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# Geology and ground-water resources of the Wellton-Mohawk area, Yuma County, Arizona

by

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Prepared in cooperation with

Arizona State Land Department

O. C. Williams, Commissioner

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# INTRODUCTION

## Purpose and cooperation

The rapid depletion of the ground-water resources of Arizona during the past few years has called attention to the need for State regulation of these resources. However, as such control must be based on adequate information as to quality, quantity, source, and movement of the ground water, the Arizona State Legislature in 1945 appropriated funds for the investigation of the important ground-water basins in the state. The work done in the Wellton-Mohawk area was performed as a part of this State-wide program. The work was done on a cooperative basis between the Arizona State Land Department, O. C. Williams, Commissioner, and the United States Geological Survey, Department of the Interior. Field work in the Wellton-Mohawk area was performed by H. M. Babcock and A. M. Sourdry, engineers; and by S. C. Brown, G. E. Hazen, and C. T. Snyder, geologists, under the direct supervision of S. F. Turner, District Engineer (Ground Water), of the Federal Geological Survey. Water analyses were made by J. D. Hem and R. T. Kiser, chemists, under the general direction of C. S. Howard, District Chemist of the Geological Survey.

## Location

The Wellton-Mohawk area is a wide, flat desert plain that extends from the town of Dome upstream along the Gila River for a distance of about 40 miles. This area is composed of the Wellton Valley on the west and of the northern part of the Mohawk Valley on the east. These two valleys are partially separated by the Copper Mountains, Baker Peaks, and Antelope Hill. The area is bounded on the east by the Mohawk Mountains; on the west by the Gila Mountains; on the north by the Muggins and Castle Dome Mountains; and on the south by the Wellton Hills, the Copper Mountains, and by an arbitrary line extending northeast from the Copper Mountains across the Mohawk Valley to the town of Mohawk. The area lies entirely within Yuma County and covers about 700 square miles.

## Climate

The Wellton-Mohawk area has a climate characterized by mild winters and hot, dry summers. The average precipitation is 4.43 inches a year at Mohawk, according to a 43-year record of the U. S. Weather Bureau. The temperature ranged from 28° F. to 118° F. during 1945. The mean annual temperature at Mohawk is 74.2° F. and the frost-free season is more than 11 months.

## History of development

The accounts of early explorers and of old settlers still living in the area indicate that the Gila River has changed materially since it first was seen by white men. At one time the river contained sufficient surface water for irrigation and supported a luxuriant growth of cottonwood and willow trees along its banks. At the present time (1946) there is no water for irrigation from surface flow of the river, and the large groves of cottonwood and willow have been replaced by less luxuriant arrow weed and salt cedar. Water now flows in the river only for short periods after infrequent, heavy local rainstorms.

The earliest agricultural development by white settlers in the area took place in conjunction with the establishment of the stations that served the early overland stage lines. The first stage line was established in 1857[1] and followed the Gila River from Fort Yuma to Sacaton, a distance of about 190 miles. Intermittent irrigation development, with the formation of several canal companies, continued in the area until 1905, when a disastrous flood on the Gila River washed out most of the canals and canal headings. Several subsequent unsuccessful attempts have been made to use the surface flow of the Gila River for irrigation, but the increased diversions of water for irrigation in the upper reaches of the Gila and Salt rivers have left progressively less surface water for use in the Wellton-Mohawk area. As a result, farmers have developed more and more ground water for irrigation. About 7,000 acres of land was under cultivation in 1946, the water for all of which was derived from wells. Plate 1 shows the cultivated areas and the locations of all irrigation wells. Table 1 contains records of typical wells in the area.

### Previous investigations

Earlier studies of the geology and ground-water resources of the Wellton-Mohawk area are described in the following reports:

1. Ross, C. P., Routes to desert watering places in the lower Gila region, Ariz.: U. S. Geol. Survey Water-Supply Paper 490-c, pp. 271-315, 1922.
2. Bryan, Kirk, Routes to desert watering places in the Papago country, Ariz.: U. S. Geol. Survey Water-Supply Paper 490-D, pp. 317-429, 1922.
3. Ross, C. P., The lower Gila Region, Ariz., a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 498, 1923.
4. Bryan, Kirk, The Papago country, Ariz., a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 498, 1925.
5. Water levels and artesian pressure in observation wells in the United States, part 6, Southwestern states and Territory of Hawaii, calendar year 1945: U. S. Geol. Survey water-supply paper in preparation.
6. Wilson, E. D., Geology and mineral deposits of southern Yuma County, Ariz.: Ariz. Bur. Mines, Geol. Ser. No. 7, Bull. 134, 1933.

## GEOLOGY AND ITS RELATION TO GROUND WATER

### Maps and field work

Field work in the Wellton-Mohawk area was done from February to April 1946. Because of the limited time available the work was planned to be of reconnaissance nature, and therefore no attempt was made to map the geology of the area in detail. The geology was mapped directly on topographic maps of the U. S. Geological Survey. Geological field work was divided as follows: the Muggins and Laguna Mountains by G. E. Hazen; the Mohawk and Castle Dome Mountains by C. T. Snyder; and the Gila and Copper Mountains, Baker Peaks, and Wellton Hills by S. C. Brown. The areal geology is shown on plate 1. An idealized section of the valley fill is shown in figure 1.

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1/ Ross, C. P., The lower Gila region, Arizona, a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 498, p. 97, 1923.

## Geologic history

The geologic history during pre-Cambrian time is obscure because the rocks have been highly metamorphosed and eroded. It is evident, however, that these metamorphic rocks are of both sedimentary and igneous origin.

Small, isolated outcrops of boulder conglomerate of possible Mesozoic age occur in the Gila and Muggins Mountains. This indicates that the Mesozoic deposits have been largely removed by erosion or that the deposition was on a minor scale.

The end of the Mesozoic era and the beginning of the Cenozoic era were marked by intense faulting and volcanism. The faulting probably produced the present-day, northwest-trending mountain ranges. The volcanism resulted in the deposition of several hundred feet of agglomerates, tuffs, and lavas. Late in Tertiary time the troughs between the mountain ranges were partly filled with boulder conglomerate and lake beds. Some of the Tertiary (?) sedimentary rocks appear to have been deposited on land, and widespread lake beds indicate that playas or shallow lakes existed over large parts of the area.

General uplift apparently marked the beginning of Quaternary time. Alternating deposition and down-cutting in the basin produced the present-day terraces (see pl. 1). Some volcanism took place simultaneously with the later uplifting, although it apparently was on a minor scale in comparison to the volcanism of the Tertiary and Cretaceous time. At the present time the Gila River is aggrading within the area, and the channel is being filled with fine silts and sands.

## Structural geology

The Wellton-Mohawk area is a part of two northwest-trending structural basins that were formed by block faulting. The major faults, which probably parallel the main mountain ranges, are covered by valley fill of Tertiary and Quaternary age.

The first period of major faulting and folding probably took place during pre-Cambrian time, and produced the highly contorted metamorphic rocks exposed in the mountains. The second period of major faulting and folding occurred at the end of the Cretaceous period and the beginning of the Tertiary period. This faulting probably produced the present-day, northwest-trending mountain ranges, and the major faults have a general N. 25° W. strike. Faulting and folding continued intermittently, on a diminished scale, through the Tertiary into the Quaternary period. This is indicated by the displacement of the older alluvium along faults on the east and northeast sides of the Muggins Mountains and by displacement of the Quaternary (?) basalt by faults in the Castle Dome Mountains. There are two distinct sets of faults in these two mountain ranges with general N. 65° W. and N. 55° E. strikes, respectively.

## Stratigraphy

### Metamorphic rocks (pre-Cambrian?)

Gneiss is the most common metamorphic rock exposed in the area. It is tentatively regarded as pre-Cambrian in age. This gneiss, where observed, appears to be metamorphosed granitic rock as in places it grades into granite.

Two distinct types of schist were observed in the area, one of sedimentary origin and the other of igneous origin. Both types are considered to be pre-Cambrian in age. A narrow zone of schist at the north end of the Gila Mountains is composed of metamorphosed sedimentary rocks. It contains marbles and slates, which are altered limestones and shales, respectively. Between the Copper Mountains and Baker Peaks is a zone of gently dipping, medium gray schist of probable sedimentary origin. Schist of sedimentary origin is also exposed on the east end of the Laguna Mountains and on the west and northwest sides of the Muggins Mountains. All other schist observed in the area is composed of metamorphosed granitic rocks.

No wells, springs, or natural tanks were observed or reported in the metamorphic rocks.

### Igneous rocks

#### Pre-Cambrian(?) granite

Two distinct types of granite were observed in the Gila Mountains. The most abundant type is a light gray to white, medium to very coarse-grained, massive granite. It weathers to a light brown to buff color. Similar granite was observed in the southern half of the Copper Mountains.

Near the northern end of the Gila Mountains is an intrusion of highly decomposed, epidotized granite porphyry. It has a medium gray color on a fresh fracture and weathers grayish brown. It disintegrates readily by weathering and breaks up into large, well-rounded boulders.

The true age of the granite is problematical, as no detailed studies have been made. It is tentatively regarded as pre-Cambrian in age; however, Wilson[2/] states it may be as late as Mesozoic or Tertiary.

No wells or springs were observed or reported in these granites. A few perennial natural tanks are reported in the higher mountains.

#### Cretaceous (?) and Tertiary volcanic rocks

Widespread areas of volcanic rocks of Cretaceous (?) and Tertiary age are exposed in the Laguna, Muggins, and Castle Dome mountains. The rocks consist of several hundred feet of flat-lying to gently-dipping, well-stratified tuffs, breccias, agglomerates, and lava flows.

In the Muggins Mountains a section of the older volcanic rocks was estimated to be more than 1,000 feet in thickness. The total thickness of volcanics is probably much more than 1,000 feet, but owing to the faulting and tilting, reliable estimates are not possible without more detailed study.

No wells or springs were reported in these volcanic rocks. Several perennial natural tanks were observed in the mountains.

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2/ Wilson, E. D., Geology and mineral deposits of southern Yuma County, Ariz.: Ariz. Bur. Mines, Geol. Ser. No. 7, Bull. 134, p. 185, 1933.

Quaternary (?) basalts

In the Castle Dome Mountains the older volcanic rocks are capped by a series of basalt flows of probable Quaternary age. Signal Butte is composed of a dark basalt that is younger than the Cretaceous (?) and Tertiary volcanic tuffs, breccia, and agglomerate of the Castle Dome and Muggins Mountains. This basalt is tentatively regarded as Quaternary in age.

The basaltic lavas are essentially non water-bearing in the area because of their limited extent and their high elevation.

## Sedimentary rocks

Pre-Tertiary (?) rocks

In a highway cut on the east side of Telegraph Pass, in the Gila Mountains, is an exposure of boulder conglomerate about 800 feet above the Gila River. The conglomerate consists of gneiss, schist, and granite boulders in a matrix of coarse red arkose. The boulders are sub-angular to poorly rounded and some are as large as several feet in diameter. The conglomerate is non-stratified and rests upon an uneven surface of granitic gneiss. The stratigraphic position and lithologic character of the conglomerate indicate an age older than Tertiary. Evidence is insufficient, however, to assign a definite age to this formation.

In the Laguna and Muggins Mountains conglomerates, which may be of Mesozoic age, are overlain by Cretaceous (?) and Tertiary volcanic rocks. Wilson[3/], with reference to these conglomerates, states:

> "These strata are gray, brown and maroon in color, and seem lithologically identical with the Mesozoic beds that appear twelve miles farther north in the Castle Dome Mountains."

These conglomerates are so tightly cemented that they are essentially non water-bearing in the area.

Tertiary (?) rocks

Probably the oldest of the sedimentary rocks in the basin tentatively assigned to the Tertiary, are the arkosic sandstones (sandstone formed from granitic debris) exposed in Baker Peaks and Antelope Hill and in the two small hills 2¼ miles southwest of Antelope Hill. A log of a Southern Pacific Railroad well (899, table 2) at Wellton shows sandstone at a depth of 1,000 feet. This sandstone may be equivalent to that of Antelope Hill. On the northwest corner of the Gila Mountains and the extreme northern end of the Mohawk Mountains are exposures of similar arkosic sandstone, thin-bedded gray to red shale, and cobble to boulder conglomerate with an arkosic matrix. An outcrop of similar sediments was observed on the west side of State Highway 95, about 4 miles west of Dome.

Tilted, well-stratified, weakly-consolidated, cross-bedded conglomerate, sandstone, arkose, clay, and silt are exposed at the northern end of the Gila Mountains, and on the south sides of the Laguna and Muggins mountains. These rocks are probably of Tertiary age.

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3/ Wilson, E. D., op. cit., p. 219.

Between the Copper Mountains and Baker Peaks is a range of low hills that rise to a maximum height of 450 feet above the plain. These hills are composed of non-stratified, moderately-cemented boulder conglomerates. Similar conglomerates were observed along the northeast side of the Gila Mountains and at the northern end of the Mohawk Mountains.

The older Tertiary (?) sediments in the area are generally poor water-bearers, as they are usually tightly cemented. The loosely-cemented conglomerates exposed along the northeast side of the Gila Mountains may take in some water. Several wells in the area penetrate the Tertiary (?) sandstones, but none of the wells are known to produce water from this formation. No springs were observed or reported that derive water from the older Tertiary sediments. The only perennial natural tanks observed or reported in the Tertiary (?) sediments are known as the Baker Tanks, on the southwest side of the Baker Peaks. These are natural potholes in the steeply-dipping arkosic sandstones and conglomerates.

Alluvial fill of probable Tertiary age and the older Tertiary sediments constitute the major part of the material that occupies the troughs between the mountain ranges of the area. The Tertiary alluvial fill is not exposed at the surface, as it is covered with Quaternary alluvium. Well logs show that the Tertiary fill is composed mostly of clays, with minor amounts of silts, sands, and gravels. The contact between the Tertiary and Quaternary formations is uncertain, owing to their lithologic similarity. Therefore, the water-bearing characteristics of the Tertiary alluvium are discussed in the following section.

Quaternary and Tertiary alluvium

Alluvium of Quaternary and Tertiary age underlies the desert plain between the mountains of the Wellton-Mohawk area. The Gila River and its tributary washes have formed terraces on this alluvial plain. There are three pronounced terraces on the north side of the river, the lowest of which ("first terrace") is the floodplain of the river. The third or oldest (highest) terrace was not observed on the south side of the river. The materials underlying the second and third terraces will be discussed here as "older alluvial fill", and those underlying the first terrace as "younger alluvial fill".

Older alluvial fill.-The second and third terraces on the north side of the Gila River lie adjacent to the Muggins and Castle Dome mountains. At the surface of the third or upper terrace is a thin mantle of boulder conglomerate that overlies undifferentiated Quaternary and Tertiary sediments. This conglomerate is composed of poorly-sorted and loosely-cemented boulders of granite, gneiss, and schist and of rhyolite, basalt, and other volcanic material. The boulders are angular to sub-angular. At the surface of the second terrace is 5 to 10 feet of cobble to boulder conglomerate. This conglomerate is underlain by clays, silts, sands, and gravels of undifferentiated Quaternary and Tertiary age.

On the south side of the Gila River, the second terrace usually is underlain by a thin deposit of silt and sand, but locally the surficial deposit consists of about 5 feet of coarse gravel.

Well logs show that the materials underlying the second terrace are predominantly silt, sand, and gravel, down to a depth of about 200 feet. Below this depth the material is predominantly clay. On the basis of age determination of similar deposits in Arizona approximately the uppermost 200 feet of these sediments is believed to be of Quaternary age, but the contact between the Tertiary and Quaternary sediments is not certain.

No wells are known to have been put down on the third terrace. Several wells have been drilled on the second terrace, and these wells are reported to yield from 500 to 1,000 gallons a minute from the sands and gravels in the uppermost 200 feet. Very little water was found below 200 feet.

Younger alluvial fill.-The floodplain of the Gila River ("first terrace") is underlain by 80 to 105 feet of loosely-consolidated gravel with scattered boulders, and by sand and silt. These sediments are of late Quaternary age and lie unconformably upon the clays of the older alluvial fill.

The sands and gravels of the younger alluvial fill are the principal water-bearing beds in the Wellton-Mohawk area. Wells in these materials produce up to 4,000 gallons a minute.

## GROUND-WATER RESOURCES

The alluvial fill contains the only important water-bearing beds in the Wellton-Mohawk area. The other rocks in the area are non water-bearing or poor water-bearers, and therefore the discussion of ground-water resources in this report is confined to the alluvial-fill materials. Although the alluvial fill has been separated into two groups according to age, namely "older alluvial fill" and "younger alluvial fill", aquifers in both groups are interconnected, so that the ground-water reservoir of the area is continuous through the older and the younger alluvial fill. The younger alluvial fill, however, has more numerous and better aquifers.

### Occurrence of ground water

Ground water occurs in large quantities in the pore spaces of the gravel, sand, silt, and clay deposits of the valley fill. Although silt and clay are more porous than gravel and sand, the pore spaces in the silt and clay are so small that little or no water can be drained or removed. Therefore, the gravel and sand layers are the chief source of water. Tables 1 and 2 contain records and logs of typical wells in the valley fill.

The older alluvial fill is composed largely of silt and clay, with thin beds of gravel and sand. Several wells drilled in the older alluvial fill have yields reported to be between 500 and 1,000 gallons a minute, with drawdowns of 20 to 60 feet. The specific capacities of these wells range from 10 to 25 gallons a minute per foot of drawdown. In the past, several attempts have been made to develop irrigation wells in these materials, but apparently water was not available in sufficient quantities to make development practical, as all the wells drilled for irrigation have been abandoned. In 1946 no wells in the older alluvial fill were used for irrigation purposes.

The younger alluvial fill is composed largely of gravel and sand with very little silt and clay, and it yields water to wells more readily than the older alluvial fill. Available well logs show alternating beds of gravel, sand, and silt with a total maximum thickness of about 100 feet. Below the younger alluvial fill the less permeable material of the older fill is encountered. Although the younger fill is comparatively thin, the proportion of permeable sand and gravel is so large that it is possible to obtain a large quantity of water with a small drawdown. The yields of wells range from about 600 to 4,000 gallons a minute, with drawdowns of 10 to 20 feet. The specific capacities of the wells range from about 60 to about 200 gallons a minute per foot of drawdown. All irrigation water in the area is derived from wells in these materials.

## Recharge

Recharge of the alluvial fill of the area is from four sources: (1) Infiltration from flows in the Gila River and its tributary washes; (2) infiltration from irrigation water applied to the land; (3) underflow of the Gila River into the area; and (4) rainfall.

### Stream flow

Infiltration from stream flow is one of the principal sources of recharge to the ground-water reservoir of the Wellton-Mohawk area. Most of the runoff in the smaller washes and creeks disappears by seepage into the stream bed materials, and the water either percolates to the water table or returns to the air by evaporation and transpiration. No tests were made in this area on the rate of infiltration from flows in desert washes. The work of Babcock and Cushing[4] in the Queen Creek area shows that, in that area, about one-half of the total stream flow is recharged to the ground-water reservoir. In the Wellton-Mohawk area, surface flows in the tributary washes seldom reach the Gila River.

At infrequent intervals, surface flow occurs in the Gila River and water percolates down through the coarse sands and gravels of the river channel to the water table.

### Irrigation

The recharge from irrigation seepage to the ground-water reservoir of the Wellton-Mohawk area was estimated to be about 9,000 acre-feet a year in 1944-45. This value was based on tests made in the Safford Valley, where somewhat similar conditions exist. In the Safford Valley it was determined that about 25 percent of the water applied directly to the land was recharged to the water table[5].

### Underflow

Underflow of the Gila River through the alluvial fill contributes recharge to the ground-water reservoir of the area. The underflow into the area at Mohawk was estimated to be 5,000 acre-feet a year. This estimate is only approximate, and detailed studies would be required to obtain a more exact figure.

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4/ Babcock, H. M., and Cushing, E. M., Recharge to ground-water from floods in a typical desert wash, Pinal County, Ariz.: Am. Geophys. Union Trans., p. 52, 1941.

5/ Turner, S. F., and others, Water resources of Safford and Duncan-Virdon Valleys, Ariz. and N. Mex.: U. S. Geol. Survey (mimeographed), p. 28, 1941.

## Rainfall

As the climate is arid, there is little recharge directly from rainfall to the ground-water reservoir of the area. Upon reaching the land surface the water from rainfall runs off as surface flow or percolates into the ground, or may evaporate back into the air. Most of the water that enters the ground directly from rainfall returns to the air by evaporation and transpiration[6] and does not reach the water table.

## Movement of ground water

A contour map of the water table was prepared as of February 1946 (see pl. 1), on the basis of water-level measurements in wells and upon land-surface elevations taken from topographic maps of the Bureau of Reclamation, United States Department of the Interior. This water-table contour map helped to determine the source and direction of movement of the ground water.

The ground water moves in a uniform manner down the slope of the water table perpendicular to the contours. The contours show that the general slope of the water table is toward the Gila River and to the west. The westward slope of the water table decreases from 10 feet per mile near the northern end of the Mohawk Mountains to 1.3 feet per mile near Wellton. This decrease in slope is largely caused by heavy pumping for irrigation along the Gila River in the vicinity of Roll and Wellton. The lowering of the water table in the irrigated areas has increased the rate of movement of ground water from the outlying areas of older alluvial fill toward the Gila River. This movement is especially noticeable in the vicinity of Wellton, where the movement of water is toward the pumping area from both sides of the river.

## Discharge

Ground water is discharged from the basin by pumping for irrigation and by natural means. Natural discharge includes transpiration and evaporation of ground water in the areas of dense growths of natural vegetation along the river channel, and underflow out of the area along the river channel through the narrows near Dome. There is no natural discharge of ground water by surface flow out of the area.

### Pumpage

All irrigation water in the area is obtained from wells. The irrigation wells range in discharge from 600 to 4,000 gallons a minute. Most of the wells are drilled to a depth of about 100 feet. The average pumping lift is from 35 to 40 feet.

The amount of water pumped from wells in the area for irrigation was computed to be 37,000 acre-feet in 1944 and 35,000 acre-feet in 1945. No pumping data are available for the years prior to 1944, but the large number of abandoned wells and farms indicate that pumping in the past was greater than it is at present. A record of each irrigation well was made, and the quantity of water pumped by each well was determined for the years 1944-45. The amount of water pumped was determined as follows: The discharge of the well was measured either with a current meter or a sharp-crested weir, or by the trajectory method. Where

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6/ Turner, S. F., and others, Ground-water resources of the Santa Cruz basin, Ariz.: U. S. Geol. Survey (mimeographed), pp. 53-61, 1943.

electric power was used, the kilowatt-hour demand for each pump was measured, and the number of hours of operation was computed from the power record. The Mohawk Municipal Water Conservation District kept accurate records of the number of hours each of their pumps was operated, which greatly facilitated the pumpage computations. For the few wells where diesel and gasoline engines were used, the amount of water pumped was estimated.

It is estimated that about 75 percent of the water pumped is discharged from the irrigated area through transpiration and evaporation. This amounted to a loss of water from the area of about 28,000 acre-feet in 1944 and 26,000 acre-feet in 1945.

### Natural discharge

Prior to the development of irrigation wells, natural discharge from the area occurred at the lower end as both surface flow and underflow of the Gila River and, in addition, discharge occurred through evaporation and through transpiration by phreatophytes (water-loving vegetation) growing along the river bottom. The lowering of the water table through pumping has greatly reduced the underflow leaving the valley. The lowering of the water table also has resulted in a saving of water because the natural vegetation has become less abundant, so that the amount of water transpired is smaller. The amount of water lost by direct evaporation where the water table is near the surface has also been reduced. No data were available to compute the amount of water lost from the area through evaporation and transpiration in the river bottoms. However, it can be assumed that this would amount to several thousand acre-feet each year. This assumption is based upon experiments conducted in the Safford Valley[7], where it was computed that 12,400 acres of dense river-bottom vegetation used 70,000 acre-feet of water annually.

Underflow out of the area, through the alluvial fill, is estimated to be less than 1,000 acre-feet a year.

### Fluctuation of the water table

The two principal factors that affect the level of the ground-water reservoir are the pumping of water for irrigation and the use of water by phreatophytes. A study of the water-level fluctuations shows that, in the alluvial fill along the river bottom, there is a seasonal lowering of the water table during the pumping season, with only a partial recovery after the pumping season.

There has been a gradual downward trend of the water table in the area since heavy pumping started (see fig. 2). On the basis of information obtained from records of the Mohawk Municipal Water Conservation District and from the local farmers, the water table in the farmed areas has been declining at an average rate of 0.9 foot a year for the past 20 years. Water levels in wells outside the farmed area have not declined as rapidly as in the farmed area. The amount of water withdrawn from storage, as indicated by the declining water levels, is estimated to have averaged about 14,000 acre-feet a year.

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7/ Turner, S. F., and others, Water resources of Safford and Duncan-Virden Valleys, Ariz. and N. Mex.: U. S. Geol. Survey (mimeographed), p. 30, 1941.

# QUALITY OF WATER

## Chemical character of ground water

The chemical character of ground water in the Wellton-Mohawk area has been determined from analyses of 74 samples. Nearly all the wells sampled obtain water from the younger alluvial fill. Wells in this fill generally yield highly-mineralized water. The dissolved mineral content of samples of ground waters in the younger alluvial fill ranged from 1,120 parts per million to 16,500 parts per million, very few samples containing less than 2,000 parts per million. A concentration of 16,500 parts per million is equivalent to 22.4 tons of dissolved matter per acre-foot of water. These waters contain mainly sodium and chloride but also contain large quantities of calcium, magnesium, and sulfate. Generally, wells in the older alluvial fill also yield rather highly-mineralized water, but in most places the dissolved-solids content of this water is less than 2,000 parts per million and usually consists mainly of sodium and chloride.

Analyses of samples from 11 typical wells in the area are included in table 3.

Plate 2 was prepared from all the available analyses, and this map shows the concentration of dissolved solids in ground waters in most of the area. Plate 2 shows that, in general, the most highly mineralized ground waters occur in the irrigated district near Roll, but highly-mineralized waters also occur both east and west of the Roll district.

## Relation of quality of water to use

### Irrigation

Ground waters from the younger alluvial fill are for the most part "injurious to unsatisfactory" for irrigation, according to the classification of Wilcox and Magistad[8/]. Not one of these waters is low enough in dissolved solids and sodium percentage to be considered "excellent to good", and probably none is low enough in all constituents even to be considered "good to injurious". Agricultural development of the area has been retarded by the poor quality of the available water.

Many wells in the younger fill now yield water much more highly mineralized than they yielded 10 or even 5 years ago. The downward trend of water levels in the area has been accompanied by an upward trend in the dissolved-solids content of the water. Figure 2 illustrates these trends for wells 689 and 812. Well 689 had the most highly mineralized water of the area in 1946. This water has increased about 10 times in dissolved-solids concentration since 1927. The water from well 812 has more than doubled in dissolved-solids concentration since 1925, and most of the change has occurred since 1933.

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8/ Wilcox, L. V., and Magistad, O. C., Interpretation of analyses of irrigation waters and the relative tolerance of crop plants: U. S. Dept. Agr., Bur. of Plant Industry, Soil and Agr. Research Administration, Riverside, Calif., (Mimeographed), 8 pp., May 1943.

## Domestic use

Nearly all the ground waters of the area are unfit for most domestic uses because of their high total mineral content and excessive hardness. Drinking water, in many instances, is hauled into the area, often from considerable distances. The few waters in the area that are low enough in dissolved solids to be satisfactory for drinking usually contain sufficient amounts of fluoride to cause permanent mottling of tooth enamel when drunk continuously by young children. In the Wellton-Mohawk area, high fluoride content is usually associated with a high percentage of sodium in the water, and waters of this type are usually obtained from wells that penetrate the older alluvial fill.

## Relation of quality of water to recharge and source of dissolved solids in ground water

Before irrigation development in areas upstream from the Wellton-Mohawk area began, the main source of recharge for the younger alluvial fill was the surface flow of the Gila River. The flood flows in the river were probably low in dissolved solids, and therefore water entering the ground-water reservoir from this source was also low in dissolved solids. Increasing use of water from the Gila River and its tributaries upstream reduced the flow of the river through the area and increased the dissolved-solids concentration of the water. As a result, the water recharged from infiltration of river water was more highly mineralized. With continued expansion of irrigation upstream, surface flows in the river in the Wellton-Mohawk area have decreased until, under present conditions (1946), there is no surface flow during a normal year. Consequently, only a very small amount of recharge can be expected from this source.

The underflow entering the area along the river channel consists of water of high mineral content. An additional amount of water of somewhat lower mineral content enters the pumped area from the older alluvial fill. Plate 2 shows that the amount of inflow from the older fill is significant because in places less highly mineralized water from the older fill apparently influences the quality of the water in the younger fill.

From the analyses, it seems likely that a major cause of the increase in mineral content of ground water in the area is the drainage from irrigated lands. This drainage water seeps downward, carrying with it some of the soluble salts that were contained in water evaporated or used by the plants. Recharge from irrigation, therefore, causes a progressive increase in the concentration of dissolved matter. Lack of movement of ground water away from the irrigated area results in re-use of the same water several times, its concentration increasing with each use.

The extent of the changes that have taken place in the quality of water in the area since development began is indicated by comparison of the analyses made in 1946 with partial analyses made 20 to 40 years ago at the University of Arizona[9]. These partial analyses show that some of the ground waters of the area had dissolved-solids concentrations as high as 5,000 parts per million in that period, but no ground waters

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9/ Catlin, C. N., Character of the ground water resources of Arizona: Univ. of Ariz., Coll. Agr., Agr. Exp. Sta. Bull. 114, pp. 173-293, 1926.

were reported with extremely high concentrations, comparable to those found in waters near Roll in 1946. It seems likely that these extremely high concentrations are a relatively recent development, probably because the pumping for irrigation has reduced the amount of salts removed from the area by natural discharge.

### Discharge of dissolved solids from the area

Dissolved solids are discharged from the area principally by underflow of the Gila River through the narrows at Dome. The last appreciable surface flow at the gaging station near Dome occurred in August 1941. Occasional flood flows in the river through the area may remove some of the accumulated dissolved matter from the ground-water reservoir, mainly because these flood flows raise ground-water levels and increase the underflow leaving the area.

The underflow leaving the area has been estimated to average less than 1,000 acre-feet per year, and it is evident that this amount of water cannot carry a large amount of salt. The underflow entering the area is estimated to be 5,000 acre-feet per year, and this water brings in many times more salt than is removed. That dissolved salts are accumulating in the ground waters of the area is indicated by the increasing concentration of water from many of the wells.

## SUMMARY AND CONCLUSIONS

The Wellton-Mohawk area is a flat desert plain that extends from the town of Dome upstream along the Gila River for a distance of about 40 miles. It lies entirely within Yuma County and covers about 700 square miles. The area is a part of two northwest-trending structural basins that were formed by block faulting. Gravel, sand, silt, and clay have been washed into these basins by the Gila River and its tributary washes. The Gila River has formed three terraces upon the desert plain. At the surface in the higher terraces are thin deposits of Quaternary alluvium. The materials underlying the surficial deposits in the second and third (upper) terraces are clays, sands, and gravels of undifferentiated Quaternary and Tertiary age, termed "older alluvial fill". The materials underlying the first (lowest) terrace are silts, sands, and gravels of Quaternary age, termed "younger alluvial fill". These materials extend to a depth of about 100 feet and are underlain by the older alluvial fill.

All the irrigation water used in the area is obtained from wells in the younger alluvial fill. About 7,000 acres was irrigated during 1945. Water can be developed from the sands and gravels of the older alluvial fill, but in lesser quantities than from the younger fill. Several attempts have been made in the past to develop water supplies for irrigation from this aquifer, but these attempts have been unsuccessful.

Ground water in the area is derived mainly from seepage losses from flows in the Gila River and tributary washes, infiltration of water used for irrigation, and underflow entering the area at the upper end. Rainfall is thought to contribute little or no recharge. It was not possible to estimate the amount of recharge from seepage losses from stream flows, but it is estimated that about 5,000 acre-feet of water enters the area each year as underflow of the Gila River. About 9,000 acre-feet of water a year, or about one-fourth of all the water pumped for irrigation, returns to the ground-water reservoir as seepage from irrigated fields. The ground water moves from the eastern and higher parts of the area to the west and toward the Gila River, where it is withdrawn for irrigation.

Ground water is discharged from the basin by pumping for irrigation and by natural means. Natural discharge includes transpiration and evaporation of ground water in the areas of dense growths of natural vegetation along the river channel, and underflow out of the area along the river channel through the narrows near Dome. There is no natural discharge of ground water by surface flow out of the area. The amount of water pumped from wells in the area was computed to be 37,000 acre-feet in 1944 and 35,000 acre-feet in 1945. About three-fourths of the water pumped was discharged from the irrigated area through transpiration and evaporation. This amounts to a loss of water from the area of about 27,000 acre-feet a year. Underflow out of the area, through the alluvial fill, was estimated to be less than 1,000 acre-feet a year.

The water table in the farmed areas has been declining at an average rate of 0.9 foot a year for the past 20 years. Water levels in wells outside the farmed areas have not declined as rapidly.

The ground water in the younger alluvial fill of the area is highly mineralized, and most of it is "injurious to unsatisfactory" for irrigation. One well in the area yielded water containing 22.4 tons of dissolved matter per acre-foot. Generally, wells in the older alluvial fill yield water that is less highly mineralized than water from the younger fill. The most highly mineralized ground waters occur in the irrigated district. Because only a small amount of dissolved salts can leave the basin, the concentration of dissolved matter in ground waters of the area is increasing. In one well, for example, the dissolved mineral content has increased 10 times since 1927.

Although a complete inventory of the ground water in the area was not made, it is evident that the amount of water annually discharged is much greater than the amount of water annually recharged. The excessive lowering of the water table and the increasing chemical concentration of the water show that the safe annual yield has been greatly exceeded, both from a quantitative and from a qualitative standpoint. About 14,000 acre-feet more water is withdrawn each year from the ground-water reservoir than is recharged.

The lowering of the water table and the increasing salt concentration of the ground water point to a continued decline of agriculture in the area. There is no way of improving these conditions except by the addition of water of low chemical concentration. If additional water could be added, provision should be made to insure that enough water leaves the area to remove the excess salts. A program of periodic water-level measurements and water analyses should be undertaken in this event, to determine changes in elevation of the water table, changes in the concentration of dissolved mineral matter in the ground water, and the amount of salts entering and leaving the area.

Table 1. Records of typical wells, Wellton-Mohawk area, Yuma County, Arizona
(All wells are drilled.)

| No. | Location | Owner | Driller | Date completed | Altitude above sea level (feet) | Depth of well (feet) | Diameter of well (in.) |
|---|---|---|---|---|---|---|---|
| | T. 7 S., R. 15 W. | | | | | | |
| d/ 563 | SE¼SE¼ sec. 30 | M.M.W.C.D. | J. W. Belt | 1929 | 298 | 89 | 20 |
| 575 | NE¼SE¼ sec. 30 | do. | do. | 1929 | - | 86 | 20 |
| | T. 8 S., R. 15 W. | | | | | | |
| 585 | NE¼NW¼ sec. 22 | Southern Pacific R.R. | do. | - | 445 | 438 | 16 |
| | T. 7 S., R. 16 W. | | | | | | |
| 668 | NE¼SE¼ sec. 26 | M.M.W.C.D. | Belt and Miller | 1928 | 286 | 83 | 20 |
| d/ 689 | NW¼NW¼ sec. 35 | do. | do. | 1927 | 284 | 83 | 20 |
| | T. 8 S., R. 16 W. | | | | | | |
| 722 | SE¼NW¼ sec. 28 | Smiley Field | do. | - | - | 419 | 16 |
| d/ 726 | NW¼SW¼ sec. 30 | Roy Kelland | I. Proebstel | 1926 | 347 | 301 | 16 |
| | T. 8 S., R. 17 W. | | | | | | |
| 784 | SE¼NE¼ sec. 2 | M.M.W.C.D. | Belt and Miller | - | 263 | 83 | 20 |
| d/ 790 | NE¼SE¼ sec. 10 | do. | - | 1930 | 257 | 128 | 20 |
| d/ 812 | SE¼NE¼ sec. 16 | M.M.W.C.D. | Belt and Miller | 1925 | - | 108 | 20 |
| 816 | NW¼NW¼ sec. 32 | W. J. Walker | I. Proebstel | 1926 | 306 | 167 | 16 |
| 819 | S½SW¼ sec. 34 | Max Noah | Belt and Proebstel | 1924 | 396 | 492 | 16 |
| | T. 8 S., R. 18 W. | | | | | | |
| d/ 870 | SW¼SE¼ sec. 31 | H.G.Hindman | F. Lydendecker | 1937 | 231 | 123 | 20 |
| d/ 882 | SE¼NE¼ sec. 34 | R.B. Deason | L. A. Smith | 1922 | 231 | 95 | 18 |

a/ Measuring point was usually top of casing, top of pump base, top of water pipe clamp, or top of well curb.

b/ T, turbine; C, cylinder; Cf, centrifugal; E, electric; G, gasoline; W, windmill.

Well records obtained by H. M. Babcock and A. M. Sourdry

| No. | Water level: Depth below measuring point (feet) a/ | Water level: Date of measurement | Pump and power b/ | Use of water c/ | Temp. °F. | Remarks |
|---|---|---|---|---|---|---|
| 563 | - | - | T,E | I | 75 | See log. Discharge 1,780 gallons a minute, measured Mar. 1946. Owned by Mohawk Municipal Water Conservation District. |
| 575 | 28.88 | May 2, 1945 | None | N | - | See log. |
| 585 | 180.57 | Jan. 15, 1946 | T,G | D | 80 | Reported discharge 200 gallons a minute. See log. |
| 668 | 24.40 | Apr. 2, 1946 | None | N | - | See log. |
| 689 | 31.41 | do. | T,E | - | 76 | Discharge 1,810 gallons a minute, measured April 2, 1946. See log. |
| 722 | 82.67 | Feb. 28, 1946 | T,E | N | - | See log. |
| 726 | 131.00 | Feb. 6, 1946 | T,E | D | 84 | Discharge 370 gallons a minute, measured May 2, 1946. See log. |
| 784 | 33.58 | May 3, 1945 | None | N | - | Reported discharge 2,100 gallons a minute with 24 foot drawdown. See log |
| 790 | 46.65 | Dec. 20, 1945 | T,E | I | 74 | Discharge 1,530 gallons a minute, measured Mar. 1946. See log. |
| 812 | 32.00 | do. | T,E | I | 74 | Discharge 1,920 gallons a minute, measured Dec. 10, 1946. See log. |
| 816 | 97.66 | Feb. 4, 1946 | None | N | - | See log. |
| 819 | 170.30 | Feb. 7, 1946 | None | N | - | Do. |
| 870 | 34.40 | Jan. 30, 1946 | T,E | I | 76 | Discharge 1,840 gallons a minute, measured April 3, 1946. See log. |
| 882 | 37.80 | Jan. 16, 1946 | C,E | I | 76 | Discharge 2,390 gallons a minute, measured Feb. 28, 1946. See log. |

c/ I, irrigation; D, domestic; N, not used.
d/ See table 3 for analysis of water sample.

Table 1. Records of typical wells, Wellton-Mohawk area, Yuma County, Arizona-Cont.

| No. | Location | Owner | Driller | Date completed | Altitude above sea level (feet) | Depth of well (feet) | Diameter of well (in.) |
|---|---|---|---|---|---|---|---|
| | T. 9 S., R. 18 W. | | | | | | |
| d/ 895 | SW¼NW¼ sec. 5 | Leo Hughes | F. E. Lydendecker | 1945 | - | 95 | 8 |
| 899 | NE¼SW¼ sec. 5 | Southern Pacific R. R. | - | 1904 | 255 | 1,120 | 12 |
| d/ 916 | SE¼NE¼ sec. 9 | J. W. Belt | Belt and Miller | 1927 | 307 | 290 | 16 |
| | T. 9 S., R. 19 W. | | | | | | |
| 962 | NW¼NE¼ sec. 1 | Jay Rohrbough | - | - | 220 | 118 | 24 |
| 975 | SE¼SW¼ sec. 4 | F. McCraw | - | 1926 | - | 95 | 18 |
| d/ 976 | SE¼SW¼ sec. 9 | do. | - | 1939 | 208 | 110 | 18 |
| | T. 8 S., R. 20 W. | | | | | | |
| d/ 1109 | SW¼SE¼ sec. 8 | Unknown | - | - | 177 | - | - |

a/ Measuring point was usually top of casing, top of pump base, top of water pipe clamp, or top of well curb.

b/ T, turbine; C, cylinder; Cf, centrifugal; E, electric; G, gasoline; W, windmill.

Well records obtained by H. M. Babcock and A. M. Sourdry

| No. | Water level: Depth below measuring point (feet) a/ | Water level: Date of measurement | Pump and power b/ | Use of water c/ | Temp. °F. | Remarks |
|---|---|---|---|---|---|---|
| 895 | 55.94 | Jan. 4, 1946 | C,E | D | 80 | See log. |
| 899 | 61.25 | Apr. 30, 1946 | None | N | - | Do. |
| 916 | 117.20 | Feb. 11, 1946 | None | N | - | Do. |
| 962 | 28.72 | Jan. 30, 1946 | Cf,E | I | - | Discharge 2,400 gallons a minute, measured Mar. 25, 1946. |
| 975 | 21.55 | Feb. 4, 1946 | C,W | N | - | See log. |
| 976 | 24.10 | Jan. 31, 1946 | T,E | I | 77 | Discharge 1,550 gallons a minute, measured Jan. 31, 1946. |
| 1109 | 17.26 | May 5, 1946 | None | N | - | - |

c/ I, irrigation; D, domestic; N, not used.
d/ See table 3 for analysis of water sample.

Table 2. Logs of typical wells, Wellton-Mohawk area, Yuma County, Arizona

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Driller's log of well 563 | | |
| Mohawk Municipal Water Conservation District, owner | | |
| SE¼SE¼ sec. 30, T. 7 S., R. 15 W. | | |
| Soil - - - - - - - - - - | 8 | 8 |
| Sand - - - - - - - - - - | 39 | 47 |
| Gravel - - - - - - - - - | 42 | 89 |
| TOTAL DEPTH - - - - - | | 89 |
| Driller's log of well 575 | | |
| Mohawk Municipal Water Conservation District, owner | | |
| NE¼SE¼ sec. 30, T. 7 S., R. 15 W. | | |
| Soil - - - - - - - - - - | 9 | 9 |
| Sand - - - - - - - - - - | 41 | 50 |
| Gravel - - - - - - - - - | 24 | 74 |
| Heavy gravel and boulders | 12 | 86 |
| TOTAL DEPTH - - - - - | | 86 |
| Driller's log of well 585 | | |
| Southern Pacific R. R., owner | | |
| NE¼NW¼ sec. 22, T. 8 S., R. 15 W. | | |
| Dry loose sand - - - - | 3 | 3 |
| Clay - - - - - - - - - - | 37 | 40 |
| Clay and gravel - - - | 150 | 190 |
| Sand and gravel, water-bearing - - - - | 35 | 225 |
| Heaving sand - - - - - | 15 | 240 |
| Water gravel - - - - - | 20 | 260 |
| Clay and gravel - - - | 148 | 408 |
| Boulders, water-bearing | 25 | 433 |
| Solid rock - - - - - - | 5 | 438 |
| TOTAL DEPTH - - - - - | | 438 |
| Driller's log of well 668 | | |
| Mohawk Municipal Water Conservation District, owner | | |
| NE¼SE¼ sec. 26, T. 7 S., R. 16 W. | | |
| Soil - - - - - - - - - - | 7 | 7 |
| Sand - - - - - - - - - - | 33 | 40 |
| Gravel - - - - - - - - - | 37 | 77 |
| Clay - - - - - - - - - - | 6 | 83 |
| TOTAL DEPTH - - - - - | | 83 |
| Driller's log of well 689 | | |
| Mohawk Municipal Water Conservation District, owner | | |
| NW¼NW¼ sec. 35, T. 7 S., R. 16 W. | | |
| Soil - - - - - - - - - - | 7 | 7 |
| Sand - - - - - - - - - - | 33 | 40 |
| Gravel - - - - - - - - - | 37 | 77 |
| Clay - - - - - - - - - - | 6 | 83 |
| TOTAL DEPTH - - - - - | | 83 |
| Driller's log of well 722 | | |
| Smiley Field, owner | | |
| SE¼NW¼ sec. 28, T. 8 S., R. 16 W. | | |
| Soil - - - - - - - - - - | 6 | 6 |
| Red sand - - - - - - - - | 20 | 26 |
| Wash sand - - - - - - - | 6 | 32 |
| Tough red clay - - - - | 99 | 131 |
| Water sand, very good | 6 | 137 |
| Tough red clay - - - - | 120 | 257 |
| Sandstone - - - - - - - | 3 | 260 |
| Tough red clay - - - - | 12 | 272 |
| Muddy flour sand - - - | 9 | 281 |
| Tough brown clay - - - | 7 | 288 |
| Sandstone and clay - - | 14 | 302 |
| Hard red clay - - - - | 3 | 305 |
| Sandy clay - - - - - - | 15 | 320 |
| Hard red clay - - - - | 6 | 326 |
| Very soft sandy clay - | 15 | 341 |
| Sandy clay - - - - - - | 12 | 353 |
| Soft red clay - - - - | 6 | 359 |
| Soft sandstone - - - - | 9 | 368 |
| Water sand, very good | 12 | 380 |
| Sandstone, mixed with water sand, in small lumps - - - - - - - - | 3 | 383 |
| Good water sand - - - | 24 | 407 |
| Muddy water sand - - - | 3 | 410 |
| Good water sand - - - | 6 | 416 |
| Brown clay - - - - - - | 3 | 419 |
| TOTAL DEPTH - - - - - | | 419 |

Table 2. Logs of typical wells, Wellton-Mohawk area-Cont.

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Driller's log of well 726 | | |
| Roy Kelland, owner | | |
| NW¼SW¼ sec. 30, T. 8 S., R. 16 W. | | |
| Clay - - - - - - - - - - - | 43 | 43 |
| Sandstone - - - - - - - | 10 | 53 |
| Gravel - - - - - - - - - | 19 | 72 |
| Clay - - - - - - - - - - | 15 | 87 |
| Sand and clay - - - - - | 15 | 102 |
| Muddy sand - - - - - - | 32 | 134 |
| Clay, fine sand - - - | 4 | 138 |
| Muddy sand - - - - - - - | 8 | 146 |
| Clay - - - - - - - - - - | 8 | 154 |
| Muddy sand - - - - - - | 6 | 160 |
| Hard clay - - - - - - - | 26 | 186 |
| Sand, clay, and sandstone | 6 | 192 |
| Clay - - - - - - - - - - | 50 | 242 |
| Sand - - - - - - - - - - | 28 | 270 |
| Clean sand - - - - - - | 9 | 279 |
| ---------- | 3 | 282 |
| Clay - - - - - - - - - - | 9 | 291 |
| Sand and clay - - - - | 10 | 301 |
| TOTAL DEPTH - - - - - | | 301 |
| Driller's log of well 784 | | |
| Mohawk Municipal Water Conservation District, owner | | |
| SE¼NE¼ sec. 2, T. 8 S., R. 17 W. | | |
| Soil - - - - - - - - - - | 3 | 3 |
| Sand - - - - - - - - - - | 3 | 6 |
| Adobe - - - - - - - - - | 2 | 8 |
| Sand - - - - - - - - - - | 22 | 30 |
| Sand with a little gravel | 8 | 38 |
| Sand and silt - - - - | 12 | 50 |
| Water gravel - - - - - | 30 | 80 |
| Yellow clay - - - - - - | 3 | 83 |
| TOTAL DEPTH - - - - - | | 83 |
| Driller's log of well 790 | | |
| Mohawk Municipal Water Conservation District, owner | | |
| NE¼SE¼ sec. 10, T. 8 S., R. 17 W. | | |
| Soil - - - - - - - - - - | 12 | 12 |
| Sand - - - - - - - - - - | 44 | 56 |
| Gravel, boulders - - - | 57 | 113 |
| Soft clay - - - - - - | 12 | 125 |
| Tough red clay - - - - | 3 | 128 |
| TOTAL DEPTH - - - - - | | 128 |

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Driller's log of well 812 | | |
| Mohawk Municipal Water Conservation District, owner | | |
| SE¼NE¼ sec. 16, T. 8 S., R. 17 W. | | |
| Silt, first water - - | 18 | 18 |
| Fine sand - - - - - - | 27 | 45 |
| Coarse gravel and sand | 63 | 108 |
| TOTAL DEPTH - - - - - | | 108 |
| Driller's log of well 816 | | |
| W. J. Walker, owner | | |
| NW¼NW¼ sec. 32, T. 8 S., R. 17 W. | | |
| Mesa, silt soil - - - | 3 | 3 |
| Hard clay soil - - - | 9 | 12 |
| Desert sand - - - - - | 18 | 30 |
| Clay with hard and soft streaks - - - - | 60 | 90 |
| Sand - - - - - - - - - | 2 | 92 |
| Good gravel - - - - - | 49 | 141 |
| Soft clay, mud - - - | 24 | 165 |
| Hard clay - - - - - - | 2 | 167 |
| TOTAL DEPTH - - - - - | | 167 |
| Driller's log of well 819 | | |
| Max Noah, owner | | |
| S½SW¼ sec. 34, T. 8 S., R. 17 W. | | |
| Topsoil - - - - - - - - | 12 | 12 |
| Coarse sand - - - - - | 6 | 18 |
| Fine sand - - - - - - | 26 | 44 |
| Clay and sand - - - - | 16 | 60 |
| Yellow clay - - - - - | 14 | 74 |
| Sand and clay - - - - | 21 | 95 |
| Soft clay - - - - - - | 30 | 125 |
| Sand - - - - - - - - - | 5 | 130 |
| Sand rock - - - - - - | 10 | 140 |
| Clay - - - - - - - - - | 9 | 149 |
| Sand, little water - | 6 | 155 |
| Clay - - - - - - - - - | 36 | 191 |
| Coarse white sand and gravel - - - - - - - | 21 | 212 |
| Red sand rock - - - - | 26 | 238 |
| Red clay - - - - - - | 46 | 284 |
| Muddy sand - - - - - | 36 | 320 |
| Cemented sand, last 10 feet very hard - - - | 105 | 425 |
| Water sand, fairly clean | 5 | 430 |
| Cemented sand - - - - | 50 | 480 |
| Water sand - - - - - | 12 | 492 |
| TOTAL DEPTH - - - - - | | 492 |

Table 2. Logs of typical wells, Wellton-Mohawk area-Cont.

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Driller's log of well 870 | | |
| H. G. Hindman, owner | | |
| SW¼SE¼ sec. 31, T. 8 S., R. 18 W. | | |
| Silt - - - - - - - - - - | 15 | 15 |
| Clay - - - - - - - - - - | 7 | 22 |
| Sand - - - - - - - - - - | 6 | 28 |
| Clay - - - - - - - - - - | 6 | 34 |
| Sand - - - - - - - - - - | 20 | 54 |
| Clay and sand - - - - - | 18 | 72 |
| Gravel - - - - - - - - - | 51 | 123 |
| TOTAL DEPTH - - - - - | | 123 |
| Driller's log of well 882 | | |
| R. B. Deason, owner | | |
| SE¼NE¼ sec. 34, T. 8 S., R. 18 W. | | |
| Adobe soil - - - - - - - | 20 | 20 |
| River sand - - - - - - - | 22 | 42 |
| Good gravel - - - - - - | 53 | 95 |
| TOTAL DEPTH - - - - - | | 95 |
| Driller's log of well 895 | | |
| Leo Hughes, owner | | |
| SW¼NW¼ sec. 5, T. 9 S., R. 18 W. | | |
| Soil - - - - - - - - - - | 18 | 18 |
| Arroyo sand - - - - - - | 12 | 30 |
| Silt - - - - - - - - - - | 5 | 35 |
| Clay and sand - - - - - | 10 | 45 |
| Arroyo sand - - - - - - | 9 | 54 |
| Silt - - - - - - - - - - | 6 | 60 |
| Gravel - - - - - - - - - | 35 | 95 |
| TOTAL DEPTH - - - - - | | 95 |
| Driller's log of well 899 | | |
| Southern Pacific R. R., owner | | |
| NE¼SW¼ sec. 5, T. 9 S., R. 18 W. | | |
| Loam - - - - - - - - - - | 15 | 15 |
| Sand - - - - - - - - - - | 75 | 90 |
| Gravel - - - - - - - - - | 20 | 110 |
| Sand - - - - - - - - - - | 75 | 185 |
| Red clay - - - - - - - - | 90 | 275 |
| Sand - - - - - - - - - - | 285 | 560 |
| Blue clay - - - - - - - | 145 | 705 |
| Sandstone - - - - - - - | 10 | 715 |
| Clay and gravel - - - - | 10 | 725 |
| Cement gravel - - - - - | 35 | 760 |
| Sandstone - - - - - - - | 45 | 805 |
| Cemented gravel - - - - | 55 | 860 |
| Sandy shale - - - - - - | 5 | 865 |
| Cemented gravel - - - - | 7 | 872 |
| Sandstone - - - - - - - | 8 | 880 |
| White clay - - - - - - - | 5 | 885 |
| Driller's log of well 899-Cont. | | |
| Broken formation - - - - | 53 | 938 |
| Hard rock - - - - - - - | 62 | 1000 |
| Red sandstone - - - - - | 66 | 1066 |
| Red clay - - - - - - - - | 44 | 1110 |
| White sand - - - - - - - | 10 | 1120 |
| TOTAL DEPTH - - - - - | | 1120 |
| Driller's log of well 916 | | |
| J. W. Belt, owner | | |
| SE¼NE¼ sec. 9, T. 9 S., R. 18 W. | | |
| Soil - - - - - - - - - - | 8 | 8 |
| Sand - - - - - - - - - - | 45 | 53 |
| Cemented gravel - - - - | 17 | 70 |
| Sand - - - - - - - - - - | 7 | 77 |
| Yellow clay - - - - - - | 18 | 95 |
| Sand and sandstone, water | 6 | 101 |
| Sand - - - - - - - - - - | 24 | 125 |
| Tough clay - - - - - - - | 5 | 130 |
| Hard clay - - - - - - - | 10 | 140 |
| Soft clay - - - - - - - | 35 | 175 |
| Tough clay - - - - - - - | 13 | 188 |
| Sand and sandstone - - | 20 | 208 |
| Tough clay - - - - - - - | 37 | 245 |
| Sand and sandstone - - | 10 | 255 |
| Hard clay - - - - - - - | 2 | 257 |
| Sand and sandstone - - | 25 | 282 |
| Clay - - - - - - - - - - | 8 | 290 |
| TOTAL DEPTH - - - - - | | 290 |
| Driller's log of well 975 | | |
| F. McGraw, owner | | |
| NE¼SE¼SW¼ sec. 4, T. 9 S., R. 19 W. | | |
| Heavy adobe soil - - - | 18 | 18 |
| Clean fine sand - - - | 4 | 22 |
| Dirty sand - - - - - - - | 19 | 41 |
| Black clay - - - - - - - | 1 | 42 |
| Coarse mixed sand - - | 8 | 50 |
| Black clay - - - - - - - | 5 | 55 |
| Muddy sand - - - - - - - | 11 | 66 |
| Clean arroyo sand with some washed gravel - | 4 | 70 |
| Good clean washed gravel | 10 | 80 |
| Good gravel but more sand | 10 | 90 |
| Good gravel - - - - - - | 4 | 94 |
| Clay - - - - - - - - - - | 1 | 95 |
| TOTAL DEPTH - - - - - | | 95 |

Table 3. Analyses of water from typical wells in Wellton-Mohawk area, Yuma County, Arizona
Numbers correspond to those in table 1 and plate 1
Analyses by Geological Survey. (Parts per million.)

| Well number | Date of collection 1946 | Depth (feet) | Specific conductance ($K \times 10^5$ at 25°C.) | Calcium (Ca) | Magnesium (Mg) | Sodium and Potassium (Na+K) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_3$) | Borate ($BO_3$) | Dissolved solids | Total hardness as $CaCO_3$ | Percent sodium |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 563 | Mar. 22 | 89 | 1,460 | - | - | - | 425 | - | 4,680 | - | - | - | - | - | - |
| 689 | Apr. 2 | 83 | 1,010 | 1,190 | 553 | 4,170 | 475 | 1,960 | 8,420 | - | - | - | 16,500 | 5,240 | 63 |
| 726 | Feb. 6 | 301 | 187 | 21 | 4.2 | 372 | 79 | 263 | 375 | 3.5 | 2.8 | 7.5 | 1,090 | 70 | 92 |
| 790 | Mar. 21 | 128 | 1,070 | 684 | 286 | 1,440 | 534 | 1,120 | 3,120 | - | - | - | 6,910 | 2,880 | 52 |
| 812 | Apr. 21 | 108 | 865 | 401 | 185 | 1,350 | 530 | 868 | 2,370 | 1.6 | 3.1 | - | 5,440 | 1,760 | 62 |
| 870 | Jan. 30 | 123 | 738 | 388 | 212 | 926 | 264 | 426 | 2,260 | 1.3 | 3.8 | 1.2 | 4,350 | 1,840 | 52 |
| 882 | Feb. 27 | 95 | 442 | 263 | 112 | 500 | 274 | 300 | 1,180 | 1.1 | .2 | .8 | 2,490 | 1,120 | 49 |
| 895 | Feb. 4 | 95 | 281 | - | - | - | 234 | - | 705 | 1.5 | - | - | - | - | - |
| 916 | Apr. 23 | 290 | 339 | - | - | - | 64 | - | 725 | - | - | - | - | - | - |
| 976 | Mar. 20 | 110 | 411 | 112 | 48 | 722 | 294 | 352 | 1,020 | - | .6 | - | 2,400 | 477 | 77 |
| 1109 | May 5 | - | 286 | - | - | - | 68 | - | 860 | - | - | - | - | - | - |

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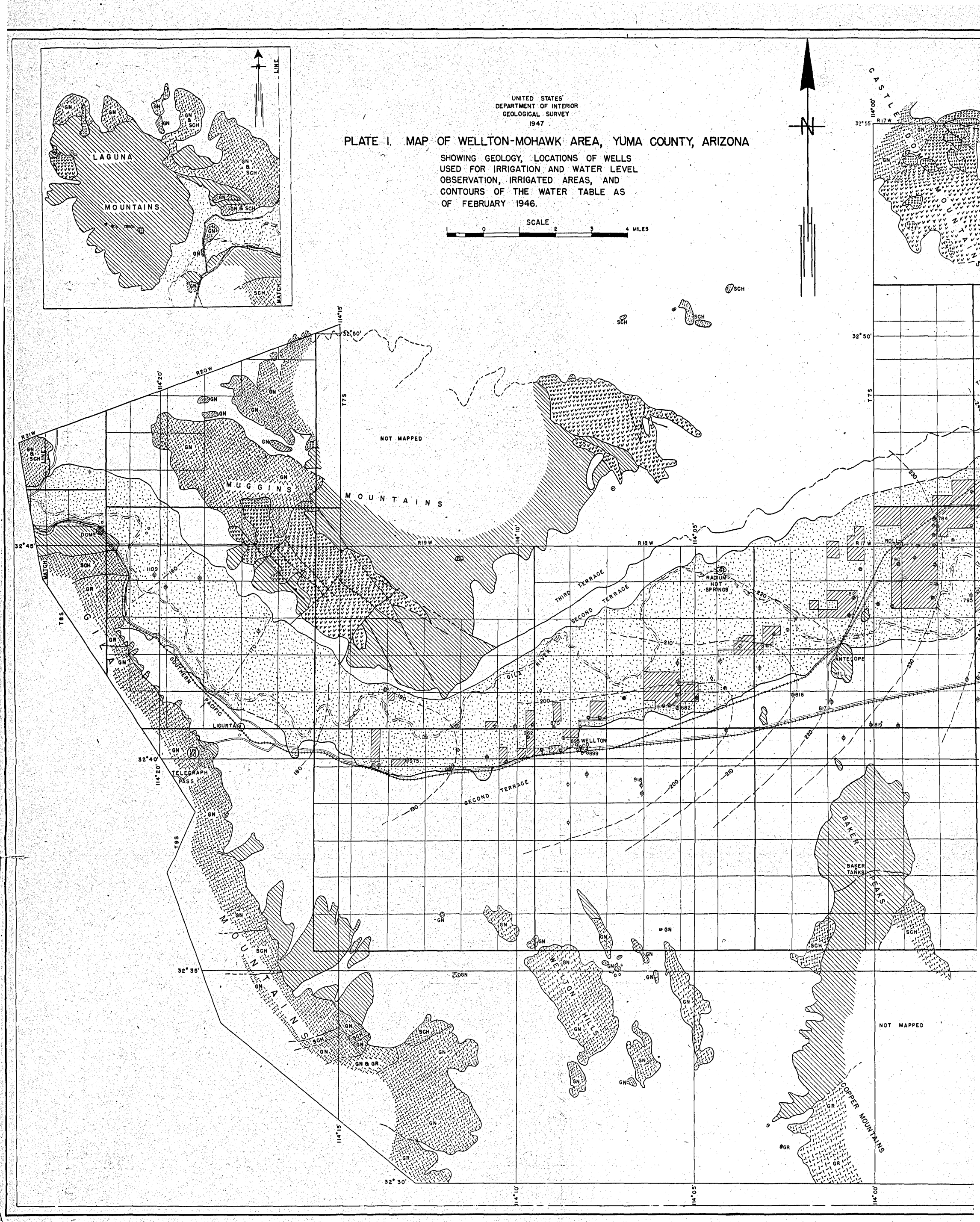
GEOLOGICAL SURVEY
1947

# PLATE I. MAP OF WELLTON-MOHAWK AREA, YUMA COUNTY, ARIZONA

SHOWING GEOLOGY, LOCATIONS OF WELLS USED FOR IRRIGATION AND WATER LEVEL OBSERVATION, IRRIGATED AREAS, AND CONTOURS OF THE WATER TABLE AS OF FEBRUARY 1946.



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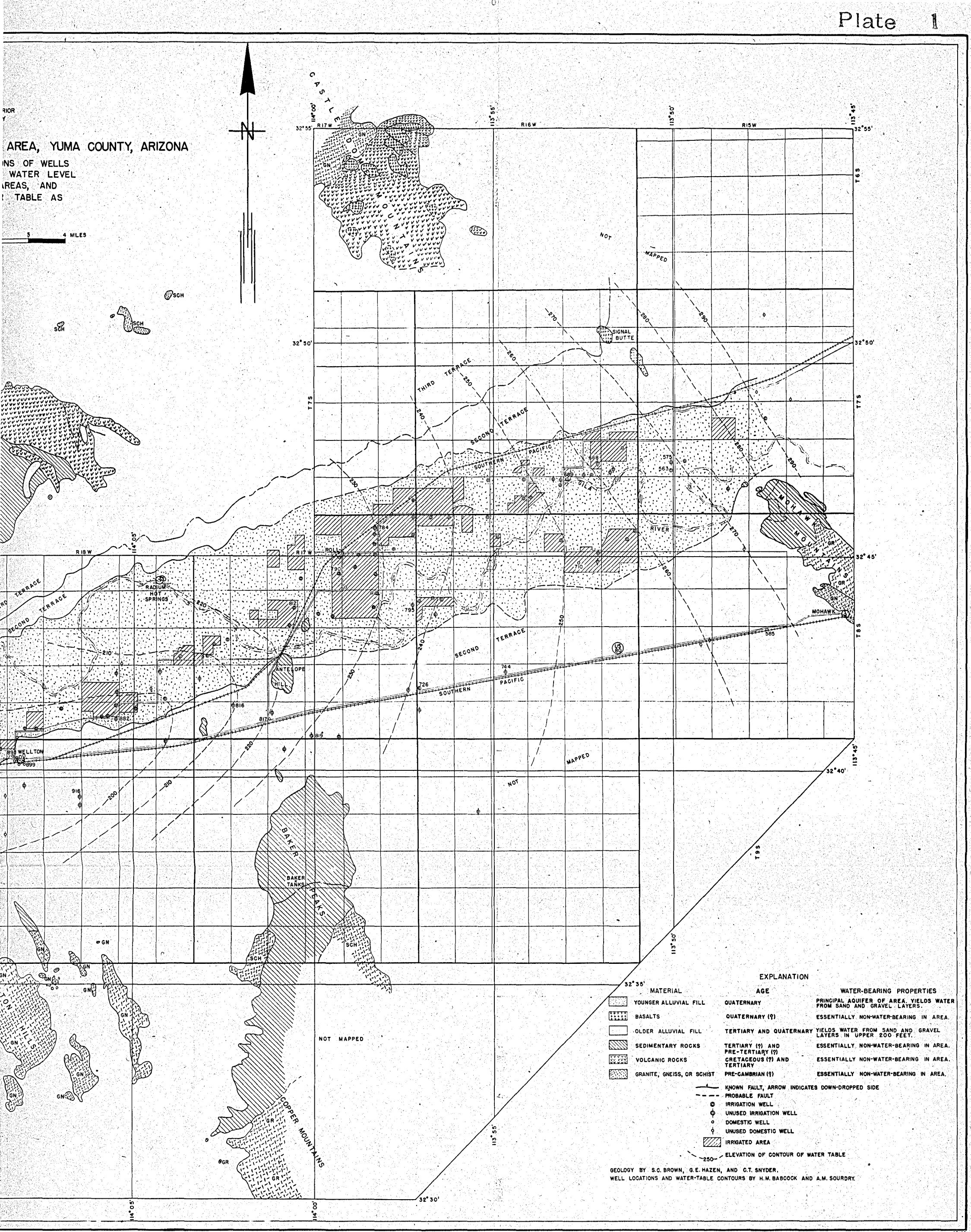
Y

AREA, YUMA COUNTY, ARIZONA

ONS OF WELLS
WATER LEVEL
REAS, AND
TABLE AS

5 4 MILES




## EXPLANATION

| MATERIAL | AGE | WATER-BEARING PROPERTIES |
|---|---|---|
| YOUNGER ALLUVIAL FILL | QUATERNARY | PRINCIPAL AQUIFER OF AREA. YIELDS WATER FROM SAND AND GRAVEL LAYERS. |
| BASALTS | QUATERNARY (?) | ESSENTIALLY NON-WATER-BEARING IN AREA. |
| OLDER ALLUVIAL FILL | TERTIARY AND QUATERNARY | YIELDS WATER FROM SAND AND GRAVEL LAYERS IN UPPER 200 FEET. |
| SEDIMENTARY ROCKS | TERTIARY (?) AND PRE-TERTIARY (?) | ESSENTIALLY NON-WATER-BEARING IN AREA. |
| VOLCANIC ROCKS | CRETACEOUS (?) AND TERTIARY | ESSENTIALLY NON-WATER-BEARING IN AREA. |
| GRANITE, GNEISS, OR SCHIST | PRE-CAMBRIAN (?) | ESSENTIALLY NON-WATER-BEARING IN AREA. |

KNOWN FAULT, ARROW INDICATES DOWN-DROPPED SIDE
PROBABLE FAULT
IRRIGATION WELL
UNUSED IRRIGATION WELL
DOMESTIC WELL
UNUSED DOMESTIC WELL
IRRIGATED AREA
250 ELEVATION OF CONTOUR OF WATER TABLE

GEOLOGY BY S.C. BROWN, G.E. HAZEN, AND C.T. SNYDER.
WELL LOCATIONS AND WATER-TABLE CONTOURS BY H.M. BABCOCK AND A.M. SOURDRY.

UNITED STATES
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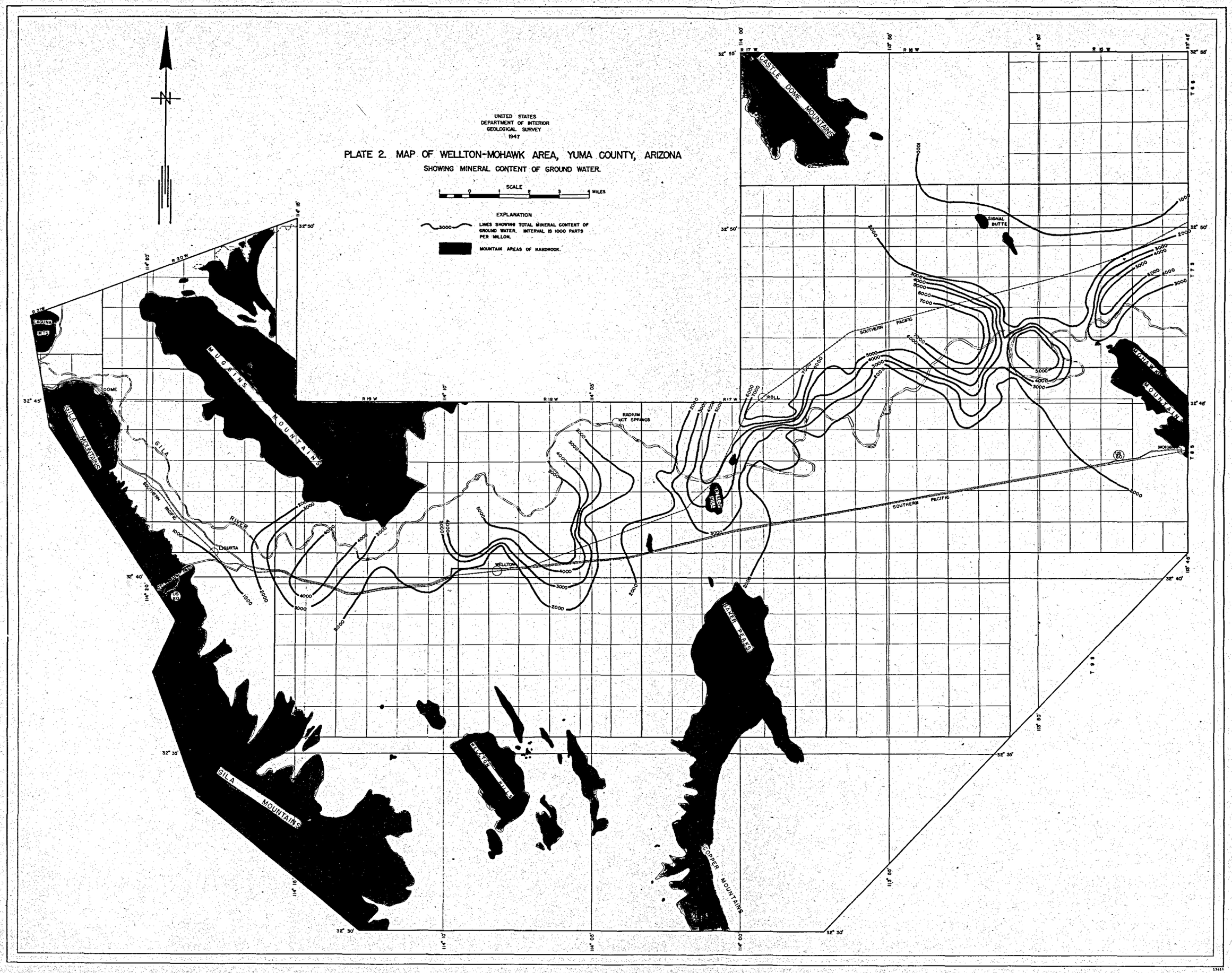
# PLATE 2. MAP OF WELLTON-MOHAWK AREA, YUMA COUNTY, ARIZONA

SHOWING MINERAL CONTENT OF GROUND WATER.



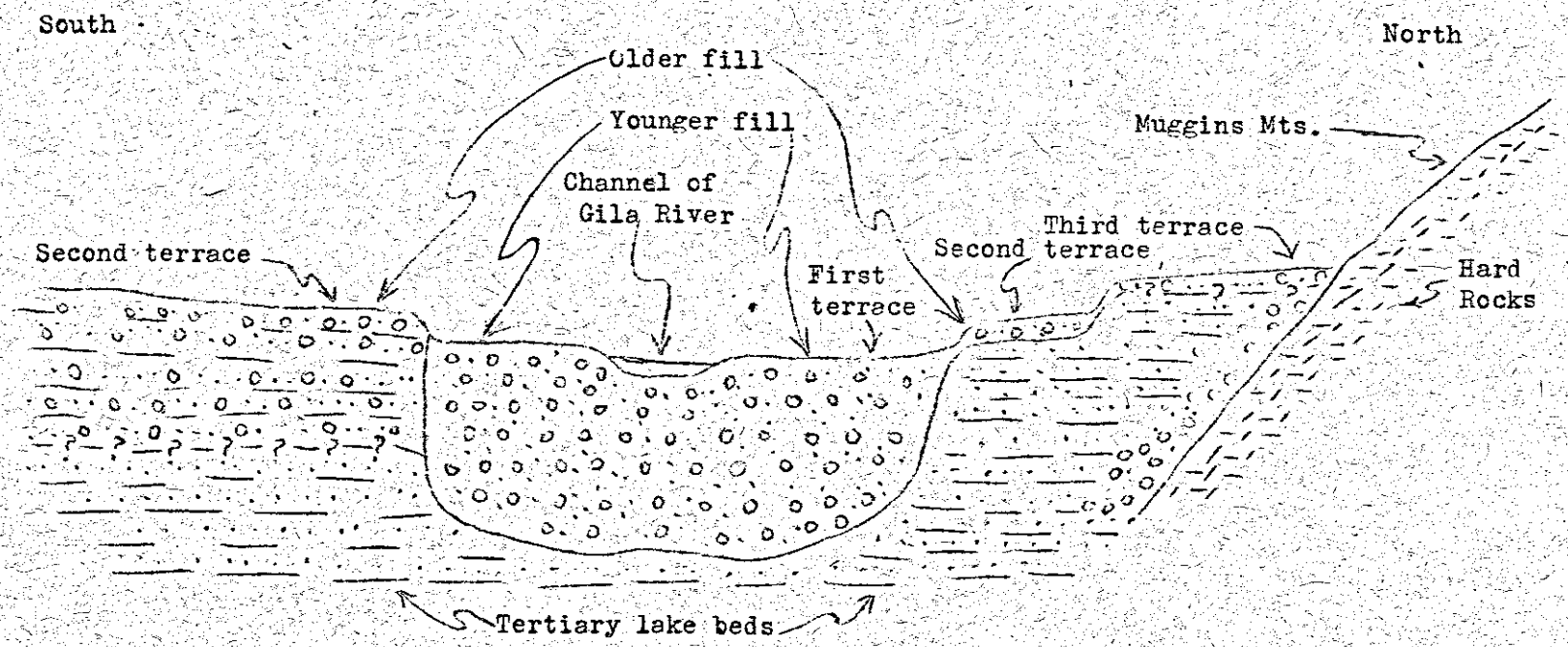



Fig. 1-Idealized section of valley fill, Wellton-Mohawk area, Yuma County, Arizona

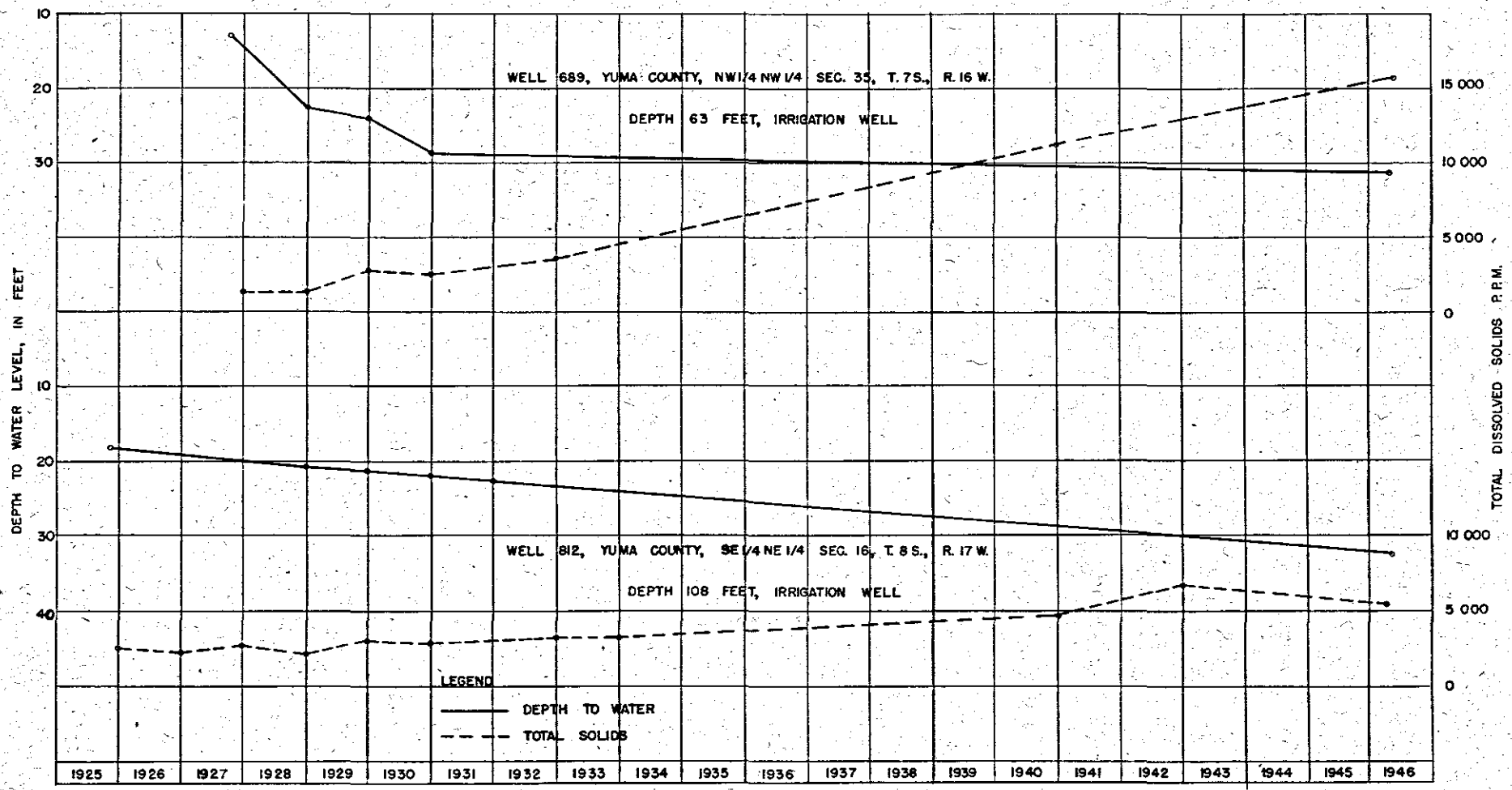



FIG. 2 — GRAPHS SHOWING FLUCTUATIONS OF WATER LEVEL IN TYPICAL OBSERVATION WELLS, AND THE CHANGES IN DISSOLVED SOLIDS, WELLTON-MOHAWK AREA, YUMA COUNTY, ARIZONA.

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