Geology and Ground-Water Conditions in the Gila Bend Indian Reservation Maricopa County, Arizona

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1647-A

Prepared in cooperation with the Bureau of Indian Affairs

WISCONSIN GEOLOGICAL SURVEY

Heindl and Armstrong—GROUND WATER, GILA BEND INDIAN RESERVATION, ARIZ.—Geological Survey Water-Supply Paper 1647-A

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By L. A. HEINDL *and* C. A. ARMSTRONG

WATER SUPPLY OF INDIAN RESERVATIONS—PAPAGO TRIBE

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GEOLOGY AND GROUND-WATER CONDITIONS IN THE GILA BEND INDIAN RESERVATION, MARICOPA COUNTY, ARIZONA

By L. A. Heindl and C. A. Armstrong

ABSTRACT

The Gila Bend Indian Reservation, Maricopa County, Ariz., comprises an area of 16 square miles about 3 miles north of Gila Bend, Ariz. The Gila River flows across the reservation at an altitude of about 620 feet, and the Gila Bend Mountains, which form the northwestern part of the reservation, rise to an altitude of about 2,000 feet.

The reservation is underlain by crystalline rocks of possible Precambrian and Mesozoic ages, red sandstone, fanglomerate, conglomerate, and volcanic rocks of probable Tertiary age, an older alluvial fill of Tertiary and Quaternary age, and channel and flood-plain deposits of Quaternary age. The Gila Bend Mountains are composed of granitic, metamorphic, and volcanic rocks, and older terrestrial deposits and appear to be a fault block that has been tilted to the west. The older alluvium and the channel and flood-plain deposits were laid down on an eroded surface of the tilted block. The flood-plain deposits are about 80 feet thick and are underlain by older alluvium, which in this area is about 300 to 500 feet thick. The sandstone, fanglomerate, and volcanic rocks are more than 1,500 feet thick.

The principal aquifer is in the valley fill, which comprises hydraulically interconnected parts of the older and younger alluvial deposits and the sandstone, fanglomerate, and conglomerate of Tertiary age. This aquifer yields water in large quantities. The crystalline rocks are virtually not water-bearing. The principal recharge to the alluvial deposits is by infiltration from the Gila River. Large quantities of water are in storage in these deposits.

The concentration of dissolved solids of most of the ground water obtained from the valley fill ranges from about 1,000 to 3,500 ppm. The water is high in sodium, chloride, boron, and fluoride. The surface water of the Gila River during periods of low flow contains more than 5,000 ppm of dissolved solids—chiefly sodium, calcium, magnesium, and chloride.

Painted Rock Dam, now being constructed across the Gila River for flood-control purposes about 11 miles downstream from the reservation, will have a spillway at an altitude of 660 feet. When the reservoir behind the dam fills to the level of the spillway, all the reservation, except for the part in the Gila Bend Mountains, will be inundated. However, long-term effects of inundation by high water likely will be unimportant because the reservoir will receive water only from infrequent maximum floods, and the water will not be retained permanently in the reservoir.

INTRODUCTION

The study of ground-water resources of the Gila Bend Indian Reservation is part of an investigation of the ground water available to the Papago Indian Tribe. The study was made by the Geological Survey in cooperation with the Bureau of Indian Affairs. The Bureau of Indian Affairs requested data regarding the possibilities of developing water supplies for both range and irrigation purposes, and an opinion regarding the possible effects of Painted Rock Dam being constructed about 10 miles downstream and west of the reservation (fig. 1).

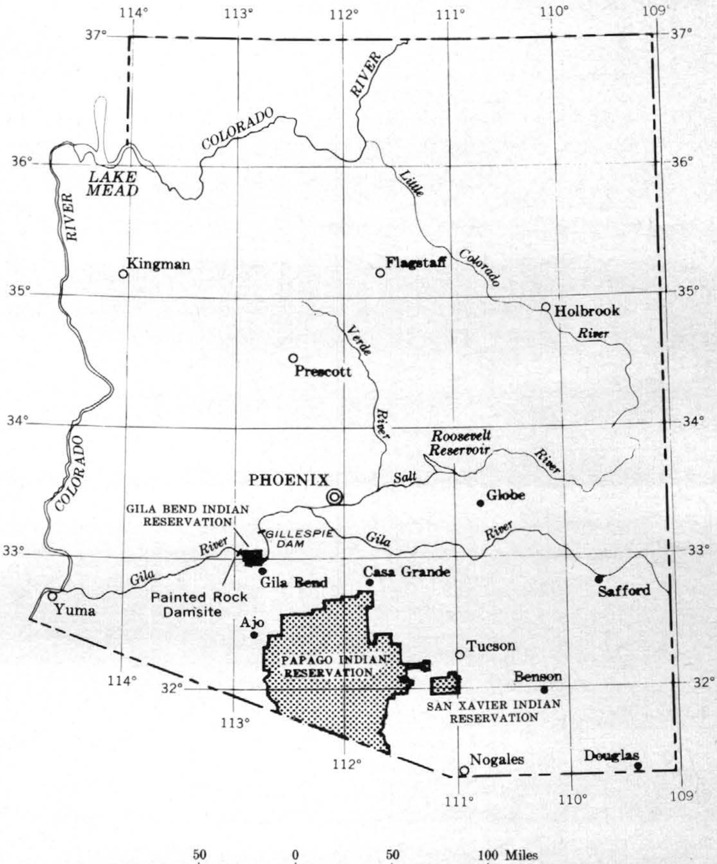


FIGURE 1.—Index map of Arizona showing Gila Bend, Papago, and San Xavier Indian Reservations.

The Gila Bend Indian Reservation, the smallest of three Papago Indian Reservations, is 16 square miles in area, and is in the Sonoran Desert section of the Basin and Range province (Fenneman, 1931). It is 3 miles north of Gila Bend, Ariz., at the north end of a large gently northward-sloping intermontane basin called the Gila Bend plain, and at the south end of the Gila Bend Mountains (fig. 2). Immediately east of the Gila Bend Indian Reservation the Gila River bends from south to west to give the region its name. The reservation is divided by the Gila River, which here marks the boundary between the Gila Bend plain and the Gila Bend Mountains.

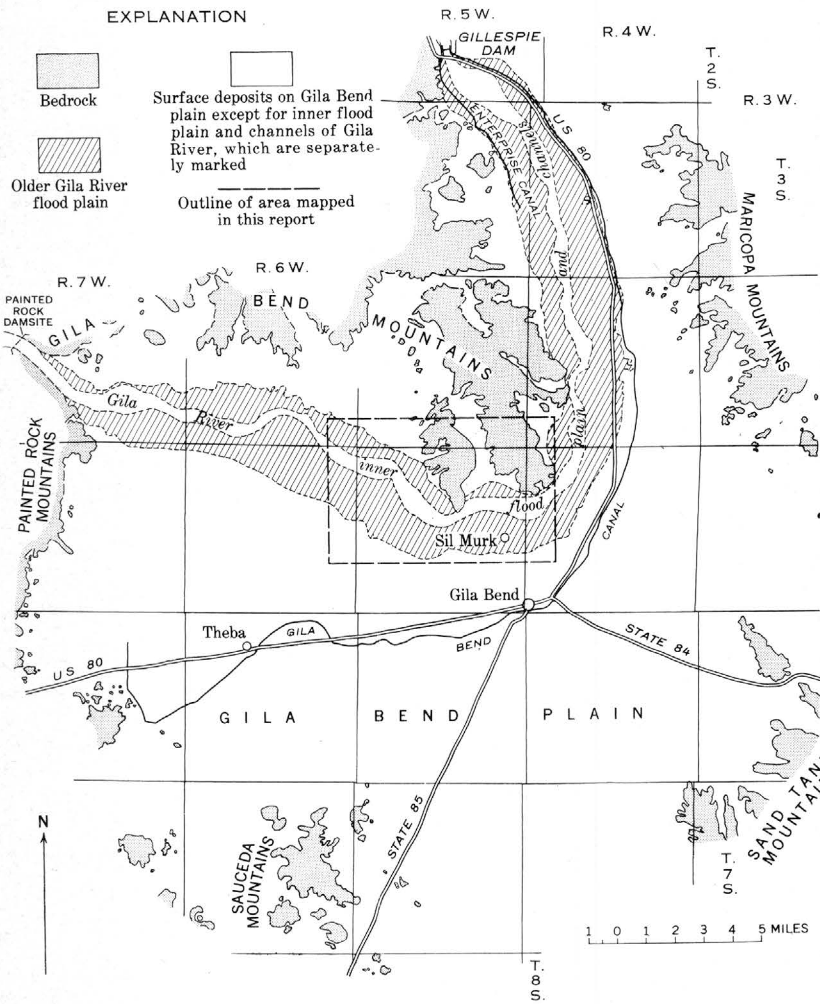


FIGURE 2.—Index map of Gila Bend plain and adjacent mountains, showing outline of hard-rock outcrops. After Babcock and others (1948, pl. 1).

The altitude of the Gila River at the southernmost tip of the Gila Bend Mountains is 620 feet, and the Gila Bend Mountains rise to an altitude of about 2,000 feet. The area is drained by the Gila River, whose gradient here is about 6 feet per mile and whose flood plain is 2 to 3 miles wide. About 10 square miles of the reservation consists of the channel and flood plain of the Gila River and low terraces of the Gila Bend plain. The rest is in the foothills and more rugged areas of the Gila Bend Mountains.

In 1955 about 375 acres of arable land was under lease to non-Indian personnel. Commercial crops of cotton, barley, alfalfa, and sorghum were grown on this land. In addition, about 1,200 acres are considered by the Bureau of Indian Affairs to be arable and a few head of cattle graze within the reservation. About 130 Papagos were permanent residents of the reservation in 1958 according to G. W. Gilmore, Papago Indian Agency superintendent (written communication, June 23, 1958). Sil Murk is the only Papago village in the area, but it is not on the reservation.

The climate of the area is arid, and is characterized by hot summers and mild winters. A climatological station was established at Gila Bend in 1903 and is still in operation, although records from the station have not been continuous. Data from the station at Gila Bend indicate that precipitation averaged about 5.5 inches per year for 52 years of record, ranging from a minimum of 2.13 inches to a maximum of 13.58 inches. The mean annual temperature for 32 years of record is about 72°F, ranging from a maximum summer temperature of 123°F to a minimum winter temperature of 11°F. Potential evaporative losses were estimated to be about 96 inches per year in the Gila Bend area (Johnson and Cahill, 1955, p. 18). The frost-free season averages about 9½ months per year.

The geology of the reservation was mapped and hydrologic data from the immediately adjacent areas were examined and brought up to date in early 1957. The fieldwork was begun by C. A. Armstrong in 1954 and completed by L. A. Heindl in 1960.

PREVIOUS INVESTIGATIONS

The geology and ground-water resources of the Gila Bend region have been discussed by several writers whose reports, listed chronologically below, have provided the regional data necessary to analyze the local conditions of the Gila Bend Indian Reservation.

1914. Phalen, W. C., Celestite deposits in California and Arizona: U.S. Geol. Bull. 540–T, p. 521–533.

Briefly describes a tilted sedimentary series associated with gypsum, sandstone, conglomerate containing pebbles of coarse-grained granite,

and basaltic flows in the north end of the Sauceda Mountains, about 15 miles south of Gila Bend.

1922. Ross, C. P., Routes to desert watering places in the lower Gila region, Arizona: U.S. Geol. Survey Water-Supply Paper 490–C, p. 271–315.

Describes watering points along roads west of Gila Bend.

1922. Bryan, Kirk, Routes to desert watering places in the Papago country, Arizona: U.S. Geol. Survey Water-Supply Paper 490–D, p. 317–429.

Describes watering points along roads south and east of Gila Bend.

1922. Ross, C. P., Geology of the lower Gila region, Arizona: U.S. Geol. Survey Prof. Paper 129–H, p. 183–197.

First description of some geologic features in the Gila Bend area; discusses crystalline rocks of two ages and Tertiary and Quaternary sedimentary and volcanic rocks, general structural relationships, history and some mineral deposits; includes first generalized geologic map of the area.

1923. 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, 237 p.

Includes resume of geologic data in Professional Paper 129–H, ground-water data in the Gila Bend area, description and physiographic history of the lower Gila River, and history of irrigation development.

1925. Bryan, Kirk, The Papago country, Arizona, a geographic, geologic, and hydrologic reconnaissance with a guide to desert watering places: U.S. Geol. Survey Water-Supply Paper 499, 436 p.

General description of physiography and ground-water conditions of Gila Bend plain.

1925. Darton, N. H., A resume of Arizona geology: Arizona Bur. Mines Bull. 119, p. 226–227.

Briefly mentions major features of the Gila Bend Mountains.

1933. Wilson, E. D., Geology and mineral deposits of southern Yuma County, Arizona: Arizona Bur. Mines Bull. 134, p. 144–147.

Briefly describes the Gila Bend Mountains and some gold and copper mineralization.

1948. Babcock, H. M., and Kendall, K. K., Geology and groundwater resources of the Gila Bend basin, Maricopa County, Arizona, *with a section on* Quality of water by J. D. Hem: U.S. Geol. Survey open-file rept.

Brief, comprehensive summary of the geology of the area with first detailed discussions of ground-water conditions and chemical quality of surface and ground water; includes tables of well records, logs, and water analyses, and a generalized geologic map.

1952. Coates, D. R., Gila Bend basin, Maricopa County, Arizona, *in* Halpenny, L. C., and others, Ground water in the Gila River basin and adjacent areas, Arizona—a summary: U.S. Geol. Survey open-file rept., p. 159–164.

Summarizes the report by Babcock, Kendall, and Hem (1948), supplemented by later pumpage and water-level data.

1955. Johnson, P. W., and Cahill, J. M., Ground-water resources and geology of the Gila Bend and Dendora area, Maricopa County, Arizona: U.S. Geol. Survey open-file rept., 53 p.

Describes the geology and hydrology of the area between Gillespie Dam and a point about 10 miles downstream from the Painted Rock damsite; brings up to date information on water resources and de-

scribes evapotranspirative regimen of river-bottom vegetation in the area; includes maps of geology, water tables, and dissolved-solids content, tables of ground-water use by bottom-land vegetation, records of selected wells, well logs and chemical analyses of water, and charts showing water-table fluctuations and other hydrologic relationships.

GEOLOGY

The Gila Bend Indian Reservation includes three principal topographic features—the Gila Bend Mountains, the flood plain of the Gila River, and the broad terrace of the Gila Bend plain (fig. 3). These features are expressions of the principal geologic units discussed in this report and shown in figure 4. The Gila Bend Mountains trend north-south and are the exposed part of a tilted fault block. They are composed of granite and associated igneous and metamorphic rocks and arkosic sandstone, fanglomerate, and volcanic deposits. The flood plain of the Gila River and the broad terrace of the Gila Bend plain south of the reservation are underlain by poorly consolidated alluvial materials.

FIGURE 3.—General view of the eastern part of the Gila Bend Mountains looking north. Main ridge is composed of crystalline rocks; ridge including hill 1106 is composed of gray boulder conglomerate and the dark cuesta in left middle ground is composed of volcanic rocks of the Sil Murk formation. The sharp bend of the Gila River, which gives the Gila Bend area its place names, occurs immediately to the right of the photograph; in the upper right, the dark area in the valley between the Gila Bend and more distant Maricopa Mountains marks part of the north-south leg of the bend; the dark area in the middle ground is the heavily vegetated land along the channel of the east-west leg of the bend. The large light area in the middle ground is cultivated land in the flood plain of the Gila River and the dissected area in the foreground is cut into older alluvial fill.

Several deep water wells in the area adjacent to the reservation provide data for speculation regarding the stratigraphy underlying the Gila Bend plain, and these data are discussed in the section "Subsurface stratigraphy."

No definitely dated late Precambrian, Paleozoic, or Mesozoic sedimentary rocks are exposed in the Gila Bend Mountains. The

1,500-foot thickness of late Precambrian rocks in the mountains 45 miles southeast of the area (McClymonds, 1959) suggests that rocks of the same age may have extended at one time as far west as the Gila Bend Mountains. Remnants of moderately thick sections of Paleozoic and possibly Mesozoic sedimentary rocks are exposed at a few places in the region (Wilson and others, 1957, 1959; McClymonds, 1959). Tertiary(?) conglomerate containing large boulders of Paleozoic limestone has been reported in nearby mountains (Wilson, 1933; McKee, 1947); these boulders suggest that the area was at one time covered by Paleozoic and possibly some Mesozoic sedimentary strata. Thick sequences of volcanic rocks, in part older than the Sil Murk formation, crop out extensively in the northern part of the Gila Bend Mountains and other nearby ranges (Wilson and others, 1957).

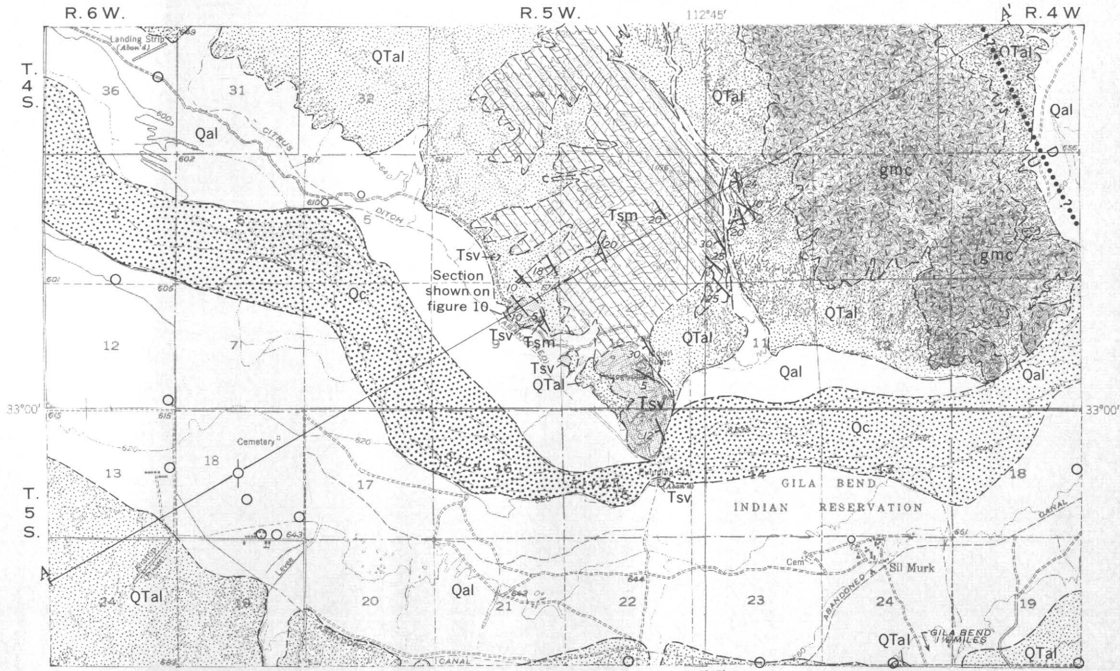
ROCKS AND THEIR WATER-BEARING PROPERTIES

CRYSTALLINE ROCKS

The main ridge of the Gila Bend Mountains is composed of metamorphic and igneous rocks, which will be referred to collectively as crystalline rocks. The ridge rises to a sharp lineral crest whose flanks are scoured by a close succession of steep, narrow ravines. The oldest rocks in the Gila Bend Mountains are gneiss and schist, which are tentatively correlated with the Cardigan gneiss of presumed Precambrian age in the Ajo area (Babcock and others, 1948, p. 6). The gneiss and schist occur only locally and are predominantly brownish gray and prominently banded or foliated. Much of the gneiss is closely jointed. The gneiss is generally more resistant to erosion than the schist and forms the bolder outcrops.

The early Precambrian(?) gneiss and schist are intruded by finely to coarsely crystalline equigranular to porphyritic granite that forms most of the Gila Bend Mountains. Wherever observed, the granite is gneissoid. The granite is generally light gray and weathers brownish or greenish gray. It contains numerous inclusions and locally these string out from bodies of older schist. The granite is well jointed to massive and weathers to well-rounded large fragments and whole or broken mineral crystals. The granitic rocks are correlated tentatively with the Chico Shunie quartz monzonite of presumed Mesozoic age in the Ajo quadrangle by Babcock and others (1948, p. 7), but Wilson and others (1957) consider the granite to be Precambrian. The gneiss, schist, and granite are intricately crisscrossed by numerous mafic, felsic, and pegmatitic dikes.

The crystalline rocks are all extensively sheared and fractured and may contain small amounts of shallow "surface" ground water, but none has been developed in this area.



Base from U. S. Geological Survey topographic maps Woolsey Peak, 1951; Theba, 1951; Gila Bend, 1951; Cotton Center, 1951

Geology by C. A. Armstrong, 1954 and L. A. Heindl, 1956

1 0 1 2 MILES

CONTOUR INTERVAL 20 AND 40 FEET
DATUM IS MEAN SEA LEVEL

EXPLANATION

Qal | Qc

Younger alluvial fill

Qal, *nearly unconsolidated gravel, sand, silt, and clay; older flood-plain deposits;* Qc, *Gila River channel and younger flood-plain deposits; yield water in large quantities to irrigation wells; may include small areas of* QTal.

QUATERNARY

QTal

Older alluvial fill

Poorly consolidated conglomerate, sandstone, and mudstone; surface deposits include fan, sheet wash, and terrace deposits; yields water in large quantities to irrigation wells; includes small areas of Qal *and channel deposits*

TERTIARY AND QUATERNARY

UNCONFORMITY

Tsv | Tsm

Sil Murk formation

Tsm, *moderately to poorly consolidated sandstone, fanglomerate, and conglomerate;* Tsv, *volcanic member and intercalated conglomerate.* Tsm *yields water in moderate quantities to irrigation wells;* Tsv *may yield small quantities of water from fractured zones or conglomerate lenses*

TERTIARY

UNCONFORMITY

gmc

Crystalline rocks

Complex of intrusive and metamorphic rocks; bear little or no water in the area

PRECAMBRIAN(?) AND MESOZOIC(?)

Contact, approximately located

U / D

Probable buried fault

U, *upthrown side;* D, *downthrown side*

28

Strike and dip of beds

Domestic or stock well

Irrigation well

Abandoned well

A — A′

Sections along line A–A′ found on figures 10 and 13

Figure 4.—Geologic map showing location of wells in the Gila Bend Indian Reservation and immediately adjacent areas.

SIL MURK FORMATION

Extensive exposures of conglomerate, fanglomerate, sandstone, and volcanic rocks crop out in the southwestern part of the Gila Bend Mountains (fig. 4). They are also presumed to underlie the Gila Bend plain immediately to the south of the Gila Bend Mountains. These rocks are here named the Sil Murk formation for their excellent exposures 2 to 4 miles northwest of the village of Sil Murk.

The topography developed on the Sil Murk formation depends on the predominant rock type involved. The sandstone and fanglomerate are less resistant to erosion than the conglomerate and volcanic deposits and typically underlie valleys or form slopes (fig. 5); the conglomerate is moderately resistant and forms a prominent ridge

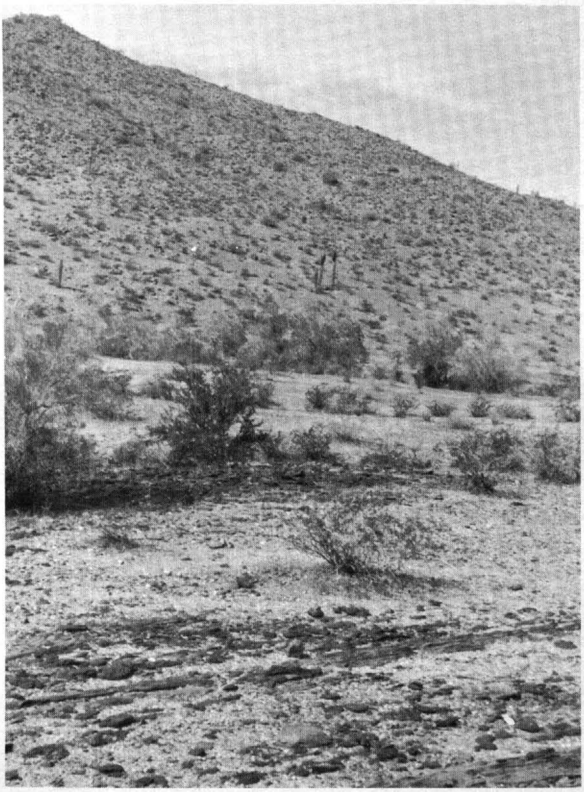


FIGURE 5.—View northwest from the center of sec. 2, T. 5 S., R. 5 W., to hill 1106 in the NW¼ sec. 3, showing topographic relationships of the Sil Murk formation. Foreground is composed of red arkosic sandstone, and hill 1106 is composed of gray boulder conglomerate. Covered area in the center of photograph is underlain by fanglomerate that is transitional between these two facies.

of rounded hills in the area; and the volcanic rocks, particularly the welded tuff, are the most resistant, forming conspicuous cuestas and low hills.

The Sil Murk formation in the area is composed of a sedimentary member overlain by a volcanic member. The sedimentary member is composed of two facies. The lower facies is predominantly a brick-red, thinly bedded, arkosic sandstone. This facies grades upward through a zone of moderately indurated fanglomerate, composed of interbedded pebbly sandstone and sandy conglomerate, into the upper facies, a gray boulder conglomerate which forms the ridge described above. At the top of the Sil Murk formation at the south end of the Gila Bend Mountains is a volcanic member composed of tuffs, flows, and intercalated conglomerate lenses.

The base and top of the Sil Murk formation are not exposed in the area but they are exposed in the Gila Bend Mountains about 6 to 10 miles north of Sil Murk. There the lower sandstone facies is locally absent; the volcanic member is intercalated between clastic deposits; and the top of the formation is a conglomerate similar to the gray boulder conglomerate exposed at the south end of the Gila Bend Mountains.

SEDIMENTARY MEMBER

The lower sandstone facies is best exposed in the narrow valley between the crystalline rocks and the prominent ridge to the west (fig. 4). Several small exposures are shown as a single outcrop on figure 4. The sandstone forms some low hillocks and bare rocky spots, inconspicuous except for their color, but is exposed best along the banks of some of the deeper washes. The brick-red sandstone is medium to coarse grained, arkosic, and contains differing but conspicuous amounts of magnetite and, less commonly, biotite. Quartz grains are angular to subrounded. The sandstone is weakly consolidated with lime. Bedding is well developed and the beds range in thickness from less than a quarter of an inch to about 12 inches (fig. 6). Pebbly and cobbly beds increase in proportion to sandy beds upward in the section. The larger fragments are composed entirely of crystalline rocks exposed in the main ridge of the Gila Bend Mountains (fig. 7). About 100 feet of sandstone is exposed in the area, but the total thickness is not exposed and may be as much as several hundred feet.

The contact between the sandstone facies and the crystalline rocks to the east is covered by alluvial material disgorged from the adjacent canyons of the Gila Bend Mountains. The contact is presumed to be depositional for lack of contradictory evidence and is so described by Babcock and others (1948, p. 4) in surrounding areas.

FIGURE 6.—Thin-bedded red arkosic sandstone that forms the lowest exposed part of the Sil Murk formation in the center of sec. 2, T. 5 S., R 5 W.

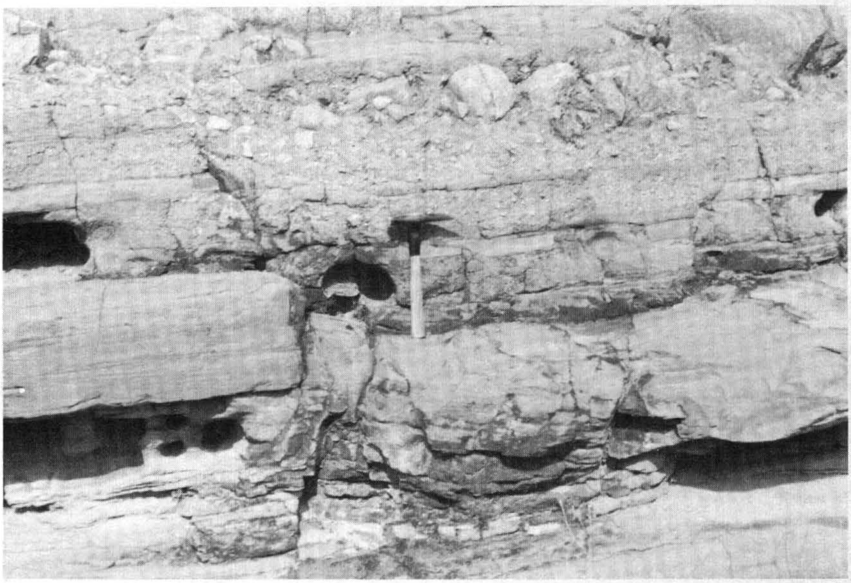


FIGURE 7.—Lower part of well-indurated fanglomerate of the Sil Murk formation in the center of sec. 2, T. 5 S., R. 5 W. The fanglomerate is composed of interbedded red arkosic sandstone and cobbly beds.

The fanglomerate forms a transitional zone between the sandstone and gray conglomerate, and is well exposed in the NW¼ sec. 2, T. 5 S., R. 5 W. in the main southwestward-trending wash coming out of the Gila Bend Mountains and the large northward-trending wash between the mountains and the gray conglomerate ridge (figs. 8 and 9). The fanglomerate is composed of interbedded light-reddish-brown pebbly sandstone and cobbly conglomerate. Generally it is better indurated than either the underlying sandstone or the overlying conglomerate. Ross (1922, p. 196 and pl. 44) reports an angular unconformity between the red sandstone and an overlying conglomerate, which he correlates with the gray conglomerate facies in the vicinity of Woolsey Tank (Ross, 1923, pl. 4) about 20 miles northwest of Sil Murk. However, the conglomerate above the unconformity in that area is a younger deposit that resembles the gray conglomerate only because it is locally well indurated by caliche.

The gray conglomerate facies of the lower member of the Sil Murk formation is composed of poorly sorted beds of boulder to pebble conglomerate, sandstone, and mudstone. There is a general decrease in the size of the fragments from the eastern to the western part of the area. The boulder beds are thick, lenticular, and poorly and irregularly developed. The pebbly sandstone and mudstone are more distinctly and thinly bedded and many of the sandstone beds are crossbedded. Generally the gray conglomerate is moderately con-

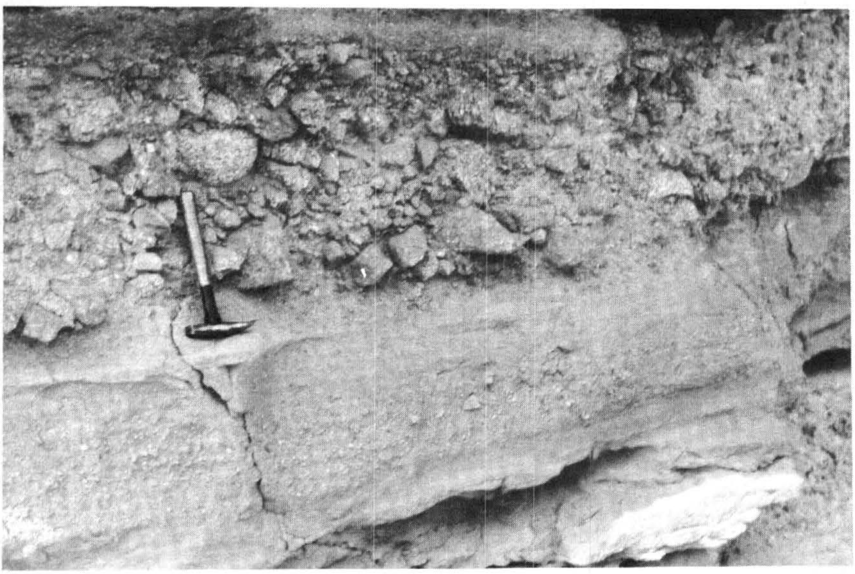


FIGURE 8.—Weakly consolidated fanglomerate underlying poorly consolidated gray conglomerate of the Sil Murk formation in the NW¼ sec. 2, T. 5 S., R. 5 W.

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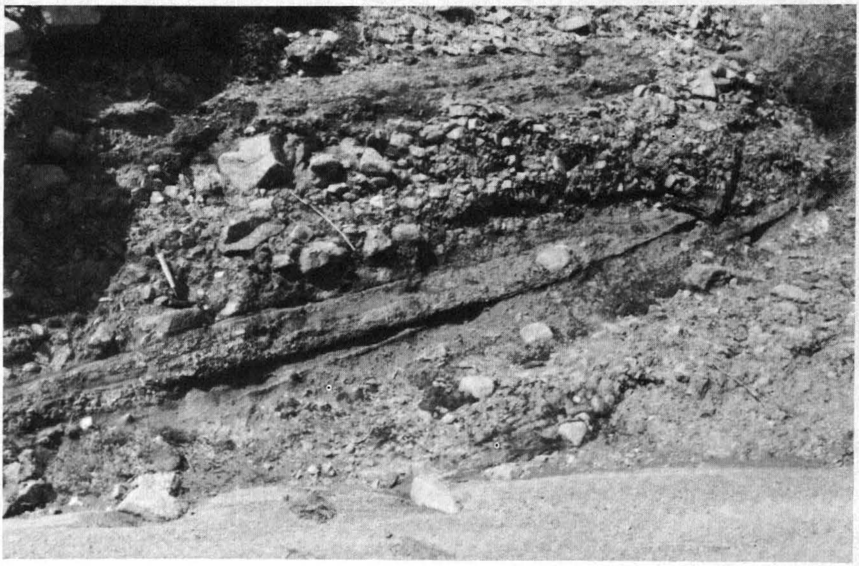

FIGURE 9.—Interbedded reddish fanglomerate and gray conglomerate of the Sil Murk formation along northward-trending wash in the NW¼ sec. 2, T. 5 S., R. 5 W.

solidated and a few thin beds are well cemented with lime. However, the unit appears to be consolidated chiefly by bonding rather than cementation because most of the calcium carbonate is present along fractures and there is little on freshly exposed surfaces of the matrix.

The larger fragments are composed of rocks derived from the Gila Bend Mountains—predominantly gneissic granite and smaller amounts of schist, quartzite, granite, and fine-grained dark-colored intrusive rocks. There are also a few fragments of felsite of possible volcanic origin whose source is not known. The matrix consists of silt, sand, and pebbles, and is composed principally of broken feldspar and quartz crystals.

The gray conglomerate is overlain by the volcanic rocks that compose the volcanic member of the Sil Murk formation, and it is overlapped by younger alluvial deposits. The total exposed thickness of the sedimentary member of the Sil Murk formation is estimated to be at least 1,500 feet. It may be thicker in other areas or below the surface.

Many porous lenticular beds occur in the sedimentary member of the Sil Murk formation, and it is one of the principal water-bearing formations in the area, as discussed in the section "Subsurface stratigraphy." Moderate quantities of ground water reportedly are produced from the sandstone of the Sil Murk formation by a well about 15 miles west of the reservation (Babcock and others, 1948, p. 10). This well produced about 150 gpm (gallons per minute) from about 600 feet of sandstone below a depth of 1,100 feet. The formations above 1,100 feet were cased off. All other deep wells in the area are open both to the Sil Murk formation and the overlying deposits, and the production from the Sil Murk formation alone cannot be determined.

VOLCANIC MEMBER

Volcanic rocks overlie the gray conglomerate in the southernmost part of the Gila Bend Mountains, and because of their resistance to erosion, they form prominent cuestas and low hills (fig. 3). These volcanic rocks constitute the volcanic member of the Sil Murk formation. Volcanic rocks crop out in five areas on the reservation (fig. 4). The largest area forms the cuesta that juts into the channel of the Gila River at the southernmost point of the Gila Bend Mountains. A small outcrop of dacitic welded tuff is exposed south of the river at the site of an abandoned pumping station. Three small areas along the west flanks of the mountains form small hills.

Volcanic rocks also underlie the alluvium locally near the mountains. Ross (1923, p. 73 and fig. 14) interprets information from bore holes drilled across the channel of the Gila River at the abandoned pumping station as indicating that "Tertiary deposits"—the volcanic member of this report—underlie the channel fill at shallow depths. In his text, Ross reports that "bedrock is less than 160 feet below the surface at any place in the channel," but in a scaled drawing, depth to "bedrock" is shown as no greater than 60 feet. The volcanic rocks may underlie the alluvium below the Gila Bend plain, but have not yet been reported from wells drilled to a maximum of nearly 1,500 feet beneath the surface.

The volcanic rocks are considered to be a member of the Sil Murk formation because beds of the volcanic rocks are reported by Babcock and others (1948, p. 7) to be interbedded with fanglomerate (gray conglomerate of this report) 3 miles north of the reservation. Within the reservation, however, the volcanic member lies in angular unconformity on an erosion surface of low relief that was cut on the gray conglomerate. Along the east front of the cuesta at the south end of the Gila Bend Mountains, the gray conglomerate dips at angles up to 30° and the volcanic beds dip at 5° to 12°; at the hill in the NW¼ sec. 9, T. 5 S., R. 5 W., the gray conglomerate dips 5° and the volcanic beds dip 10° (fig. 10). All the dips are to the southwest. Also, the lowest unit of the volcanic member, an eolian tuffaceous sandstone, thickens southward, and this unit and an overlying conglomerate lens in the volcanic member are absent at the hill in sec. 9.

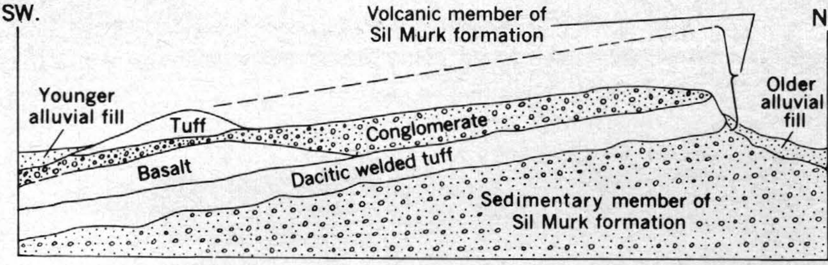

FIGURE 10.—Diagrammatic section of a small hill in the NW¼ sec. 9, T. 5 S., R. 5 W., showing local angular unconformity between the sedimentary and volcanic members of the Sil Murk formation and erosional surfaces within the volcanic member.

These stratigraphic variations in the volcanic member indicate that local relief of about 200 to 300 feet per mile along the strike of the deposits had developed on the gray conglomerate member before the volcanic member was laid down. The regional significance of this unconformity cannot be evaluated from the exposures in the mapped area.

The volcanic member is composed of eolian tuffaceous sandstone, dacitic tuff and welded tuff, basalt flows, and intercalated conglomerate lenses. The eolian sandstone is exposed only near the south end of the prominent cuesta in sec. 15, T. 5 S., R. 5 W. It is yellowish green to light brown and under the hand lens has a salt-and-pepper appearance, in which the light fraction is composed of quartz shards and altered feldspar(?) fragments and the dark fraction is composed of small cinders, magnetite, and biotite. The eolian sandstone varies considerably in its degree of induration. Generally it is friable, but locally it is strongly cemented with calcium carbonate. The unit is well bedded and has thin but not persistent laminae. The crossbeds have a general northwest strike and dip to northeast. At a cursory glance, the eolian tuffaceous sandstone is similar in appearance to the thin-bedded fraction of the sandstone of the sedimentary member of the Sil Murk formation. The rocks may be distinguished, however, by the presence of tuffaceous material and crossbeds in the eolian sandstone in contrast to the comparatively clean arkosic composition and regular dips of the lower sandstone.

The eolian sandstone is overlain by a 4-foot-thick flat-lying laminated ash bed that transects the more steeply dipping crossbeds of the eolian sandstone (fig. 11). The ash bed is brownish red to light buff, and flecked with dark-brown or black biotite grains. The ash bed is overlain by dacitic welded tuff that forms the cliff capping the cuesta at the south end of the Gila Bend Mountains (fig. 12). The lower 2 feet of the welded tuff is a black glassy vitrophyre which weathers into rough slabs and grades upward into a welded tuff hav-

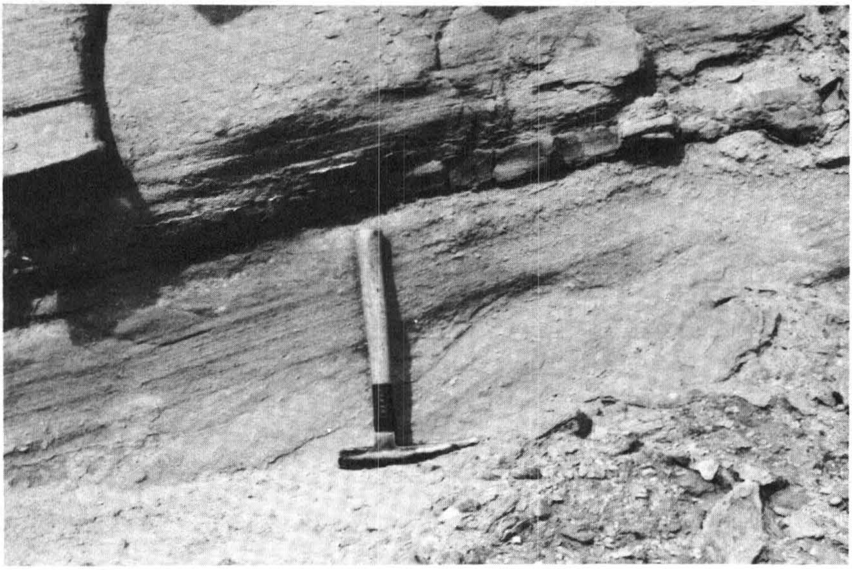

FIGURE 11.—Contact between the crossbedded eolian tuffaceous sandstone and the ash bed at the base of the dacitic welded tuff of the volcanic member of the Sil Murk formation in the NW¼ sec. 15, T. 5 S., R. 5 W.

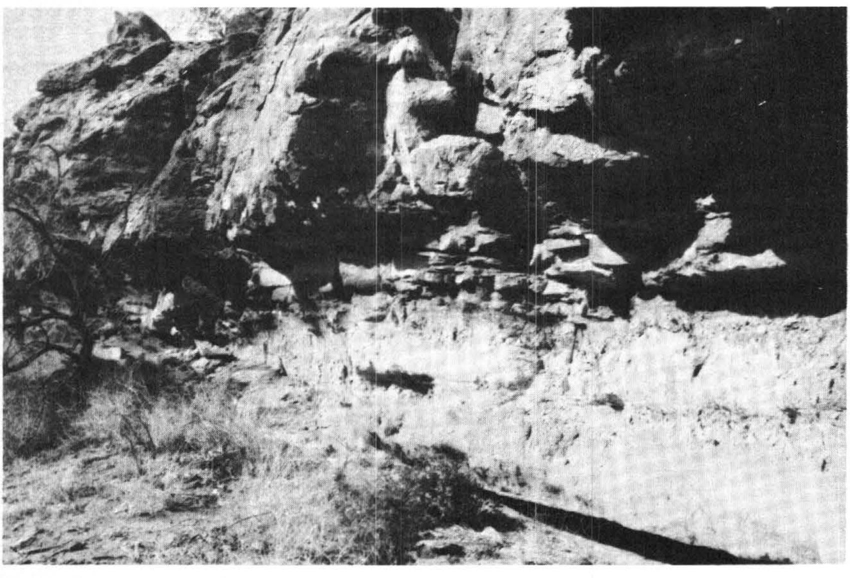

FIGURE 12.—Dacitic welded tuff showing massive welded tuff, slabby vitrophyre, and basal ash bed of the volcanic member of the Sil Murk formation in the NW¼ sec. 15, T. 5 S., R. 5 W.

ing a cryptocrystalline instead of a glassy groundmass. The welded tuff weathers brown, but on the fresh surface it is grayish lavender to brownish red. It is composed of quartz and feldspar crystals, flattened pumiceous fragments, and scattered angular rock fragments in a vuggy cryptocrystalline matrix. Some of the rock fragments appear to be andesitic. There is a rough alinement of feldspar crystals and pumiceous fragments parallel to the bedding, but the unit is massive. At the cliff face the rock breaks into irregular fragments irrespective of the fragment alinement, but on dipslopes it tends to spall more or less parallel to the bedding.

The conglomerate lenses in the volcanic member are composed largely of crystalline-rock fragments similar to those of the gray conglomerate. At the north end of the exposure of the volcanic member in sec. 10, T. 5 S., R. 5 W., the conglomerate lens appears to interfinger with the gray conglomerate, but the contact area is covered by a heavy rubble, derived from the cliffs of dacite and the underlying conglomerate, and the relationship is not exposed.

Two sections, measured by Brunton compass and pace traverse, are described below. The dacitic welded tuff that forms the cap of the cuesta in sec. 10, T. 5 S., R. 5 W. is correlated with the dacitic welded tuff at the base of the section in sec. 9 (fig. 10), and the units are numbered consecutively from bottom to top.

Section 1. Volcanic member at the south end of the Gila Bend Mountains in sec. 10, T. 5 S., R. 5 W.

	Thickness (feet)
Tertiary:	
Erosion surface (essentially a dipslope on unit 3).	
Sil Murk formation:	
Volcanic member (strike, N. 55° W.; dip, 5° SW.):	
3. Dacitic tuff and welded tuff: lavender to brownish-red, weathering brown; in units about 20 to 30 ft thick that contain thin black basal vitrophyre beds; locally underlain by about 4 ft of thin-bedded brownish-red to light-buff ash at the base; forms cliffs	50±
2. Conglomerate: gray; small boulder to small pebble; contains fragments of volcanic rocks of intermediate composition in addition to granite, gneiss, and schist fragments which predominate; forms poorly exposed slopes covered by scree from overlying dacite; lenticular, pinches out at the northern and southern ends of the cuesta and apparently fills a channel cut into unit 1	0–150±
1. Tuffaceous sandstone: gray, yellow-green, light-brown; thin-bedded; flecked with biotite; characterized by irregular dips and strikes that suggest eolian crossbedding	30–150±
Maximum measured thickness of volcanic member	175±
Angular unconformity.	
Gray conglomerate.	

Section 2. Volcanic member on the small hill in the NE¼ sec. 9, T. 5 S., R. 5 W.

	Thickness (feet)
Tertiary:	
Erosion surface.	
Sil Murk formation:	
Volcanic member (strike, N. 55° W.; dip, 10° SW.):	
6. Tuff: lavender; fine-grained, possibly dacitic; forms small blocky exposure on west end of dipslope ridge	15±
5. Conglomerate: gray; fragments of both gneissic and volcanic rocks; pebble to small cobble, few gneissic boulders as much at 4 ft. in maximum dimension; forms slopes	70±
4. Basalt: black; fine-grained, containing small red-brown blebs up to 1 mm in width of iddingsite(?); wedges out to east	0–10±
3. Dacitic welded tuff: gray to light-lavender, biotite speckled; massive; forms prominent cliff at east base of hill	20±
Maximum measured thickness of volcanic member	115±
Low angular unconformity.	
Sedimentary member.	

The exposure in the NW¼SW¼ sec. 10, T. 5 S., R. 5 W. contains basalt that is similar to the basalt described above.

There are no wells or springs in these volcanic rocks and the interbedded conglomerate. Except for the basalt, the volcanic rocks seem to be nearly impervious and cannot be considered favorably as potential aquifers, except where they may be highly fractured. The interbedded conglomerate beds, however, are porous and many carry moderate supplies of ground water below the water table.

CORRELATION, AGE, AND ORIGIN

The Sil Murk formation is the fanglomerate unit described by Babcock and others (1948). However, the correlation of the Sil Murk formation with the Locomotive fanglomerate in the Ajo area (Gilluly, 1946) suggested by Babcock and others (1948, p. 3) is questionable for lack of corroborative information and because of the differences between the two units. Their principal similarities are that both units lie in depositional contact on gneissic rocks and that both are composed of deformed alluvial-fan deposits. Neglecting differences in color and composition, which for a single unit may vary widely from place to place, the principal differences are stratigraphic position relative to overlying deposits, degree of structural deformation, and degree of alteration. The Locomotive fanglomerate is overlain by five mappable units and is separated from the alluvium that partly fills the adjoining basin by four erosional or angular unconformities (Gilluly, 1946); the sedimentary member of the Sil Murk formation is overlain by only the volcanic member and is separated by only one unconformity from the alluvium that underlies the Gila Bend plain. The Locomotive fanglomerate has been extensively deformed—possibly thrust faulted (E. D. Wilson, oral communication, 1957)—and has undergone weak hydrothermal alteration locally; whereas the Sil Murk formation has been warped and folded only mildly and is unaltered. Furthermore, north of the reservation the Sil Murk formation strikes toward the "older volcanic rocks" mapped by Babcock and others (1948, pl. 1). Reconnaissance in the area suggests that the Sil Murk formation either underlies or is contemporary with the "older volcanic rocks," and that the "older volcanic rocks" are lithologically and structurally similar to the Batamote andesite in the Ajo area (Gilluly, 1946). Mapping of the Papago Indian Reservation supports but does not prove this correlation. Consequently the Sil Murk formation is tentatively considered to be younger than the Locomotive fanglomerate, although correlation with the Locomotive cannot be absolutely precluded at this time. In their similarities and differences, the two deposits reflect the tremendous intricacy of local control in the development of Cenozoic geology in southern Arizona, and it is preferable to give them discrete identities until their equivalence can be demonstrated.

The Sil Murk formation dips gently to the southwest and its dip-slopes have resulted from the westward tilting of the Gila Bend Mountains fault block. The composition of the conglomerate fragments also indicates its direct derivation from the crystalline core of the Gila Bend Mountains as they were uplifted and tilted. This faulting is generally considered to be of late(?) Tertiary to Quaternary age (Wilson and Moore, 1959). However, the Sil Murk formation appears to pass under the older alluvial fill of the Gila Bend plain which is tentatively considered to be of possible Pliocene and Pleistocene age. Furthermore, north of the mapped area the volcanic member appears to underlie or be a part of the extensive deposits of the "older volcanic rocks" described by Babcock and others (1948). Regional consideration of the age of the "older volcanic rocks" and related deposits suggests that they either antedate or are contemporaneous with the major expression of basin-and-range faulting. Consequently a late middle(?) Tertiary age for the Sil Murk formation seems to be tenable at this time.

The change in color, texture, and fragment size from the basal arkosic sandstone to the gray conglomerate occurs gradually through the transitional fanglomerate that lies between them. This fact suggests that the Sil Murk formation represents a time of gradual change in local environment which, in turn, reflects the uplift of the Gila Bend Mountains fault block. Probably elsewhere in the region the transitional zone between the sandstone and conglomerate is represented by erosional or angular unconformities. The red fine-grained arkosic sandstone suggests flood-plain deposition in an area of low relief; the considerable thickness of the gray boulder conglomerate suggests deposition from a rapidly rising nearby highland. The volcanic member indicates volcanic activity contemporaneous with the uplift.

TERTIARY AND QUATERNARY ALLUVIAL DEPOSITS

The material that partly fills the basins around the mountains and overlaps the lower slopes of the mountains is collectively referred to as alluvium. The critical distinction between these alluvial deposits and the Sil Murk formation which was also deposited as alluvium is that the alluvial deposits were laid down within the basins that are present today, whereas the Sil Murk formation was laid down in basins that have disappeared.

The alluvium is composed of poorly consolidated gravel, sand, silt, and clay that were deposited as irregular overlapping lenses by stream action or sheetflow, or as small to large discontinuous fine-grained lenses in ephemeral ponds and lakes or backswamp areas. The materials are poorly to well sorted, and the sorting in adjacent lenses may differ radically. Two major groupings of alluvial deposits are exposed at the surface.

From their surface exposures the alluvial deposits can be grouped into two units: older alluvial fill and younger alluvial fill; these deposits represent two late stages in the depositional history of the basin-fill deposits. A moderate thickness of alluvial material underlying the Gila Bend plain is known only from well logs, and it is arbitrarily included in the older alluvial fill, although parts of it may be much older than the part exposed at the surface.

The contact between the older and younger alluvial fills is drawn arbitrarily along the foot of the terraced surface that forms the Gila Bend plain, and delineates some of the more recent flood-plain deposits of the Gila River from the materials into which the river is entrenched.

Three sets of terraces above the present flood plain and more or less parallel to the river were mapped by Kendall (*in* Babcock and others, 1948, pl. 1). Only the younger two are exposed within the area shown on figure 4 and they are not delineated as terraces. They are mapped

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as part of the older alluvial fill and form low dissected discontinuous benches along the contact of the older and the younger alluvial fills. The terraces are covered by a deposit of silt, sand, and small rounded pebbles that ranges from a thin veneer to a few feet in thickness. They are above the water table everywhere in the area.

OLDER ALLUVIAL FILL

The exposed parts of the older alluvial fill include conglomerate in the dissected alluvial fans that crop out along the flanks of the Gila Bend Mountains, thin terrace deposits, and deposits of generally fine grained gravel, sand, and silt that underlie the Gila Bend plain. Presumably, the latter are continuous with the subsurface part of the older alluvial fill, which is predominantly sand, silt, and clay. Near the mountains the older alluvial fill rests unconformably on an erosion surface cut on crystalline rocks and the Sil Murk formation. In this zone it is seldom more than 50 feet thick. Under the Gila Bend plain, the thickness of the older alluvial fill is estimated to range from about 300 to 500 feet. The subsurface stratigraphy is discussed in a following section.

The age of the older alluvial fill cannot be proved but it probably spans the Tertiary-Quaternary boundary. The predominantly sand, silt, and clay deposits of the older alluvial fill seem to be lithologically and structurally similar to thick fine-grained deposits in other areas of Arizona. Near Safford the exposed parts of such deposits are of Blancan (Pliocene-Pleistocene) age (Gazin, 1942), and near Benson and north along the San Pedro Valley they range in age from mid-Pliocene through early Pleistocene (Gazin, 1942; Lance, 1960). The older alluvial fill in the Gila Bend basin may be of similar age.

Babcock and others (1948, p. 8) presume that much of the valley fill may have accumulated when the basin had no through drainage; but similar deposits may be laid down by poorly integrated or sporadic drainage. However, they presumed a considerably thicker older alluvial fill than is described in this report. At the present time, the subsurface geology of the Gila Bend area is not well enough known to demonstrate the presence or absence of bedrock barriers at altitudes sufficient to result in internal drainage in the Gila Bend area in late Tertiary and Quaternary time.

Moderate to large quantities of ground water are obtained from the older alluvial fill, but its productivity cannot be separated from that of the younger alluvial fill and the underlying formation because wells that produce from the older alluvial fill are perforated to be open also to one or both of the other units.

YOUNGER ALLUVIAL FILL

Flood-plain and channel deposits of the Gila River comprise the younger alluvial fill. These deposits are entrenched into the older alluvial fill and are clearly related to the present and near-recent regimen of the Gila River. The younger alluvial fill is composed of silt, sand, and gravel, and is in general less consolidated than the older alluvium. The channel deposits are unconsolidated. The younger alluvial fill commonly is finer than the exposed parts of the older alluvial fill near the mountains and coarser than the older alluvial fill into which it is entrenched.

The flood-plain deposits form a broad swath through the center of the area mapped, and are reported to be as much as 80 feet thick (Babcock and others, 1948, p. 9). The more permeable sand and gravel layers of the flood plain are highly productive aquifers. Their separate yield is not known because no irrigation wells in the area produce from the younger alluvial fill alone. The combined aquifers locally yield more than 3,000 gpm.

SUBSURFACE STRATIGRAPHY

Deep wells are the only source of information about the sedimentary deposits and older rocks underlying the Gila Bend plain. Information regarding these wells is obtained from drillers' logs (table 1) and from one partial set of well cuttings. It is difficult to correlate the drillers' logs, partly because of the highly variable character of the alluvial materials and partly because of the differences in judgment and nomenclature of the several drillers. Furthermore, it is often difficult in drilling to determine the point at which significant changes in the formations occur. Nevertheless, the major changes in lithology can be identified by interpretation of the drillers' logs in the light of the information gained from the available well cuttings. On this basis, the following interpretation of the subsurface stratigraphy is offered.

Babcock and others (1948) and Ross (1923) suggest that the older alluvial fill is 1,100 feet thick in the vicinity of Gila Bend. On the basis of information from more recent logs and the drill cuttings, it is suggested that only 300 to 500 feet of the rocks penetrated by the drills in the area mapped is older alluvium and that the materials below these depths are part of the Sil Murk formation.

TABLE 1.—*Drillers' logs, except as indicated, of selected wells in the vicinity of Gila Bend Indian Reservation, Maricopa County Ariz.*

[Asterisks (*) indicate postulated break between older alluvial fill and conglomerate of Sil Murk formation. Plus symbols (+) indicate postulated break between conglomerate and sandstone of Sil Murk formation]

	Thickness (feet)	Depth (feet)
T. 5 S., R. 4 W.		
SE¼SE¼NE¼ sec. 18:		
Sandy silt	18	18
Sand	6	24
Sand and gravel with a little clay	6	30
Sand, gravel, and boulders	24	54
Strata of clay and sand (from 24 to 100 is water bearing)	46	100
Dry clay	22	122
Clay and strata of sand (water)	82	204
Dry clay	6	210
Sandy clay with small gravel (water)	40	250
Dry clay	10	260
Strata of clay, packed sand, and sand	20	280
Strata of cemented sand and sand	20	300
Sandy clay	20	320
Strata of cemented sand, sand, and small gravel	10	330
Strata of clay and sand	14	344
Sandy clay	66	410
Strata of dry clay and sandy clay (from 280–422 has some water)	12	422
Strata of sandy clay and sandstone	18	440
Dry clay	12	452
Sandy clay (water?)	18	470
Clay with small gravel (dry)	31	501
SE¼SE¼SE¼ sec. 19:		
Soil	3	3
Silt, gravel, clay	15	18
Sand, small gravel	16	34
Sand, gravel, boulders	6	40
Sand, sandstone, clay	50	90
Strata of sand, clay	74	164
T. 5 S., R. 4 W.—Con.		
SE¼SE¼SE¼ sec. 19—Continued		
Sand, small gravel with strata of cemented sand	21	185
Strata of sand, gravel, clay, cemented sand	51	236
Dry clay	19	255
Sandy clay with strata of sand rock	71	326
Dry clay	14	340
Strata of clay, sand, cemented sand, water	42	382
Dry clay	9	391
Strata of clay, sand, sandstone (water)	49	440
Dry clay	11	451
Sandy clay with strata of dry clay; some water in sandy clay	49	500
Dry clay with small gravel	20	520
Dry clay	58	578
Strata of sand clay and cemented sand; some water	6	584
Dry clay	46	630
Silty clay, a little water	20	650
Dry clay	6	656
Strata of clay, pack sand, and small gravel (water)	34	690
Dry clay	10	700
* * *		
Strata of sand, gravel, cemented sand, gravel	38	738
Strata of clay, sand, gravel, cemented sand, gravel	20	758
Strata of sand, gravel, clay with mountain rock	43	801
Mountain wash sand and mountain rock	125	926

TABLE 1.—*Drillers' logs, except as indicated, of selected wells in the vicinity of Gila Bend Indian Reservation, Maricopa County, Ariz.*—Continued

	Thickness (feet)	Depth (feet)
T. 5 S., R. 5 W.		
SE¼SE¼NW¼ sec. 18:		
Clay	40	40
Boulders and gravel	42	82
Gravel	480	562
Clay with streaks of sand	212	774
Clay	21	795
Hard sand, dark	20	815
Dark sand	10	825
Clay	10	835
+ + +		
Hard sandy shale	30	865
NW¼SW¼SE¼ sec. 18:		
Surface sand and gravel	45	45
Small gravel with streaks of clay	195	240
Clay	20	260
Light-colored sand and gravel	20	280
Clay	80	360
Sand and gravel with streaks of clay	170	530
* * *		
Gray clay embedded with gravel	40	570
Sand with streaks of clay	200	770
Sand and gravel	70	840
+ + +		
Black sand and gravel	100	940
Red gravel	20	960
SW¼SE¼SE¼ sec. 18–1:		
Surface sand and gravel	312	312
Fine sand with streaks of clay	178	490
* * *		
Sand	105	595
Coarse sand	20	615
Clay	125	740
Sand, coarse, with streaks of clay	49	789
Sand and gravel	44	833
+ + +		
Hard sand	16	849
Black sand, hard	37	886
Brown sand	55	941
Dark sand	59	1, 000
Clay	31	1, 031

	Thickness (feet)	Depth (feet)
T. 5 S., R. 5 W.—Con.		
SW¼SE¼SE¼ sec. 18–2:		
Sandy clay	45	45
Gravel and boulders	30	75
Sand, gravel, and boulders	80	155
Gravel and clay	50	205
Gravel and clay	95	300
Sand and gravel	125	425
Sand and gravel	175	600
Sand and gravel with some rock and clay	200	800
SE¼SE¼SW¼ sec. 22:		
Topsoil	5	5
Gravel and boulders	70	75
Sand with clay streaks	225	300
* * *		
Mildly rocky dark in color	120	420
Solid red rock, mild	217	637
+ + +		
Hard-packed sand	313	950
Coarse sand with gravel	80	1, 030
Clay with sand	220	1, 250
Sand with gravel streaks	60	1, 310
Sandy clay	73	1, 383
Cemented sand	64	1, 447
SW¼SW¼SE¼ sec. 23 (log based on well-cutting sample analysis):		
Light-reddish-brown silt with arkosic sand	325	325
Light-reddish-brown silt	125	450
* * *		
Coarse sand to granule gravel; fragments predominantly quartz and feldspar, some granitic rock and minor amounts of magnetite	100	505

TABLE 1.—*Drillers' logs, except as indicated, of selected wells in the vicinity of Gila Bend Indian Reservation, Maricopa County, Ariz.*—Continued

	Thickness (feet)	Depth (feet)
T. 5 S., R. 5 W.		
SW¼SW¼SE¼ sec. 23—Continued		
Same as 550-ft. sample, but finer grained and contains more magnetite	50	600
Same as 550-ft sample	150	750
+ + +		
Medium-grained subangular to subrounded sand containing fragments of moderately cemented light-reddish-brown arkosic sandstone and biotite flakes; some granitic fragments and one piece of red volcanic(?) rock	200	950
Same as 950-ft sample; magnetite common	225	1,175
Same as 950-ft. sample except almost no magnetite; few fragments of buff tuffaceous(?) sandstone	125	1,300
Same as 950-ft. sample; several reddish sandstone fragments	75	1,375
Same as 950-ft sample; fragments of reddish sandstone up to half an inch in maximum dimension	25	1,400
T. 5 S., R. 5 W.—Con.		
SW¼SW¼SE¼ sec. 23—Continued		
About half the material composed of reddish and grayish sandstone; reddish sandstone is fine grained, arkosic, with biotite flakes; gray sandstone is fine grained, arkosic; bedding plane with gray mudstone in one fragment; sandstone lightly cemented with lime; no granitic fragments	25	1,425
Same as 1,425-ft. sample	50	1,475
SW¼SW¼SE¼ sec. 24:		
Topsoil	30	30
Coarse sand and gravel	240	270
Sandy clay	220	490
* * *		
Cemented sand	120	610
Sand and boulders	240	860
Sand, clay, and gravel	225	1,085
+ + +		
Clay	145	1,230
Gravel, cemented sand	170	1,400
T. 5 S., R. 6 W.		
NW¼NW¼SE¼ sec. 11:		
Surface sand and clay	40	40
Clay	435	475
Small gravel	122	597
Clay	13	610
* * *		
Small gravel	80	690
Clay and gravel	38	728
Small gravel	172	900
+ + +		
Hard fine sand	20	920

The estimate of thickness was revised for the following reasons: Most logs report materials described as "black sand, hard," "red gravel," or "cemented sand" at depths greater than 850 feet. These descriptions better fit the lower facies of the sedimentary member of the Sil Murk formation than either the gray conglomerate of the Sil Murk or older alluvial deposits. Furthermore, drill cuttings from the well in sec. 23, T. 5 S., R. 5 W. contain many fragments of light-reddish-brown sandstone from 950 to 1,475 feet. This sandstone is identical with sandstone in the lower facies of the sedimentary member of the Sil Murk formation. Fragments of the sandstone, both from surface exposures and from drill cuttings, are very friable. Because the fragments are so numerous and so friable, it is not likely that they represent pebbles or cobbles of the sandstone from either the gray conglomerate or the older alluvial fill. Consequently, the material below about 850 feet is presumed to represent the lower facies of the sedimentary member of the Sil Murk formation in place. Above the lower facies there is a zone about 500 feet thick. The zone is generally described in the well logs as "sand and gravel," or "sand and boulders," with only a few references to "clay." This zone is considered to be the gray conglomerate of the Sil Murk formation because the gray conglomerate is more resistant than the sandstone facies and more likely would have been the unit preserved as caprock during the erosion interval that preceded the deposition of the valley fill. The upper 300 to 500 feet, except for the near-surface deposits, are generally described as containing considerable "clay" and these deposits are assigned to the older alluvial fill. The relationships are shown graphically in figure 13.

The older alluvial fill is believed to have been deposited on an old eroded surface cut on the Sil Murk formation. The erosion surface dipped away from the mountains, gently to the west and south and somewhat more steeply to the east. The extent of this bench outside of the area mapped is beyond the scope of this investigation.

STRUCTURE

The regional structural relations of the Gila Bend area are described by Babcock and others (1948, p. 6) as follows:

> The valley that lies between the Maricopa Mountains and the Gila Bend and Sand Tank Mountains [fig. 2] 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

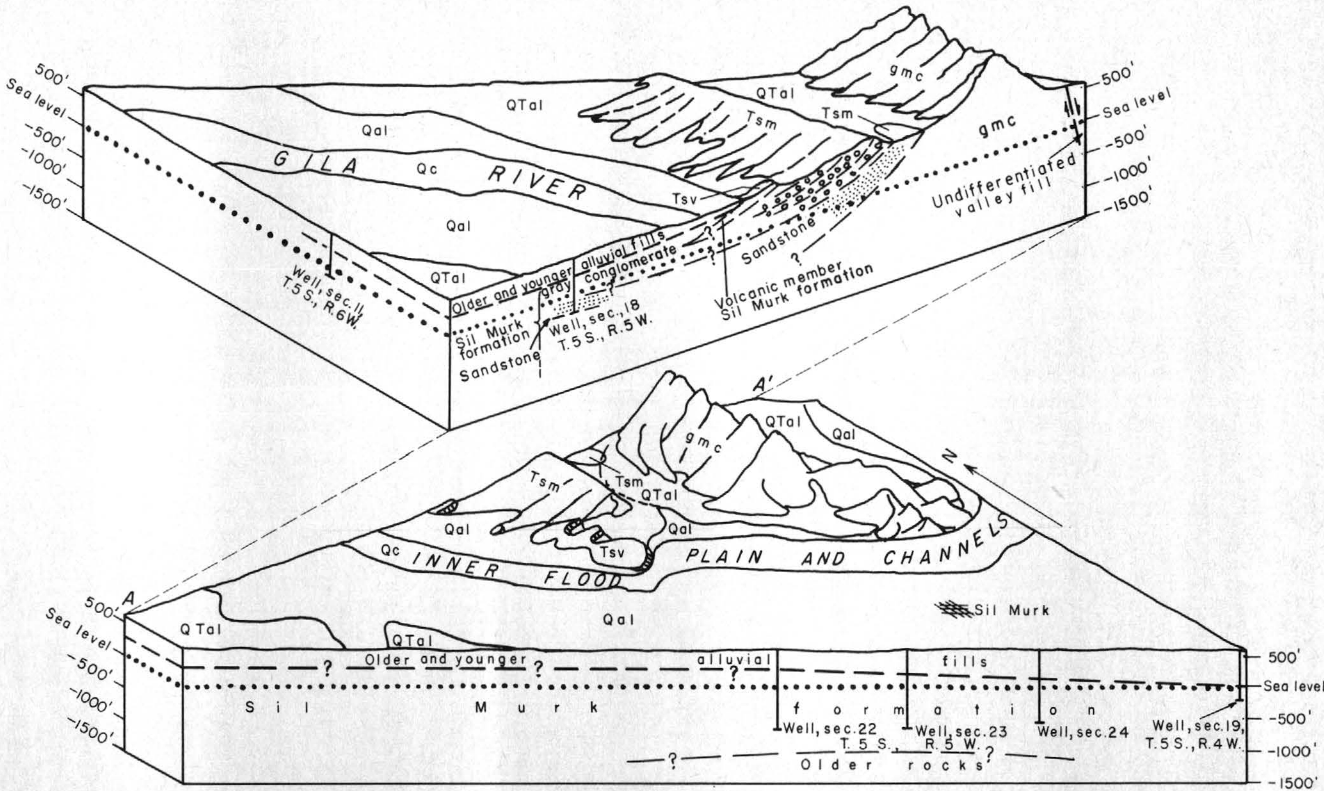

FIGURE 13.—Generalized block diagram with sections through the Gila Bend Mountains and Gila Bend plain, showing postulated relationships between crystalline rocks, sandstone, conglomerate, and the volcanic facies of the Sil Murk formation, and undifferentiated older and younger alluvial fills. "Older rocks" indicate the possibility of rocks older than the Sil Murk formation and younger than crystalline rocks. Block is broken along line *A–A'* shown on figure 4.

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 grantitic 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.

The criteria described above and the moderate westward dip of the Sil Murk formation indicate that the Gila Bend Mountains are a tilted fault block, upthrown on the east side and sloping back to the west. Some of the materials penetrated at depths of nearly 850 feet in sec. 18, T. 5 S., R. 5 W., are correlated with the Sil Murk formation, and thus the Gila Bend Mountains seem to extend as a single block to at least the vicinity of sec. 18 (fig. 4). Ross (1923, p. 73 and pl. 11) also suggests that the mountain block extends under the alluvium toward Gila Bend.

Small faults, either parallel or transverse to the trend of the mountains, occur locally within the Sil Murk formation but are not shown on figure 4.

GEOLOGIC HISTORY

The schist and gneiss of probable early Precambrian age represent ancient sedimentary, volcanic, and igneous rocks that had been deformed, intruded, and beveled by erosion, possibly several times, before the deposition of the red arkosic sandstone in Tertiary time. Information from nearby areas suggests also that some granitic intrusions may have occurred during early Precambrian time, but the age of the granite in the Gila Bend Mountains has not been determined and possibly some of it may have been intruded after the deposition of Paleozoic strata.

Shallow seas covered the area during much of the late Precambrian and Paleozoic time, and a few thousand feet of limestone and smaller thicknesses of mudstone and sandstone were laid down. During most of Mesozoic time the area was being deformed and eroded. It was deformed and elevated into mountains or high-standing areas, possibly in more than a single pulse. The deformation possibly was accompanied by the intrusion of granite which locally may have engulfed the Paleozoic strata. Some of the mountains were high and rugged, and the area stood above sea level for a long time, and the Paleozoic rocks were completely stripped from the area.

By late Mesozoic or early Tertiary time only the crystalline rocks were exposed over much of the area. Erosion had left a moderately rough terrain over which large quantities of andesistic and rhyolitic flows, tuffs, agglomerates, and sediments were laid down. As the volcanic materials accumulated, locally filling the deeper depressions, the relief became more subdued. These deposits were poured out spasmodically, and they were accompanied by the intrusion of small granitic bodies; locally the volcanic activity was interrupted by periods of quiet.

The sediments constituting the sandstone facies of the Sil Murk formation were deposited on a flood plain within a drainage area of low relief in the vicinity of the Gila Bend Mountains. Uplift of the crystalline core of the mountains occurred along structural lines more or less parallel to the trend of the present mountains, and the increased relief provided the coarse debris that is interbedded with the fine-grained deposits in the fanglomerate of the Sil Murk formation. The uplift of the Gila Bend Mountains continued, and the old drainage system which brought in the fine-grained sediments was either diverted away from the area or obliterated. The drainage in the area became consequent on the backslopes of the rising Gila Bend Mountains and the coarse gray conglomerate was laid down. The deposition of the coarse deposits was punctuated by volcanism, one result of which was deposition of the volcanic member of the Sil Murk formation in the area mapped. To the north, however, a much thicker sequence of flows was laid down.

During late Tertiary time, episodic uplift and movement along normal faults on the east side of the Gila Bend Mountains tilted the fault block to the west. The tilting led to the erosion of the Sil Murk formation down to the gray conglomerate, and led to the development of broad valleys around the Gila Bend Mountains far away from their present fronts. The slopes of the late Tertiary Gila Bend Mountains dropped gradually toward a valley floor to the south. The gradients of these slopes were such that at distances of 3 to 5 miles from the present mountain fronts, the ancient ground surface was 300 to 500 feet below the present floor of the Gila Bend plain.

Deposition of the older alluvial fill in the low areas around the Gila Bend Mountains began in late Tertiary and continued through most of the Quaternary. The reasons for the change from dissection to aggradation are not known, but the change was regional in character and may have been related to regional tilting or subsidence, or climatic change, or a combination of these factors. The coarse- to fine-grained deposits of the 300 to 500 feet of older alluvial fill underlying the Gila Bend Indian Reservation and the immediately adjacent area were laid down in a broad basin having poorly integrated but through drainage, with an outlet probably around the south end of the Painted Rock Mountains. The gradient of the drainage was so low that minor changes in stream regimen produced temporary lakes within which predominantly clay bodies were deposited.

During this time the region sank slowly relative to the surrounding areas, and the top of the late Tertiary-Quaternary deposits in the Gila Bend area is at an altitude of about 700 feet, whereas the top of the late Tertiary-Quaternary deposits along the lower Colorado River is now at an altitude of about 1,100 feet.

Subsequently, the ancient Gila River developed through drainage across the basin and began its present cycle of downcutting and deposition. Babcock and others (1948, p. 4–5) describe this interval as follows:

> Volcanic eruptions produced cones and basalt flows [not exposed in the area of this report] 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 [fig. 2], 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.
>
> 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. 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 than 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.

WATER RESOURCES

The Gila Bend Indian Reservation, compared to many other parts of the Sonoran Desert, is favorably located in regard to water supply because it as astride the Gila River. Even though flow in the Gila River is rare, an ample supply of ground water is easily available, although its quality may be poorer than is desired. In contrast, in the mountain areas ground water is scarce or nonexistent.

SURFACE WATER

The Gila Bend Indian Reservation includes a 6-mile reach of the Gila River which is dry or nearly dry, except during floods. Streamflow records of the Gila River below Gillespie Dam (U.S. Geol. Survey, reference *a*) show that the long-term, 1922–58, average flow is about 186,000 acre-feet per year. During this period flow ranged from less than 100 to more than 1,000,000 acre-feet per year. From 1922 to 1941, the average annual flow was about 325,000 acre-feet per year and flow in only 3 of the 20 years was less than 25,000 acre-feet. In contrast, the average annual flow during 1942–58 was about 23,000 acre-feet per year and in only 3 of the 17 years was the flow greater than 25,000 acre-feet. The lower flow since 1941 is due primarily to drought conditions and secondarily to additional upstream storage and diversion.

The Gila River was not always so barren of flow. Early writers refer to subsistence fishing, diversions for irrigation, rafting to Yuma down the Gila from above its junction with the Salt River, and to thickly overgrown banks teeming with geese, ducks, deer, and beaver (Ross, 1923, p. 64–67). In regard to a contrast drawn by an early explorer between the "reddish water" of the Colorado and the "sea green waters" of the Gila, Ross (1923, p. 66) commented that "by no stretch of the imagination could the present day mud-laden water of the Gila be considered 'sea green'." Ross was fortunate to see "mud-laden waters;" today the mud has been long laid and the water is only an occasional statistic.

Much of the flood flow over Gillespie Dam in the past 25 years has not reached the narrows at Painted Rock. It is assumed that the loss of flow is due to evapotranspiration and to downward percolation, but the amount to be attributed to each is not known. Also, it is not known how much of the percolation reaches the water table.

No quantitative comparison of inflow and outflow can be made in the Gila Bend area because no long-term records are available from the narrows at Painted Rock. However, comparison of the flow records at Gillespie Dam with those at Dome, Ariz., about 120 miles downstream from the dam, in the following tabulation gives some measure of channel losses in this region and provides a striking contrast between the average flows of selected intervals during the periods of record.

	Average annual flow (thousands of acre-feet)			
Station	*1904–21*	*1922–41*	*1942–58*	*1922–58*
Gillespie Dam	No record	325	23	190
Dome	1,100	200	1.4	110

In the Gila Bend area, prehistoric Indians irrigated small acreage by diversions from the Gila River. Similar irrigation methods were tried intermittently by white settlers in the last half of the 19th century, but were unsuccessful, due largely to the erratic flows of the Gila River and to a lack of understanding of the problems of farming in the area (C. R. Olberg, *in* Ross, 1923, p. 95–117). Traces of abandoned canals are evident in the area. An abandoned pumping station in sec. 15, T. 5 S., R. 5 W. identifies the head of the old Papago Canal, which was built in 1891 and abandoned sometime after 1923. The irrigation canals shown on figures 2 and 4 obtain their water from Gillespie Dam.

Painted Rock Dam (fig. 2) is currently (1960) being constructed for flood-control purposes. Its spillway is planned for an altitude of 660 feet, or about 40 feet higher than the site of the abandoned pumping station. When the water in the reservoir behind the dam is at the level of the spillway, the flood plain of the Gila River within the reservation will be inundated. Possible effects of impoundments behind the dam are discussed briefly on pages 38 and 42.

GROUND WATER

The water-bearing formations in the Gila Bend Indian Reservation area consist chiefly of sand and gravel beds in the older and younger alluvial fills. In addition, some water may be obtained from the Sil Murk formation. The crystalline rocks are chiefly non-water-bearing and are not discussed further. The ground-water body in the older and younger alluvial fills is considered to be interconnected with that in the Sil Murk formation and the units are discussed together as forming a single aquifer—the valley fill.

VALLEY FILL

The area considered in this report is too small to permit an overall estimate of its ground-water resources from data obtained within its limits alone. Earlier reports on ground water in the Gila Bend region, particularly those by Babcock and others (1948) and Johnson and Cahill (1955), have been freely drawn upon for this necessary information.

OCCURRENCE OF GROUND WATER AND SLOPE OF THE WATER TABLE

All the wells in the area obtain water from permeable units in the valley fill. Available data regarding these wells are shown in table 2. Depths to water range from about 35 to 60 feet and the slope of the water table generally follows the surface slopes. The gradient of the surface slope is westward at 10 feet per mile, and the gradient of the water table is probably about the same (Johnson and Cahill, 1955, pl. 2).

TABLE 2.—*Description of selected wells in the Gila Bend*

Location: Serial number following section number designates wells within the same 10-acre plot.
Type of well: Dr, drilled; Tw, drilled test.
Type of lift: C, cylinder; E, electric; G, gasoline-powered jack; T, turbine; W, windmill.
Altitude of land surface: By interpolation from U.S.G.S. topographic maps, rounded to nearest 5 ft.

Location	Construction data								Type of lift
	Type of well	Year completed	Total depth of well (feet)	Casing record					
				Diameter (inches)	Depth (feet)		Perforation (feet)		
					From	To	From	To	
T. 4 S., R. 6 W.									
SW¼SE¼NE¼ sec. 36-1	Dr	--------	960	24	--------	-------	100	300	T; E
SW¼SE¼NE¼ sec. 36-2	Dr	--------	-------	--------	--------	-------	-------	------	T; E
T. 5 S., R. 4 W.									
SE¼SE¼NE¼ sec. 18	Dr	1950	501	20	0	501	130	482	T; E
SE¼SE¼SE¼ sec. 19	Dr	1951	926	20	0	908	255	908	T; E
T. 5. S., R. 5 W.									
NW¼SE¼NE¼ sec. 5-1	Dr	--------	-------	20	--------	-------	-------	------	--------
NW¼SE¼NE¼ sec. 5-2	Dr	1954	256	10	0	256	-------	256	C; W
SE¼SE¼NW¼ sec. 18	Dr	--------	865	20	0	835	227	835	--------
NW¼SW¼SE¼ sec. 18	Dr	--------	960	20	0	890	400	890	T; E
SE¼SW¼SE¼ sec. 18	Dr	1957	410	20	0	410	-------	------	T; E
NE¼SE¼SE¼ sec. 18	Dr	--------	550	20	0	550	-------	------	T; E
SW¼SE¼SE¼ sec. 18-1	Dr	1947	1,031	20	0	1,000	150	900	--------
SW¼SE¼SE¼ sec. 18-2	Tw	1957	800	12½	--------	-------	-------	------	--------
SW¼SE¼SE¼ sec. 18-3	Dr	1957	708	20	0	708	-------	------	T; E
SE¼SE¼SW¼ sec. 22	Dr	1957	1,447	20	0	1,424	254	1,424	T; E
SW¼SW¼SE¼ sec. 23	Dr	1957	1,475	20	0	824	216	1,307	T; E
				16	824	1,307			
NE¼NW¼NW¼ sec. 24	Dr	1945	130	10	--------	-------	-------	------	C; WG
SW¼SW¼SE¼ sec. 24	Dr	1957	1,400	20	0	1,400	100	1,400	T; E
T. 5 S., R. 6 W.									
SW¼SW¼SE¼ sec. 1	Dr	1956	-------	--------	--------	-------	-------	------	T; E
SE¼SE¼SE¼ sec. 12	Dr	--------	-------	--------	--------	-------	-------	------	T; E
SE¼SE¼NE¼ sec. 13	Dr	--------	280	20	--------	-------	-------	------	T; E

Indian Reservation and vicinity, Maricopa County, Ariz.

Water-level depth: Reported depths indicated by R.
Rate of discharge: All figures are rounded; reported yields are indicated by R; estimated yields by E.
Use: A, abandoned; D, domestic; I, irrigation; S, stock.
Supplementary data: x, log or analysis in tables 2 and 3.

Hydrologic data					Supplementary data			
	Water level		Discharge					
Altitude of land surface (feet)	Depth (feet)	Date measured	Rate (gpm)	Date measured	Use	Log	Chemical analysis of water	Remarks
605	38.03	December 1953	2,500 1,600	April 1953 August 1956	I	------	x	Yield dropped as pumping rate in well 36-2 increased.
------	38.03	do	400 1,000	April 1953 August 1956	I	------	--------	About 10 ft west of well 36-1. Not shown separately on map.
655	27.07	do	1,400	June 1955	I	x	x	Drawdown reported 54 ft at 1,400 gpm.
705	77.35	do	2,000	April 1953	I	x	x	Drawdown reported 80 ft at 2,000 gpm.
------	--------	--------	--------	--------	A	------	--------	About 10 ft north of well 5-2. Abandoned 1954; not shown separately on map.
610	35.41	December 1954	30R	--------	S	------	x	Yield reported from bailing test.
630	60R	1948	--------	--------	A	x	--------	Abandoned 1949.
635	55.76	December 1953	1,000	August 1956	I	x	x	Drawdown reported 130 ft at 1,000 gpm.
645	--------	--------	--------	--------	I	------	--------	About 100 ft west of well 18-3.
640	51.48	December 1953	2,800	August 1956	I	------	--------	Drawdown reported 54 ft at 2,800 gpm.
645	57.22	do	2,900	do	A	x	x	About 50 ft west of well 18-3. Drawdown reported 40 ft at 2,900 gpm. Abandoned December 1956; not shown separately on map.
------	--------	--------	--------	--------	A	x	--------	Test hole reamed out to make well 18-3. Not shown separately on map.
645	--------	--------	--------	--------	I	------	--------	
665	--------	--------	--------	--------	I	x	--------	
655	--------	--------	--------	--------	I	x	--------	Pilot hole drilled to 1,475 ft; well reamed out to take 16- and 20-in. casing to 1,307 ft. Partial set of well cutting samples available to 1,475 ft, Arizona Bureau of Mines Well-Sample Library No. 783. Log based on well cuttings only.
645	33.19	October 1945	5E	--------	DS	------	x	See figure 14 for hydrograph.
680	--------	--------	--------	--------	I	x	--------	
605	76R	--------	2,800	August 1956	I	------	--------	
615	--------	--------	2,500	July 1948	I	------	--------	
625	62.35	April 1953	2,800	April 1946	I	------	--------	
	56.90	June 1955	2,300	August 1956				

Earlier reports suggest that ground water moved out of the Gila Bend area through the Painted Rock narrows, but water-level measurements not available to the earlier writers indicate that at least part if not most of the water in the basin moves southwest past Theba around the south end of the Painted Rock Mountains (fig. 2). This southern area of subsurface outflow has considerable bearing on the possible effects of the Painted Rock Dam on water levels in the area, as will be discussed under "Fluctuations."

RECHARGE

Recharge in the area occurs from four sources: infiltration from flow in the Gila River and its tributaries; infiltration from canals and irrigation water applied to the land; underflow of the Gila River; and direct precipitation. Infiltration from flow in the Gila River is the principal source of recharge to the upper parts of the alluvial aquifers, and recharge by infiltration from tributary streams, underflow, and direct precipitation is considered to be small or negligible. Some recharge to the Sil Murk formation probably occurs from precipitation and runoff on the exposed areas and from runoff where the volcanic member forms a partly buried barrier across the present channel of the Gila River. Annual recharge from all sources of the Gila Bend basin has been estimated to average between 40,000 and 50,000 acre-feet for the years 1947–53 (Johnson and Cahill, 1955, p. 14–18).

Recharge within the Gila Bend Indian Reservation, because of the small amount of irrigation development along its margins, is probably limited and may be no more than enough to replenish evapotranspirative losses.

DISCHARGE

Discharge from the Gila Bend basin occurs by evapotranspiration, surface flow, underflow, and pumping. Johnson and Cahill (1955, p. 29) estimate that during 1947–53 a total of about 115,000 acre-feet was discharged annually, including about 85,000 acre-feet by pumping. Estimates of annual pumpage for irrigation purposes in the Gila Bend basin for 1946–56 (U.S. Geological Survey, reference *b*; Harshbarger and others, 1957) are shown graphically in figure 14.

None of the ground water pumped for irrigation was obtained from wells on the reservation proper. The effects of pumping beyond the limits of the reservation are discussed under "Storage."

STORAGE

The southern and western parts of the Gila Bend Indian Reservation are underlain by as much as about 800 feet of saturated alluvium that consists of the younger and older alluvial fills and the coarser units

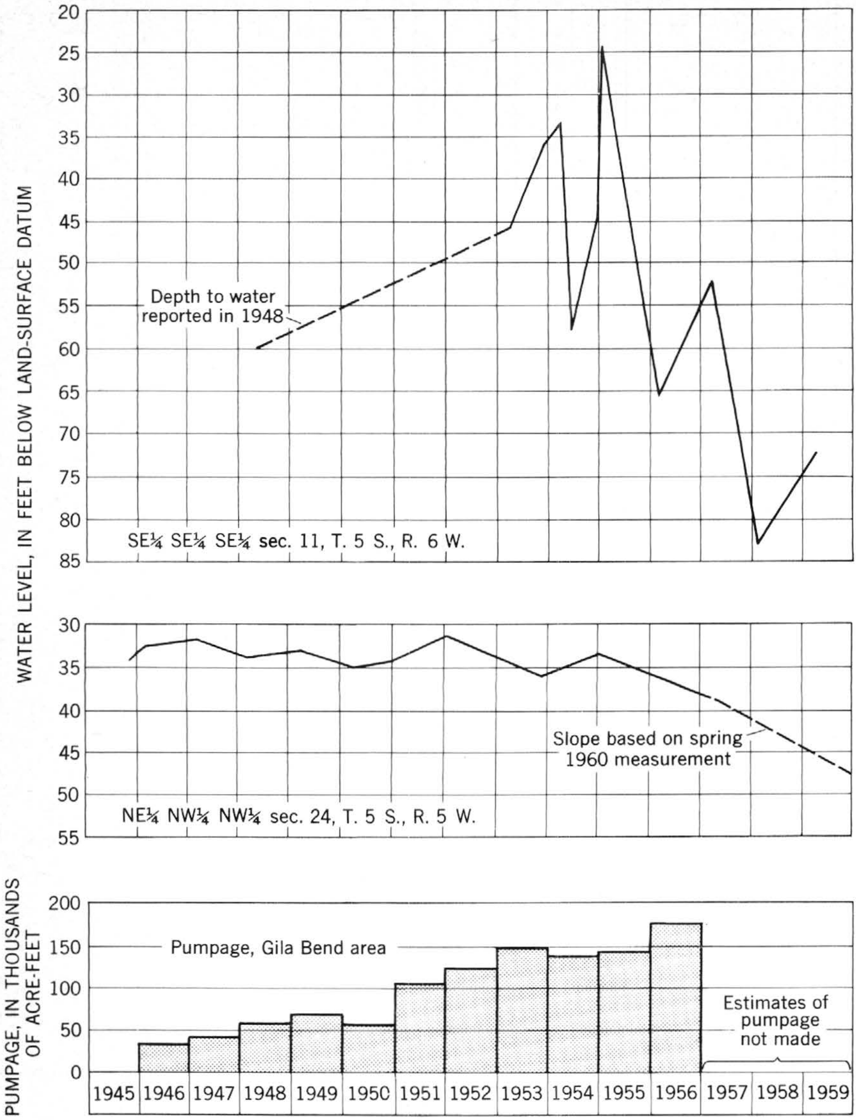

FIGURE 14.—Annual ground-water pumpage in the Gila Bend area during 1946–56, and water-level fluctuations in wells, sec. 24, T. 5 S., R. 5 W. and sec. 11, T. 5 S., R. 6 W., in or near the Gila Bend Indian Reservation.

of the Sil Murk formation. The amount of water that may be removed from saturated alluvium in other parts of Arizona is about 10 to 20 percent of the total volume of the saturated material. The amount of available ground water in storage below the Gila Bend Indian Reservation down to about 300 feet is estimated conservatively to be about 50,000 to 100,000 acre-feet of water per 100 feet of saturated material. Below 300 feet the amount of water in storage is not estimated because the subsurface shape of the contact between the alluvium and older rocks and the permeability of the deposits at depth are not known. However, this permeability may be assumed to be smaller than that of the upper 300 feet of deposits, and the amount of available ground water in storage is assumed to be correspondingly smaller.

The saturated sediments underlying the reservation are interconnected with those below adjacent parts of the ground-water basin. There is pumping for irrigation in the adjacent parts of the basin and the effects of this removal of ground water from storage extend to all parts of the basin. The seasonal recharge of the younger alluvium along the channel of the Gila River may partly replenish the ground water that has been removed from the adjoining valley fill, but such recharge has not been sufficient to offset the losses, as indicated by the continuous decline in water levels in wells.

FLUCTUATIONS

In the heavily irrigated areas away from the river, the water table in the Gila Bend basin has declined on the average of from 3 to 6 feet per year since 1945. The hydrograph of a well in sec. 11, T. 5 S., R. 6 W. (fig. 14), immediately west of the area mapped (fig. 4), shows a more rapid decline than usual for the area. Quarterly water-level measurements between the winter of 1953 and the spring of 1955 show characteristic seasonal fluctuations and graphically demonstrate the effects of summer pumpage for irrigation and recovery during the nonpumping seasons. The fluctuations in spring water-level measurements for 1954–59 show the cumulative effects of pumpage for irrigation and the seasonal variations in recovery, which in part depend on the amount of surface flow in the Gila River. The sharp rise in the last half of 1954 and the early months of 1955 may be due to heavy flow in the Gila River below Gillespie Dam during the late summer of 1954. In contrast, a domestic and stock well in an unirrigated part of the flood-plain deposits, in sec. 24, T. 5 S., R. 5 W. (fig. 14), showed small fluctuations, apparently either in response to fluctuations of streamflow in the Gila River alone or in response to a combination of streamflow fluctuations and the effects of the general regional lowering of the water table.

Effects of impoundments behind Painted Rock Dam on water levels are difficult to evaluate because no data are available regarding the expected frequency with which water will reach different levels, the length of time the water would be allowed to remain in the reservoir,

TABLE 3.—*Chemical analyses of water from selected wells in the vicinity of the Gila Bend Indian Reservation, Maricopa County, Ariz.*

[Analyses by U.S. Geological Survey; chemical constituents in parts per million]

Location	Date of collection	Depth (feet)	Temperature (°F)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids		Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	Remarks
														Parts per million	Tons per acre-foot				
T. 4 S., R. 6 W.																			
SW¼SE¼NE¼ sec. 36	Apr. 16, 1953	------	83	29	116	22	358	150	142	618	3.2	8.8	----	1,370	1.86	380	67	2,440	
T. 5 S., R. 4 W.																			
SE¼SE¼NE¼ sec. 18	July 3, 1953	501	79	24	30	3.5	316	132	100	392	4.0	2.2	----	937	1.27	90	88	1,690	Sampled periodically.
Do	Aug. 22, 1956	------	78	----	------	------	------	132	------	405	------	------	----	--------	------	98	----	1,700	Total iron 0.03 ppm (1953).
SE¼SE¼SE¼ sec. 19	Apr. 23, 1953	926	82	28	65	6.3	423	106	155	600	4.0	1.7	1.2	1,340	1.82	188	83	2,390	
T. 5 S., R. 5 W.																			
NW¼SW¼SE¼ sec. 18	Apr. 16, 1953	960	80	35	192	63	767	172	356	1,320	3.1	30	2.0	2,850	3.88	738	69	4,830	
NE¼SE¼SE¼ sec. 18	do	550	76	30	242	72	626	219	283	1,240	2.1	40	1.4	2,640	3.59	900	60	4,490	
SW¼SE¼SE¼ sec. 18–1	Sept. 12, 1950	1,031	77.5	33	160	43	606	234	233	1,020	2.0	20	----	2,230	3.03	576	70	3,920	
NE¼NW¼NW¼ sec. 24	Apr. 17, 1953	130	75	26	114	40	268	238	136	484	.6	14	----	1,200	------	449	56	2,130	Sampled periodically.
Do	Aug. 22, 1956	------	85	25	248	97	368	235	227	980	.4	8.9	----	2,070	2.22	1,020	44	3,830	
T. 5 S., R. 6 W.																			
SE¼SE¼SE¼ sec. 12	Apr. 16, 1953	------	75	32	210	49	580	183	262	1,080	2.0	19	1.4	2,340	3.18	726	63	4,000	
SE¼SE¼NE¼ sec. 13	Apr. 10, 1946	230	74	----	118	39	565	236	181	915	2.3	5.9	----	1,940	2.64	------	----	3,460	Do.
Do	Sept. 11, 1952	------	76	37	296	90	811	257	399	1,580	1.9	16	----	3,360	4.57	------	61	5,680	
Do	Aug. 23, 1954	------	76	38	461	131	1,170	263	619	2,370	1.1	23	----	4,940	6.72	------	60	8,050	
Do	June 16, 1955	------	77	44	304	122	840	257	425	1,710	1.9	21	----	3,590	4.88	1,260	59	6,020	

and rates of siltation. In general, however, large and long-standing impoundments will tend to raise the water level. Any long-term rise in the water table along the Gila River above the dam may create a pressure differential that will make the water table slope toward the south end of the Painted Rock Mountains. Small temporary impoundments, such as would have been produced by the runoff during 1942–56, probably will have little or no effect on the ground water in addition to the normal effects of floodflows.

QUALITY OF WATER

The dissolved-solids content of water taken from wells in the older and younger alluvial deposits generally ranges from about 1,000 to 5,000 ppm (parts per million) as shown in table 3. According to U.S. Department of Agriculture standards, these waters are classified as "doubtful to unsuitable" for irrigation because they contain high concentrations of sodium and boron and relatively high concentrations of dissolved solids. Most of the water is hard, has a salty taste, and contains more than 1.5 ppm of fluoride, which makes it unsuitable for domestic use according to U.S. Public Health Service standards (California State Water Pollution Control Board, 1952, p. 123).

Surface water that enters the Gila Bend basin during periods of low flow sometimes contains more than 5,000 ppm of dissolved solids and is high in sodium and chloride. Johnson and Cahill (1955, p. 35–37) report:

> The period 1942–53 inclusive has been one of drought in most of the Southwest * * * except for the effects of floods of short duration, the flow of the river at Gillespie Dam gradually decreased in the period 1944–53. In 1947, 69,500 acre-feet was diverted into the canals; in 1953 the quantity available for diversion was only 22,000 acre-feet. During this same period the waters became more highly mineralized. In the water year 1943–44 the weighted average dissolved-solids content was about 3,800 ppm; in the water year 1952–53, about 5,000 ppm. Except when diluted with floodflows, the surface water diverted into the canals * * * is classed as 'unsuitable' for irrigation (Wilcox, 1948).
>
> Floodflows in the Gila River contain much less dissolved material than low flows. The water is of excellent quality in comparison with normal riverflow, though it is hard. The following tabulation indicates the difference in dissolved-solids content between flows greater than 500 cfs (cubic feet per second) and flows less than 500 cfs.
>
> The effect of the quality of the surface water in the Gila River upon the quality of the ground-water supply of the Gila Bend area is of great importance. For example, by mixing ground water with the surface water diverted into the canals, the dissolved-solids content can be reduced sufficiently to make the water suitable for irrigation of some crops. Some of this mixture recharges the ground-water reservoir by downward seepage from canals and fields. Some leaching of the alluvial materials is likely to occur as this water moves downward to the water table, and the net effect may be to increase the concentration of dissolved material in the ground water.

Date	Flows greater than 500 cfs		Flows less than 500 cfs	
	Mean discharge (cfs)	Dissolved solids (ppm)	Mean discharge (cfs)	Dissolved solids (ppm)
1951				
July 11–20			21.8	5,450
July 21–27, Aug. 2			29.9	4,640
July 28–31			457	1,460
Aug. 1, 3			207	1,860
Aug. 4, 5	2,075	487		
Aug. 6–10	734	877		
Aug. 11–15, 18–26			86.7	5,220
Aug. 16, 17			176	2,110
Aug. 27	586	881		
Aug. 28–31	8,500	417		
Sept. 1	4,640	262		
Sept. 2	2,540	543		
Sept. 3, 4	507	2,140		
Sept. 5–10			248	5,660
Sept. 11–20			174	5,790
Sept. 21–30			100	6,000

An important source of recharge of river water in the Gila Bend area is floodflows. These better quality waters tend to reduce the concentration of dissolved materials in the ground-water supply.

It is considered likely that a long-term tendency exists for the quality of the water supply in the Gila Bend area to deteriorate, at least in the downstream part. This tendency exists because more dissolved material is being brought into the area than is leaving.

Surface water is made usable by diluting it with ground water from wells. Although the mixed water, as well as the ground water itself, is classified as not being particularly suitable for irrigation purposes, it continues to be used successfully to raise some salt-tolerant crops such as cotton, alfalfa, barley, and sorghum. This is possible partly because the water is hard and the high calcium and magnesium contents partly offset the effects of high sodium content. Also, the soil in the Gila Bend area is sandy rather than clayey and drains readily; therefore, soluble salts tend to be leached rather than accumulated (Johnson and Cahill, 1955, p. 38).

The dissolved-solids content of water from shallow wells, those less than 300 feet deep, ranges from about 1,200 to 5,000 ppm. The dissolved-solids content of water from wells deeper than 300 feet ranges from about 950 to 2,850 ppm. No significant difference can be discerned at this time between the quality of water from shallow and deep wells, but available data do show that the quality of water from the shallow wells fluctuates more than that from deep wells. This is because the deep wells are open to receive water from the full thickness of penetrated alluvium and the water discharged from them is undoubtedly a mixture of water from many zones. No data are available from the area to determine whether or not there are zones of water of preferred quality in the valley fill. Babcock and others (1948, p. 10 and table 2) report that one well about 15 miles west of the reservation produced water from 600 feet of sandstone which was penetrated below a depth of 1,100 feet. The formations above 1,100 feet were cased off. The dissolved-solids content of water from this well was reported to be 1,060 ppm. The chemical quality was, in general, similar to that of the water shown in table 3 of this report, except that the calcium, magnesium, and bicarbonate contents were proportionally lower and the sodium and potassium combined and chloride contents were proportionally higher. The water from this well was reported to contain 93 percent sodium, which is somewhat higher than the approximate average of 60 percent sodium for the wells in table 3 of this report.

The quality of water in shallow wells in the flood plain of the Gila River seems to respond to changes in the flow in the river and the amount pumped from the ground-water reservoir. A 130-foot well in sec. 24, T. 5 S., R. 5 W., which is pumped for domestic and stock purposes only, yielded water that contained 1,200 ppm of dissolved solids in 1953 and about 2,000 ppm in 1956. The dissolved solids in a 280-foot irrigation well in sec. 13, T. 5 S., R. 6 W., however, increased from about 2,000 ppm in 1946 to nearly 5,000 ppm in 1954 and then decreased to about 3,600 ppm in 1955. The changes in dissolved-solids content are apparently related to flow in the river because 1952 and 1953 were years of almost no flow past Gillespie Dam, and 1954 and 1955 were years of above-average flow.

Impoundment of large quantities of flood water of comparatively low dissolved-solids content behind Painted Rock Dam may result in small temporary decreases in the dissolved-solids content of ground water in the younger alluvium. On the other hand, impoundment of water in quantities similar to the level of runoff during 1942–58 will have almost no effect.

AVAILABILITY OF GROUND WATER FOR FUTURE DEVELOPMENT

The Bureau of Indian Affairs estimates that within the Gila Bend Indian Reservation, about 1,200 acres, in addition to about 375 acres under cultivation in 1955, is arable. The annual publication of the University of Arizona Agricultural Experiment Station entitled, "Arizona Agriculture" gives consumptive-use figures by crops. These figures range from about 2½ to 5½ acre-feet per acre. In general, it is estimated that about 4 acre-feet of water is needed to irrigate crops in southern Arizona. The amount of water needed to irrigate the 1,200 acres is estimated to be about 5,000 acre-feet per year.

It is assumed that the 5,000 acre-feet needed to irrigate the 1,200 acres will be obtained from ground-water sources underlying the Gila Bend Indian Reservation. These sources have been estimated conservatively to contain between 50,000 and 100,000 acre-feet of available water per 100 feet of saturated material to a depth of about 300 feet. Below 300 feet the amount of available ground water in storage per 100 feet of saturated thickness is presumed to be smaller. Depths to water range from about 35 to 60 feet and water levels in heavily irrigated areas in the Gila Bend basin have declined on the average from 3 to 6 feet per year. For the purposes of this discussion, the average depth to water in the reservation is assumed to be about 50 feet in 1960 and the average decline, when the 1,200 acres are irrigated will be about 5 feet per year. During an assumed 25-year period of irrigation the water table therefore would be expected to be lowered about 125 feet, to a total depth of 175 feet. During this 25-year period the median depth to water, rounded to the nearest 10 feet, would be about 90 feet. The median thickness of saturated material above the 300-foot level for this period, therefore, would be about 210 feet, and would contain about 100,000 to 200,000 acre-feet of available water.

These calculations ignore the possible changes in the rates of recharge and withdrawal that result principally from fluctuations in the amount of annual flow in the Gila River and ground-water pumpage for irrigation in the Gila Bend basin. Nonetheless, it seems conservative to assume that there is sufficient ground water in storage in the upper 300 feet of alluvial deposits beneath the Gila Bend Indian Reservation to irrigate 1,200 acres for at least 25 years.

The chemical quality of water available from the upper 300 feet of alluvium apparently changes in response to large withdrawals from storage and fluctuations in the amount of flow in the Gila River. For the period of record, these changes in general have been deleterious. It must be anticipated that, unless the period of increased withdrawals corresponds with a period of large runoff of low dissolved-mineral content in the Gila River, the quality of water above the 300-foot level will deteriorate. Data are insufficient to determine the effects on chemical quality of long-term pumping of the water from below 300 feet.

SUMMARY AND CONCLUSIONS

1. The principal aquifer in the area is the valley fill, which comprises the hydrologically interconnected younger and older alluvial fills and the coarser fraction of the Sil Murk formation. The saturated thickness of the valley fill under the reservation ranges from about 800 to more than 1,400 feet and yields of wells are adequate for irrigation purposes.

2. In the mountain and foothill areas, ground-water supplies in quantities sufficient for domestic purposes may be obtained locally in the Sil Murk formation and in the crystalline rocks.

3. Depths to water under the Gila River flood plain and the Gila Bend plain range from about 35 to 60 feet. The water table in nonirrigated areas along the Gila River shows only small declines and fluctuates either in response to streamflow in the Gila River alone or in combination with the regional lowering of the water table.

4. Pumpage for irrigation purposes in the surrounding Gila Bend basin increased from about 30,000 to 180,000 acre-feet per year in 1946–56. The water table in irrigated areas declined at about 3 to 6 feet per year during the same period.

5. Annual recharge from all sources for the Gila Bend basin is estimated to average between 40,000 and 50,000 acre-feet for 1947–53. Recharge within the Gila Bend Indian Reservation is estimated to be limited to an amount sufficient to replenish evapotranspirative losses.

6. Surface flow in the Gila River is regulated by upstream storage and diversions and the riverbed is dry except during peak floods.

7. Water levels under the reservation, even without further irrigation development within its boundaries, may be expected to decline eventually because of ground-water use elsewhere in the basin and upstream appropriation of surface water.

8. Ground water in storage beneath the Gila Bend Indian Reservation is sufficient to irrigate the 1,200 acres of arable land not under cultivation at this time for at least 25 years.

9. Although the chemical quality of water is not considered by accepted standards to be particularly suitable for irrigation, the water continues to be used successfully to raise salt-tolerant crops.

10. The temporary impoundment of water behind the Painted Rock Dam may increase recharge and raise the water table, particularly following large impoundments held for long periods.

11. Impoundment of flood water and recharge behind Painted Rock Dam may result in a small temporary decrease in the dissolved-solids content of ground water in the younger alluvial fill.

12. Impoundment of floodwater in quantities similar to the flows of 1942–58 will result in little or no effect on ground water under the reservation.

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