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Geological Survey

Geology and ground-water resources of the San Simon Basin, Cochise and Graham Counties, Arizona

By

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With a section on quality of water

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Prepared in cooperation with
Arizona State Land Department
O. C. Williams, Commissioner

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Purpose and cooperation

The need for State regulation of ground-water resources in Arizona has become increasingly apparent in recent years. Inasmuch as such control must be based upon adequate information as to the quantity, quality, and use, as well as the source and movement of the ground water, the Arizona State Legislature in 1945 appropriated funds for the investigation of the ground-water resources of the State. The investigation is being made by the Geological Survey, United States Department of the Interior, under a cooperative agreement with the Arizona State Land Department, O. C. Williams, Commissioner.

Field work was started in March 1946 and was done by R. L. Cushman and M. B. Booher, engineers, and by R. S. Jones, geologist, under the general direction of S. F. Turner, district engineer of the Geological Survey in charge of ground-water investigations in Arizona. Water analyses were made by J. D. Hem and R. T. Kiser, chemists of the Quality of Water Division of the Geological Survey.

Location and extent

The San Simon Basin is a part of the structural trough that extends from the vicinity of Rodeo, New Mexico, northwest to the vicinity of Globe, Arizona (fig. 1). For this report the San Simon Basin is limited on the south by an arbitrary east-west line between T. 16 S. and T. 17 S., 19 miles south of the town of San Simon; on the southwest and west by the Chiricahua, Dos Cabezas, and Pinaleno (Graham) mountains; on the north by the Safford Basin; and on the east by the Peloncillo Mountains. The ground-water resources of the Cactus Flat-Artesia area (fig. 1) are not discussed in this report. The basin ranges in width from 10 to 25 miles and is about 60 miles in length. San Simon Creek, which flows along the axis of the basin, enters the upper, or southern, end of the basin at an altitude of about 4,000 feet, and it flows into the Safford Basin at an altitude of about 3,000 feet.

The Southern Pacific Railroad and State Highway 86 pass through Bowie and San Simon, the only two towns in the basin. The principal agricultural development of the basin is in the vicinity of the town of San Simon.

Climatological data

Climatological data have been collected in the towns of Bowie (elev. 3,756 ft.), and San Simon (elev. 3,609 ft.), for 72 years and 52 years, respectively. The mean monthly and mean annual precipitation at these towns are given in table 1. The frost-free season at San Simon was 212 days during 1945. In the cultivated area the last killing frost in the spring occurred on April 12 and the first killing frost in the fall occurred on November 9. The mean annual temperature at San Simon is 62.8 degrees Fahrenheit.

History of development

The first white settlers in the San Simon Basin were the ranchers that entered the basin about 1870. These ranchers developed ground water from shallow wells for domestic and stock use. The depth to water was too great for economical pumping for irrigation with the equipment available at that time. Artesian water was first encountered in 1910, in a deep well drilled for the Southern Pacific Railroad at San Simon. The flowing well that resulted encouraged further prospecting for artesian water.

By 1915 there were 127 flowing wells in the basin, all near the town of San Simon, producing a total flow of about 11,000 acre-feet of water a year[1]. A large part of this water was wasted. Economic conditions preceding and during World War I stimulated agricultural development, and about 1,200 acres of land was cultivated in the vicinity of San Simon in 1919. With the passing of this period many farms were abandoned, leaving a considerable number of unused and uncontrolled flowing wells. The water from these wells spread over the adjacent lands or found its way into San Simon Creek. These formerly cultivated lands were sold or leased to cattlemen, whose stock found watering places at the numerous flowing wells.

In 1940[2] about 400 acres of land was under cultivation, and about 3,100 acre-feet of water was produced from wells. About 2,700 acre-feet of this water was discharged from the 88 flowing wells measured, and 400 acre-feet was pumped from non-flowing wells. About 1,000 acre-feet of the water produced from flowing wells was wasted. Some of the unused flowing wells were not measured in 1940.

The increased prices for agricultural products during World War II resulted in expansion of the cultivated acreage, and about 1,000 acres was under cultivation in 1946. These lands were irrigated from 140 wells that developed water from artesian aquifers, and from three pumped wells that developed water from non-artesian aquifers. Forty-three of the artesian wells were also pumped at times. A total of 5,800 acre-feet of water was discharged from wells in 1946. Of this, 3,500 acre-feet flowed and 2,100 acre-feet was pumped from the artesian aquifers, and 200 acre-feet was pumped from non-artesian aquifers. About 1,400 acre-feet of water from the flowing wells was wasted

Previous investigations

The San Simon Basin was studied by Schwennesen[3] in 1913 and 1915.

Turner, McDonald, and Hem[4] in 1940 made a reconnaissance study of the rates of flow of water from the artesian wells, of the pressure head of the artesian water, and of the quality of the ground waters.

GEOLOGY AND ITS RELATION TO GROUND WATER

Maps and field work

The geological work done in this investigation was, of necessity, strictly reconnaissance in nature. The large area covered and the limited time available prohibited any detailed work, although many localities were noted in which further geological study would be desirable. Field work was done during the period September 1-15, 1946.

1/ Schwennesen, A. T., Ground water in San Simon Valley, Ariz. and N. Mex.: U. S. Geol. Survey Water-Supply Paper 425-A, p. 14, 1915.

2/ Turner, S. F., McDonald, H. R., and Hem. J. D., Ground-water conditions in the San Simon artesian basin, Cochise County, Ariz. (manuscript report in files of U. S. Geol. Survey), 1941.

3/ Schwennesen, A. T., Ground water in the San Simon Valley, Ariz. and N. Mex.: U. S. Geol. Survey Water-Supply Paper 425-A, 1917.

4/ Turner, S. F., McDonald, H. R., and Hem. J. D., Ground-water conditions in the San Simon artesian basin, Cochise County, Arizona (manuscript report in files of U. S. Geol. Survey), 1941.

The geologic mapping of the area was done on topographic maps of the Geological Survey. Contact prints of aerial photographs were used to interpret some of the geology. The topographic maps were combined to make the base map, plate 1.

Character of the basin

The San Simon Basin lies in a part of the large structural trough which extends from the vicinity of Rodeo, New Mexico, northwest to the vicinity of Globe, Arizona. The part of the trough in which the basin lies was formed by downfaulting between two nearly parallel mountain chains. The mountains, which are composed of impermeable rocks, retain ground water within the trough. The Peloncillo Mountains, consisting of volcanic rocks and older sedimentary and granitic rocks, lie along the northeast side of the basin. The chain of mountains along the southwest side of the basin includes the Chiricahua, Dos Cabezas, and Pinaleno Mountains. The rocks in this mountain chain include ancient schists as well as rocks similar to those in the Peloncillo Mountains.

The rocks of the mountains are mostly resistant, hard, and relatively impermeable. Most of the precipitation runs off these hard rocks of the mountains and into the valley. A part of the precipitation enters fractures and solution openings in the hard rocks and issues at lower elevations as springs. In general, the hard rocks are relatively unimportant as aquifers and will not be discussed further in this report. Their water-bearing character is shown on plate 1.

The San Simon Basin contains a thick series of beds of clay, silt, sand, and gravel. These sediments are unconsolidated at the surface and the amount of consolidation probably increases with depth. The sediments are probably underlain by volcanic tuffs and breccias in the deeper parts of the basin.

The thick series of clays, silts, sands, and gravels constitutes the "older alluvial fill" of the basin. The deposits along streams and washes are termed "Recent alluvial fill" in this report. As most of the ground water in the San Simon Basin occurs within the fill, this report pertains mainly to the ground water in these deposits.

Rocks underlying older fill

The rocks underlying the older fill are volcanic tuffs and breccias, similar to those shown on plate 1 as "older volcanic rocks." Moderately consolidated clays, silts, sands, and gravels may be interbedded in places with these deep volcanic rocks.

Drill cores from a reported depth between 5,500 and 6,500 feet in the San Simon deep well (4264, pl. 2) were identified as volcanic breccias. No accurate information was available as to the depth where this volcanic breccia was first encountered. These volcanic rocks may be several thousand feet in thickness, as they probably correlate with the volcanic rocks in the adjoining mountains.

Older alluvial fill

The sedimentary deposits resting upon, and in some places probably interbedded with, the volcanic rocks were derived from the rocks comprising the adjoining mountain masses. While the mountains were being eroded the San Simon trough was being partly filled. Smaller hills and ridges were buried by the debris of gravel, sand, and silt. These buried hills and ridges influence the movement of ground water by acting as partial ground-water barriers.

The deposits of the older fill consist of beds and lenses of clay, silt, sand, sandstone, gravel, and boulder conglomerate, carried into the basin from the surrounding mountains by streams and by sheet runoff. As the slope lessened and the carrying power of the water dimished, the boulders were dropped first, followed by gravel, sand, silt and clay. Therefore, the deposits grade in texture from the large boulders on the higher slopes to smaller particles at lower elevations. Each succeeding rain, with its accompanying runoff, did not occur in exactly the same area, or with the same force or duration. Because of these naturally fluctuating conditions the water deposited, for example, sand or silt over areas where gravel had been dropped before. During the larger floods fingers of coarse gravel were deposited along stream channels and the channels shifted from time to time as deposition continued. The deposits of different texture therefore interfinger. The materials deposited on the steeper slopes, near the mountains, were predominantly boulders, gravels, and sands. Those deposited on the more moderate slopes, away from the mountains, were mainly sands and silts. However, thin channel deposits of gravel are scattered throughout the basin, although they are naturally more abundant near the mountains.

During the past, the San Simon Basin was probably without exterior drainage, and lakes occupied the lower parts of the basin. Clays and silts normally were deposited in these lakes, although exceptionally large floods deposited some gravel and sand fingers. The alternation of beds of gravel, sand, silt, and clay is shown in driller's logs of wells (table 2). With respect to the clays of the "lake-bed zone," Schwennesen[5] states:

> "In the middle and upper portions of San Simon Valley the lake beds are not exposed but are found in wells beneath the surface mantle of stream deposits. Dense, homogeneous, non water-bearing blue clay, 300 to 400 feet thick, which is believed to be the upper member of the lacustrine formation, is found in almost all the wells near San Simon and Bowie within about 150 feet of the surface. This is the confining bed which holds the artesian water under pressure. Beneath the blue clay is a series of beds of gray, yellow, or reddish clays interbedded with sand or fine gravel, as a rule containing thin layers of hard sandstone. In the center of the valley these beds persist to a reported depth of 1,230 feet, which is the greatest depth attained by the drilling. They contain the artesian water that has been found in this vicinity and are believed to be in part lake deposits but probably include older stream deposits, as the information furnished by the drillers' logs is not sufficiently specific to make it possible to differentiate with certainty between these two kinds of deposits."

Water from areas of limestone and volcanic rocks usually carries calcium and bicarbonate in solution. Some of these dissolved salts are deposited between the particles of sand and gravel, forming caliche. Layers of relatively impermeable caliche were formed near the surface in a part of the outcrop area of the "gravel zone" near the edges of the fill. Streams have cut channels through the caliche, enabling water from rain and from stream-flow to enter the fill along the stream channels.

The silts, sands, and gravels overlying the lake-bed clays were probably deposited by streams and by sheet runoff. These materials are

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5/ Schwennesen, A. T., Ground water in San Simon Valley, Ariz. and N. Mex.: U. S. Geol. Survey Water-Supply Paper 425-A, pp. 8-9, 1917.

shown on the geologic map (pl. 1) as "older fill", although Schwennesen[6] described them as "younger stream deposits." Ground water in these deposits is not under artesian pressure.

Recent alluvial fill

The Recent, or younger, alluvial fill consists of gravels, sands, and silts deposited along existing stream channels. These deposits are usually unconsolidated. They are usually relatively thin and are not important as aquifers in the central part of the basin. Shallow wells have been dug in Recent alluvial fill along some of the stream channels in the mountains that border the basin.

GROUND-WATER RESOURCES

The older alluvial fill is the principal source of ground water in the San Simon Basin. The Recent alluvial fill is not an important aquifer in the central part of the basin, and therefore the occurrence of ground water in the Recent fill will not be discussed further in this report. Most of the ground water obtained in the older alluvial fill is from artesian aquifers interbedded with lake-bed clays, and smaller amounts are obtained from non-artesian aquifers overlying the uppermost layer of lake-bed clay. Toward the mountains the lake-bed clays pinch out, so that the aquifers blend into a common non-artesian ground-water reservoir.

Artesian aquifers

Occurrence of ground water

Ground water under artesian pressure occurs in lenses of permeable sand and gravel, interbedded with clay, sandstone, and conglomerate. The water-bearing sand and gravel beds lie at depths ranging from about 350 to at least 2,500 feet. The individual water-bearing beds range from less than 1 foot to about 50 feet in thickness (see table 2). The beds of sandstone and conglomerate do not yield water readily to wells. These beds usually occur below 700 feet, becoming more common with increasing depth. Well 4646 (see pl. 2) was drilled to a depth of 2,000 feet, but no water was reported to have been encountered below 928 feet, although several beds of cemented sand and gravel were penetrated below that depth. Logs of other deep wells in the basin, however, show that water-bearing sands exist to a depth of at least 2,500 feet.

Source of ground water

The principal source of recharge to the artesian beds is seepage from stream flows on the gravel zone of the valley fill near its contact with the hard rocks of the mountains. Most of the recharge occurs during the months when the streams are flowing clear water fed by runoff from slow winter rains or from melting snow. Tests on Queen Creek[7] and on

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6/ Op. cit., p. 9

7/ Babcock, H. M., and Cushing, E. M., Recharge to ground water from floods in a typical desert wash, Pinal County, Ariz.: Am. Geophys. Union Trans., Reports and papers, Hydrology, pp. 49-56, 1942.

the Santa Cruz River and Rillito Creek[8] showed that clear water percolates into the material underlying the stream channels up to 15 times faster than does silty water from flash floods. The water that enters the gravel zone moves downward and outward into the artesian aquifers of the lake-bed zone.

A large part of the ground water moving into the San Simon Basin from the south is forced to the land surface about 14 miles north of Rodeo, New Mexico, by a ground-water barrier, forming a marshy area of about 1,600 acres, known as the San Simon Cienaga. The change in slope of the water table at the cienaga indicates the presence of a partial ground-water barrier. Analyses of many water samples from the vicinity of the cienage also indicate that part of the ground water moving northward into the basin is brought to the surface by a barrier. This barrier may be part of the clay beds of the lake-bed zone. More detailed work will be needed to determine the exact nature of the barrier, and to determine the amount of water that moves into the artesian system past the cienaga.

Discharge of ground water

Ground water is discharged from the artesian aquifers in the basin by natural and artificial means. Natural discharge occurs as underflow out of the basin. Artificial discharge includes water produced from flowing and pumped wells, and leakage of water into the non-artesian aquifers through or around deteriorated casings of artesian wells.

Natural discharge

Ground water in the artesian aquifers moves slowly northwestward and is probably discharged as undeflow into the Safford Basin. This movement of the artesian water toward the Safford Basin is indicated by the gradual decline in pressure head and by the gradual increase in dissolved-mineral content of the water in a northwest direction. The amount of water discharged in this manner is not known.

Artificial discharge

The amount of water artificially discharged from flowing and pumped wells penetrating artesian aquifers was about 5,600 acre-feet in 1946. The water was discharged from 140 wells, of which 43 were pumped part of the time. The combined rate of flow of water from the flowing wells was about 2,200 gallons a minute, and those which were pumped had a combined rate of discharge of about 8,000 gallons a minute. The flowing wells ranged in rate of flow from a seep to about 120 gallons a minute. The average rate of discharge from the pumped wells was about 185 gallons a minute.

Water from the artesian aquifers enters the permeable beds of the non-artesian aquifers through breaks in the casings of the artesian wells, or by moving upward around the outside of the well casings. The amount of this discharge has not been determined.

The artesian wells range in depth from 200 feet to at least 2,000 feet, and range in diameter from 2 inches to 10 inches. Most of the wells are between 600 and 900 feet in depth and are between 4 and 6 inches in diameter. Table 3 shows records of typical wells in the basin. Generally,

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8/ Turner, S. F., and others, Ground-water resources of the Santa Cruz Basin, Ariz.: U. S. Geol. Survey (mimeographed), pp. 45-53, 1943.

the wells are cased only from the land surface into the uppermost layer of lake-bed clay, so that the wells obtain water from every artesian aquifer penetrated. Many wells have become obstructed below the casing, either by caving of the clay walls or by "sanding up" of the uncased hole in the water-bearing beds. These obstructions increase the loss of artesian head through friction until the rate of flow of water from a well is insufficient to provide an adequate supply. The rate of flow from well 4633 (pl. 2) gradually diminished from 50 to 8 gallons a minute but, after the well was cleaned of obstructions, the flow increased to approximately the former rate of 50 gallons a minute.

The casings in several old wells formerly protruded above the land surface but have disintegrated by rusting so that the top of the casing is below the land surface. Grass roots and soil have plugged the orifices of the wells, and the well locations are marked by small areas of luxuriant grass using the water that seeps upward from the buried wells.

A large part of the water produced from flowing wells is wasted in non-beneficial use. Many wells have been abandoned, and the locations of these wells are marked by groves of cottonwood trees that derive water from the wells. In addition, many of the flowing wells that have not been abandoned are used only part of the time. About 1,400 acre-feet, or 40 percent, of the ground water that flowed from wells was wasted in 1946.

Head of the artesian water

The elevation to which water will rise under artesian pressure in wells is highest in the southeastern part of the basin and decreases gradually to the northwest. The pressure head is sufficient to raise water above the land surface within an area which extends along San Simon Creek from a point about 9 miles southeast of the town of San Simon to a point at least 22 miles northwest of San Simon. The flowing-well area averages 4 miles in width for about 14 miles in the southeast part. In the northwest part, the width of the area is not accurately defined because there are not sufficient artesian wells in which to observe the pressure head. Schwennessen[9] states:

> "In the fall of 1915 the heads in about sixty of the flowing wells in the vicinity of San Simon were measured and found to range from a fraction of a foot to 42 feet (above the land surface)."

Decline in artesian head

The head of the artesian water has decreased since the first artesian wells were completed. A comparison of the head in 1915 with that in 1946 (table 4), shows that the decrease in head has not been equal throughout the basin. The decrease of the artesian head has not been as great outside the flowing-well area as within the flowing-well area. The maximum decrease in artesian pressure was 33 feet in the flowing-well area near San Simon between 1915 and 1946. The decrease in head has been about 10 feet in the vicinity of Bowie between 1915 and 1946. These data indicate that the decrease of head in the flowing-well area is due not so much to depletion of the artesian supply as to interference among wells, as will be discussed in the following section.

9/ Schwennesen, A. T., Ground water in the San Simon Valley, Ariz. and N. Mex.: U. S. Geol. Survey Water-Supply Paper 425-A, p. 14, 1917.

Fluctuations in artesian head

Fluctuations in artesian head in the flowing-well area of the San Simon Basin are principally the result of interference among wells. Water discharges from a flowing artesian well because the pressure head of water in the aquifer is sufficient to raise the water above the orifice of the well. Movement of water into the well causes a reduction in pressure head within the aquifer. This pressure reduction extends from the well in all directions in the aquifer and decreases as the distance from the well increases. Water moves from the areas of least pressure reduction to the well, where the pressure reduction is greatest. The pressure reduction in the aquifer at the well gradually approaches a maximum, and the well then flows at a nearly constant rate. The areas of pressure reduction caused by several discharging wells that obtain water from the same aquifer eventually overlap and result in additional pressure reduction at each well. This additional pressure reduction causes the rate of discharge of water from each well to decrease. The pressure reduction in an artesian aquifer caused by flow from a well is increased when the well is pumped. Seasonal fluctuations of pressure head occur in the artesian aquifers in the vicinity of San Simon during the summer months, when some of the artesian wells are pumped. The seasonal pressure reduction is at least 8 feet in the most heavily pumped area, southeast of San Simon. (see well 4600, fig. 2). The pressure reduction diminishes in magnitude away from the pumped area, and 5 miles to the northwest of San Simon it amounts to less than 1 foot. The seasonal pressure-head reduction caused by pumping sometimes causes nearby wells temporarily to cease flowing. Well 4658 (see pl. 2) usually flows at a rate of 20 gallons a minute; however, during the pumping season of 1946 the well ceased to flow and the water level stood approximately 0.5 foot below the orifice of the well.

Non-artesian aquifers

Occurrence of ground water

Non-artesian ground water occurs in the permeable lenses of sand and gravel that are usually interbedded with lenses of silt and clay at relatively shallow depths. The water-bearing beds range in depth from 60 to at least 150 feet below the land surface.

The depth to the water table is least along the axis of the basin and increases toward the mountains which border the basin. The water table slopes downward to the northwest along the axis of the basin, at a gradient steeper than that of the land surface. Ground water is at the land surface in the San Simon Cienaga; it is 60 feet below land surface at the town of San Simon; and it is 80 feet below land surface near San Simon Creek at a point 34 miles northwest of the town of San Simon.

Source of ground water

The sources of recharge to the non-artesian aquifers are: (1) Seepage from stream flow; (2) percolation directly from precipitation; (3) percolation from irrigation; (4) underflow into basin; and (5) leakage from artesian aquifers. Stream flows of clear water fed by runoff from slow winter rains or melting snows seep into the permeable sediments of the gravel zone or into the sediments underlying the stream channels. Flows of silty water caused by rapid runoff from torrential summer rains also cause recharge, but the rate of seepage is less than for the flows of clear water. A part of the seepage from stream flows enters the non-artesian aquifers.

The recharge to ground water from precipitation is believed to be small. The precipitation usually occurs in such small amounts that practically all of it returns to the atmosphere by evaporation or is used by plants and does not pass below the zone of root penetration.

The amount of recharge to the non-artesian aquifers from irrigation water applied to the land was estimated to be 900 acre-feet in 1946. Experiments in the nearby Safford Basin[10/] showed that 25 percent of the irrigation water applied to the land percolates downward to the ground-water reservoir. The soils in the farmed area of the San Simon Basin probably contain more caliche and more clay than the soils in the farmed area of the Safford Basin, and therefore the amount of recharge from irrigation in the San Simon Basin was estimated to be only about 15 percent of the water applied rather than 25 percent.

Underflow into the basin occurs in the vicinity of the San Simon Cienaga; however, a large quantity of this water is discharged by evaporation and plant use within the cienaga. The amount of ground water that passes the cienaga into the non-artesian aquifers of the San Simon Basin has not been determined.

Water from the artesian aquifers enters the permeable beds of the non-artesian aquifers through breaks in artesian well casings, or by moving upward around the outside of the well casings. The amount of recharge that occurs in this manner has not been determined.

Discharge of ground water

Ground water is discharged from the non-artesian aquifers in the basin by natural and artificial means. Natural discharge includes water used in the San Simon Cienaga and possible underflow out of the basin. Artificial discharge is by pumping from wells.

Natural discharge

Ground water is discharged naturally from the non-artesian aquifers by evaporation and plant use in the San Simon Cienaga, where the water table lies at or near the land surface. On the basis of studies of evaporation of ground water from wetted land surfaces and use of ground water by native plants in the nearby Safford Basin[11/], it was estimated that the natural discharge of ground water is about 5 acre-feet per acre per year in the cienaga. Therefore, the natural discharge from the 1,600 acres in the cienaga is about 8,000 acre-feet of ground water a year.

Artificial discharge

Water was artificially discharged from the non-artesian aquifers through three irrigation wells, which pumped approximately 200 acre-feet in 1946. The wells yielded an average of 400 gallons a minute each when pumped, and the average yield per foot of drawdown was about 10 gallons a minute. The irrigation wells are about 100 feet deep and are 12 inches in diameter.

10/ Turner, S. F., and others, water resources of Safford and Duncan-Virden Valleys, Ariz. and N. Mex.: U. S. Geol. Survey (mimeographed), pp. 28 and 36, 1941.

11/ Idem., pp. 7-12.

Fluctuations of the water table

Only a few wells tap water in the non-artesian aquifers in the basin. Seasonal fluctuations in these shallow wells were less than 1 foot in 1946 in the vicinity of the town of San Simon (see wells 4262, 4366, and 4500, fig. 2). The trend of the water table has been upward between 1940 and 1946, and the average net rise was 0.6 foot during that period. This rise may be the result of leakage of water from the artesian aquifers to the shallow, non-artesian aquifers.

Safe yield

All factors of recharge and natural discharge have not been quantitatively determined in the San Simon Basin and therefore the annual safe yield of water from the aquifers of the basin has not been estimated in this report. The available data indicate that the pressure head in the artesian aquifers has decreased since the first artesian wells were completed. It is estimated that 25 percent of the artesian water discharged at the land surface is wasted. Water now being wasted by uncontrolled flowing wells and by leakage through breaks in the artesian well casings could be conserved, and the discharge from the artesian aquifers would thereby be reduced.

It is probable that the annual safe yield of water from the non-artesian aquifers has not been exceeded, because water levels in wells in the pumped area have not declined. About 200 acre-feet of water was pumped from these aquifers in 1946, and during this period water levels rose slightly in wells near the town of San Simon (fig. 2).

QUALITY OF WATER

By

J. D. Hem

Chemical character of ground water

In the 1946 study of the San Simon Basin, 40 samples of ground water from the basin were analyzed. Table 5 shows analyses of typical samples. Analyses were available for 60 samples taken from wells in the vicinity of the town of San Simon in 1940 and 1941. In an earlier publication of the Geological Survey[12] there are a few analyses of ground waters from the San Simon artesian area. The following discussion of chemical character of ground water in the area is based upon about 100 analyses, made in 1940, 1941, and 1946.

In general, the water from wells in the artesian aquifers in the San Simon Basin in Cochise County has only moderate amounts of dissolved matter. Comparison of the analyses made in 1940 and 1941 with those made in 1946 indicates that the chemical character of water from the artesian aquifers has not changed during the period. Most samples from these wells contained between 200 and 300 parts per million of dissolved matter, and no samples from the basin in Cochise County contained as much as 500 parts per million. Waters from different parts of the basin differ considerably in the proportions of the constituents present, although concentrations of dissolved matter in the artesian waters encountered near the town of San Simon are uniform. In the western

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12/ Schwennessen, A. T., Ground water in San Simon Valley, Ariz. and N. Mex.: U. S. Geol. Survey Water-Supply Paper 425-A, pp. 17 and 21, 1917.

part of the flowing-well area the waters are soft, containing mostly sodium and bicarbonate, with large amounts of fluoride. One well in this locality (4257, pl. 2) yielded water containing 38 parts per million of fluoride, and several samples with 10 to 20 parts per million were obtained in the area. In the eastern part of the flowing-well area the waters contain mainly calcium and bicarbonate, with smaller amounts of fluoride.

Waters from the part of the basin south of the San Simon Cienaga also contain moderate amounts of dissolved matter, consisting mainly of calcium and bicarbonate. A few samples have been collected in the northwestern part of the basin, and apparently waters in this part of the basin are more concentrated than in the central and southern parts. Some of the waters from the northwestern part of the basin are highly mineralized, and these more highly mineralized waters contain mostly sodium, chloride, and sulfate, with comparatively large amount of fluoride.

Chemical character of surface water

There are no perennial streams in the basin. A few flood flows from San Simon Creek were sampled at Safford, after they had entered the Gila River, and these waters usually contained between 500 and 900 parts per million of dissolved solids, consisting mainly of sodium, bicarbonate, and chloride. Samples of flood waters were not obtained from the creek in the upper part of the basin, but it is likely that these flood flows are less highly mineralized than the flows sampled at Safford. A sample of the surface flow of Cave Creek was moderately mineralized, containing about 300 parts per million of dissolved matter, mostly calcium and bicarbonate. Cave Creek receives flow from springs in the Chiricahua Mountains and enters the basin south of the San Simon Cienaga.

Relation of quality of water to use

Irrigation

The quality of waters of the basin is interpreted with respect to irrigation according to the classification of Wilcox and Magistad[13]. Nearly all the waters in the flowing-well area west of San Simon are "injurious to unsatisfactory" for irrigation on the basis of sodium percentage, although they are comparatively low in dissolved solids. The harder artesian waters that occur east of San Simon are "excellent to good" for irrigation. Most ground waters south of the San Simon Cienaga are also "excellent to good" for irrigation. Ground waters in northwestern part of the basin are rather highly mineralized and high in sodium percentage, so that nearly all those sampled are "injurious to unsatisfactory" for irrigation.

Domestic use

Judged solely on the basis of palatability and hardness, ground waters in the basin might be considered satisfactory for domestic use. Chemical analyses show, however, that practically all these waters are high in fluoride. Fluoride content has particular significance with

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

respect to drinking-water supplies. It is generally recognized that waters containing excessive amounts of fluoride may cause permanent mottling of the tooth enamel of children who drink such waters during the time their permanent teeth are forming. According to the Public Health Service[14] a satisfactory drinking water should contain no more than 1.5 parts per million of fluoride. One sample taken in 1940 from well 4257, near San Simon, contained 38 parts per million of fluoride, the highest concentration that has been found in the investigations of the Geological Survey in Arizona. Concentrations of 10 parts per million or more of fluoride are relatively common in the San Simon area, although they are rare in the State as a whole. The harder waters of the basin generally contain less fluoride than the soft waters, but even the hard waters usually contain more than 1.5 parts per million. Most of the waters analyzed from the part of the basin south of the San Simon Cienaga were also high in fluoride.

Artesian waters in the area west of San Simon are soft, some having almost no hardness, and in this respect the waters are excellent for domestic use. Waters in the eastern part of the flowing-well area are moderately hard. Ground waters in the northwest part of the basin are generally high in sodium, chloride, and sulfate, and usually these waters contain excessive amounts of fluoride.

Relation of quality of water to recharge and source of dissolved matter

The artesian waters in the basin obtain most of their dissolved matter from the valley-fill materials with which they have been in contact. The low dissolved solids of the waters in the vicinity of the town of San Simon indicates that the fill contains little soluble matter. The differences in chemical character between waters east of San Simon and west of San Simon probably result from differences in the character of the valley fill. The mountains to the west are composed mainly of granitic rocks. The alluvial deposits derived from these mountains contain waters that are low in hardness but have a relatively high fluoride content. The mountains to the east are composed mainly of volcanic rocks. The alluvial deposits derived from these mountains contain waters that are relatively high in hardness but have a relatively low fluoride content.

The chemical analyses indicate that water in the San Simon Cienaga is similar to ground waters that occur near Rodeo, New Mexico (fig. 1), a few miles upstream. The waters moving northward into the basin probably are brought near the surface of the ground at the cienaga by impermeable materials in the valley fill.

The few samples obtained from wells near San Simon in the non-artesian aquifers are not sufficient to identify conclusively the sources of recharge to the shallow ground waters of the basin. The non-artesian waters generally are more highly mineralized than artesian waters in the same area. A part of the water is derived by leakage from artesian wells through faulty or deteriorated casings. Water also enters the non-artesian aquifers from stream flow and irrigation. The amount of recharge from irrigation has been discussed in the section entitled "Ground-water resources".

14/ Public Health Service Drinking Water Standards, 1946: Reprint No. 2697, Public Health Reports vol. 61, no. 11, pp. 371-384, March 15, 1946.

Discharge of dissolved solids from the basin

Natural discharge of dissolved matter from the basin occurs through the northwestward movement of the ground water. Concentrations of dissolved matter in artesian waters in the lower part of the basin are considerably higher than those of artesian waters near San Simon. This increase in concentration may be due in part to an increase in the amount of soluble matter in the valley fill. Investigations in the Safford Valley indicate that highly mineralized water from the San Simon Basin is entering the Safford Valley as underflow. The observed movement of highly mineralized water is through shallow aquifers that may or may not be connected with the artesian aquifers in the San Simon Basin, and it is not known whether or not the water originates in the upper or lower parts of the basin or in the Cactus Flat-Artesia area. The main movement may be from artesian aquifers in the San Simon Basin into artesian aquifers in the Safford Valley.

Increased use of water for irrigation probably would have no effect on the quality of the artesian waters because the infiltration from irrigated areas could not enter the artesian aquifers. However, an increase in irrigation would probably increase the dissolved-solids content of the non-artesian aquifers because the water percolating downward from irrigation will have been concentrated by evaporation and use of water by growing plants. Removal of excess soluble matter from the basin was not an important problem in 1946.

SUMMARY AND CONCLUSIONS

The San Simon Basin lies in Cochise and Graham Counties along San Simon Creek, between two ranges of mountains. The basin trends northwest from San Simon Cienaga to the Safford Basin. It ranges in width from 10 to 25 miles and is about 60 miles in length.

The basin occupies part of a structural trough that was formed by down-faulting between two nearly parallel mountain chains. The basin contains alluvial fill derived from igneous, metamorphic, and sedimentary rocks in the nearby mountains. The fill is composed of clays, silts, sands, and gravels. The clays were deposited in lakes and form relatively continuous zones. These clay zones confine ground water under artesian pressure in the underlying sand and gravel. Most of the ground water in the basin is derived from these artesian aquifers.

The variability in the mineral content of the artesian water near the town of San Simon was caused by the differences in composition of the rocks from which the alluvial fill was derived. The mountains to the west are composed mainly of granitic rocks. The alluvial deposits derived from these mountains contain waters that are low in hardness but have a relatively high fluoride content. The mountains to the east are composed mainly of volcanic rocks. The alluvial deposits derived from these mountains contain waters that are relatively high in hardness but have a relatively low fluoride content.

The first flowing wells in the basin were completed in 1910. By 1915 there were 127 flowing wells, producing a total flow of about 11,000 acre-feet of water a year. A large part of this water was wasted. After World War I many farms were abandoned, leaving a considerable number of unused and uncontrolled flowing wells. In 1940 about 400 acres of land was under cultivation, and about 2,700 acre-feet of water was discharged from the 88 flowing wells measured and 400 acre-feet was pumped from non-flowing wells. About 1,000 acre-feet of the water produced from the flowing wells was wasted. During 1946 about 1,000 acres was irrigated from 140 artesian wells and from three pumped wells that developed water from non-artesian aquifers. Forty-three of the artesian wells were pumped at times. A total of 5,800 acre-feet of water was discharged in 1946. Of this, 3,500 acre-feet flowed and 2,100 acre-feet was pumped from the artesian aquifers, and 200 acre-feet was pumped from non-artesian aquifers. About 1,400 acre-feet of water from the flowing wells was wasted in non-beneficial use. Water now being wasted by uncontrolled flowing wells and by leakage through breaks in the casings of the artesian wells could be conserved, and the discharge from the artesian aquifers would thereby be reduced.

The head of the artesian water has decreased since the first flowing wells were completed. The decrease was about 30 feet between 1915 and 1946 in the flowing-well area near San Simon. Near Bowie, in an area of non-flowing wells, the decrease in head was about 10 feet during the same period. The larger decrease in head in the flowing-well area was partially caused by interference among closely spaced wells.

Analyses of water samples from wells in the artesian aquifers in the basin show that these waters generally contain between 200 and 300 parts per million of dissolved matter, and no samples contained as much as 500 parts per million. The artesian water in the western part of the flowing-well area is "injurious to unsatisfactory" for irrigation, owing to the high percentage of sodium. The artesian water in the eastern part of the flowing-well area is "excellent to good" for irrigation. The fluoride content in nearly all the waters analyzed was about 1.5 parts per million, and therefore may cause mottling of the teeth of children who drink the waters.

Ground water in the artesian aquifers of the San Simon Basin can be conserved by: (1) Properly casing or sealing all wells that tap artesian water, thus preventing leakage of artesian water into the non-artesian aquifers; and (2) installing adequate shut-off valves on all flowing wells, using these valves to control the flow to the amount that can be beneficially used. Careful records should be kept of the amount of water produced from all the wells in the basin. These records, together with records of the water levels in wells in the non-flowing-well areas and of the artesian head in the flowing-well area, are among the data necessary to determine accurately the annual safe yield of water from the artesian aquifers. The safe yield cannot be estimated until the amount of underground leakage from the artesian aquifers through wells is known or the leakage is stopped.

Table 1. - Mean monthly and annual precipitation, in inches, at Bowie and San Simon, Arizona.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Bowie	0.86	1.23	0.81	0.22	0.23	0.34	2.54	2.40	1.10	0.64	0.68	1.02	12.07
San Simon	0.50	0.61	0.65	0.21	0.18	0.17	1.42	1.68	0.83	0.42	0.47	0.81	7.95

Table 2. - Logs of wells in San Simon Basin, Arizona.

	Thickness (feet)	Depth (feet)
Log of well 839		
Southern Pacific Co., owner,		
SE¼N½ sec. 36, T. 9 S., R. 27 E.		
Hardpan - - - - - - - - -	32	32
Gravel - - - - - - - - -	6	38
Yellow clay - - - - - - -	52	90
Sand and gravel - - - -	34	124
Yellow clay - - - - - - -	8	132
Gravel - - - - - - - - -	12	144
Blue clay - - - - - - - -	96	240
Blue clay and sand - -	14	254
Gravel and sand - - - -	6	260
Blue clay - - - - - - - -	24	284
Sand - - - - - - - - - -	4	288
Yellow clay - - - - - - -	34	322
Sand and clay - - - - -	4	326
Blue clay - - - - - - - -	70	396
Sandstone - - - - - - - -	4	400
Blue clay - - - - - - - -	192	592
Gypsum and clay - - - -	143	735
Gypsum - - - - - - - - -	30	765
TOTAL DEPTH - - - - - - -		765

	Thickness (feet)	Depth (feet)
Log of well 4151		
Southern Pacific Co., owner,		
SE¼ sec. 4, T. 15 S., R. 28 E.		
Fill - - - - - - - - - - -	4	4
Sandy clay - - - - - - - -	12	16
Sand and gravel - - - -	8	24
Brown clay - - - - - - - -	28	52
Sandy gray clay - - - - -	16	68
Sandy brown clay - - - -	16	84
Sandy gray clay with streaks of white lime -	12	96
Jack sand and red clay -	22	118
Sandy gray clay - - - - -	18	136
White clay and hard jack sand - - - - - - - -	9	145
Blue clay - - - - - - - -	49	194
Hard gray clay with layers of sand - - - -	6	200
Blue clay - - - - - - - -	70	270
Sandy yellow clay - - -	12	282
Jack sand with a little yellow clay - - - - - - -	5	287
Sandy yellow clay - - -	2	289
Coarse gravel - - - - - -	2	291
Sandy yellow clay - - -	39	330
Sand (hard cemented) - -	10	340
Hard cemented sand and thin layers of packed sand - - - - - - - - - -	10	350
Hard cemented sand and thin layers of jack sand - - - - - - - - - -	20	370
Yellow clay and gravel -	10	380
Dirty sand and gravel- -	6	386
Sticky yellow clay - - -	54	440
Hard cemented sand and gravel - - - - - - -	61	501
TOTAL DEPTH - - - - - - -		501

Table 2. - Logs of wells in San Simon Basin, Arizona - cont.

	Thickness (feet)	Depth (feet)
Log of well 4152		
Southern Pacific Co., owner,		
SE¼ sec. 4, T. 13 S., R. 28 E.		
Clay and soil - - - - -	87	87
Yellow clay - - - - - -	64	151
Blue shale - - - - - -	124	275
Yellow clay - - - - - -	115	390
Clay and gravel - - - -	100	490
Yellow clay - - - - - -	20	510
Conglomerate, water - -	13	523
Yellow clay - - - - - -	30	553
Gravel, tight cut - - -	45	598
Conglomerate and boulders - - - - - - -	15	613
Conglomerate - - - - -	62	675
Cemented gravel - - - -	30	705
Conglomerate - - - - -	63	768
TOTAL DEPTH - - - - - -		768
Log of well 4264		
Oil test well		
SE¼NE¼ sec. 27, T. 13 S., R. 30 E.		
0-1,511 feet, driller's log		
1,730-2,462 feet, from Carl Sauer[1]		
3,627-6,649 feet, from S. J. Funk[2]		
Soil - - - - - - - - -	2	2
Clay and gypsum - - -	93	95
Water gravel - - - - -	30	125
Clay - - - - - - - - -	50	175
Water gravel - - - - -	5	180
Blue clay and shale -	214	394
Yellow clay - - - - -	6	400
Blue shale and soapstone - - - - - -	230	630
Brown shale - - - - -	65	695
Water sand - - - - - -	15	710
Light brown shale - -	25	735
Sand, water flowing -	7	742
Brown shale - - - - -	25	767
Blue shale and soapstone - - - - - -	70	837
Brown shale - - - - -	58	895
Light brown shale - -	10	905
Brown shale - - - - -	110	1,015
Water sand, artesian -	50	1,065
Red shale - - - - - -	40	1,105
Water sand - - - - - -	23	1,128
Red shale - - - - - -	72	1,200
Red sandy shale - - -	60	1,260
Log of well 4264, cont.		
Water sand, artesian - -	30	1,290
Red shale - - - - - - -	15	1,305
Water sand - - - - - - -	15	1,320
Red sandy shale - - - -	20	1,340
Red sticky shale - - - -	15	1,355
Red sandy shale - - - -	40	1,395
Red clay - - - - - - - -	20	1,415
Red sandy clay - - - - -	45	1,460
Red sticky clay - - - -	51	1,511
Lime shale - - - - - - - -	-	1,730
Fine sand - - - - - - -	15	1,745
Soft lime shale - - - -	279	2,024
Sand - - - - - - - - - -	6	2,030
Cemented gravel - - - -	22	2,052
Shale - - - - - - - - -	8	2,060
Sand - - - - - - - - - -	8	2,068
Alternating layers of very reddish sandy shale, cemented gravel, and conglomerate; also thin layers of soft limestone. Temperature of earth at this depth about 165° F.	394	2,462
		3,627
Trace of water - - - - -	6	3,633
		4,050
Red water sand; flow not strong - - - - - - - -	10	4,060
		4,152
Red sandstone, some water	8	4,160
		5,250
Salt water raised 350 feet, but disappeared while drilling and bailing.	5	5,255
Last water flowed 20 gallons a minute, temperature 274° F. at bottom of hole - - - -		6,649
TOTAL DEPTH - - - - - -		6,649

1/ Sauer, Carl, Basin and range forms in the Chiricahua area: Univ. Calif., Publications in Geog., vol. 3, no. 6, pp. 355-56, 1930.

2/ Trustee and manager of this well.

Table 2. - Logs of wells in San Simon Basin, Arizona - cont.

	Thickness (feet)	Depth (feet)
Log of well 4363		
Southern Pacific Co., owner,		
N½S½ sec. 30, T. 13 S., R. 31 E.		
Surface fill - - - - - -	3	3
White caliche - - - -	12	15
White caliche; streaks of red caliche - - -	30	45
Sandy brown clay; water	22	67
Sand and gravel - - -	18	85
Sandy brown clay - - -	6	91
Sand and gravel - - -	3	94
Sandy brown clay - - -	60	154
Blue sticky clay - - -	216	370
Brown sticky clay - -	110	480
Sticky clay, thin streaks of brown clay	30	510
Brown sticky clay; streaks of gray - - -	80	590
Fine sand - - - - - - -	2	592
Brown clay; streaks of white lime - - - - -	53	645
Brown clay and blue clay	10	655
Fine sand - - - - - - -	5	660
Brown clay; streaks of white lime - - - - -	45	705
Fine sand - - - - - - -	5	710
Red clay; streaks of white lime - - - - -	30	740
Red clay; streaks of white lime - - - - -	33	773
Sand; streaks of white lime - - - - - - - - -	3	776
Sand - - - - - - - - - -	9	785
Red clay, streaks of cemented gravel - - -	90	875
Sandy clay - - - - - - -	10	885
Cemented sand; streaks of red clay - - - - -	15	900
TOTAL DEPTH - - - - -		900

Table 2. - Logs of wells in San Simon Basin, Arizona - cont.

	Thickness (feet)	Depth (feet)
Log of well 4646		
Harry Birlenbach, owner,		
SW¼SE¼ sec. 16, T. 14 S., R. 31 E.		
Surface soil - - - - - -	3	3
Light brown clay and silt, considerable lime	71	74
Light brown clay and silt, highly calcareous, water at 75 feet - -	46	120
Light blue clay - - -	203	323
Evenly graded waterworn particles of light blue shale or clay; first water stratum - - - -	2	325
Blue clay - - - - - - -	45	360
Light brown clay - - -	4	364
Blue clay - - - - - - -	8	372
Fine clear sand - - -	3	375
Blue clay - - - - - - -	25	400
Light brown clay; lime	171	571
Sand; flowed 10 gallons a minute - - - - - - -	11	582
Partly cemented sand and gravel - - - - - -	3	585
Brown clay mixed with lime - - - - - - - -	72	657
Sand and gravel; flowed about 1 gallon a minute - - - - - - -	1	668
Sticky brown clay - -	14	682
Partially cemented sand and gravel - - - - - -	11	693
Brown clay - - - - - - -	21	714
Partially cemented sand and gravel; water - -	2	716
Clay - - - - - - - - - -	5	721
Partially cemented sand and gravel; water - -	5	726
Fine cemented sand and clay - - - - - - - - -	21	747
Partially cemented fine sand; water - - - - - -	5	752
Very fine cemented sand and clay - - - - - - -	130	882
Fine sand; water - - -	3	885
Fine cemented sand - -	41	926
Fine sand - - - - - - -	2	928
Log of well 4646, cont.		
Very fine sand, some cemented clay and fine sand - - - - - - -	812	1,740
Cemented sand and gravel - - - - - - - -	25	1,765
Cemented sand and clay	10	1,775
Cemented sand and gravel - - - - - - - -	5	1,780
Cemented sand and clay	25	1,805
Cemented sand, clay, and gravel - - - - - -	5	1,810
Cemented sand and clay	20	1,830
Cemented sand and gravel - - - - - - - -	5	1,835
Cemented fine sand and clay - - - - - - - - -	165	2,000
TOTAL DEPTH - - - - - -		2,000

No water was encountered below 928 feet.

Table 3. - Records of typical wells in San Simon Basin,
Cochise and Graham Counties, Arizona.
(All wells are drilled except well 4500. Wells 839 and 872 are in Graham County; all others are in Cochise County.)

No.	Location	Owner	Date completed	Depth of well (feet)	Diameter of well (in.)
	T. 9 S., R. 27 E.				
839	SE¼NW¼ sec. 36	Southern Pacific Railroad	1911	765	-
	T. 10. S., R. 29 E.				
d/ 872	NW¼NW¼ sec. 31	W. E. Ellsworth	-	1,925	10
	T. 13 S., R. 28 E.				
4151	SE¼ sec. 4	Southern Pacific Railroad	-	501	-
4152	do.	do.	-	768	-
	T. 13 S., R. 29 E.				
d/ 4200	SW¼SW¼ sec. 6	A. R. Spikes	1913 ?	835	6
d/ 4204	SW¼SE¼ sec. 24	do.	1915 ?	960	6
	T. 13 S., R. 30 E.				
d/ 4250	SE¼NW¼ sec. 3	U. S. Dept. Agriculture	1915 ?	860	4
d/ 4254	SE¼SE¼ sec. 14	S. M. Morse	1913	900	9

a/ Measuring point was usually top of discharge pipe, top of water-pipe clamp, or top of casing.
b/ C, cylinder; T, turbine; Cf, centrifugal; W, windmill; G, gasoline; E, electric; H, hand.

Well records collected by R. L. Cushman and H. R. McDonald

No.	Water level: Depth above (+) or below (-) measuring point (feet) a/	Water level: Date of measurement	Pump and power b/	Use of water c/	Temp. °F.	Remarks
839	-111 e/	-	-	Ind.	-	Cased to 735 feet. Not on map. See log.
872	Flows	Sept. 3, 1941	None	D, S	106	"Whitlock No. 1 well" oil test. Flows 300 gallons per minute.
4151	-	-	-	Ind.	-	In Bowie. See log.
4152	-	-	-	Ind.	-	Do.
4200	-9.7 -12.9	May 2, 1941 June 12, 1946	C, W	S	80	Well 21, Water-Supply Paper 425-A. See graph, figure 2.
4204	Flows	-	T, G	D, S, I	105	Measured flow: Nov. 19, 1940, 24 gallons per minute; April 10, 1946, 30 gallons per minute. Well 28, Water-Supply Paper 425-A.
4250	+12.2 +3.1	Oct. 26, 1915 June 19, 1946	None	D, S	95	Measured flow: Nov. 19, 1940 and June 26, 1944, 1 gallon per minute. Well 29, Water-Supply Paper 425-A. See graph, figure 2.
4254	+3	April 1941	-	S	90	Measured flow: April 29, 1941 10 gallons per minute; April 8, 1946, 7 gallons per minute. Well 33, Water-Supply Paper 425-A.

c/ Ind., industrial; D, domestic; S, stock; I, irrigation; P, public supply; N, not used.
d/ See table 5 for analysis of water sample.
e/ Water level reported.

Table 3. - Records of typical wells in San Simon Basin, Cochise and Graham Counties, Arizona - cont.

No.	Location	Owner	Date completed	Depth of well (feet)	Diameter of well (in.)
d/ 4258	SW¼NE¼ sec. 25	Mrs. Lizzie Lewis	1915	880	5
d/ 4261	SE¼SE¼ sec. 25	Woolston	-	73	4
4262	NW¼SW¼ sec. 30	W. F. Lewis	1930	64	4
4264	NE¼SW¼ sec. 26	-	-	6,649	12
d/ 4267	SE¼NW¼ sec. 3	U. S. Dept. Agriculture	-	-	6
	T. 13 S., R. 31 E.				
d/ 4355	NE¼SE¼ sec. 20	C. S. Graves	1913 ?	615	4
4363	NW¼SW¼ sec. 30	Southern Pacific Railroad	1944	900	10
4378	SW¼SE¼ sec. 33	Chas. Record	1941	106	12
d/ 4380	SE¼SE¼ sec. 33	Phil Ebsen	1927	700	6
	T. 14 S., R. 30 E.				
4500	NE¼SE¼ sec. 1	U. S. Dept. Agriculture	-	74	60
	T. 14 S., R. 31 E.				
4600	NW¼NW¼ sec. 3	W. J. Purcell	1915	626	5

Well records collected by R. L. Cushman and H. R. McDonald

No.	Water level: Depth above (+) or below (-) measuring point (feet) a/	Water level: Date of measurement	Pump and power b/	Use of water c/	Temp. °F.	Remarks
4258	+6 -5.8	Nov. 19, 1940 June 12, 1946	None	S, I	87	Measured flow: April 29, 1941, 4 gallons per minute; not flowing in 1946. Well 40, Water-Supply Paper 425-A.
4261	-60.4 -59.7	Dec. 10, 1940 Feb. 8, 1946	C, W	D	64	-
4262	-61.5 -61.1	Dec. 10, 1940 April 22, 1942	C, W	N	-	See graph, figure 2.
4264	-	-	None	N	-	San Simon oil test No. 1. See log.
4267	-	-	C, W	S	70	-
4355	+1.5	Nov. 20, 1940	Cf, G	D, S, I	81	Deepened to 648 feet, 1945. Measured flow, Nov. 20, 1940, 1 gallon per minute. Now pumped for irrigation; measured discharge 147 gallons per minute, April 8, 1946.
4363	Flows	-	T, E	P, Ind	-	Normal flow 6 gallons per minute. Reported pumped discharge 500 gallons per minute. See log.
4378	-57 e/	April 1941	T, G	I	-	Measured discharge 378 gallons per minute, April 9, 1946.
4380	+5	April 29, 1941	Cf, G	D, I	80	Reported flow 25 gallons per minute, 1941; 10 gallons per minute, 1946. Reported pumped discharge 150 gallons per minute, 1946.
4500	-70.0	Dec. 11, 1940	C, G	N	-	Dug well. See graph, figure 2.
4600	-1.2	April 22, 1942	C, H	N	-	See graph, figure 2.

Table 3. - Records of typical wells in San Simon Basin, Cochise and Graham Counties, Arizona - cont.

No.	Location	Owner	Date completed	Depth of well (feet)	Diameter of well (in.)
d/ 4633	NE¼SW¼ sec. 14	Marshall Barnes	1920	690	4
d/ 4646	SW¼SE¼ sec. 16	Henry Birlenbach	1921	2,000	10
d/ 4662	NW¼SE¼ sec. 25	J. L. Freeman	1920	600	6
	T. 15 S., R. 32 E.				
d/ 4902	SE¼SE¼ sec. 34	State of Ariz.	-	280	7
	T. 16 S., R. 32 E.				
d/ 4912	SE¼SE¼ sec. 21	Elmore Walker	-	114	6

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

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

Well records collected by R. L. Cushman and H. R. McDonald

No.	Water level: Depth above (+) or below (-) measuring point (feet) a/	Water level: Date of measurement	Pump and power b/	Use of water c/	Temp. °F.	Remarks
4633	+17.5 +9.8	Dec. 11, 1940 June 19, 1946	None	S, I	80	Measured flow 60 gallons per minute, Dec. 11, 1940. See graph figure 2.
4646	+14 e/	April 1941	None	D, S, I	88	Measured flow; April 30, 1941, 62 gallons per minute; Aug. 2, 1946, 44 gallons per minute. See log.
4662	-13.8 -17.3	Dec. 11, 1940 Apr. 9, 1946	C, W, G	D, S, I	78	Obstructed at 460 feet.
4902	-19.4	Oct. 2, 1946	C, W	S	64	Near San Simon Cienaga.
4912	-91.5	Oct. 1, 1946	C, W	S	-	-

c/ Ind. industrial; D, domestic; S, stock; I, irrigation; P, public supply; N, not used.
d/ See table 5 for analysis of water sample.
e/ Water level reported.

Table 4. - Water levels in artesian wells, 1915 and 1946, showing decline in artesian head, San Simon Basin, Cochise County, Arizona

Well number	Depth (feet)	Water level in feet above (+) or below (-) land surface 1915	1946	Decline (feet)
4004	567	-70	-80	10
4006	334	-41	-58	17
4153	530	-100	-128	28
4200	835	-5	-11	6
4205	860	-40	-49	9
4250	860	+13	+4	9
4373	665	+31	-2	33
4600	626	+24	-6	30
4647	-	+27	-2	29
4661	660	+13	-2	15

Table 5. - Analyses of water from typical wells, San Simon Basin, Arizona. Numbers correspond to numbers given in table 3 and shown on plates 1 and 2. Analyses by Geological Survey. (Parts per million.)

Well number	Date of collection	Depth (feet)	Specific conductance ($K \times 10^5$ at 25° C.)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Total hardness as $CaCO_3$	Percent sodium
872	Sept. 3, 1941	1,925	159	12	7.4	334	205	301	195	11	1.0	962	60	92
4200	Dec. 2, 1941	835	38.7	11	3.9	68	102	62	28	1.5	-	224	43	77
4204	April 10, 1946	960	56.6	3.0	1.1	124	250	47	12	4.0	0.9	315	12	96
4250	Nov. 19, 1940	860	51.0	4.5	6.6	114	136	94	17	20	1.0	324	38	87
4254	May 1, 1941	900	43.8	8.5	4.8	88	147	78	9.0	7.0	-	268	41	82
4258	Nov. 19, 1940	880	41.4	8.0	4.4	84	128	86	9.0	4.7	1.4	261	38	83
4261	Dec. 10, 1945	73	142	92	24	201	266	385	93	5.2	2.7	934	328	57
4267	Feb. 8, 1946	-	82.2	26	9.5	157	338	121	19	5.9	0.3	571	104	77
4355	Nov. 20, 1940	615	41.1	50	7.4	32	152	80	10	1.0	1.5	257	155	31
4380	April 30, 1941	700	41.8	50	8.7	33	148	90	9.0	1.6	-	265	161	31
4633	Dec. 11, 1940	690	40.8	52	7.4	29	155	77	9.0	0.8	1.8	253	160	28
4646	May 1, 1941	2,000	42.3	22	5.2	71	139	98	5.0	3.2	-	272	76	67
4662	Dec. 11, 1940	600	41.5	54	7.9	27	154	79	8.0	1.7	2.0	256	167	42
4902	Oct. 2, 1946	280	43.0	40	4.7	52	197	44	9.0	4.0	1.2	252	120	49
4912	Oct. 1, 1946	114	28.5	42	4.9	13	144	28	2.0	0.8	0.7	162	125	19

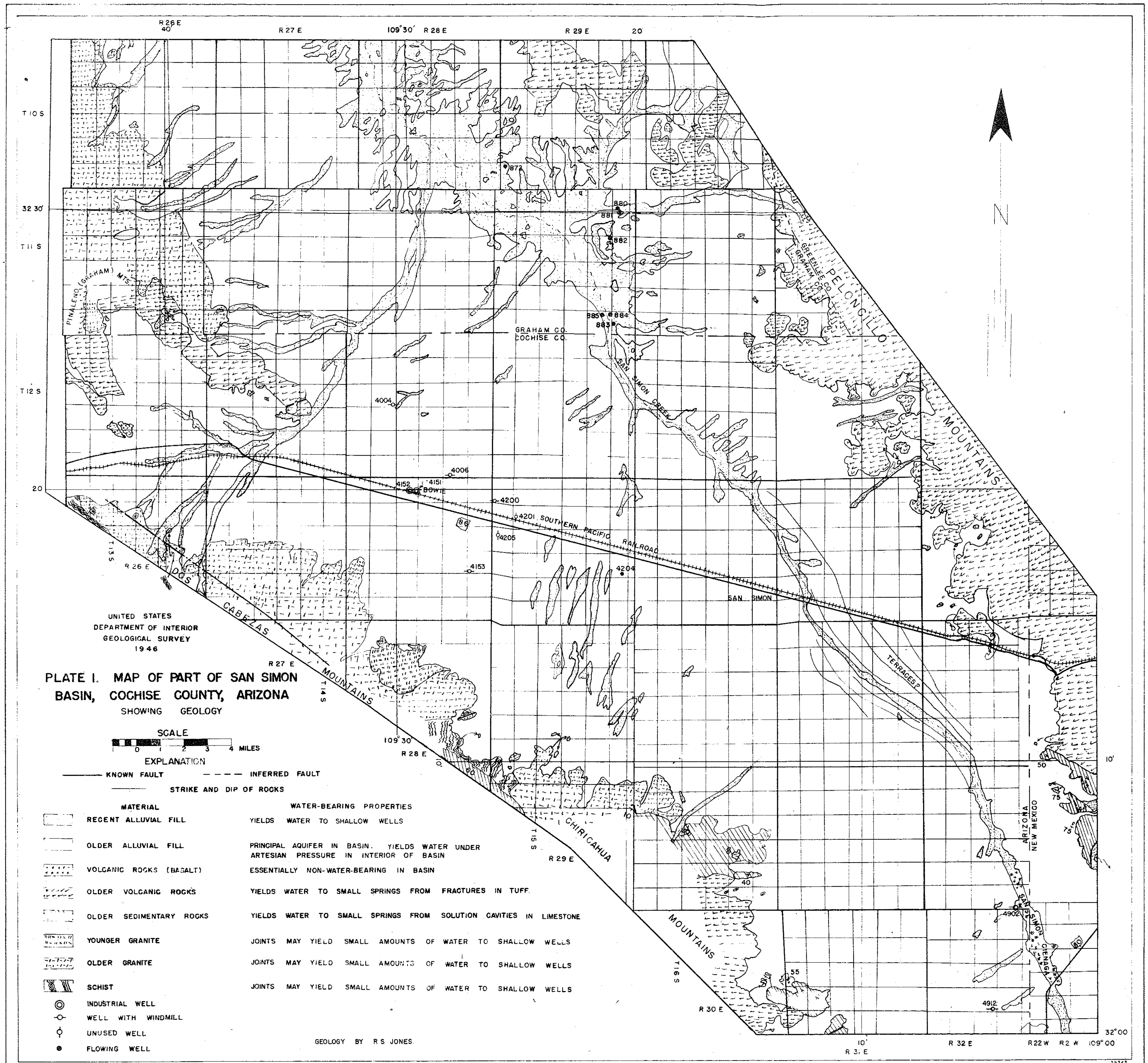

PLATE I. MAP OF PART OF SAN SIMON BASIN, COCHISE COUNTY, ARIZONA SHOWING GEOLOGY

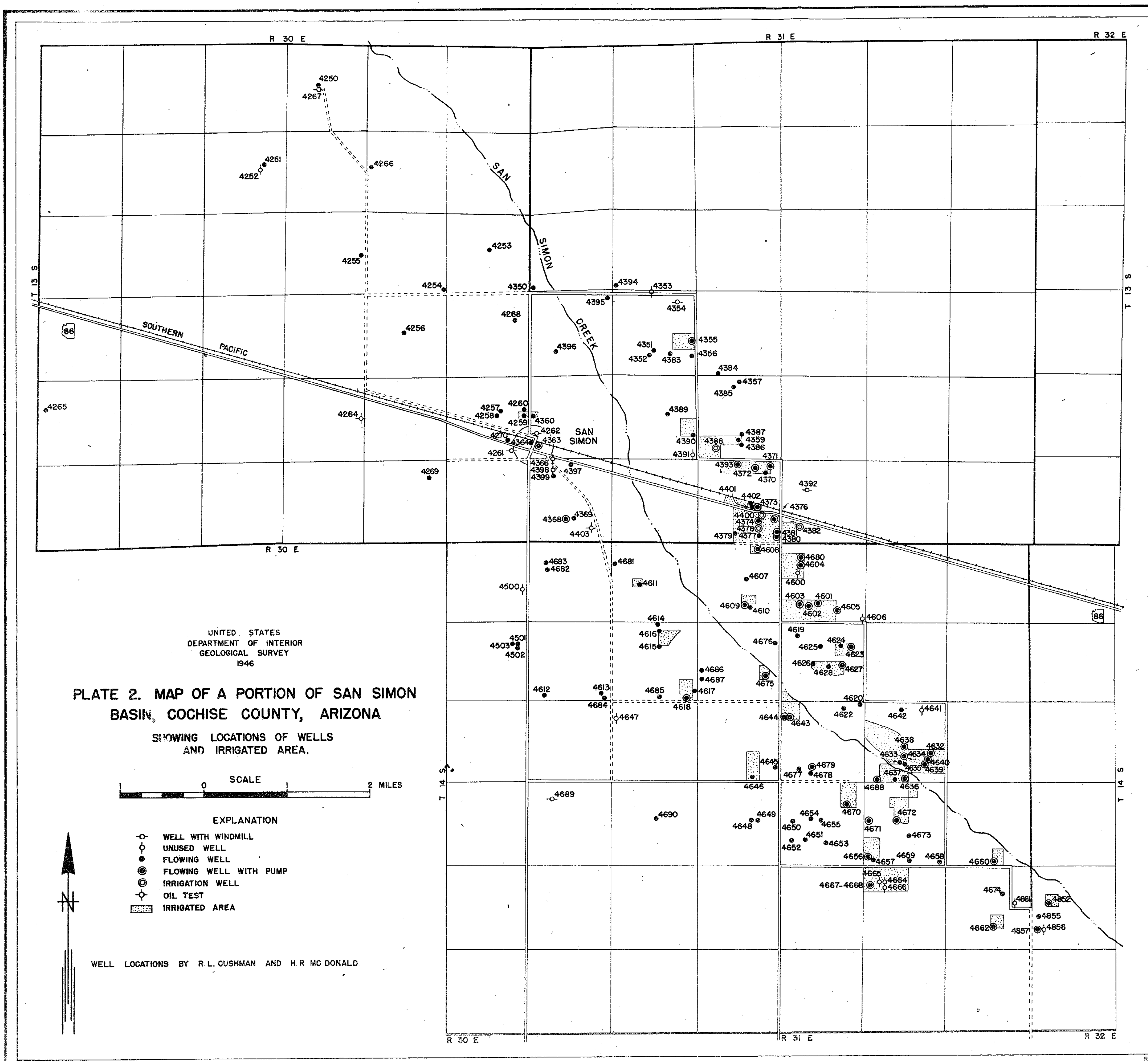

PLATE 2. MAP OF A PORTION OF SAN SIMON BASIN, COCHISE COUNTY, ARIZONA

SHOWING LOCATIONS OF WELLS AND IRRIGATED AREA.

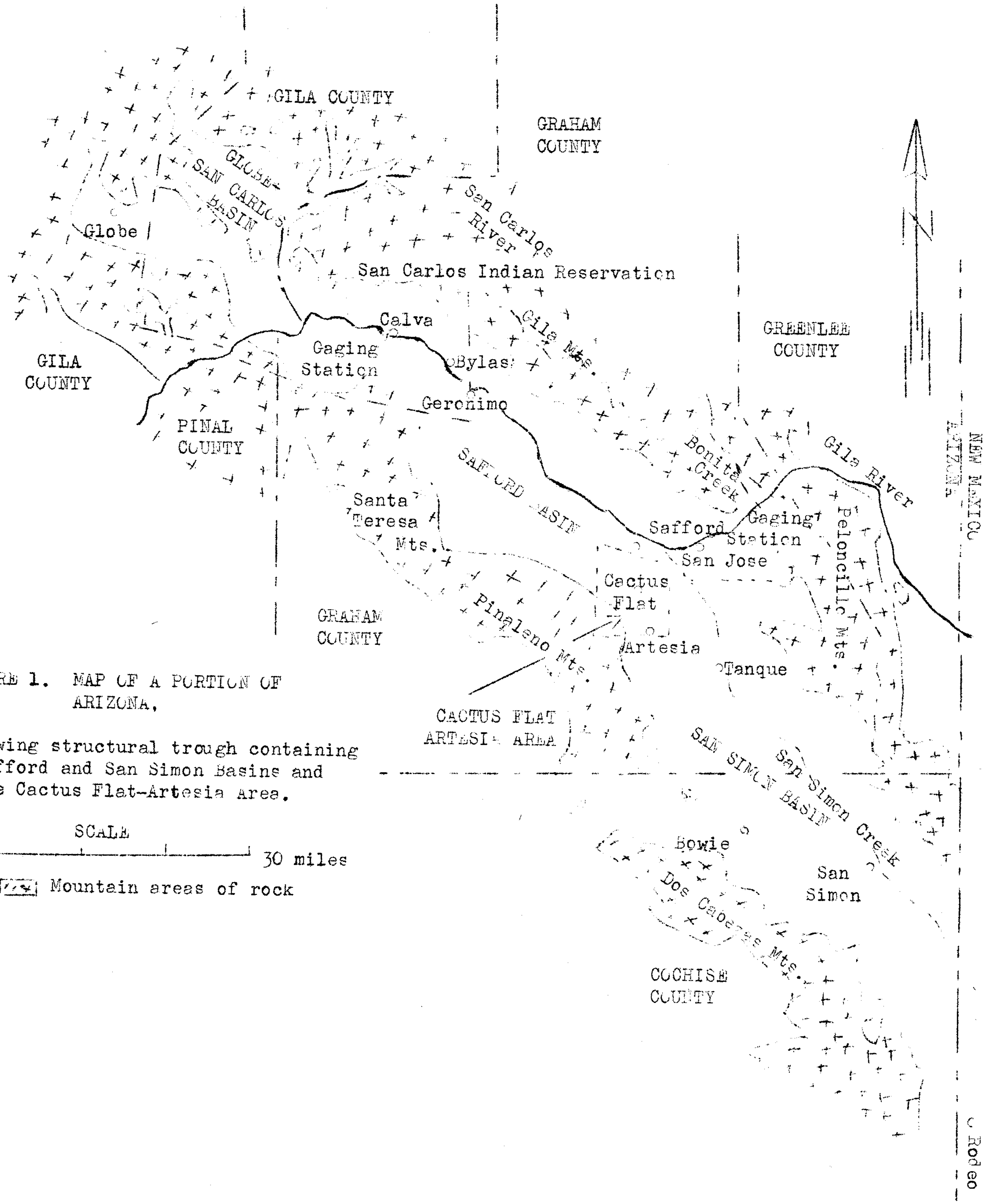

FIGURE 1. MAP OF A PORTION OF ARIZONA,

showing structural trough containing Safford and San Simon Basins and the Cactus Flat-Artesia Area.

SCALE

0 ——— 30 miles

Mountain areas of rock

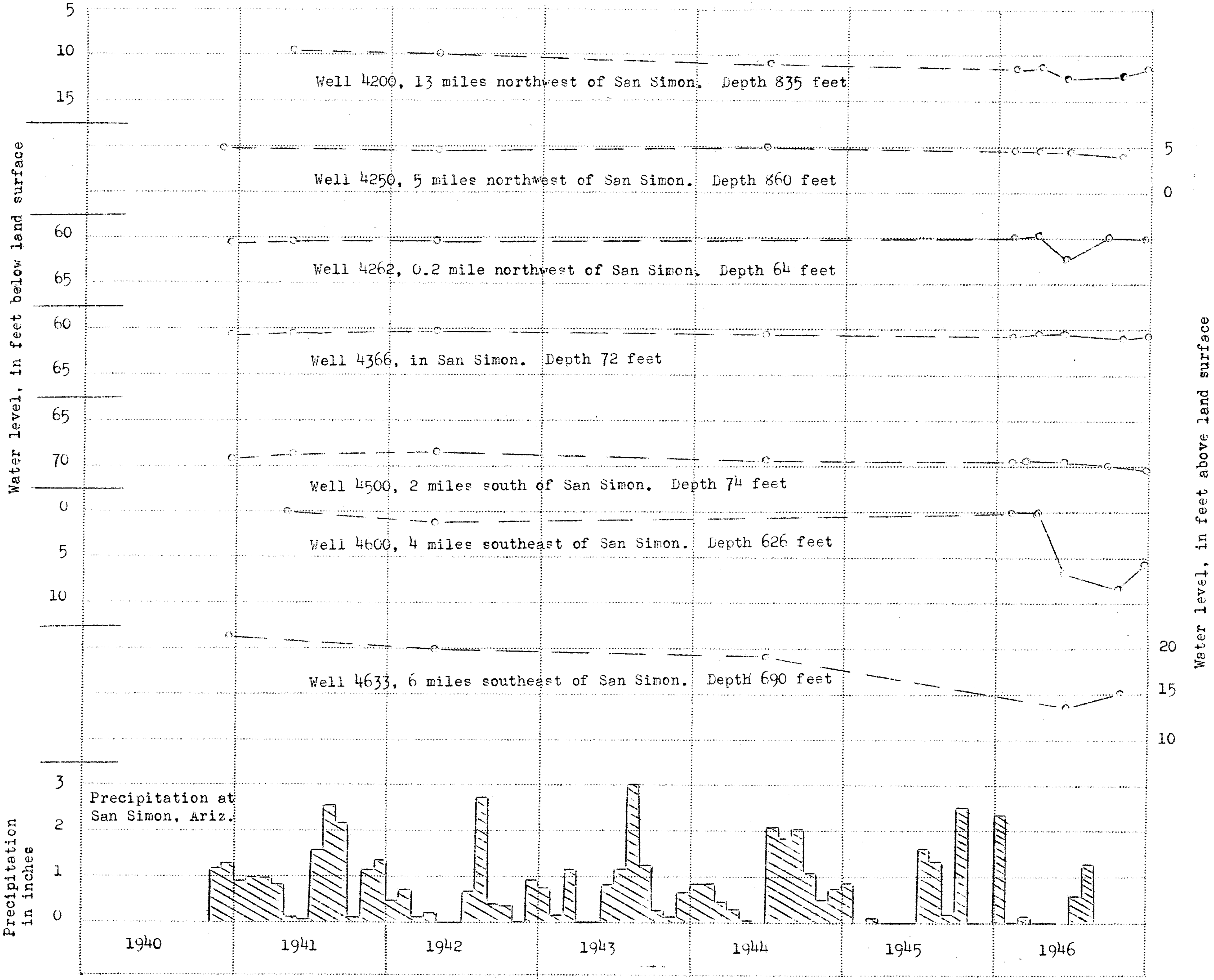

Figure 2.--Graphs showing fluctuations of water level in observation wells, and precipitation at San Simon, Arizona in inches, San Simon Basin, Cochise County, Arizona.