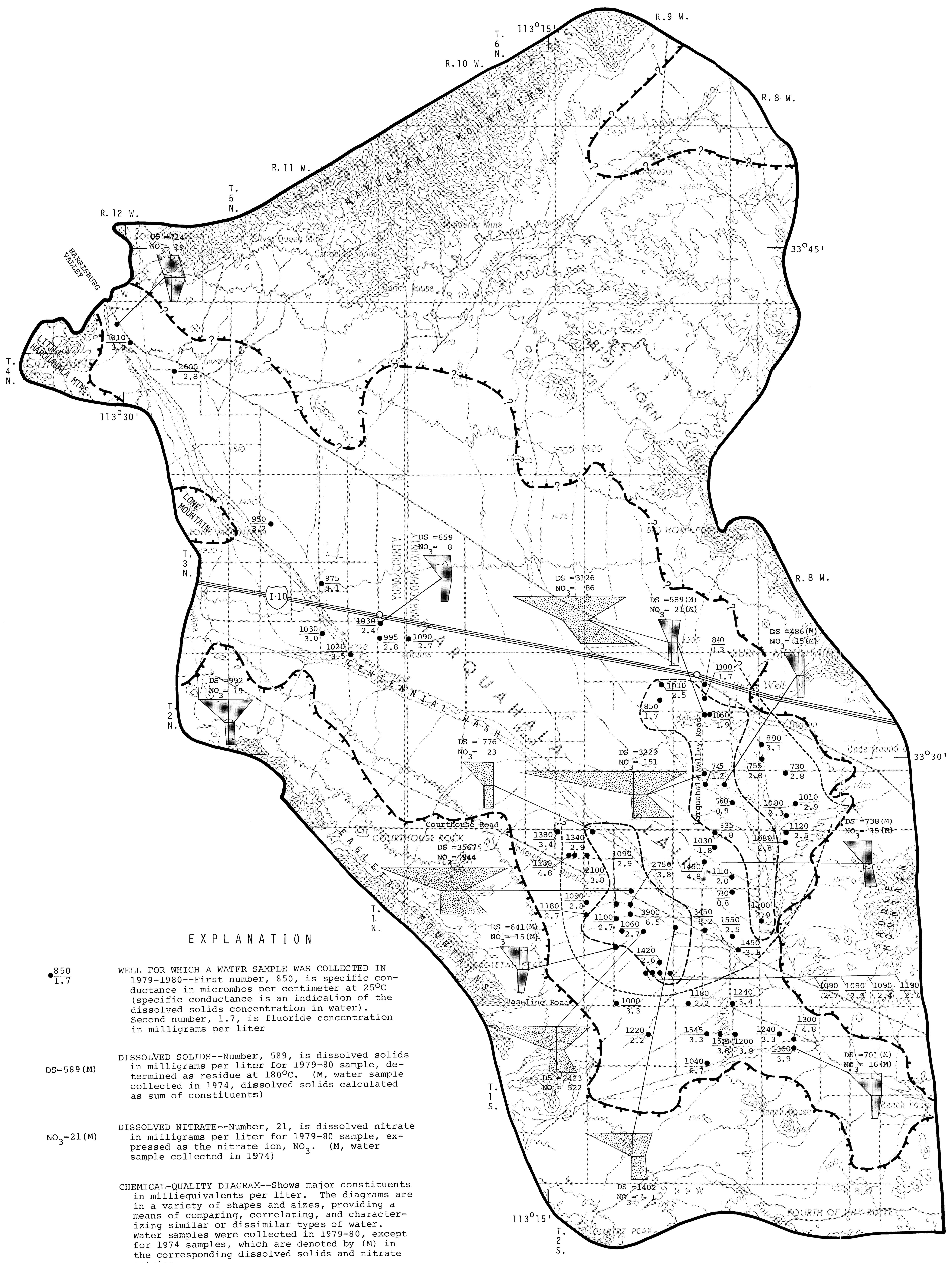
CHANGE IN WATER LEVEL, 1953-1980, IRRIGATED AREA, AND HYDROGRAPHS OF THE WATER LEVEL IN SELECTED WELLS

MAPS SHOWING GROUND-WATER CONDITIONS IN THE HARQUAHALA PLAINS AREA MARICOPA AND YUMA COUNTIES, ARIZONA--1980

by
C. G. Graf

PREPARED IN COOPERATION WITH UNITED STATES GEOLOGICAL SURVEY

ARIZONA DEPARTMENT OF WATER RESOURCES



EXPLANATION

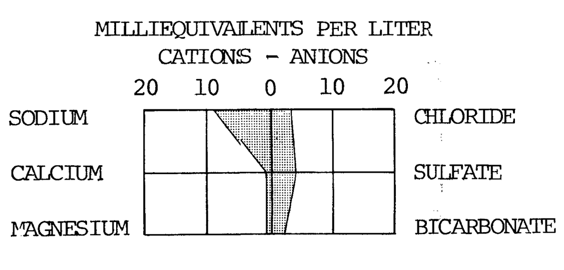
$\frac{850}{1.7}$ WELL FOR WHICH A WATER SAMPLE WAS COLLECTED IN 1979-1980--First number, 850, is specific conductance in micromhos per centimeter at 25°C (specific conductance is an indication of the dissolved solids concentration in water). Second number, 1.7, is fluoride concentration in milligrams per liter

DS=589(M) DISSOLVED SOLIDS--Number, 589, is dissolved solids in milligrams per liter for 1979-80 sample, determined as residue at 180°C. (M, water sample collected in 1974, dissolved solids calculated as sum of constituents)

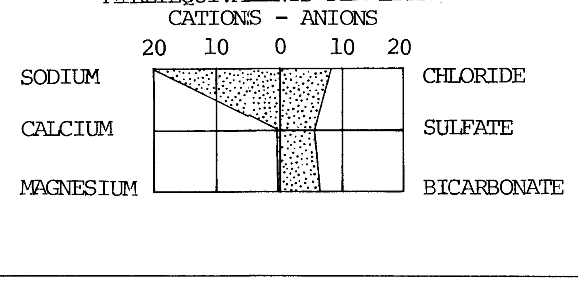
NO_3=21(M) DISSOLVED NITRATE--Number, 21, is dissolved nitrate in milligrams per liter for 1979-80 sample, expressed as the nitrate ion, NO_3. (M, water sample collected in 1974)

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. Water samples were collected in 1979-80, except for 1974 samples, which are denoted by (M) in the corresponding dissolved solids and nitrate entries

Sample from well obtaining water from main water-bearing unit



Sample collected from the perched zone



APPROXIMATE AREA IN WHICH PERCHED GROUND WATER IS KNOWN TO BE PRESENT

GENERALIZED LIMIT OF FINE-GRAINED BEDS--Slightly modified from Cooley (Denis, 1971, pl.2). Queried where uncertain

APPROXIMATE BOUNDARY OF THE MAIN WATER-BEARING UNIT--The main water-bearing unit is principally alluvium, which consists of clay, silt, sand, and gravel. In part of the area the permeable beds of sand and gravel are overlain by thick fine-grained beds; the fine-grained beds, principally clay, probably contribute only small amounts of water to irrigation wells. Outside the boundary of the main water-bearing unit, faulted or fractured consolidated rocks and thin alluvial deposits in narrow valleys may yield small amounts of water to wells. Boundary queried where uncertain

ARBITRARY BOUNDARY OF GROUND-WATER AREA

CHEMICAL QUALITY OF GROUND WATER

In the Harquahala Plains area, the ground water from the main water-bearing unit is suitable for the irrigation of most crops. However, without treatment to remove excess dissolved fluorides, the ground water generally is unsuitable for human consumption. The specific conductance of water, values for which are shown on the map, differs with the concentration of ions in solution; an estimate of the dissolved-solids concentration may be obtained by multiplying the specific conductance by 0.6. Generally, the dissolved-solids concentrations are about 400 to 1,000 mg/L (milligrams per liter). The specific conductance for a few water samples, however, indicated dissolved-solids concentrations of 1,500 to 2,000 mg/L; these water samples may have been contaminated by water from the perched zone or by poorer quality water in localized zones within the main water-bearing unit. The maximum contaminant level for dissolved solids in public water supplies is 500 mg/L, as proposed in the secondary drinking-water regulations of the U.S. Environmental Protection Agency (1977b, p. 17146). The U.S. Environmental Protection Agency (1977a, b) has established primary and secondary regulations for the quality of water provided by public water systems. Primary drinking-water regulations, enforceable either by the Environmental Protection Agency or by the States, govern contaminants in drinking-water that have been shown to affect human health. Secondary drinking-water regulations, intended as guidelines for the States but not Federally enforceable, apply to contaminants that affect aesthetic quality. The regulations express limits as "maximum contaminant levels," where contaminant means any physical, chemical, biological, or radiological substance or matter in water.

The maximum contaminant level for fluoride in public water supplies differs according to the annual average maximum daily air temperature (Bureau of Water Quality Control, 1978, p. 6). The amount of water consumed by humans, and, therefore, the amount of fluoride ingested depends partly on air temperature. In the Harquahala Plains area, the annual average maximum daily air temperature is about 85°F, and the maximum contaminant level for fluoride is 1.4 mg/L. The fluoride concentrations in ground water from the main water-bearing unit are greater than 1.4 mg/L in nearly all of the water sampled. Fluoride concentrations range from 0.8 to 6.7 mg/L and average about 3.0 mg/L.

Perched water from six wells was collected for chemical analysis. In five of the wells, water was collected either by pumping or bailing the column of perched water standing in the well. In one well, a stream of water cascading into the well from the perched zone was sampled. The perched water contains larger amounts of dissolved solids than ground water from the main water-bearing unit. The concentrations of dissolved solids for the perched water range from 1,402 to 3,567 mg/L, except for one sample that contained 776 mg/L of dissolved solids. Fluoride concentrations also are higher and range from 3.2 to 17.6 mg/L; the average fluoride concentration is 6.8 mg/L.

Dissolved nitrate in four of the six perched water samples exceeded the maximum contaminant level of 10 mg/L expressed as nitrogen, N (Bureau of Water Quality Control, 1978, p. 5), equivalent to 45 mg/L expressed as the nitrate ion, NO_3. The dissolved nitrate concentrations measured in the six samples were 1, 23, 86, 151, 522, and 944 mg/L, expressed as the nitrate ion, NO_3. In comparison, water from the main water-bearing unit contains dissolved nitrate in concentrations generally ranging from 8 to 21 mg/L, again expressed as the nitrate ion, NO_3. Despite the unsuitability of the perched water for domestic use, the water has been utilized because it is found at much shallower depth than water from the main water-bearing unit. At least one domestic system presently withdraws water from the perched zone.

SELECTED REFERENCES

Bureau of Water Quality Control, 1978, Drinking water regulations for the State of Arizona: Arizona Department of Health Services duplicated report, 39 p.

Denis, E.E., 1971, Ground-water conditions in the Harquahala Plains, Maricopa and Yuma Counties, Arizona: Arizona State Land Department Water-Resources Report 45, 44 p.

__________ 1976, Maps showing ground-water conditions in the Harquahala Plains area, Maricopa and Yuma Counties, Arizona--1975: U.S. Geological Survey Water-Resources Investigations 76-33, 2 sheets.

Kam, W., 1964, Geology and ground-water resources of McMullen Valley, Maricopa and Yuma Counties, Arizona: U.S. Geological Survey Water-Supply Paper 1665, 64 p.

Metzger, D.G., 1957, Geology and ground-water resources of the Harquahala Plains Area, Maricopa and Yuma Counties, Arizona: Arizona State Land Department Water-Resources Report 3, 40 p.

National Academy of Sciences and National Academy of Engineering, 1973, [1974], Water quality criteria, 1972: U.S. Environmental Protection Agency Report, EPA-R3-73-033, 594 p.

Ross, C.P., 1923, The lower Gila region, Arizona--a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U.S. Geological Survey Water-Supply Paper 498, 237 p.

Stulik, R.S., 1964, Effects of ground-water withdrawal, 1954-63, in the lower Harquahala Plains, Maricopa County, Arizona: Arizona State Land Department Water-Resources Report 17, 8 p.

U.S. Bureau of Reclamation, 1976, Central Arizona Project geology and ground water resources report, Maricopa and Pinal Counties, Arizona: U.S. Bureau of Reclamation publication, 105 p.

U.S. Environmental Protection Agency, 1976 [1978], Quality criteria for water: U.S. Environmental Protection Agency publication, 256 p.

__________ 1977a, National interim primary drinking-water regulations: U.S. Environmental Protection Agency Report, EPA-57019-76-003, 159 p.

__________ 1977b, National secondary drinking-water regulations: Federal Register, vol. 42, no. 62, March 31, 1977, p. 17143-17147.

U.S. Geological Survey, 1975, Annual report on ground water in Arizona with emphasis on Gila Bend Basin, McMullen Valley, and the southeast part of the Harquahala Plains, Spring 1973 to Spring 1974: Arizona Water Commission Bulletin 9, 45 p.

Varga, R.J., 1977, Geology of the Socorro Peak area, western Harquahala Mountains: Arizona Bureau of Geology and Mineral Technology Circular 20, 20 p.

5 0 5 MILES
5 0 5 10 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL

CHEMICAL QUALITY OF WATER

MAPS SHOWING GROUND-WATER CONDITIONS IN THE HARQUAHALA PLAINS AREA
MARICOPA AND YUMA COUNTIES, ARIZONA--1980
by
C. G. Graf