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Geological Survey

Geology and ground-water resources of the Gila Bend Basin, Maricopa County, Arizona

By

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With a section on quality of water

By

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Prepared in cooperation with
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C. C. Williams, Commissioner

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CONTENTS

TABLES

ILLUSTRATIONS

INTRODUCTION

Purpose and cooperation

The need for State regulation of ground-water resources in Arizona has been apparent for many years. However, as such regulation must be based on adequate information as to quantity, quality, source, and movement of the ground water, the Arizona State Legislature, in 1945, appropriated funds for the investigation of the ground-water resources of the State. The work done in the Gila Bend Basin was performed as a part of this State-wide program. The work was done on a cooperative basis between the Arizona State Land Department, C. C. Williams, Commissioner, and the U. S. Geological Survey, United States Department of the Interior. Field work in the basin was performed by H. M. Babcock and A. M. Sourdry, engineers; and K. K. Kendall, geologist, under the direct supervision of S. F. Turner, District Engineer (Ground Water), of the Federal Geological Survey. Analytical data for the Gila River at Gillespie Dam were obtained from the Salt River Valley Water Users' Association. 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 Gila Bend Basin is a wide, gently sloping desert plain that extends from the northern tip of the Painted Rock Mountains, upstream along the Gila River for a distance of about 36 miles to Gillespie Dam. The basin is bounded by the Gila Bend Mountains and the Buckeye Hills on the north; the Maricopa and the Sand Tank Mountains on the east; the Sauceda Mountains on the south; and the Sentinel lava flow and the Painted Rock Mountains on the west. The basin lies entirely within Maricopa County and covers an area of about 800 square miles.

Climatological data

The climate at Gila Bend (altitude 737 feet), which is near the center of the basin, is characterized by hot, dry summers and mild winters. Summer temperatures frequently exceed 115 degrees Fahrenheit. The mean annual temperature at Gila Bend is 72.2° F., and the frost-free season is about 9½ months. The average precipitation at Gila Bend is 6.1 inches, according to a 52-year record of the U. S. Weather Bureau.

History of development

The accounts of the early explorers and settlers of the region tell of farming along the Gila River by the Indians. There are still remnants of some of these old Indian irrigation canals throughout the area.

The first irrigation by white settlers took place in connection with the early overland stage lines. The first of these lines was established in 1857, and extended along the Gila River from Yuma to Sacaton. Small farming communities grew up around some of the stage stations. One of these stations was established south of the Gila River near Gila Bend. Later, irrigation districts were organized, canals were dug, and brush diversion dams were built along the river. According to a report of the Governor of the Territory of Arizona to the Secretary of the Interior[1/], the following canals were being

1/ Report of the Governor of Arizona to the Secretary of the Interior, p. 42, 1901.

operated in 1901 in the Gila Bend Basin: The Enterprise Canal, constructed in 1886; the East Riverside Canal, constructed in 1893; and the Lower Gila Bend Canal, constructed in 1895. The Citrus Canal, which heads in the Gila Bend Indian Reservation, was constructed in the early eighties and was operated for only a few years. The James Bent Canal, constructed in 1910, and the Gillespie Dam, constructed in 1921, are the most recent irrigation developments in the area.

Most of these canals were constructed without adequate study of the quantity of water available for diversion, and were later abandoned. At present (1947) the Enterprise Canal and the Gila Bend Canal, both diverting water at Gillespie Dam, are the only canals being used in the basin. In 1946, about 19,000 acres of land was irrigated primarily with surface water. However, as the availability of surface water has become more and more uncertain, irrigation wells have been drilled to supplement this supply. In addition, about 2,000 acres was irrigated entirely with ground water in 1946. Plate 1 shows cultivated areas, and the locations of all irrigation wells. Tables 1, 2, and 3 show records, logs, and analyses of water from typical wells in the basin.

Previous investigations

Earlier studies of the geology and ground-water resources of the Gila Bend Basin are described in the following reports:

1. Phalen, W. C., Celestite deposits in Calif. and Ariz.: U. S. Geol. Survey Bull. 540-T, pp. 521-533, 1914.
2. 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.
3. 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.
4. 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.
5. 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 499, 1925.

GEOLOGY AND ITS RELATION TO GROUND WATER

The geology of the area has an important bearing on the ground-water supplies. Therefore the manner in which the Gila Bend Basin was formed-that is-the geologic history and structure, is described briefly. The rocks and their water-bearing properties are described in more detail.

Maps and field work

No reliable maps of the basin were available. The geologic field work was done without maps from February 1, 1946, to April 15, 1946. Later, aerial photographs became available, and 3 weeks in the winter of 1946-47 were spent in the field mapping geology on these photographs. The geologic maps prepared from these photographs were then reduced to a smaller scale and combined on a base map adapted from the Arizona State Highway Planning Survey, to form the geologic map, plate 1. An area about 3 miles long and 1 mile wide, along the Gila River in the extreme western part of the mapped area (see plate 1), was mapped without the help of photographs.

Geologic history

Ancient schist and gneiss, the metamorphosed remnants of still older rocks, comprise part of the mountains in the Gila Bend area. These rocks are probably pre-Cambrian in age and are tentatively correlated with the Cardigan gneiss[2/] of the Ajo quadrangle.

Marine rocks were deposited in some parts of southwestern Arizona during Paleozoic time. These marine strata were not observed in the Gila Bend area, but there is evidence that they were formerly exposed and that since they have either been removed by erosion or buried. Fanglomerate that crops out in the Sand Tank Mountains contains boulders of these marine rocks, notably fossiliferous limestone which is considered to be of Upper Devonian (middle Paleozoic) age by Stoyanow[3/]. These limestone boulders show that Upper Devonian strata were exposed in mountains of the Gila Bend area during the deposition of the fanglomerate.

Granitic rocks intruded older rocks in a large part of the area, possibly in Mesozoic time. The relationship of these rocks to the Paleozoic strata that were formerly exposed was not determined. Most of the granitic rocks are tentatively correlated with the Chico Shunie quartz monzonite of the Ajo area, which Gilluly[4/] suggests may be Mesozoic.

From the evidence available in this and adjacent regions, it appears that mountains were formed in the area about the end of the Mesozoic era or the beginning of the Cenozoic era. These mountains contained Paleozoic strata and crystalline rocks and were eroded before the formation of the present-day mountains. During erosion they contributed rock material which built up alluvial fans in the intermontane basins. Although the Paleozoic strata and much of the crystalline rock of these mountains have been removed by erosion, some of the fan materials remain. This fanglomerate is tentatively correlated with the Locomotive fanglomerate of the Ajo quadrangle. In discussing the age of the Locomotive fanglomerate, Gilluly[5/] states:

> "The only definite information as to the absolute age of the Locomotive fanglomerate is that it contains transported noncrystalline limestone boulders with fossils of Devonian, Mississippian (?), and Pennsylvanian age. . .
>
> "With respect to the local problems, however, the fossils serve merely to fix the age of the Locomotive fanglomerate as post-Pennsylvanian. No fossils except indeterminate woody fragments have been found in the matrix material. If the long history represented in the post-fanglomerate record is taken into account, the fanglomerate can hardly be younger than middle Tertiary."

2/ Gilluly, James, The Ajo mining district, Arizona: U. S. Geol. Survey Prof. Paper 209, 1946, pp. 10-15.

3/ Stoyanow, A. A., personal communication, 1946.

4/ Op. cit., pp. 17-21.

5/ Op. cit., p. 38.

Gilluly suggests, then, that the Locomotive fanglomerate is probably middle Tertiary or older. The Locomotive (?) fanglomerate of the Gila Bend Basin may indeed be much older than middle Tertiary, as it closely resembles rocks of possible Mesozoic age in the Castle Dome and Muggins Mountains, described by Wilson[6]. In the present report the fanglomerate is considered probably Tertiary in age.

The older volcanic rocks in the Gila Bend area are possibly Mesozoic or younger, as in a few places they lie on an erosional surface of the probably Mesozoic Chico Shunie (?) quartz monzonite. Fragments of volcanic rock were not seen in the lower part of the Locomotive (?) fanglomerate. This negative evidence does not preclude vulcanism before the deposition of the fanglomerate, but it does suggest that none of the volcanic rocks is older than the Locomotive (?) fanglomerate. The upper part of the Locomotive (?) fanglomerate is interbedded with basaltic flows and tuffs. Although the relationship of all of the older volcanic rocks to the fanglomerate was not observed, it is probable that vulcanism began while the fanglomerate was being deposited.

After the major part of the volcanic activity, fault-block mountains were formed by tilting and faulting of the older rocks, probably in Tertiary time. Although erosion of these mountains may have obliterated the original relief due to faulting, the fault blocks are the principal structural features of the Gila Bend Basin. The present-day mountains are a manifestation of these Tertiary (?) fault blocks, after alteration by long-continued erosion and renewed faulting.

Alluvium washed in from the adjacent mountains has partly filled the Gila Bend Basin. Records of wells indicate that the first material deposited on the Locomotive (?) fanglomerate in the basin was a great thickness of lake-bed clay. This was followed by alternating beds of gravels, sands, and clays that extend to the land surface. These upper beds are similar to Quaternary rocks in the Ligurta area, described by Ross[7], and are probably of the same age. The sequence of clay overlain by alternating beds of coarser materials suggests a change from lake to playa conditions which was concurrent with an increase of erosion. Either climatic change or renewed uplift of the mountains could have caused this increase of erosion. The partly buried pediments at the bases of some of the mountains suggest that the increase of erosion was due to climatic change, but the steep, straight scarps along the southeastern part of the Gila Bend Mountains suggest recent faulting and uplift.

After the closed basins were partly filled with alluvium, through drainage developed and the broad outline of the Gila River drainage was formed.

Volcanic eruptions produced cones and basalt flows that are associated with the three terraces formed by the Gila River as it deepened its valley in the valley-fill deposits. Some of the lava flows dammed the river temporarily. One of these dams, made during the forming of the highest (oldest) terrace by lava from a cone in the northern part of the Painted Rock Mountains, diverted the river around the southern end of these mountains. This diversion of the river is indicated by the extension of the highest terrace toward the southern end of the Painted Rock Mountains (see pl. 1).

6/ Wilson, Eldred D., Geology and mineral deposits of Southern Yuma County, Arizona: Arizona Bur. Mines, Geol. Ser. No. 7, Bull 134, p. 219, 1933.

7/ Ross, Clyde 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, p. 75, 1923.

The river was also dammed at the site of Gillespie Dam by a lava flow from Woolsey Peak to the west, which may have diverted the river through the Gila Bend Mountains[8]. This basalt flow occurred before the lower terrace was cut, as it lies on either the upper (oldest) terrace, or the middle terrace, and caps a cut bank above the lower (youngest) terrace.

Additional cones and flows were formed at about the same time. The deposits capping the middle terrace contain a layer of ash produced during these eruptions.

Records of wells indicate that, after the surface of the lower terrace was cut and a thin veneer of gravel was deposited on it, the Gila River cut a valley about 80 feet deep that was then partly refilled with unconsolidated silt, sand, and gravel. The present Gila River channel and flood plain were then cut in this material. The braided channels of the Gila River lie 5 to 15 feet below the flood plain in an inner valley about one-half mile wide. The stream is now building up this inner valley with alluvium.

Land forms and structure

The Gila Bend Basin is a broad plain transversed by mountain ranges. The basin is in the Sonoran Desert section of the Basin and Range province[9], and is typical of that section.

The mountain ranges appear to be fault blocks and possess many topographic and geologic features considered characteristic of fault-block mountains by Fenneman. The mountain ranges are roughly parallel and trend north or northwest, except for the Buckeye Hills and the central part of the Gila Bend Mountains, which trend east-northeast. Each of the ranges is approximately straight and continuous. The height and breadth do not vary abruptly. The mountain foot in several places is straight, and in some places the straight foot crosses the trend of the geologic structure visible in the mountains, suggesting the presence of faults.

Faults are not shown on the geologic map (pl. 1), because the location and mapping of faults were outside the scope of this investigation. However, the tectonic map of the United States[10] shows several faults along mountain fronts in the Gila Bend region. The tectonic map indicates major faults on the east side of the Gila Bend Mountains, east and west sides of the Sand Tank Mountains, and west side of the Maricopa Mountains.

Most of the mountain ranges are in an advanced stage of erosion. Erosion has produced pediments that extend from the foot of the mountain ranges in many places. Some of these pediments are large; about 10 miles south of Gillespie Dam the granitic pediments extending from the opposing ranges are separated by not more than 4 miles of alluvial fill (see pl. 1). These pediments were noted in exposures and in well logs. There is an abrupt change of slope where the pediments join the mountains. This change of slope at the upper edge of a pediment is characteristic and does not, in general, mark a fault. However, in many places a major fault parallel to the mountain range lies near the lower edge of the pediment. Pediments do not appear to be extensive in the part of the basin that is west of Gila Bend, and the valley fill may be very thick in many places.

8/ Ross, C. P., op. cit.

9/ Fenneman, N. M., Physiography of western United States, McGraw-Hill Book Co., Inc., pp. 367-377, 1931.

10/ Longwell, Chester R., and others, Tectonic map of the United States, Am. Assoc. Petroleum Geologists, 1944.

The valley that lies between the Maricopa Mountains and the Gila Bend and Sand Tank Mountains appears to be a structural trough with faults along the east and west sides. The scarps on the west side of this valley, particularly along the southeastern part of the Gila Bend Mountains, are relatively high, steep, and straight, suggesting that some of the faulting is recent. The Gila Bend and the Sand Tank Mountains, which are on the west side of the supposed trough, lie along a structural axis which trends northwest. The existence of this structural axis is indicated by the alinement and uniform trend of the two mountain ranges; by the similarity in the two mountain ranges of a granitic core, flanked on the west by fanglomerate and interbedded rocks; and by well logs that show the presence of fanglomerate and interbedded rocks beneath the alluvial fill at Gila Bend. Other evidences are the major fault on the east side of the two mountain ranges and scarps in the relatively weak fanglomerate that suggest recent faulting parallel to the granitic core.

Structural details of the Sauceda and the Painted Rock Mountains also show the northwest-southeast trend that is characteristic of the greater part of the Gila Bend area, although the evidence is not as strong as in the Gila Bend and the Sand Tank Mountains. The older volcanic rocks in the northern part of the Painted Rock Mountains strike northwest, forming hogbacks that cross the north-trending range. Likewise, in the northern part of the Sauceda Mountains, the outcrop pattern of both the older volcanic rocks and the Cardigan (?) gneiss trends northwest. Along the northeast side of the Sauceda Mountains discontinuous outcrops of a distinctive basalt may be exposures of dikes. The outcrops trend northwest in line with outcrops of similar rock, outside the mapped area, in the northwest part of the Painted Rock Mountains. All these outcrops may be parts of the same dike system. Between the two mountain ranges there are small outcrops of the older volcanic rocks. These outcrops suggest that bedrock lies close to the surface everywhere between the Sauceda and Painted Rock Mountains, possibly forming a barrier to ground water.

Rock formations and their water-bearing character

Gneiss and schist (pre-Cambrian(?))

The oldest rocks exposed in the Gila Bend Basin are the gneiss and schist in the north part of the Sauceda Mountains, near Black Gap. Small areas of similar rocks are exposed in the north part of the Sand Tank Mountains, in the Maricopa Mountains, and in the east part of the Gila Bend Mountains, and these rocks appear to be inclusions in granitic rocks. Only the fringes of the mountain ranges were examined, and the central parts may include other outcrops of the gneiss and schist. The gneiss and schist are tentatively correlated with the Cardigan gneiss, which is exposed in the Ajo quadrangle. Gilluly[11] tentatively assigned a pre-Cambrian age to the Cardigan gneiss. The Cardigan gneiss, in its type locality, is composed of both gneiss and schist.

The gneiss and schist in the Gila Bend Basin are prominently banded or foliated and deeply weathered. These rocks are light gray and the outcrops are weathered light reddish brown or light brownish gray. Some of the gneiss is highly jointed and stained dull green or dull red. The stronger gneiss forms high, rugged hills, with crags and prominent outcrops; and the schist and weaker gneiss form low, rounded hills, with few outcrops.

Although wells, springs, and natural tanks are not known in these rocks in the Gila Bend Basin, wells in joint zones might yield small supplies of ground water.

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[11] Op. cit., pp. 10-15.

Granitic rocks (Mesozoic(?))

Granitic rocks of possible Mesozoic age are exposed in much of the area. They crop out in the Buckeye Hills, the Maricopa Mountains, the east part of the Gila Bend Mountains, and the north part of the Sand Tank Mountains. Granitic rocks have been encountered in wells that pass through the sedimentary rocks in the valley between the Maricopa Mountains and the Gila Bend Mountains. The granitic rocks of the area are tentatively correlated with the Chico Shunie quartz monzonite of the Ajo quadrangle described by Gilluly[12].

The granitic rocks in the Gila Bend area, as in the Ajo quadrangle, include varieties that are coarsely porphyritic and that are gneissoid in many places; finer-grained, equigranular rock; alaskitic rock; and associated pegmatite and aplite. The granitic rocks intrude the pre-Cambrian (?) gneiss and schist. Inclusions in the granitic rocks are numerous. Most of the granitic rocks are light gray to dark gray, although some of the porphyritic rocks contain large pink feldspar crystals. The outcrops are weathered pale reddish brown. Most of the granitic rocks form prominent saw-toothed mountain ranges. Pediments were cut on granitic rocks at the base of some of the mountains.

Springs and tanks are not known in these rocks, although granitic rocks in other parts of the lower Gila region contain natural tanks. Artificial tanks could be constructed in many of the ravines in the granitic rocks of the Gila Bend Basin. Wells in these rocks are not known and probably would yield little or no water.

Fanglomerate and interbedded rocks (Tertiary(?))

Fanglomerate of Tertiary(?) age crops out in the north part of the Sand Tank Mountains and in the west part of the Gila Bend Mountains and is tentatively correlated with the Locomotive fanglomerate of the Ajo quadrangle, described by Gilluly[13]. The fanglomerate and interbedded rocks probably underlie many areas covered by volcanic rocks and alluvium. A log of well 5040 at Gila Bend, owned by the Southern Pacific Railroad, shows rocks below 1,100 feet that are similar to the fanglomerate and interbedded sandstones and volcanic rocks.

The fanglomerate unit consists principally of fanglomerate, but contains interbedded volcanic rocks and sandstones. The fanglomerate is cemented and contains unsorted boulders, cobbles, pebbles, sand, and silt. Boulders as large as 15 feet in diameter were observed. Rock fragments observed in the fanglomerate in the Gila Bend Mountains are nearly all granitic. In the Sand Tank Mountains the rock fragments are principally granitic, but there are also fragments of schist, sandstone, conglomerate, quartzite, fossiliferous limestone, and fossiliferous quartzite. The fanglomerate is locally well-indurated and forms high rounded hills, steep slopes, and cliffs.

The volcanic rocks of the unit, correlated with those described in the next section, are flows and tuffs. The flows are massive basaltic porphyries, medium brownish red or medium gray in color and the observed flows are less than 30 feet thick. The tuffs are composed of well-sorted and well-bedded rock fragments that are principally of volcanic origin. The tuffs are light greenish gray or light red. The volcanic rocks form cuestas, mesas, and irregular hills.

[12] Op. cit., pp. 17-21.

[13] Op. cit., pp. 35-39.

The sandstones in the unit were observed in the southeast part of the Gila Bend Mountains. The rock is a moderately indurated well-sorted cross-bedded porous arkosic sandstone of buff to red color. A sandstone layer more than 200 feet thick was observed in one place. The sandstones form small hills and prominent red cliffs.

Tanks and springs were not observed in the fanglomerate unit, but the deep wells at Gila Bend obtain water from aquifers that appear to be the porous sandstone layers interbedded with the fanglomerate. Similar sandstone layers might yield small supplies of ground water to wells of moderate depth in some other parts of the area.

Older volcanic rocks (Tertiary(?))

Volcanic rocks tentatively designated as Tertiary in age outcrop in the central and southwest parts of the Gila Bend Mountains, in the Painted Rock Mountains, the north part of the Sand Tank Mountains, the north part of the Sauceda Mountains, and at the west end of the Buckeye Hills.

The older volcanic rocks form prominent hogbacks, cuestas, mesas, and irregular hills and mountains. Most of these rocks are tuffs, basaltic flows, and intrusive rocks. The basalts are primarily fine-grained rocks that are porphyritic or vesicular in many places. They are light gray on a fresh surface and weather light brown. No wells, springs, or natural tanks are known in the older volcanic rocks in the Gila Bend Basin, although tanks exist in similar rocks in nearby areas. It is possible that small supplies of ground water can be obtained from wells drilled in areas where these rocks are highly fractured or vesicular, but no areas of water-bearing rocks were located during the present investigation.

Valley fill and associated volcanic rocks (Tertiary and Quaternary)

Alluvial fill of Tertiary and Quaternary age partially fills the intermontane troughs of the Gila Bend Basin. This fill has been washed into the basin from the surrounding mountains or brought into the basin by the Gila River and its tributary streams. The materials deposited when the basin was closed, and had interior drainage, are termed here "older valley fill" and are of undifferentiated Tertiary and Quaternary age. The materials deposited after exterior drainage had developed are termed "younger valley fill" and are of probable Quaternary age. Flows of basalt, here termed the "younger volcanic rocks", occurred during the deposition of the younger valley fill.

In successive periods of down cutting the Gila River has formed three terraces in the basin, above the present flood plain. The materials underlying the present flood plain are the silts, sands, and gravels of the younger valley fill, which partially fills the youngest and deepest valley cut into the older valley fill. The three terraces and the remainder of the basin are underlain by several hundred feet of gravel, sand, silt, and clay of the older valley fill, which is capped by a relatively thin veneer of Quaternary alluvium.

Older valley fill (Tertiary and Quaternary)

The older valley fill (see pl. 1) is composed of materials of Quaternary age at the land surface, and of the underlying undifferentiated Quaternary and Tertiary lake-bed clays and coarser materials.

Well logs indicate that the materials encountered in deep wells at Gila Bend are, in order from top to bottom, about 300 feet of gravel and sand with some clay; about 800 feet of lake-bed clay with some sand; and more than 600 feet of fanglomerate and associated rocks. The upper 1,100 feet is valley fill of Tertiary and Quaternary age, and the lower 600 feet is probably the Tertiary(?) fanglomerate and interbedded rocks previously described. The Tertiary-Quaternary contact, which is within the upper 1,100 feet, possibly occurs at the top of the lake-bed clays.

Logs of wells in the part of the Gila Bend Basin between the Gila Bend Mountains and the Maricopa Mountains indicate more than 1,000 feet of partly consolidated sand, gravel, and boulders. The material is older valley fill of Tertiary and Quaternary age, and lake-bed clays similar to those penetrated by wells at Gila Bend were not encountered. The trough between the Gila Bend Mountains and the Maricopa Mountains is narrower than the trough in which the lake-bed clays near Gila Bend were deposited; probably the streams in this narrower trough had a steep gradient and deposited coarse, unsorted alluvium. The coarseness of the alluvium may also indicate that exterior drainage from this part of the basin existed during deposition of the alluvium. Sand and gravel layers in the older valley fill between the Gila Bend Mountains and the Maricopa Mountains yield water readily to wells (see logs, table 2). Seventeen wells of large capacity that develop water from this fill were being pumped for irrigation in 1946.

Younger volcanic rocks (Quaternary)

The younger volcanic rocks form flows and cones at Gillespie Dam and in the west and southwest parts of the basin. Deposits of Quaternary alluvium capping the middle terrace of the Gila River, north of Smurr (see pl. 1), contain a bed of volcanic ash 1 to 2 feet thick. The flows lie on the older valley fill or on the middle or upper terraces of the Gila River, and are therefore essentially contemporaneous with the younger valley fill.

The flows range from 10 to 50 feet in thickness. Vesicular zones occur in the upper and lower parts of the flows. The rock is generally a fine-grained gray basalt that weathers reddish brown. The younger volcanic rocks are probably not aquifers in the Gila Bend Basin, as there is no evidence that they occur below the water table.

Younger valley fill (Quaternary)

The younger valley fill is Quaternary alluvium deposited by the Gila River and its tributary washes. The terrace, flood-plain, and channel deposits of the Gila River, which consist of this alluvium, are shown on plate 1, but similar deposits along the tributary washes are not indicated. The Gila River terrace deposits are relatively thin veneers of silt, sand, and pebbles upon older valley fill; the terrace scarps are indicated by lines, but the terraces are otherwise mapped together with the underlying older valley fill (see pl. 1).

Records of wells indicate that younger valley fill underlies the flood plain of the Gila River to a depth of at least 80 feet. Some of the more permeable sand and gravel layers in this material are excellent aquifers, yielding large amounts of water to a few irrigation wells northwest of Gila Bend.

GROUND-WATER RESOURCES

The important water-bearing formations in the Gila Bend Basin are the Tertiary(?) fanglomerate and associated rocks; the older valley fill; and the younger valley fill. The other formations in the area are essentially non-water-bearing, and will not be discussed further. The ground water in the older and younger valley fill is interconnected; thus the ground-water reservoir is continuous throughout all of the valley fill. Therefore, the ground-water resources of the older and younger valley fill will be discussed together.

Fanglomerate and interbedded rocks

Ground water occurs in the pore spaces of the sandstone beds of the fanglomerate unit that underlies the older valley fill in the basin. The available data indicate that these sandstone beds are not thick, and it is unlikely that water could be obtained from them in sufficient quantity for irrigation. Well 5040, which has a reported discharge of 150 gallons a minute, apparently obtains its water from sandstone beds in the fanglomerate (see tables 1 and 2). The fanglomerate was encountered at about 1,100 feet in this well, and all water above this depth was cased off. The well was then drilled an additional 646 feet into the fanglomerate. No wells have been drilled in the fanglomerate where it crops out in the Gila Bend and Sand Tank Mountains, but it is possible that sufficient quantities of water for domestic and stock use could be obtained by drilling into the sandstone beds of the fanglomerate near these outcrop areas.

Valley fill

Occurrence and movement of ground water

Large quantities of ground water occur in the pore spaces of the gravel, sand, silt, and clay deposits of the valley fill. Although the silt and clay have a higher porosity than the gravel and sand, the pore spaces in the silt and clay are so small that the water is held by molecular attraction and very little can be drained or removed under normal hydrostatic pressure. The beds of well-sorted gravel and sand, containing large pore spaces, yield water readily and are the chief source of water in the valley fill. Tables 1 and 2 show records and logs of typical wells in the valley fill.

The older valley fill in the vicinity of Gila Bend is composed largely of clay and silt, with thin beds of sand and gravel in the upper 300 feet. Deep wells at Gila Bend penetrated sand, gravel, clay, and sandy clay to a depth of about 300 feet, and clay from about 300 feet to about 1,100 feet. Quantities of water sufficient for domestic and stock use can be developed from the older valley fill wherever it occurs in the basin. It is possible that small irrigation wells could be developed from the older valley fill in the vicinity of Gila Bend. Farther north, between the Gila Bend Mountains and the Maricopa Mountains, the older valley fill has more sand and gravel and irrigation wells of large capacity have been developed. Logs of wells drilled in this locality, along the Gila Bend Canal south of Gillespie Dam, show large amounts of boulders, gravel and sand. Lake-bed clays, similar to those encountered at Gila Bend, are not present in the wells drilled so far. In 1946 there were 17 large irrigation wells along the Gila Bend Canal which developed water from the older valley fill. The average discharge of these wells was 2,400 gallons a minute, and the average specific capacity was 56 gallons a minute per foot of drawdown. These wells were drilled to an average depth of 550 feet.

The younger valley fill is composed largely of gravel and sand with very little silt and clay, and yields water to wells more readily than the older valley fill. Only a few irrigation wells have been drilled in these materials, and not enough data are available to determine accurately its water-bearing properties or thickness. However, the few wells that have been drilled in these materials produce from 2,000 to 3,000 gallons a minute. These wells were drilled to an average depth of 350 feet, and they probably extend into the older valley fill and obtain some water from it.

Movement of ground water is always down the slope of the water table. The slope of the water table in the valley fill is toward the Gila River and downstream, and generally follows the slope of the land surface. The slope of the water table is less than the slope of the land surface and the depth to water becomes progressively greater toward the mountains. The depth to water ranges from 405 feet in well 5250, near the margin of the basin, to 35 feet in well 5350, north of Gila Bend. Except during high stages, the Gila River is effluent (receives water from the ground-water reservoir) from place to place throughout the basin; between these places it is normally dry.

Recharge

Recharge or replenishment of the ground-water supply of the valley fill is from four sources: (1) Infiltration from flows in the Gila River and its tributary washes; (2) infiltration from canals and from irrigation water applied to the land; (3) underflow of the Gila River into the basin; and (4) rainfall.

Stream flow

Infiltration from stream flow is one of the principal sources of recharge to the ground-water reservoir of the Gila Bend Basin. At infrequent periods surface flow occurs in the Gila River, and water percolates down to the water table through the coarse sands and gravels of the river channel. Usually the flows passing Gillespie Dam are small and most of the water is recharged to the ground-water reservoirs. Occasionally, during wet years, large floods occur which cause the river to flow throughout its entire course in the basin. The following table gives the flow of the Gila River at Gillespie Dam for the 6 years ending September 30, 1945:

Water year (Oct. 1 to Sept. 30)	Water diverted into Gila Bend Canal (acre-feet)	Water diverted into Enterprise Canal (acre-feet)	Discharge, Gila River below Gillespie Dam (acre-feet)
1939-40	60,050	6,869	6,393
1940-41	95,960	7,639	1,036,262
1941-42	78,010	7,390	17,700
1942-43	64,650	6,760	14,170
1943-44	72,520	8,367	13,486
1944-45	74,650	7,337	7,376

With the exception of the water year 1940-41, most of the water that passed over Gillespie Dam was probably recharged to the ground-water reservoir. Of the 1,036,262 acre-feet of water that passed over the dam in 1940-41, 589,700 acre-feet passed the gaging station at Dome and about 450,000 acre-feet was lost in transit. Assuming that the loss in flow was uniform throughout the 120 miles between the two stations, about 135,000 acre-feet was contributed to the Gila Bend Basin in 1940-41. The average loss in flow in the Gila Bend Basin during the remaining 5 years of the period was about 12,000 acre-feet per year. Most of this was probably recharged to the ground-water reservoir, and the remainder was lost through transpiration and evaporation.

No tests were made in this area to determine the amount of recharge from flows in desert washes. The work of Babcock and Cushing[14] in the Queen Creek area shows that in a typical desert wash about one-half of the total stream flow is recharged to the ground-water reservoir. In the Gila Bend Basin, surface flows in desert washes seldom reach the Gila River, as the runoff has been absorbed in the stream channels.

Irrigation

The recharge from irrigation seepage to the ground-water reservoir of the Gila Bend Basin was estimated to be about 36,000 acre-feet a year during the 6-year period ending October 1, 1945. 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[15] and the loss in flow in the largest canals was about 0.2 percent of the flow per mile.

Underflow

The amount of water entering the basin as underflow along the channel of the Gila River at Gillespie Dam is probably small but it may be significant. Jakosky[16] made a geophysical investigation at the dam to determine the relations between the geological formations and the subsurface movement of ground water. The investigation indicated that aquifers exist beneath the volcanic rocks that lie west of the dam and at the dam. Jakosky apparently did not estimate the quantity of underflow beneath the dam, and without additional information this cannot be computed. However, this quantity is relatively small in comparison to the total surface flow at the dam.

Rainfall

Recharge to the ground-water reservoir directly from rainfall is small. Upon reaching the land surface the precipitation may run off as surface flow, may percolate into the ground, or may evaporate back into the atmosphere. Most of the water that enters the ground directly from rainfall is returned to the atmosphere by evaporation and transpiration,

14/ 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., pp. 49-56, 1941.

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

16/ Jakosky, J. J., Exploration geophysics, Times Mirror Press, pp. 373-374, 1940.

according to experiments conducted in the Santa Cruz Basin[17].

Discharge

Ground water is discharged from the basin by pumping for irrigation and by natural means. Natural discharge includes ground water leaving the basin through surface flow, underflow, evaporation, and transpiration.

Pumpage

Pumping in any part of the basin affects the ground-water supply of the entire basin, as all ground water not lost through evaporation and transpiration would otherwise leave the basin as surface flow or underflow.

The principal development of ground water has occurred since 1937, along the Gila Bend Canal. Abandoned wells indicate that small amounts of ground water were pumped prior to 1937. Three irrigation wells were drilled in 1937, six in 1938, five in 1940, one in 1943, and two in 1946, making a total of 17 wells. These wells pump the major part of the water withdrawn from the ground-water reservoir in the basin. In addition to these 17 wells, there were seven other irrigation wells in operation in the basin in 1946. These seven wells are along the Gila River, north of Theba. The total amount of water pumped for irrigation in the basin was determined to be 33,300 acre-feet in 1946. No data were available to compute the amount of water pumped prior to 1946. The amount of water pumped was determined as follows: The discharge of each well was measured with a current meter or a sharp-crested weir, or by the trajectory method. Where 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 records. For the two wells where Diesel engines were used, the amount of water pumped was estimated on the basis of crop usage.

Natural discharge

At the western end of the basin the Gila River passes through a gap between the Painted Rock Mountains and the Gila Bend Mountains (see plate 2). Low hills of hard rock crop out within the gap and divide the Gila River into two channels. The south channel is about 400 feet wide (see pl. 3) and the north channel is about 800 feet wide. The thickness of the fill in these channels was not measured. The entire underflow of the basin passes through the narrow gap between the mountains. The amount of underflow leaving the basin was not measured, but it is probably several thousand acre-feet a year. Detailed studies are required to obtain a reliable figure.

A part of the ground water is forced to the surface in the vicinity of this gap, and leaves the basin as surface flow (pl. 2). In January 1947 the surface flow in the south channel was measured as 2.9 cubic feet a second. At least an equal amount of water was flowing through the north channel, which made a total surface flow of about 6 cubic feet a second leaving the basin. If this rate of flow were constant throughout the year, the amount of ground water annually discharged from the basin as surface flow would be about 4,400 acre-feet. However, during the summer months when the river-bottom vegetation is making heavy withdrawals from the ground-water reservoir, the water table is lowered, and the amount of ground water leaving the basin as surface flow is reduced.

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

The greater part of the natural discharge of ground water from the basin occurs as evaporation and transpiration in the river bottom. Sufficient data were not available to determine accurately the amount of this discharge. However, it was estimated that the amount used is probably not less than 50,000 acre-feet a year and may be as much as 100,000 acre-feet a year. These estimates are based upon the area of phreatophytes in the basin in comparison with the area of phreatophytes in the Safford Valley, where experiments conducted by Turner and others[18], indicated that 12,400 acres of dense river-bottom vegetation used 70,000 acre-feet of water annually.

Fluctuations of the water table

Measurements of the fluctuation of the water table are of primary importance in the study of ground-water resources. The alluvial fill of the Gila Bend Basin is a natural underground reservoir, and the fluctuations of the water level in wells show the extent of depletion and replenishment of this reservoir. The two principal factors that cause a lowering of the water table are pumping water for irrigation and use of water by phreatophytes.

The conclusions at the end of this report are based on the depths to water when the wells were drilled and the depths to water measured during this investigation. There has been a gradual downward trend of the water table in the area of heavy pumping along the Gila Bend Canal. The water table in irrigation wells in this area has been declining at an average rate of 1.5 feet a year since the wells were drilled. No information is available to indicate the fluctuations of the water table in other parts of the basin.

QUALITY OF WATER

By

John D. Hem

Chemical character of the ground water

Twenty-five samples of water collected from wells in the Gila Bend Basin in 1946 were analyzed by the Geological Survey. One of these samples was from the Tertiary(?) fanglomerate and interbedded rocks; six were from the older valley fill in the vicinity of Gila Bend; 15 were from the older valley fill between the Maricopa and the Gila Bend Mountains; and three were from the younger valley fill at the western edge of the basin. Analyses of samples from 11 wells in the basin are included in table 3.

Fanglomerate and interbedded rocks

The water from well 5040 (table 3) is derived from sandstone in the fanglomerate unit, and the aquifers above this unit are cased off. The water contained mostly sodium and chloride, with small amounts of calcium and magnesium. The fluoride content was 6.9 parts per million, which was higher than the fluoride content of most of the other waters in the basin. The water from the fanglomerate is similar in chemical character to waters from the older valley fill near Gila Bend.

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

Older valley fill

Waters in the older valley fill in the outlying areas south of Gila Bend contain moderate amounts of dissolved solids. Deep wells near the Gila River, northwest of Gila Bend, generally yield rather highly mineralized water. These deep wells derive part of their water from the younger valley fill. The range of dissolved-solids concentration in the six samples analyzed was from 358 to 2,140 parts per million. The less highly mineralized waters contained mostly sodium and bicarbonate, and the more highly mineralized waters contained mostly sodium and chloride. All except the two most dilute waters contained more than 1.5 parts per million of fluoride.

Waters from the older valley fill between the Maricopa and the Gila Bend Mountains are highly mineralized. The range in concentration of dissolved solids in the 15 samples collected was from about 1,200 to about 2,200 parts per million. Most of the dissolved matter consisted of sodium and chloride. In general, waters from the older valley fill in this area contain proportionately larger amounts of calcium and magnesium and smaller amounts of fluoride than waters from the older valley fill near Gila Bend.

Younger valley fill

Waters from the younger valley fill are highly mineralized. Dissolved solids in waters from three wells near the western edge of the basin ranged from 1,420 to 4,010 parts per million. Most of the dissolved matter consists of sodium and chloride, although the waters contain large amounts of calcium and magnesium.

Chemical character of surface water

Surface flow of the Gila River reaching Gillespie Dam, at the northern end of the Gila Bend Basin, is usually composed of highly mineralized drainage waters from the Salt River Valley. During most of the 12-month period ending September 30, 1945, the surface flow contained about 4,000 parts per million of dissolved solids, mostly sodium and chloride, but with much calcium and sulfate. Most of the drainage water is diverted into the Gila Bend and Enterprise Canals and used for irrigation in the Gila Bend Basin. Occasional flood flows spill over the dam and pass on downstream. These flood flows are probably composed of moderately mineralized water, as indicated by the few analyses available. Flood flows enter the river occasionally from washes in the basin, but no samples were collected from these sources.

Relation of quality of water to use

Irrigation

The surface water diverted at Gillespie Dam at low flow is considered "injurious to unsatisfactory" for irrigation under the standards set by Wilcox and Magistad[19]. Fifteen irrigation wells pump water that has from 1,200 to 2,200 parts per million of dissolved solids into the Gila Bend Canal. This ground water dilutes the surface water diverted at Gillespie Dam, but the mixture is probably so highly mineralized that it is "injurious to unsatisfactory" for irrigation. Water from most of the wells in the older valley fill in the vicinity of Gila Bend has a high percentage of sodium and is high in chloride so that it, also, must be considered "injurious to unsatisfactory" for irrigation. Because of

19/ 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. Plant Industry, Soil and Agr. Research Administration; Riverside, Calif. (mimeographed), 8 pp., May 1943.

the poor quality of the water available, only crops that are tolerant to highly mineralized water may be grown in the basin.

Domestic use

Most of the ground waters of the basin are hard, and they contain sufficient sodium and chloride to have a noticeable salty taste. The waters from the fanglomerate unit and from the older fill may, in some instances, be only moderately hard, and in the outlying areas may be only moderately mineralized, but most of these waters contain excessive amounts of fluoride. Most ground waters of the basin contain enough fluoride to cause mottling of the tooth enamel of children who may drink the waters continuously. According to the U. S. Public Health Service[20/] a satisfactory drinking water should contain no more than 1.5 parts per million of fluoride. The only waters of the basin that contain less than 1.5 parts per million of fluoride occur in the older fill in outlying areas and between the Maricopa and the Gila Bend Mountains.

Relation of quality of water to recharge

The irrigation wells along the Gila Bend Canal south of Gillespie Dam yield water of lower content of dissolved solids than the low-flow waters of the Gila River that now reach the dam. This indicates that water in the valley fill between the Maricopa and the Gila Bend Mountains was derived from recharge of water with a lower content of dissolved solids than any water now available for recharge in this area except flood flows in the Gila River now passing Gillespie Dam. Because the present pumpage exceeds the average amount of recharge from flood flows, it is likely that much of the water being withdrawn by the irrigation wells in this vicinity is being taken from storage, and is water which has been in storage in the area for a long period. When the water table is lowered by this withdrawal, part of the water pumped will be replaced with highly mineralized waters leaving the Salt River Valley as underflow, or as drainage from irrigated fields south of Gillespie Dam. Hence, the concentration of dissolved matter in ground waters of this area probably will increase in the future.

Water from deep wells at Gila Bend and along the Gila River downstream from Gila Bend is somewhat higher in sodium percentage and in fluoride than the waters from the irrigation wells along the Gila Bend Canal. These characteristics are also found in waters from Agua Caliente Springs, which lie outside the Gila Bend Basin, about 35 miles downstream from Gila Bend. The waters of the deep wells near Gila Bend possibly come from sources similar to those of the Agua Caliente Springs. It is unlikely, however, that subterranean inflows in the Gila Bend Basin contribute significant amounts of recharge to the valley fill.

Discharge of dissolved solids from the basin

Most of the dissolved solids that leave the basin are contained in the small surface outflow, representing effluent seepage, and the underflow of the Gila River, at the west end of the basin. The highest concentration of dissolved solids in these waters was about equal to the average concentration of dissolved solids (4,000 parts per million) in the surface flow past Gillespie Dam in 1945. The amount of surface flow and underflow that leaves the basin is much less than the total flow that enters the basin. Therefore, dissolved matter must be accumulating in the basin. During the 12-month period ending September 30, 1945, more than 450,000 tons of soluble salts entered the basin in surface flow and

20/ Public Health Service drinking water standards, 1946: Reprint 2697, Public Health Repts., vol. 61, No. 11, pp. 371-384, Mar. 15, 1946.

underflow of the Gila River at Gillespie Dam[21].

The accumulation of soluble salts in the basin is gradually increasing the concentration of dissolved matter in the ground water. No data are available to show how much dissolved matter the ground water of the basin formerly contained, and therefore the extent of the increase in concentration of dissolved solids which may have already occurred cannot be determined. However, it is likely that concentrations have increased and that they will continue to increase.

SUMMARY AND CONCLUSIONS

The Gila Bend Basin is a wide, gently sloping desert plain that extends from the northern tip of the Painted Rock Mountains, upstream along the Gila River for a distance of about 36 miles to Gillespie Dam. The basin lies entirely within Maricopa County and covers an area of about 800 square miles.

Many attempts have been made in the past to develop the surface flow of the Gila River for irrigation. Most of these attempts were made without adequate study of the quantity of water available for diversion, and consequently they were unsuccessful. At present (1947) the Enterprise Canal and the Gila Bend Canal, both diverting water at Gillespie Dam, are the only canals being used in the basin. In 1946 about 19,000 acres of land was irrigated primarily with surface water. However, as the availability of surface water has become more and more uncertain, irrigation wells have been drilled to supplement this supply. In addition, about 2,000 acres was irrigated entirely with ground water in 1946.

The basin is composed of several structural troughs that were formed by block faulting. Gravels, sands, silts, and clays, the "older valley fill," have been washed into the basin from the surrounding mountains. The Gila River has cut three terraces in the older valley fill in the basin, above the present flood plain. The materials underlying the river flood plain are silts, sands, and gravels of Quaternary age, and are termed "younger valley fill." This younger fill, which is underlain by the older valley fill, is at least 80 feet in thickness and is capable of yielding large amounts of water for irrigation. As indicated above, the terraces and the remainder of the basin are underlain by several hundred feet of gravel, sand, silt, and clay of the older valley fill, and it is capped by a relatively thin veneer of Quaternary alluvium. The older valley fill is of undifferentiated Tertiary and Quaternary age. It is underlain, in places, by fanglomerate and interbedded rocks of Tertiary(?) age. The ground water in the older and younger valley fill is interconnected and the ground-water reservoir is continuous throughout all of the valley fill.

Ground water occurs in limited quantities in the sandstone beds of the fanglomerate unit, and in large quantities in the gravel and sand deposits of the older and younger valley fill. The older valley fill in the vicinity of Gila Bend contains very little sand and gravel, and the yield from wells drilled in these materials is small. North of Gila Bend, between the Gila Bend and the Maricopa Mountains, the older valley fill consists of large amounts of boulders, gravel, and sand, and the yield from wells drilled in this area is large. The average discharge of wells is 2,400 gallons a minute, and the average specific capacity is 56 gallons a minute per foot of drawdown. The average depth to water

21/ McDonald, H. R., Wolcott, H. N., and Hem, J. D., Geology and ground-water resources of the Salt River Valley area, Maricopa and Pinal Counties, Ariz.: U. S. Geol. Survey (mimeographed), p. 31, 1947.

is 60 feet. The younger valley fill is composed largely of gravel and sand. The water table is nearer the surface and this material yields water to wells more readily than the older valley fill.

Movement of ground water is always down the slope of the water table. The slope of the water table in the valley fill is toward the Gila River and downstream, and generally follows the slope of the land surface.

Ground water in the valley fill is derived from four sources: (1) Infiltration from flows in the Gila River and its tributary washes; (2) infiltration from canals and from irrigation water applied to the land; (3) underflow of the Gila River into the basin; and (4) rainfall. The loss in flow of the Gila River through the basin is about 12,000 acre-feet a year, and during exceptionally wet years the loss in flow is much greater. Most of this water is recharged to the ground-water reservoir. The recharge from irrigation seepage to the ground-water reservoir of the basin was estimated to be about 36,000 acre-feet a year. The amount of water that enters the basin as underflow is probably small.

Ground water is discharged from the basin by pumping for irrigation and by natural means. The total amount of water pumped for irrigation in the basin was computed to be 33,300 acre-feet in 1946. Natural discharge includes ground water that leaves the basin as surface flow and underflow, and by evaporation and transpiration. The amount of water leaving the basin as surface flow was estimated to be about 4,400 acre-feet a year. The amount of water leaving the basin as underflow was not measured, but it is probably several thousand acre-feet a year. The amount of water leaving the basin through transpiration and evaporation was estimated to be not less than 50,000 acre-feet a year and may be as much as 100,000 acre-feet a year.

There has been a downward trend of the water table in the area of heavy pumping along the Gila Bend Canal. The water table has been lowering at the rate of about 1.5 feet a year since heavy pumping started in this area.

Water from most of the wells in the basin is generally highly mineralized and most of it contains more than 1.5 parts per million of fluoride.

Soluble salts are accumulating in the basin. The accumulation of soluble salts in the basin will cause an increase in the concentration of dissolved matter in the ground water.

Continued study of the ground-water resources will be needed to determine the safe annual yield of the basin. Periodic water-level measurements and water analyses should be made to determine changes in elevation of the water table and changes in concentration of dissolved mineral matter in the ground water, and observations should be made to determine the amounts of salts entering and leaving the basin.

Table 1. Records of wells in Gila Bend Basin, Maricopa County, Arizona. (All wells are drilled).

No.	Location	Owner	Driller	Depth of well (feet)	Diameter of well (in.)
	T. 3 S., R. 4 W.				
d/ 4879	NW¼SE¼ sec. 6	Gillespie Land and Irrigation Co.	Roscoe Moss	530	20
d/ 4885	SE¼NW¼ sec. 8	do.	do.	370	20
d/ 4897	NW¼NW¼ sec. 21	do.	do.	300	20
	T. 4 S., R. 4 W.				
d/ 4925	NE¼NE¼ sec. 4	do.	do.	640	20
	T. 5 S., R. 4 W.				
d/ 5040	NW¼SE¼ sec. 31	Southern Pacific Railroad	-	1,746	11
	T. 7 S., R. 5 W.				
d/ 5245	NE¼NE¼ sec. 6	A. H. Stout	Buckey	290	6
	T. 8 S., R. 5 W.				
d/ 5250	SE¼NW¼ sec. 2	do.	-	495	6
	T. 5 S., R. 5 W.				
5350	SW¼SE¼ sec. 13	U. S. Indian Serv.	-	-	10
	T. 3 S., R. 5 W.				
5440	NW¼SW¼ sec. 2	C. W. Davis	A. G. Tschuer	256	24
	T. 2 S., R. 5 W.				
d/ 5465	SW¼NE¼ sec. 35	Gillespie Land and Irrigation Co.	Roscoe Moss	400	20
5502	SE¼SW¼ sec. 36	do.	-	65	12
	T. 4 S., R. 6 W.				
d/ 6195	NE¼NE¼ sec. 29	C. L. Stephens	A. G. Tschuer	340	20

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

b/ T, turbine; C, cylinder; A, air lift; E, electric; G, gasoline; W, windmill; O, diesel.

Records obtained by H. M. Babcoc[illegible] 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
4879	63.02	May 27, 1946	T,E	I	75	Measured discharge 3,020 gallons a minute, May 1946. See log.
4885	68.81	Dec. 18, 1945	T,E	I	74	Measured discharge 2,280 gallons a minute, May 1946. See log.
4897	69.67	do.	T,E	I	74	Measured discharge 2,600 gallons a minute, April 1946. See log.
4925	76.90	May 2, 1946	T,E	I	80	Measured discharge 2,350 gallons a minute, May 27, 1946. See log.
5040	-	-	T,E	Ind.	107	Reported discharge 150 gallons a minute. See log.
5245	255.25	Jan. 23, 1945	C,G	S	80	-
5250	405e/	-	C,G	S	78	-
5350	34.99	Oct. 23, 1945	C,W	D	-	-
5440	25e/	-	T,E	I	-	See log.
5465	50.45	Dec. 18, 1945	T,E	I	74	Measured discharge 2,150 gallons a minute, April 1946. See log.
5502	49.15	April 26, 1945	None	N	-	-
6195	31.50	Jan. 15, 1946	None	N	-	See log.

c/ I, irrigation; Ind., industrial; S, stock; D, domestic; N, not used.
d/ See table 3 for analysis of water sample.
e/ Water level reported.

Table 1. Records of wells in Gila Bend Basin, Maricopa County, Arizona-Cont.

No.	Location	Owner	Driller	Depth of well (feet)	Diameter of well (in.)
	T. 5 S., R. 6 W.				
d/ 6205	NW¼SE¼ sec. 2	Les Narmore	-	418	20
d/ 6215	SE¼NE¼ sec. 13	Orr	-	280	20
	T. 6 S., R. 6 W.				
6260	NE¼NE¼ sec. 4	Gillespie Land and Irrigation Co.	M. J. Houck	244	6

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

b/ T, turbine; C, cylinder; A, air lift; E, electric; G, gasoline; W, windmill; D, diesel.

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
6205	19.93	Jan. 15, 1946	T,O	I	76	Measured discharge 1,900 gallons a minute, April 29, 1945
6215	30e/	-	T,O	I	74	Measured discharge 2,780 gallons a minute, April 1946.
6260	122.00	April 27, 1945	A,G	D	-	See log.

c/ I, irrigation; Ind., industrial; S, stock; D, domestic; N, not used.
d/ See table 3 for analysis of water sample.
e/ Water level reported.

Table 2. Well logs, Gila Bend Basin, Maricopa County, Arizona.

Driller's log of well 4879.
Gillespie Land and Irrigation Co., owner. NW¼SE¼ sec. 6, T. 3 S., R. 4 W.

	Thickness (feet)	Depth (feet)
Sandy silt	39	39
Gravel	31	70
Clay, sand, and gravel	20	90
Clay and small gravel	130	220
Hard clay and gravel	276	496
Cemented gravel	34	530
TOTAL DEPTH		530

Driller's log of well 4885.
Gillespie Land and Irrigation Co., owner. SE¼NW¼ sec. 8, T. 3 S., R. 4 W.

	Thickness (feet)	Depth (feet)
Clay	18	18
Hard packed clay	4	22
Gravel to 6 inch	4	26
Clay and gravel	12	38
Clay sand	19	57
Gravel	22	79
Clay and caliche	7	86
Clay and gravel	50	136
Gravel, clay, and streaks of conglomerate	38	174
Gravel	5	179
Gravel, clay, and streaks of conglomerate	25	204
Cemented gravel	5	209
Gravel, clay, and cemented gravel	17	226
Coarse sand and gravel	48	274
Cemented gravel	2	276
Coarse sand and gravel	94	370
TOTAL DEPTH		370

Driller's log of well 4897.
Gillespie Land and Irrigation Co., owner. NW¼NW¼ sec. 21, T. 3 S., R. 4 W.

	Thickness (feet)	Depth (feet)
Soil	2	2
Clay	4	6
Sand and clay	9	15
Clay and small gravel	15	30
Sand	11	41
Clay	29	70
Sand (water)	10	80
Small gravel	9	89
Clay and gravel	21	110
Small gravel	39	149
Shell, hard	2	151
Gravel	15	166
Shell	7	173
Gravel and shell	53	226
Loose gravel	74	300
TOTAL DEPTH		300

Driller's log of well 4925.
Gillespie Land and Irrigation Co., owner. NE¼NE¼ sec. 4, T. 4 S., R. 4 W.

	Thickness (feet)	Depth (feet)
Loose gravel	40	40
Caliche	68	108
Gravel	16	124
Clay and gravel	56	180
Caliche, clay, and gravel	75	255
Sand and gravel	15	270
Clay and gravel	40	310
Soft clay and gravel	90	400
Decomposed granite	220	620
Granite	20	640
TOTAL DEPTH		640

Table 2. Well logs, Gila Bend Basin, Maricopa County, Arizona-Cont.

	Thickness (feet)	Depth (feet)
Driller's log of well 5040.		
Southern Pacific Railroad, owner.		
NW¼SE¼ sec. 31, T. 5 S., R. 4 W.		
Sand and gravel - - - -	25	25
Clay and boulders - - -	20	45
Fine sand - - - - - - - -	20	65
Fine gravel - - - - - - -	15	80
Coarse gravel - - - - - -	12	92
Clay - - - - - - - - - -	53	145
Fine sand (water-bearing)	30	175
Sandy clay - - - - - - -	50	225
Fine sand - - - - - - - -	10	235
Sandy clay - - - - - - -	235	470
Clay (hot mud) - - - -	410	880
Cemented clay - - - - - -	20	900
Coarse sand - - - - - -	5	905
Hard clay - - - - - - - -	215	1,120
Hard clay and rock - -	50	1,170
Sand - - - - - - - - - -	15	1,185
Sand and rock - - - - - -	25	1,210
Rock - - - - - - - - - -	49	1,259
Clay with gravel - - -	12	1,271
Rock - - - - - - - - - -	13	1,284
Clay and gravel - - - -	23	1,307
Rock - - - - - - - - - -	5	1,312
Clay and gravel - - - -	10	1,322
Red rock - - - - - - - -	9	1,331
Clay and gravel - - - -	24	1,355
Light rock - - - - - - -	6	1,361
Clay and gravel - - - -	32	1,393
Quartz rock - - - - - - -	5	1,398
Cemented gravel - - - -	18	1,416
Clay - - - - - - - - - -	11	1,427
Cemented gravel - - - -	18	1,445
Clay - - - - - - - - - -	20	1,465
Boulders in clay - - -	9	1,474
Clay and gravel - - - -	21	1,495
Boulders in clay - - -	15	1,510
Clay and gravel - - - -	20	1,530
Rock - - - - - - - - - -	25	1,555
Clay - - - - - - - - - -	13	1,568
Hard rock - - - - - - - -	33	1,601
Clay - - - - - - - - - -	11	1,612
Rock - - - - - - - - - -	9	1,621
Driller's log of well 5040 - Continued.		
Clay - - - - - - - - - -	19	1,640
Rock - - - - - - - - - -	7	1,647
Clay - - - - - - - - - -	17	1,664
Rock - - - - - - - - - -	9	1,673
Clay - - - - - - - - - -	8	1,681
Rock - - - - - - - - - -	13	1,694
Clay - - - - - - - - - -	14	1,708
Rock - - - - - - - - - -	6	1,714
Sand - - - - - - - - - -	18	1,732
Clay - - - - - - - - - -	8	1,740
Rock - - - - - - - - - -	6	1,746
TOTAL DEPTH - - - - - -		1,746
Driller's log of well 5440.		
C. W. Davis, owner. NW¼SW¼ sec. 2, T. 3 S., R. 5 E.		
Sandy soil - - - - - - -	6	6
Clay - - - - - - - - - -	3	9
Sandy clay - - - - - - -	1	10
Clay - - - - - - - - - -	2	12
Coarse gravel (first water at 25 feet) - - - - -	20	32
Decomposed granite gravel	150	182
Granite gravel in clay	38	220
Decomposed granite gravel	25	245
Granite gravel in clay	3	248
Decomposed granite gravel	8	256
TOTAL DEPTH - - - - -		256
Struck conglomerate at 256 feet.		

Table 2. Well logs, Gila Bend Basin, Maricopa County, Arizona-Cont.

	Thickness (feet)	Depth (feet)
Driller's log of well 5465. Gillespie Land and Irrigation Co., owner. SW¼NE¼ sec. 35, T. 2 S., R. 5 W.		
Silt	30	30
Gravel	28	58
Coarse sand	3	61
Caliche	9	70
Caliche and clay	8	78
Clay and gravel	18	96
Caliche	6	102
Sandy clay	48	150
Clay and gravel	6	156
Sandy clay	47	203
Gravel	22	225
Loose gravel	20	245
Clay and gravel	15	260
Gravel	20	280
Clay and gravel	28	308
Sand and gravel	6	314
Clay and gravel	16	330
Gravel	10	340
Sand and gravel	12	352
Clay and gravel	48	400
TOTAL DEPTH		400
Driller's log of well 6195. C. L. Stephens, owner. NE¼NE¼ sec. 29, T. 4 S., R. 6 W.		
Soil	5	5
Gravel in clay	7	12
Clay	24	36
Gravel	4	40
Shells and gravel in clay	196	236
Gravel	6	242
Shells and gravel in clay	44	286
Gravel	16	302
Shell	8	310
Gravel in clay	14	324
Hard clay	6	330
Gravel in clay	10	340
TOTAL DEPTH		340
Driller's log of well 6260. Gillespie Land and Irrigation Co., owner. NE¼NE¼ sec. 4, T. 6 S., R. 6 W.		
Soil	4	4
Caliche	20	24
Fine dry sand and packed gravel	50	74
Caliche	15	89
Conglomerate	64	153
Red clay	15	168
Quicksand	5	173
Red clay	19	192
Fine sand	27	219
Red clay and sand	25	244
TOTAL DEPTH		244

Table 3. Analyses of water from wells in Gila Bend basin, Maricopa County, Arizona. Numbers correspond to numbers given in table 1 and shown on plate 1. Analyses by Geological Survey (parts per million).

Well No.	Date of collection (1946)	Depth (feet)	Specific conductance ($K \times 10^5$ at 25°C.)	Percent sodium	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$
4879	May 27	530	268	60	-	-	-	233	-	645	-	-	-	-
4885	do.	370	286	-	-	-	-	256	-	690	-	-	-	-
4897	Apr. 10	300	269	-	134	46	361	186	205	660	1.1	11	1510	524
4925	May 27	640	278	-	-	-	-	240	-	660	-	-	-	-
5040	Feb. 5	1,746	185	93	22	1.6	365	47	130	465	6.9	8.8	1060	62
5245	Jan. 31	290	120	87	23	4.4	227	107	124	236	6.9	2.0	676	76
5250	do.	495	72.4	57	36	18	102	303	34	32	.4	68	440	164
5465	Apr. 9	400	377	58	202	71	503	257	327	945	.7	5.7	2180	796
6195	Apr. 12	340	372	68	135	62	580	230	280	965	2.7	5.4	2140	592
6205	Apr. 10	418	168	80	50	9.4	293	191	92	382	2.6	2.9	926	164
6215	do.	280	346	73	118	39	565	236	181	915	2.3	5.9	1940	455

Plate 2. Looking downstream along Gila River at western end of Gila Bend Basin, showing gap between Painted Rock Mountains (left) and Gila Bend Mountains (right). Hard-rock outcrop in right foreground divides river into two channels. Water in river is ground-water inflow brought to the surface by the constriction.

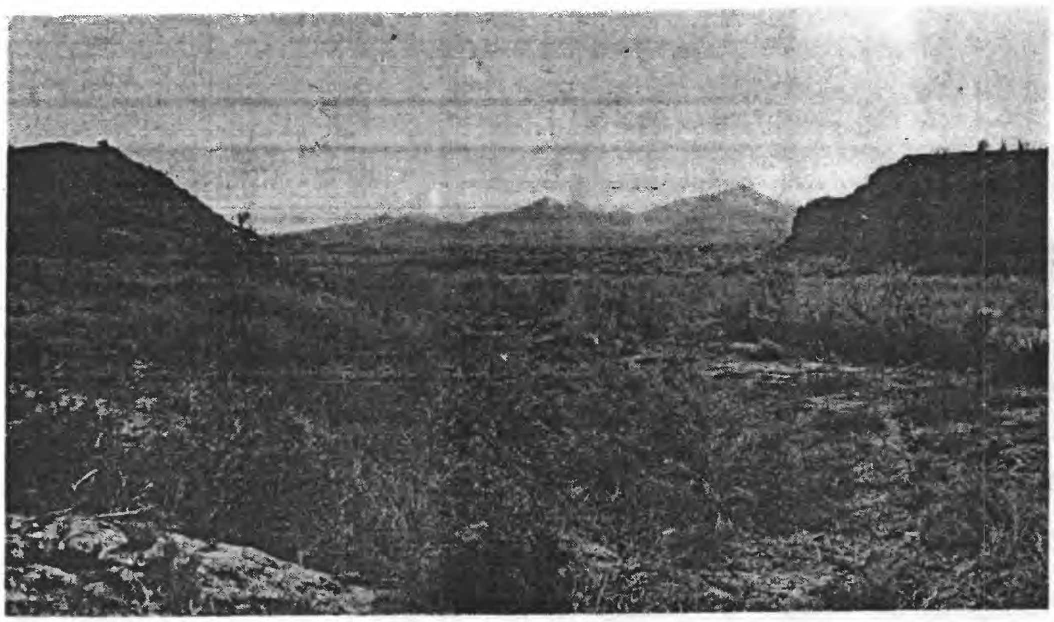

Plate 3. Looking upstream at south channel of Gila River at western end of Gila Bend Basin. Northern tip of Painted Rock Mountains at right. Hard-rock outcrop at left divides river into two channels.