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GROUND WATER IN SAN SIMON VALLEY, ARIZONA AND NEW MEXICO.

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INTRODUCTION.

LOCATION AND AREA.

San Simon Valley is in southeastern Arizona and the adjacent part of New Mexico. Most of the valley lies in Graham and Cochise counties, Ariz., but a small part of it is in Grant County, N. Mex. (See fig. 1.) The valley extends north-northwestward for 85 miles from the head of San Bernardino Valley, 20 miles north of the Mexican boundary, to the Gila Valley. Its southern part is narrow, averaging about 10 miles in width. It widens toward the north, reaching a maximum width of 35 miles where it is crossed by the Southern Pacific Railroad. North of the railroad it narrows to about 25 miles at a point where it opens into the Gila Valley.

DEVELOPMENT.

The first white settlers came into San Simon Valley in the early seventies. As the climate was arid and dry-farming methods had not been developed, and as there seemed to be no available supply of water for irrigation, they depended for a livelihood upon stock raising. For this purpose the region was particularly well adapted. In the central parts of the valley grass for summer grazing is ordinarily abundant, and the mountains furnish pasturage for the fall and winter, when the grass in the valleys becomes scarce. Large areas of the valley are covered with brush, mostly creosote, cat's-claw, mesquite, and sagebrush. When the grass crop fails in years of drought stock subsists largely on the sagebrush and the leaves and beans of the mesquite.

Until seven or eight years ago the valley was occupied only by cattle ranches and was consequently very sparsely settled, but since

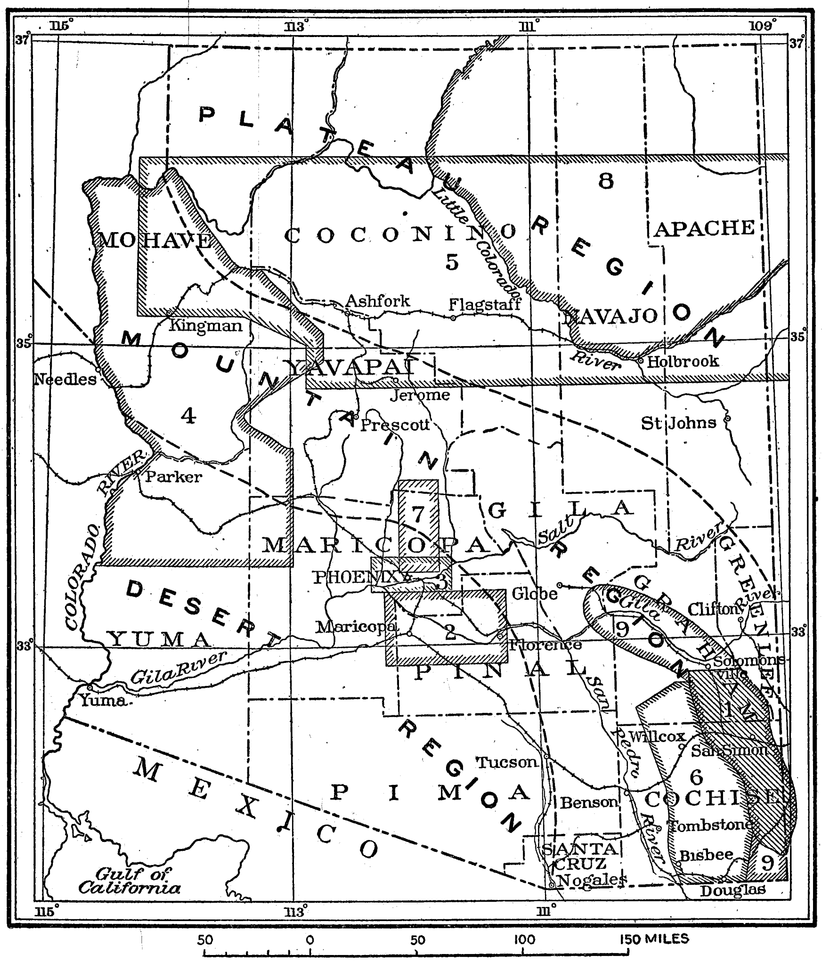


FIGURE 1.—Map showing physiographic provinces in Arizona and areas covered by Survey reports dealing with ground water. 1. San Simon Valley (Water-Supply Paper 425–A, the present paper); 2, Water-Supply Paper 104; 3, Water-Supply Paper 136; 4, Bulletin 352; 5, Bulletin 435; 6, Water-Supply Paper 320; 7, Water-Supply Paper 375; 8, Water-Supply Paper 380; 9, water-supply paper in preparation.

that time there has been a rapid influx of settlers, due chiefly to the discovery of artesian water. This discovery, which was made at San Simon late in 1910, encouraged settlements not only in the vicinity of San Simon but also in other parts of the valley. Before that time the only known ground-water supply was that from the upper horizon, from which relatively shallow wells were drawing. This supply is adequate for domestic and stock use and also for the heavier demands of the railroads at San Simon and Rodeo, but throughout most of the valley, where the land is suitable for agriculture, the water of this upper horizon is too far below the surface for economical pumping for irrigation. The discovery of a lower formation which contains water under pressure has therefore made irrigation possible over a considerable area, either from flowing wells or from other deep wells in which the water rises near enough to the surface to be profitably pumped.

The principal agricultural areas of San Simon Valley are the San Simon area and Artesia Valley, where artesian water is used for irrigation; the Bowie area, where water for irrigation is pumped from wells; and the Rodeo area, where dry farming, supplemented by irrigation with flood waters, is practiced. The positions of these areas are indicated on Plate I.

SCOPE AND PURPOSE OF REPORT.

The ground-water survey of San Simon Valley was begun in December, 1913, when about 10 days were spent in making discharge and pressure measurements of flowing wells and in collecting samples of water. The field work was completed in the fall of 1915, when the whole valley was investigated in detail and measurements were made wherever possible of the flowing wells that had been measured in 1913 in order to determine how the performance of the wells in 1913 and 1915 compared. Many new flowing wells were also measured and almost all other wells and springs in the valley were visited.

The survey was undertaken by the United States Geological Survey in cooperation with the Arizona Agricultural Experiment Station to obtain reliable information that might be furnished in response to requests received from the general public and that might be used by the Federal Government in the classification of the public lands.

The field work was done and most of the report was prepared by A. T. Schwennesen, of the United States Geological Survey, under the supervision of O. E. Meinzer, who is in charge of the Survey's ground-water investigations. The chapter on agriculture was written by R. H. Forbes, of the Arizona Agricultural Experiment Station. The water analyses were made in the laboratories of the Experiment Station by A. E. Vinson and P. W. Moore. The topographic map was made by Cornelius Schnurr, F. A. Danforth, and S. E. Taylor, of the Geological Survey.

ACKNOWLEDGMENTS.

For well records and other information acknowledgment is especially due the following settlers of the valley: Messrs. J. S. McCrory, Gordon Wharton, G. E. Ebsen, E. A. Washburn, J. D. Averill, J. H. Hibler, J. L. Hill, James Roundtree, A. G. Pierce, Frank Sumrell, and J. B. Garland. Many other settlers also supplied information and extended courtesies. Melvis Smith, driver and general assistant, aided greatly by his intimate knowledge of the region.

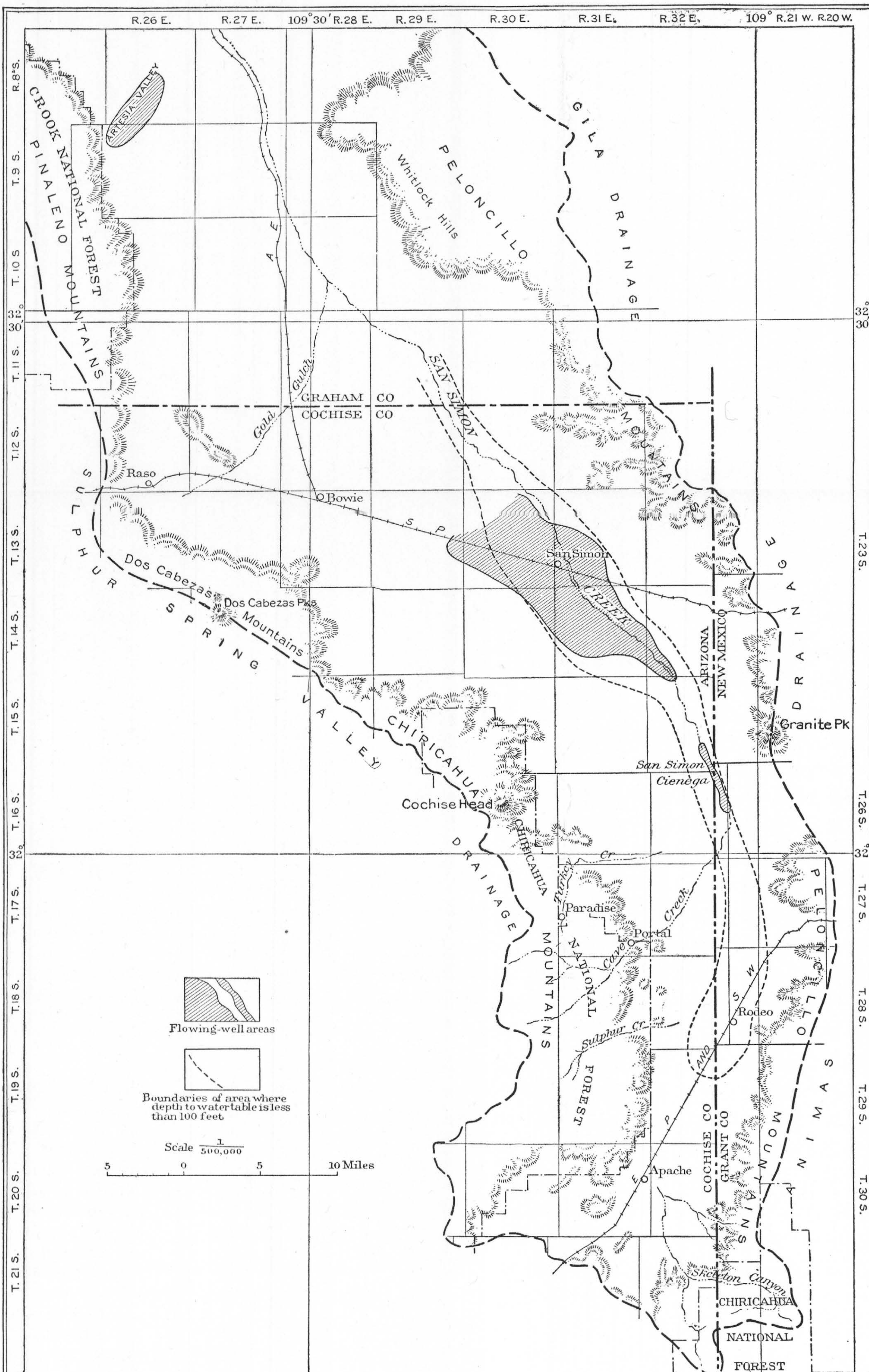
PHYSIOGRAPHY.

BOUNDING RANGES.

San Simon Valley occupies the trough between two nearly parallel mountain chains. On the east the valley is bounded by the Peloncillo Range, which separates it from Animas Valley and the upper Gila Valley. On the west it is separated from Sulphur Springs and Aravaipa valleys by a mountain chain comprising the Chiricahua, Dos Cabezas, and Pinaleno ranges. In the southern part of the region the mountains on both sides of the valley trend almost due north and south, but farther north they swing westward and continue in a northwesterly direction to Gila River.

Along the west side of the valley the mountains are much broader and loftier than on the east side. The Chiricahua Mountains, which form the southern link of this chain, extend from the head of the San Bernardino drainage, about 20 miles north of the Mexican boundary, northward 35 miles to Apache Pass. They are massive and rugged and rise to elevations of more than 8,000 feet above sea level, or 4,000 feet above the valley. Cochise Head has an elevation of 8,100 feet and is one of the most prominent landmarks in the region. The range is timbered, principally with pine, oak, and juniper, and is included in the Chiricahua National Forest. The mountain slopes that rise from San Simon Valley are precipitous and are cut by many canyons, at the mouths of which large, steep alluvial fans extend out into the valley. The principal watercourses are Sulphur, Cave, Turkey, and Whitetail creeks. Most of the streamways carry little or no water during most of the year, even in the mountains, but in times of heavy rain they discharge large amounts into the valley.

The Dos Cabezas Mountains extend northwestward from the Chiricahua Range for 20 miles to the pass through which the Southern Pacific Railroad crosses into Sulphur Spring Valley. The range takes its name from prominent twin peaks, which rise 1,500 to 2,000 feet above the main part of the range to an elevation of about 8,000 feet. The range is almost bare and has no important streamways leading to San Simon Valley.



MAP OF SAN SIMON BASIN, ARIZ.-N. MEX., SHOWING AREAS OF FLOWING WELLS AND AREAS IN WHICH DEPTH TO WATER TABLE OF UPPER GROUND-WATER HORIZON IS LESS THAN 100 FEET.

The Pinaleno Mountains extend northwestward from the Dos Cabezas Range to Gila River, a distance of about 30 miles, and separate San Simon Valley from Aravaipa Valley. The southern part of the range is low and not very conspicuous, but toward the Gila the crest rises, culminating in Graham Peak. The northern part of the Pinaleno Range is heavily timbered and is included in the Crook National Forest.

The Peloncillo Mountains consist of a single ridge for most of the distance from the south end to Steins Pass, north of which they are much wider and are broken into numerous short, irregular ridges and small mountain groups. Near the north end of the range the Whitlock Hills project into the valley from the main range. The average elevation of the crest of the Peloncillo Range is about 5,500 feet above sea level. The most prominent peaks are Ash Peak (at the northern end of the range), Doubtful Peak, Stein Peak (just north of Steins Pass), and Cienaga Peak (8 miles south of the pass), all of which are approximately 6,000 feet high. The southern part of the range contains some timber and is included in the Chiricahua National Forest, but the greater part of the range is bare. Tule Wells Canyon and Ward Canyon, in the northern part of the range, and Cottonwood, Post Office, Skull, and Skeleton canyons, in the southern part of the range, contain the largest streamways.

On the south San Simon Valley is separated from San Bernardino Valley by a low, inconspicuous divide that extends from a point near the mouth of Texas Canyon, at the foot of the Chiricahua Mountains, eastward to a point at the foot of the Peloncillo Mountains, 3 or 4 miles south of Skeleton Canyon. The El Paso & Southwestern Railroad crosses this divide about 1½ miles south of Moore's Spur.

THE VALLEY.

The valley has the form of a broad, shallow trough, the sides of which are formed by the alluvial slopes that extend down from the bordering mountains. Where the valley is narrow the bases of the alluvial slopes almost meet at the axis, but where the valley is wide it has the appearance of a nearly level plain with upward-curving edges.

At the San Bernardino divide the elevation of the valley is approximately 4,700 feet above sea level, and at the lower end, where it joins the Gila Valley, it is about 3,000 feet, so that the average grade northward is about 20 feet to the mile. The slopes of the sides are much greater than the axial slope, grades of more than 100 feet to the mile being common.

The drainage of San Simon Valley finds outlet into Gila River through the so-called San Simon Creek. Between the San Bernardino divide and Rodeo the accumulated storm run-off from the slopes drains through a broad, shallow draw with no very definite outlines. Below Rodeo the draw is one-fourth to three-fourths mile wide and takes more definite shape, its flat bottom being 15 to 20 feet below the general valley surface and bordered by bluffs. The drainage does not follow any definite channel but spreads over the whole of the flat. About 15 miles below Rodeo the draw empties into the San Simon Cienaga, a low, marshy area, in which the ground water is at the surface. This cienaga is 5 miles long, from one-fourth to one-half mile wide, and contains about 1,200 acres. In addition to the drainage from the upper valley, it receives, through Cave Creek, the run-off from some of the highest parts of the Chiricahua Mountains.

San Simon Creek has its source at the lower end of the cienaga and follows the axis of the valley to the Gila. For most of its course it has a deep, narrow channel with high vertical banks. This channel has been formed almost entirely since the region was first settled by Americans. At its source the creek is fed by the nearly perennial overflow from the cienaga, but some distance downstream it is normally dry. In the vicinity of San Simon a small continuous flow is maintained by waste water from the flowing wells. At a number of places in the lower part of the valley the channel has been cut nearly to the ground-water level, and here water may be found, even in the dry season, by making a shallow excavation in the bottom of the channel. For 20 miles back from the Gila the surface is greatly dissected, owing to the lowering of the Gila River valley during late geologic time and the consequent lowering of the outlet for San Simon Creek.

In the upper and middle portions of San Simon Valley the work of the streams is mainly aggradational and consequently the surface of the valley is in general even.

GEOLOGY.

PRE-QUATERNARY ROCKS.

The core of the Pinaleno, Dos Cabezas, and Chiricahua mountains consists of gneisses and schists which were regarded by Gilbert[1] as pre-Cambrian. Unconformably upon this basement lie sedimentary and metamorphic rocks of Paleozoic age, consisting principally of limestone, sandstone, shale, and quartzite. Lavas of probable Tertiary age are also widely distributed.

The Peloncillo Mountains consist principally of igneous rocks and rocks composed of volcanic fragments. These rocks are probably largely of Tertiary age.

[1] Gilbert, G. K., Report on the geology of portions of New Mexico and Arizona examined in 1873: U. S. Geog. and Geol. Surveys W. 100th Mer., vol. 3, pp. 509–513, 1875.

The rocks that outcrop in the mountains no doubt extend beneath the valley and form the floor on which the valley fill was deposited (fig. 2).

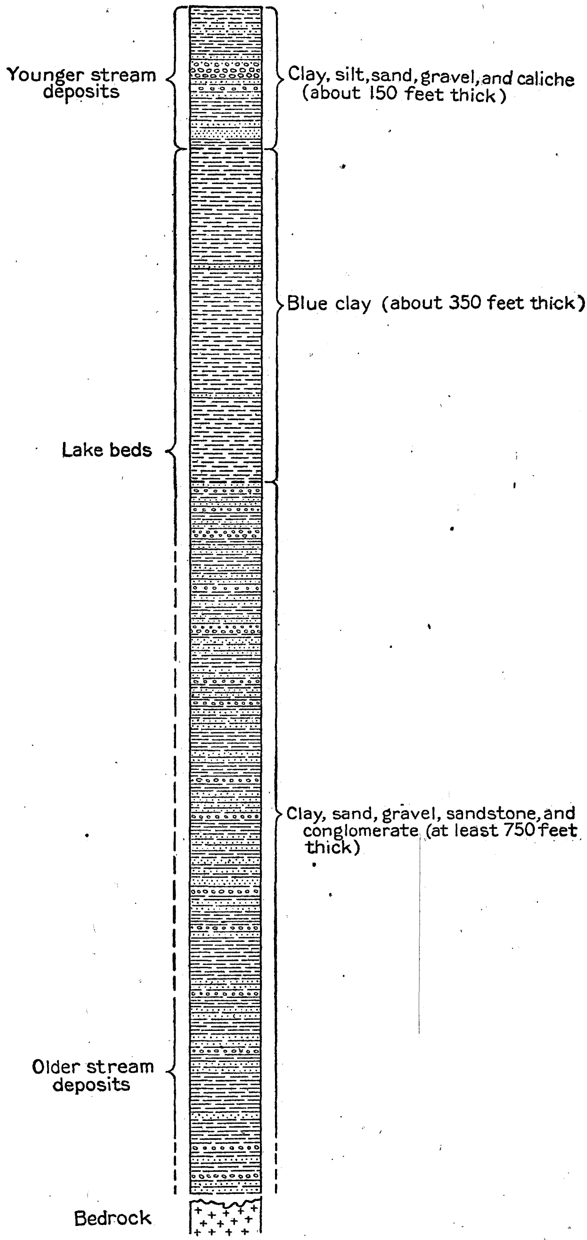


FIGURE 2.—Generalized columnar section of San Simon Valley, Ariz.-N. Mex.

QUATERNARY DEPOSITS.

OLDER STREAM DEPOSITS.

The oldest valley fill apparently consists of stream deposits, which are covered by younger beds in most places and which are difficult to distinguish from the younger stream deposits where they are exposed at the surface. In two places, however, it is believed they have been recognized—in an area of low, rounded gravel hills near Railroad Pass, west of Bowie, and in the gravel hills south of the San Simon Cienaga. The deposits are prevailingly gray, somewhat lighter in color than the recent stream deposits, and contain coarser and better-assorted gravel. The principal distinguishing feature, however, is their hilly topography, which represents a mature stage of erosion and contrasts sharply with the simple aggradational forms assumed by the younger stream deposits. In the general character of their materials and topography the beds in San Simon Valley resemble the gravels which underlie the lake beds in the Gila basin on the San Carlos Indian Reservation and which were identified by the writer as the oldest valley fill. These older stream deposits have probably been reached in at least some of the deeper wells.

LAKE BEDS.

Beds which were deposited in a lake or other body of water outcrop over a large area in the lower dissected portion of San Simon Valley. They consist chiefly of gray, yellow, and greenish-blue clay and gray and reddish sand. The sands are commonly interbedded with thin beds of tuff and thin layers or partings of indurated coarse-grained sandstone. Beds of fine, well-assorted gravel, belonging to the same series, are exposed at a number of places. Structurally they form a very flat syncline whose axis coincides nearly with the axis of the valley.

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.

In a well drilled to a depth of 1,000 feet at Rodeo, in the upper part of the valley, beds of the same general character and succession as in the vicinity of San Simon were reported. Farther up the valley wells have not been sunk deep enough to reach the lake beds, but their thickness at Rodeo indicates that they extend a long distance south.

YOUNGER STREAM DEPOSITS.

The younger stream deposits lie at the surface over perhaps two-thirds of the area of the valley. They overlie the lake beds, probably mantle the older stream deposits in many places, and lie directly on the pre-Quaternary rocks in some places. At the lower end of the valley they form only a thin covering and have in many areas been eroded away entirely, leaving the underlying lake beds at the surface. Toward the head of the valley they thicken, and in the San Simon and Bowie areas they are usually found in wells to a depth of about 150 feet. Near Rodeo and farther south wells end in the younger stream deposits at depths of 300 to 400 feet.

The younger stream deposits consist of clay, silt, sand, gravel, and boulders, the materials in some of the beds being well sorted and in others mixed. The individual beds are lenticular and as a rule not continuous for great distances.

In the interior portions of the valley the sediments are finer and better stratified than along the edges of the valley, where the rough débris from the mountains has been dumped unsorted.

LAVA BEDS.

Lava covers small areas near the east edge of the valley between Rodeo and Apache and larger areas in the vicinity of Moore's Spur and the San Bernardino divide. The lava is a grayish-black or reddish-brown vesicular basalt. It rests on the valley fill or is interbedded with it.

PRECIPITATION.

SEASONAL DISTRIBUTION AND CAUSE.

The following statements in a report of the United States Weather Bureau,[1] regarding the seasonal distribution and cause of the pre-

[1] Summaries of climatological data by sections: U. S. Weather Bur. Bull. W, vol. 1, sec. 3, pp. 21–22, 1912.

cipitation in southern Arizona and southwestern New Mexico apply in general to the San Simon drainage basin:

The precipitation occurs principally during two portions of the year, a primary maximum fall occurring during the months July to September, inclusive, and a secondary maximum during the colder months of the year. But little precipitation occurs during the later autumn months and practically none at the lower elevations during April, May, and June.

The precipitation of winter is the result of general storm movement over the district, induced by the low areas that develop over the Gulf of California and the lower Colorado Valley, the greater part of the moisture from which, however, is deposited in regions far to the eastward. In the high elevations much of the precipitation of winter occurs as snow.

The rains of summer are local in character and generally traceable to the influence of the mountains interposing their masses to the free passage of the rain-bearing winds. These winds, in their passage over the high elevations, are cooled by the consequent elevation and expansion sufficiently to cause condensation and precipitation, and while the maximum intensity of these local storms of summer is confined largely to the adjacent mountain areas, the upper currents distribute the precipitation to some extent over the adjacent valleys and plains.

RECORDS.

Precipitation records have been kept, with few interruptions, at Bowie since 1867, at San Simon since 1881, at Paradise since 1908, and at Rodeo since 1910. The mean monthly and mean annual precipitation at those places is given in the following table:

Mean monthly and mean annual precipitation, in inches, in the San Simon drainage basin.

Station.	Elevation above sea level (feet).	Length of record (years).	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Bowie	3,756	[a] 45	0.99	1.57	1.08	0.17	0.27	0.50	2.80	2.79	1.13	0.66	0.72	1.13	13.81
San Simon	3,609	[b] 33	.43	.52	.64	.10	.13	.15	1.07	1.66	.58	.36	.44	.69	6.77
Paradise	5,436	[c] 8	.93	1.25	1.15	.33	.11	.85	4.58	3.04	2.01	.82	.93	2.20	18.20
Rodeo	4,118	[d] 6	.69	.60	.62	.15	.06	.60	2.74	1.59	.98	.92	.46	1.74	11.15

[a] No records for years 1895 to 1898, inclusive. Records incomplete for years 1867, 1871, 1872, 1902, and 1913.
[b] No records for years 1901 and 1902. Records incomplete for years 1881, 1888, 1889, 1897, 1898, and 1911 to 1914, inclusive.
[c] Records incomplete for years 1908, 1911, and 1915.
[d] Records incomplete for years 1912 and 1913.

The records show a very irregular distribution of precipitation. The difference in the precipitation at Bowie and at San Simon is striking. Although both places are in the valley only 16 miles apart and the difference in elevation of the two stations is only 153 feet, Bowie receives more than twice as much precipitation as San Simon. The heavier precipitation at Bowie is probably due to the influence of the near-by Dos Cabezas Mountains, which lie directly across the path of the moisture-laden southwest winds. The moisture is condensed and mostly precipitated in the mountains, but some of the precipitation is carried into the adjacent valley areas. At Rodeo the precipitation is also much greater than at San Simon. This is due partly to the higher altitude but probably also to the proximity of the lofty Chiricahua Mountains. Paradise, which is a small mining town about 12 miles northwest of Rodeo in the Chiricahua Mountains, receives a much heavier precipitation than any of the stations in the valley.

GROUND-WATER HORIZONS.

In the San Simon and Bowie areas, in the vicinity of Rodeo, and possibly also in the lower part of the valley, there are two separate and distinct ground-water horizons.

The upper horizon is in the mantle of sediments called in this report the younger stream deposits (p. 9). The water in these deposits is under little or no pressure and in wells does not rise appreciably above the water table. It is locally referred to as surface water, and shallow wells that tap only this supply are called surface wells.

The lower ground-water horizon is in the deeply buried sediments beneath the blue clay which lies under the younger stream deposits (p. 8). The water of this lower horizon is under hydrostatic pressure and rises in wells above the level of the upper ground water; in the vicinity of San Simon it rises to the surface.

WATER AT UPPER HORIZON IN SAN SIMON AND BOWIE AREAS.

OCCURRENCE AND SOURCE.

The upper ground water in the San Simon and Bowie areas is found in beds of gravel or sand or in beds that consist of a mixture of these materials. Wells in the vicinity of San Simon usually penetrate one principal water-bearing bed of loose, fairly coarse gravel and several minor water-bearing beds composed of loose, porous sand. The water-bearing beds are separated by beds of red or yellow clay, caliche (carbonate of lime), or impervious mixtures of these materials.

In all the wells in the Bowie area of which records are available the water of the upper horizon was found in sand or in mixed clay and gravel commonly called wash.

The source of the water is the precipitation in the valley and the run-off from the mountainous portions of the drainage basin. The principal intake areas are the steep upper portions of the stream-built slopes. Probably very little of the water that is precipitated or shed on the flatter middle portions of the valley reaches the ground-water level.

DEPTH TO WATER TABLE.

The depth to the water table is less than 100 feet throughout a belt of land that extends along the axis of the valley, including nearly all of the San Simon flowing-well area and also a narrow strip on each side of San Simon Creek north and south of the flowing-well area (Pl. I). The shallowest water is at the San Simon Cienaga, where the water table is practically at the surface. Northward the depth gradually increases until at San Simon the water table is 60 to 70 feet below the surface. Northward from San Simon the water table approaches nearer to the surface in the region bordering San Simon Creek, and at the Triangle Cattle Co.'s well, 4 miles north-northwest of San Simon, it is only 35 feet to water. Below this place the water table apparently slopes northward at about the same grade as the surface of the land, for at the Posey ranch, 15 miles below San Simon, the water table is reported to be about 40 feet below the surface.

Outward from the axis of the valley the depth to water increases. Northeastward up the slopes toward the Peloncillo Mountains and southwestward toward the Chiricahua Mountains the depth to the water table increases rapidly, but on the plain extending westward from San Simon toward Bowie the depth increases more gradually.

YIELD.

In the San Simon area all irrigation supplies are drawn from the lower or artesian horizon, and there are no heavy demands on the supply of the upper horizon except at the pumping plant of the Southern Pacific Co. at San Simon, where two 12-inch bored wells, 133 feet deep, furnish all the water that is required for the railroad's use. For watering stock and for domestic uses the supply has never been known to fail anywhere in the area. In fact, there is every indication that the supply is large and if need be could be drawn upon for irrigation.

In the Bowie area the supply of ground water at the upper horizon is small, and wells, even for stock and domestic uses, must generally be sunk to the lower horizon.

WATER AT LOWER OR ARTESIAN HORIZON IN SAN SIMON AND BOWIE AREAS.

OCCURRENCE AND SOURCE.

The first bed in which the water rises under hydrostatic pressure is generally found immediately under the blue clay, usually at depths of 400 to 600 feet below the surface, below which water-bearing beds are encountered at intervals to the greatest depth to which wells have been drilled, which in the San Simon area is somewhat more than 1,200 feet. These water-bearing beds are separated by layers of impervious materials, recognized by well drillers as clay, shale, sandstone, conglomerate, cemented gravel, hardpan, concrete, and rock.

The character of the material composing the water-bearing beds differs somewhat in different localities. In the San Simon area the beds on the east side of San Simon Creek, and also those on the west side of the creek in the southern part of the artesian area, generally consist of coarse sand and fine gravel, whereas north and west of San Simon and in the region immediately south of the town the water-bearing beds consist largely of fine sand. In the Bowie area the water-bearing beds in almost all the wells consist of coarse white sand.

In the San Simon and Bowie areas the essential conditions for artesian wells are fulfilled. The beds of sand and gravel serve as the pervious stratum for the entrance and passage of the water, and the blue clay serves as the impervious confining stratum.

Practically all the artesian water of San Simon Valley originates in the rain and snow that fall on the mountainous parts of the San Simon drainage basin and the upper parts of the valley. The supply from this source is large in the aggregate and is by no means inadequate to provide the artesian water that is known to occur in the valley. Some inhabitants of the region believe, however, that ground water from Animas Valley, which lies east of San Simon Valley, seeps into the San Simon basin. It is true that the ground water of Animas Valley lies higher than the level to which the artesian water in San Simon Valley rises, but it is improbable that any great amount of water seeps through the intervening Peloncillo Mountain barrier.

HEAD.

The water that supplies the artesian basin passes into the water-bearing beds in the elevated outcrop zones along the edges of the valley and downward beneath the impervious blue clay. As the water-bearing beds descend from an altitude of about 4,000 to 4,500 feet above sea level at the outcrop zone to an altitude of about 3,000 to 3,500 feet at the center of the basin the water below the blue clay is under considerable pressure. This pressure causes the water to rise in wells when the blue clay is penetrated.

In the flowing-well areas (Pls. I and II) the pressure is sufficient to force the water above the surface. In the Bowie area and in other areas adjacent to the San Simon flowing-well area the pressure is great enough to force the water far above the level of the water-bearing beds but is not sufficient to force it to the ground surface.

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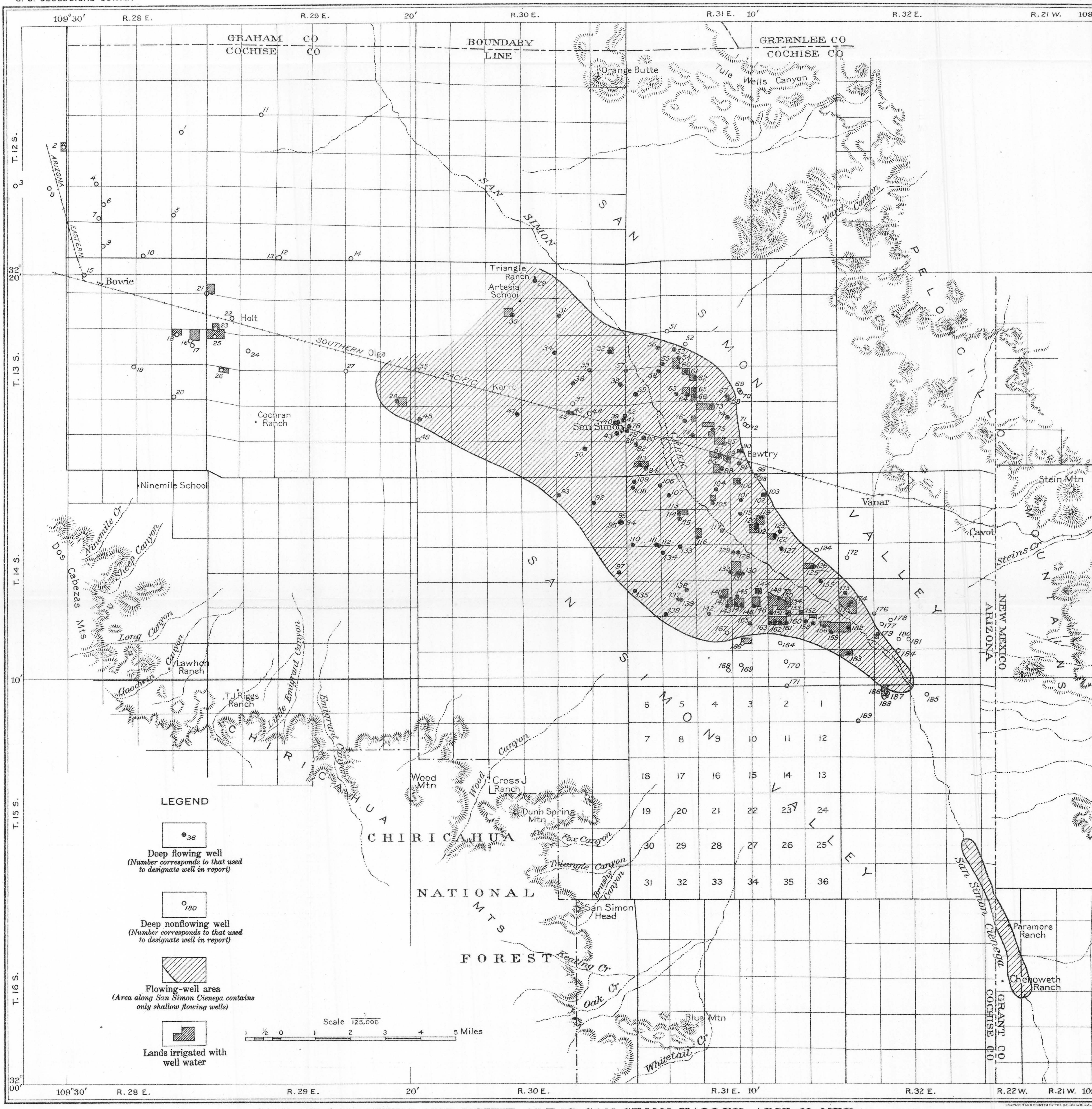
In the fall of 1915 the heads in about sixty of the flowing wells in the vicinity of San Simon were measured and were found to range from a fraction of a foot to 42 feet. The average head in all of the wells measured was about 15.5 feet. (See table, pp. 22–26.)

Comparison with measurements made in December, 1913, shows that on the whole there has been a large decrease in head. The average head of eight wells measured in 1913 was 31 feet. In 1915 when the same wells were measured the average head was 19 feet, a decrease of 39 per cent. Five of the wells (Nos. 61, 76, 127, 133, and 148) had lost about 50 per cent of their head, one well (No. 85) had lost 14 per cent, and two wells (Nos. 57 and 104) had gained 71 and 44 per cent, respectively. Whether the loss of head in most of the wells is due to an actual depletion of the artesian supply or to some other cause is not conclusively shown by the data. The fact that some of the wells gained pressure during the interval between 1913 and 1915 suggests that loss of head is not general throughout the area and that in many of the wells it may be due largely to local causes. Faulty well construction is believed to have caused much of the loss of head and the diminishing flow. As a general rule wells are cased for only a short distance into the blue clay and consequently they often become obstructed by the caving of the clay walls and by the sanding up of the uncased bore in the water-bearing beds.

Outside the flowing-well area the hydrostatic pressure is not sufficient to force the water to the surface. Many deep wells have been drilled along the margins of the flowing-well area and in the vicinity of Bowie. The depth to water in these wells ranges from a few feet to over 100 feet. (See table, pp. 22–26.) Throughout a large area on the plain extending west from Bowie and north from Bowie east of the Arizona Eastern Railroad the water in deep wells penetrating to the lower horizon generally rises to levels less than 50 feet below the surface, and that depth is ordinarily considered the limit of economical pumping for irrigation. On the higher ground west and south of Bowie the water does not rise high enough in wells to be economically pumped for extensive irrigation.

YIELD.

The total number of flowing wells listed in the table (pp. 22–26) and shown on the map (Pl. II) is 127. This includes all the wells in the San Simon area that were flowing in October, 1915. The flow of these wells ranges from less than 1 gallon to about 300 gallons per minute, and the average flow from 116 wells measured in 1915 was 52 gallons per minute. The combined yield of the 127 wells, if they flowed continuously, would be approximately 15 second-feet, or 11,000 acre-feet per year. The largest flows are obtained east



MAP OF SAN SIMON AND BOWIE AREAS, SAN SIMON VALLEY, ARIZ.-N. MEX.

SHOWING LOCATION OF DEEP WELLS, FLOWING-WELL AREAS, AND LANDS IRRIGATED WITH WELL WATERS of San Simon Creek, where the average yield is about 80 gallons per minute, and in the southern part of the flowing-well area, west of the creek, where the average flow is about 90 gallons per minute. North, west, and south of San Simon the flows are small, the average being about 12 gallons per minute.

Comparison of the flows of 12 wells measured in 1913 and 1915 shows that in two years the aggregate yield of these wells decreased 45 per cent, and that individual wells showed decreases in flow ranging from 20 to 80 per cent. Whether this is due to the failure of the artesian supply or to other causes is a very important question which affects the welfare of the whole region. No doubt the caving and filling with sand of the uncased portions of the wells has caused much of the decrease in flow, for when failing wells are cleaned out the flow immediately increases, and new wells that are brought in almost invariably yield much more than older wells in the same locality. That the supply is not failing to the extent that the comparisons of the flows in 1913 and 1915 would indicate is shown by the fact that there has been no noticeable shrinking of the flowing-well area and by the fact that the water level in nonflowing deep wells outside of the area has not been lowered to any great extent within the last two years. Many wells along the margin of the area which yielded only very small flows when they were completed are still flowing.

The diminished flow of the wells may in a measure be due to the exceeding dryness of the summer of 1915. This surmise is, however, in itself disquieting, for it would indicate that the storage capacity of the artesian reservoir was small and that the limit of development had about been reached. In that event a large increase in the number of wells and consequently heavier drafts on the supply might cause a serious water shortage in the event of a protracted drought.

None of the flowing wells have been pumped for irrigation sufficiently to prove their capabilities under those conditions and to determine the effect of pumping on the flow of surrounding wells.

In the Bowie area a number of deep nonflowing wells are pumped for irrigation. Yields of 600 to 800 gallons per minute, or 10 to 20 gallons per minute for each foot of drawdown under steady pumping, are reported from some of the larger plants.

METHODS AND COST OF CONSTRUCTING WELLS.

Most of the wells are 4 to 6 inches in diameter and are cased for only 150 to 200 feet—a short distance into the blue clay. Many of the older wells have, however, caved or have been partly filled with sand. At the present time, therefore, the best practice dictates the use of standard casing which is carried to the bottom and perforated at the water-bearing beds.

By the jetting process, which is used almost exclusively, wells can be sunk through the unconsolidated valley fill quickly and cheaply. The charge for putting down wells of the usual size by contract is from 50 to 75 cents per foot. Under the cooperative system, whereby a group of farmers purchase and operate a drilling rig jointly, wells have been put down at even less cost. The average cost of the partly cased flowing wells in the San Simon area is between $500 and $600. In the Bowie area the cost of larger wells cased to the bottom and used for pumping is from $1,000 to $2,000.

CONSERVATION OF ARTESIAN SUPPLY.

The importance of preventing waste and conserving the artesian supply can not be overemphasized. In the early days of developing many of the wells in the San Simon region were allowed to flow continuously, and the water that was not used ran to waste. Now most of the large wells are fitted with valves so that they can be shut off when not in use, but the flow of a few large wells and many small wells is still wasted. Though the waste from any one well may appear of slight importance, the aggregate annual waste in the district is proportionately very large. When it is considered that a well flowing only 10 gallons a minute discharges over 5,250,000 gallons, or 16 acre-feet, in a year the importance of controlling the flow may be realized. A State law somewhat similar to the one in New Mexico for regulating the construction and use of artesian wells is needed.

QUALITY.

The analyses in the table on page 17 indicate that the waters from the lower horizon in the San Simon and Bowie areas generally contain only moderate amounts of dissolved mineral matter. In 24 of the 25 waters analyzed the total solids range from 224 to 468 parts per million. One water, that from the E. W. Burress well (No. 47) in the western part of the flowing-well area, is very highly mineralized, the analysis showing 6,578 parts per million of total solids. The waters from this part of the area, where the flows are small, are in general more highly mineralized than those from the region of the largest flows east and south of San Simon. As in other valleys of the Southwest in which the valley fill is derived largely from igneous and metamorphic rocks rich is sodium, the waters from the San Simon and Bowie areas of the San Simon Valley are predominantly of the sodium carbonate or "black alkali" type.

Analyses of ground waters from artesian horizon in San Simon and Bowie areas, San Simon Valley, Ariz.–N. Mex.

[Analysts, A. E. Vinson and P. W. Moore, of Arizona Agricultural Experiment Station.]

No. of well.[a]	Constituents in parts per million.							Quality for irrigation.	Quality for domestic use.
	Total solids.	Carbonate radicle(CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chloride (Cl).	Permanent hardness as $CaSO_4$.	Black alkali as Na_2CO_3.		
22	330	21	139	16	6.1	....	89	Fair.	Good.
25	284	0	117	40	18	....	44	Good.	Do.
28	468	48	162	189	9.7	....	157	Fair.	Fair.
29	386	44	48	69	17	....	85	...do....	Good.
30	338	28	62	88	13	....	76	...do....	Do.
33	312	16	107	80	6.1	....	123	...do....	Do.
47	6,578	0	55	4,225	23	1,349	....	Poor.	Bad.
48	418	36	149	86	12	....	170	Fair.	Good.
61	294	0	137	75	7.3	11	....	Good.	Do.
76	286	6.0	119	80	5.4	....	72	...do....	Do.
79	322	60	24	72	4.8	....	98	Fair.	Do.
85	330	0	146	80	4.2	8.5	....	Good.	Do.
104	234	22	44	46	4.8	....	42	...do....	Do.
111	304	0	122	61	3.6	....	70	...do....	Do.
113	282	0	122	74	4.8	....	64	...do....	Do.
121	344	0	150	77	8.5	24	....	...do....	Do.
125	308	0	149	74	7.3	24	....	...do....	Do.
127	284	0	128	65	54	....	21	...do....	Do.
132	284	0	124	77	1.2	....	28	...do....	Do.
148	302	0	146	72	2.4	....	17	...do....	Do.
149	300	0	140	76	6.1	....	17	...do....	Do.
151	242	0	146	78	6.6	5.4	....	...do....	Do.
152	372	0	168	80	6.6	41	....	...do....	Do.
179	224	0	125	37	6.1	....	25	...do....	Do.
182	316	0	131	51	6.1	....	17	...do....	Do.

[a] Numbers correspond to those used in table of well records (pp. 22–26) and on Pl. II.

All the waters analyzed from the region east and south of San Simon are of good quality for irrigation and domestic use. Although most of these waters are of the sodium carbonate type, the amounts of dissolved salts are so small that with the good drainage outlet afforded through San Simon Creek there is not much danger of the alkali interfering with agriculture. The flowing-well waters analyzed from the region west of San Simon are all classed as "fair" irrigating waters except that from the Burress well (No. 47), which can not be used for irrigation. The waters classed as fair can be used with safety where the soil is loose and well drained, but on poorly drained soils some precautions would be necessary to prevent accumulation of alkali. For domestic use all the waters are satisfactory except that from well No. 47, which is a poor domestic water because of its high sulphate content and excessive hardness.

In the Bowie area the water from the Blanks well (No. 25) is a good irrigating and domestic water. That from the Bowsher well (No. 22) is fairly good for irrigating and entirely satisfactory for domestic use. As these two waters are believed to be more or less representative, and as the soils are generally sandy and well drained, there should not be much trouble with alkali in this area.

TEMPERATURE.

The usual range in the temperature of the waters is between 77° and 84° F. (See table, pp. 22–26.) In the region east and south of San Simon the temperatures are very uniform, very few of the waters exceeding or falling below these limits. In the region west of San Simon the waters are much warmer, temperatures of more than 90° being common, and at three wells temperatures of more than 100° were observed. These three were the Lyday well (No. 28) and the Baker well (No. 48), where the water has a temperature of 105°, and the Triangle Cattle Co. well (No. 29), where the temperature is 109°. The most plausible explanation for these abnormally high temperatures is that somewhere in their passage underground the waters are heated by uncooled lavas.

GROUND WATER IN THE RODEO AREA.

OCCURRENCE AND SOURCE.

The chief water-bearing formations in the Rodeo area are the younger stream deposits (see p. 9 and fig. 2) that cover almost the entire area. Along the border of the valley these deposits consist largely of coarse gravels which readily absorb the water shed from the mountain slopes. This water percolates downward and fills all the pores in the valley fill below the water table. As the tendency of water is to follow the paths of least resistance and to seek the lowest levels, the largest accumulations of ground water are generally found in the low central parts of the valley.

In that part of the Rodeo area from the vicinity of Apache north to San Simon Cienaga ground-water supplies can be obtained anywhere along the axis of the valley and the adjacent lower portions of the alluvial slopes by sinking wells to the water-bearing gravels and sands. Most wells penetrate at least two water-bearing beds and some three or four. In the central part of the valley northeast of Apache the first water-bearing bed is usually encountered at depths of 100 to 120 feet below the surface, the second between 150 and 170 feet, and the third between 200 and 250 feet. In the vicinity of Rodeo the first water stratum is generally found between 70 and 80 feet, the second between 90 and 100, and the third at about 150 feet. Farther north along the draw leading to San Simon Cienaga the first water-bearing bed usually lies between 50 and 60 feet from the surface, the second at about 70 feet, and the third between 80 and 90 feet. At San Simon Cienaga water is virtually at the surface, and in many wells on the higher ground bordering the cienaga water is found within 25 feet of the surface.

In the Moore's Spur area and the part of the valley between Moore's Spur and Apache ground-water conditions are much less favorable. Most of the supplies in this region are obtained from small springs or seeps, of which there are many in this region. (See Pl. III.) These springs are a result of a reversal of the conditions that govern ground-water supplies in most parts of the valley. Ordinarily the surface waters that percolate into the ground accumulate as ground water in the lower part of the valley fill, where, as a rule, porous beds are found. In this region, however, the lower part of the valley fill is impervious, or at least there is a layer of impervious material near the surface, which prevents the water from sinking and causes it to accumulate in the gravelly upper layers of the valley fill and to break out in springs wherever there is an opening.

DEPTH TO WATER AND QUANTITY.

The position of the water table with respect to the surface is approximately indicated by the water level in wells. The depth to water in all the wells measured during the later part of 1915 is shown on the map of the Rodeo area (Pl. III). The area where the depth to water is less than 100 feet is outlined on the general map (Pl. I).

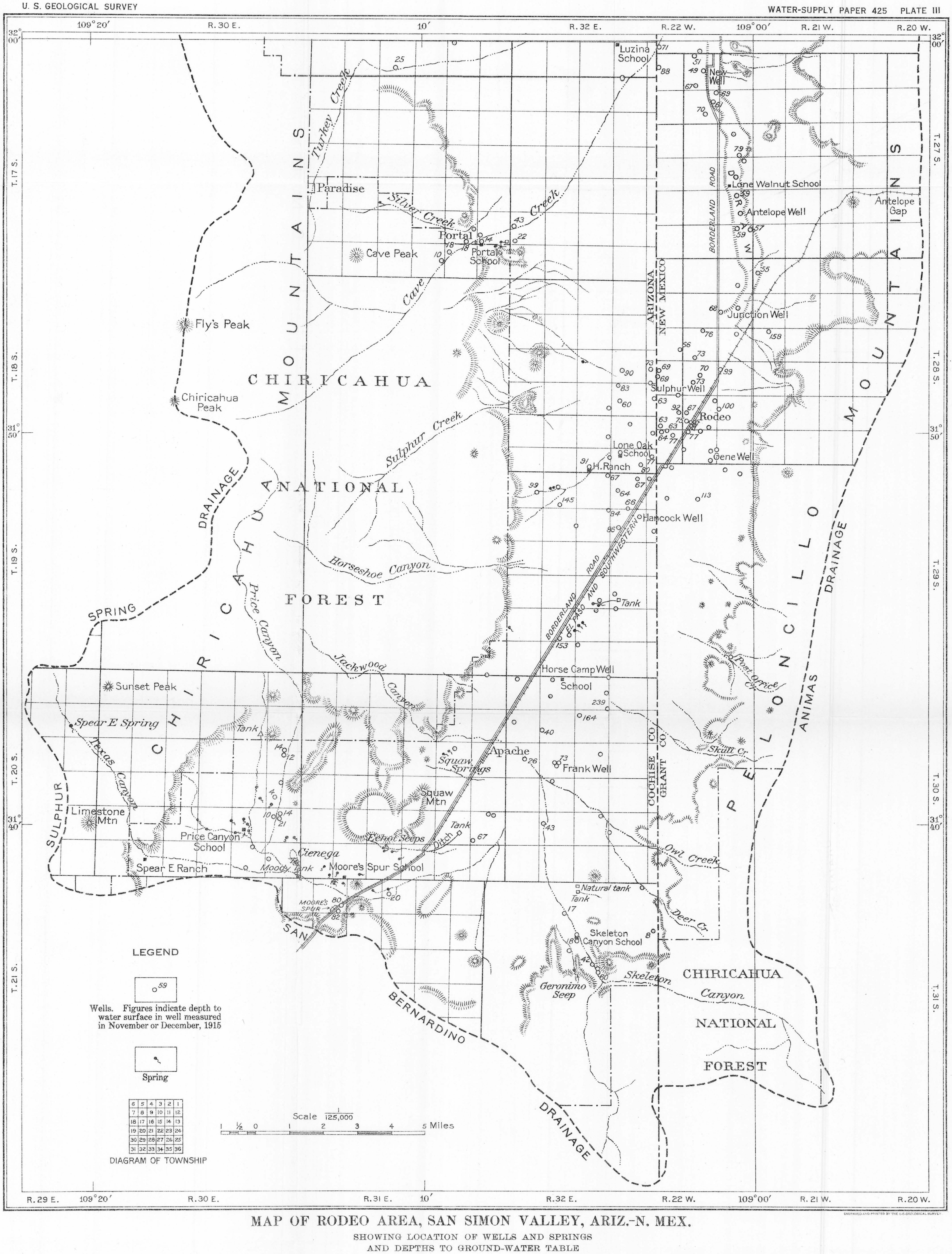
In the region southwest of Apache and in the vicinity of Moore's Spur the supply of ground water is small. The principal sources of supply are the springs. At a few places spring water is collected in earth reservoirs and used to irrigate gardens and small fields, but generally the springs furnish only enough water for stock and domestic use. As the springs are supplied entirely by the local rainfall the flow differs with the seasons, and during periods of drought most of them diminish greatly in flow or go dry. In some places, principally along the stream courses and in localities where the presence of ground water is indicated by springs, small supplies are obtained from shallow wells. At Moore's Spur some supplies are obtained at depths of 100 to 150 feet from beds of basalt ("malpais") interbedded with the valley fill, but generally attempts to obtain adequate supplies from the deeper valley sediments have been unsuccessful.

In the region from Apache northwest to San Simon Cienaga ground-water conditions are much more favorable. Most of the wells are near the center of the valley, where the supply is largest and also most accessible. As shown by the measurements indicated on the map (Pl. III), the water table slopes with the ground surface but at a lesser rate, so that the depth to water decreases from the edges of the valley down the slopes toward the center of the valley and also northward in the direction of the principal slope of the valley. In the area shown on the map (Pl. I), extending from a line 4 miles south of Rodeo to San Simon Cienaga and including the central drainage depression and narrow strips on either side, there is approximately 45 square miles where the depth to the water table is less than 100 feet. Outside of this tract the depth to water ranges from 100 to 300 feet, except near the mouths of some of the mountain canyons, where shallow water is found in the gravels overlying the bedrock.

Some idea as to the yield of wells in this region may be gained from the performance of the pumping plant of the El Paso & Southwestern Co. at Rodeo. The plant consists of a 20-horsepower Stover crude-oil engine, a multi-stage Layne centrifugal pump, and a well 13 inches in diameter and 160 feet deep. The normal water level in the well is 80 feet below the surface. The pump is set 100 feet below the surface and discharges into a tank at a point 32 feet above the ground. Under continuous pumping at the rate of approximately 200 gallons per minute the vacuum gage registers 3 pounds per square inch, which is equivalent to a draw down of 7 feet below the pump or a total draw down of 27 feet. The capacity of the well is therefore about 7½ gallons for each foot of draw down. The performance of this plant indicates that while the quantity of water is doubtless sufficient to supply irrigating plants of moderate capacity the lift is so great that pumping for the irrigation of ordinary crops would probably not be profitable.

QUALITY.

As shown by the analyses in the table on page 21, the waters of the Rodeo area generally contain only a moderate amount of dissolved mineral matter. The total solids in the waters analyzed range from 160 to 364 parts per million. Like the waters from the San Simon and Bowie areas they are mostly of the sodium carbonate type, but contain only small amounts of this salt, and, on the whole, they compare favorably with the best deep-well waters in the region to the north. For irrigation and domestic use they are all of good quality.



MAP OF RODEO AREA, SAN SIMON VALLEY, ARIZ.-N. MEX.

SHOWING LOCATION OF WELLS AND SPRINGS AND DEPTHS TO GROUND-WATER TABLE

Analyses of ground waters from Rodeo area, San Simon Valley, Arizona-New Mexico.

[Analysts, A. E. Vinson and P. W. Moore, of Arizona Agricultural Experiment Station.]

Source.	Owner and designation.	Location.	Constituents in parts per million.							Quality for irrigation.	Quality for domestic use.
			Total solids.	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chloride (Cl).	Permanent hardness as $CaSO_4$.	Black alkali as Na_2CO_3.		
Spring	Price Canyon School	Sec. 26, T. 20 S., R. 30 E., Ariz.	224	0	38	36	14	Neutral	Neutral	Good	Good.
Do	Moody Spring	SE. ¼ sec. 36, T. 20 S., R. 30 E., Ariz.	176	0	40	24	6.5	11		do	Do.
Do	Echol seeps	NE. ¼ sec. 33, T. 20 S., R. 31 E., Ariz.	192	0	62	23	4.8		13	do	Do.
Do	Squaw Springs (N. A. Neeley).	NW. ¼ sec. 14, T. 20 S., R. 31 E., Ariz.	192	0	49	44	6.7		11	do	Do.
Well	Mrs. M. K. Morgan	NW. ¼ sec. 6, T. 20 S., R. 32 E., Ariz.	160	0	85	9.7	8.0	Neutral	Neutral	do	Do.
Spring	Mr. Darter	SW. ¼ sec. 28, T. 19 S., R. 32 E.	358	0	55	21	14		3.2	do	Do.
Well	San Simon Cattle Co. (Hancock well).	NE. ¼ sec. 10, T. 19 S., R. 32 E., Ariz.	190	0	76	17	12		2.1	do	Do.
Do	Paul McCarty	SW. ¼ sec. 25, T. 28 S., R. 22 W., N. Mex.	180	0	79	14	12		13	do	Do.
Do	D. M. Phillips	NW. ¼ sec. 1, T. 29 S., R. 22 W., N. Mex.	162	0	86	20	13		11	do	Do.
Do	El Paso & Southwestern Co.	Rodeo, N. Mex.	218	0	19	11	12		15	do	Do.
Do	C. E. New	do	248	0	39	5.2	11		19	do	Do.
Do	M. F. Gilbert	SW. ¼ sec. 36, T. 26 S., R. 22 W., N. Mex.	364	0	229	22	6.1	95		do	Do.
Do	E. R. Edwards	NE. ¼ sec. 31, T. 27 S., R. 21 W., N. Mex.	334	0	171	32	10	5.4		do	Do.
Do	San Simon Cattle Co. (headquarters).	SW. ¼ sec. 33, T. 18 S., R. 32 E., Ariz.	180	0	70	9.5	12		11	do	Do.

DEEP WELLS IN SAN SIMON VALLEY.

The following table presents the data collected in 1913 and 1915 regarding wells in the San Simon and Bowie areas that end in the lower or artesian horizon.

Records of wells in San Simon and Bowie areas ending in lower or artesian horizon.

No.	Location in township: Section.	Location in township: Quarter.	Owner or designation.	Elevation of mouth of well above sea level.	Depth.	Diameter of casing at top.	Measurements: Date.	Measurements: Height of water above (+) or below (−) surface.	Measurements: Flow per minute.	Measurements: Temperature of water.
				Feet.	*Feet.*	*In.*		*Feet.*	*Galls.*	*°F.*
			T. 12 S., R. 28 E.							
1	13	NW.	G. C. Davis	3,612	770	6¼	Dec. 15, 1915	−72		
2	17	SE.	J. O. Gurley	3,730	567	6¼	Dec. 16, 1915	*a* −70		
3	19	SE.	E. Craig		485	8	do	−145		
4	21	SE.	D. Grimshawe		*a* 500	4	Dec. 15, 1915	−40		
5	25	SW.	Westley Wheeler	3,660	500	5	do	−29		
6	27		J. A. Wheeler		333	4	do	*a* −60		
7	28	SE.	do		328	4	do	*a* −60		
8	29	NE.	Geo. B. Rentchler		200	5⅝	do	*a* −110		
9	34	SW.	W. V. Griffith			4	do	*a* −70		
10	35	SW.	J. W. Lancaster		334	4	do	−41		
			T. 12 S., R. 29 E.							
11	8	SE.	Mr. McFarland		548	4	Dec. 15, 1915	*a* −30		
12	33	SW.	Henry D. Sweet		1,068	8¼	Dec. 13, 1915	−92		
13	33	SW.	do		760	8¼	do			
14	35	SW.	Mr. Goode		*a* 900	12	do	−18		
			T. 13 S., R. 28 E.							
15	4	SE.	Bowie Improvement Co		435	8	Dec. 16, 1915	−106		
16	13	NE.	W. G. McCampbell		440	5⅝	Dec. 12, 1915	−49		
17	13	NE.	do		610	8¼	do	−50		
18	13	NW.	H. Kluge		595	5⅝	do	−50		
19	22	NE.	H. L. Deffenbaugh		300	4	Dec. 14, 1915	−60		
20	24	SW.	T. M. Winsor		530	5⅝	Dec. 12, 1915	−100		
			T. 13 S., R. 29 E.							
21	6	SW.	L. C. Brenizer		835	6¼	Dec. 13, 1915	*a* −5		
22[b]	7	SE.	M. C. Bowsher		482	4	do			
23	7	SW.	G. Killough		656	5⅝	Dec. 11, 1915	−23		
24	17	NW.	Alice C. Burnett	3,700	597	6¼	do	−20		
25[b]	18	NW.	J. G. Blanks		860	8¼	do	−40		83
26	19	NW.	H. E. Galloway		463	9	do	−45		
27			W. D. Armstrong	3,651	601	4	do	−30		
28[b]	24	SE.	Mrs. E. M. Lyday		960	6¼	do		26	105

a Approximate. *b* For analysis of water, see p. 17.

Records of wells in San Simon and Bowie areas ending in lower or artesian horizon—Continued.

T. 13 S., R. 30 E.

No.	Location in township: Section.	Quarter.	Owner or designation.	Elevation of mouth of well above sea level.	Depth.	Diameter of casing at top.	Measurements: Date.	Height of water above (+) or below (−) surface.	Flow per minute.	Temperature of water.
				Feet.	*Feet.*	*In.*		*Feet.*	*Galls.*	°*F.*
29[b]	3	NW.	Triangle Cattle Co.	3,553	860	4	Dec. 29, 1913	...	[a]10	109
							Oct. 26, 1915	+13	5	109
30[b]	9	NE.	Fred H. Jones	3,569	900	5	Dec. 29, 1913	...	...	98
							Oct. 26, 1915	+18	8	93
31	11	NW.	J. B. Moore	3,566	950	6	Oct. 26, 1915	...	4	96
32	13	NE.	Miss L. K. Stanbery	3,587	760	3	Oct. 25, 1915	+11	11	88
33[b]	14	SE.	Globe Co.	3,588	...	9⅝	Dec. 29, 1913	...	30	90
							Oct. 25, 1915	...	21	90
34	15	SE.	Mary C. Miller	3,580	...	8⅝	Dec. 29, 1913	...	23	96
							Oct. 26, 1915	...	18	96
35[c]	18	SW.	J. F. Dowdle	3,608	900	5	Dec. —, 1913	...	([d])	67
36	23	NW.	M. Q. Hardin	3,593	900	6	Oct. 26, 1915	+ 9	9	92
37	23	SW.	Geo. H. Ebsen	3,595	...	...	...do	...	...	...
38	24	NE.	W. C. Morrison	3,593	860	4	Oct. 25, 1915	...	3	80
39	25	NE.	Mrs. Lewis	3,607	880	5	Oct. 23, 1915	...	1	75
40	25	NE.	...do	3,607	880	5	...do	...	14	80
41	25	NE.	Geo. E. Sligh	3,610	900	5	Oct. 27, 1915	+ 3	9	84
42	25	NE.	...do	3,608	...	4	...do	...	1	77
43	25	SE.	Mrs. Stencil	3,607	...	5	...do	+19	45	81
44	26	NE.	Thos. Lane	3,597	...	6⅝	Oct. 26, 1915	−11	...	...
45	26	NW.	J. H. Averill	3,594	935	2	...do	...	1	84
46	26	NW.	...do	3,594	860	4	...do	+ 9	1	78
47[b]	28	NE.	E. W. Burress	3,603	1,230	5	Dec. 10, 1915	...	([e])	...
48[b]	30	NW.	B. F. Baker	3,661	930	5	Dec. 29, 1913	...	[a]10	105
							Dec. 11, 1915	...	2	105
49[c]	30	SW.	G. N. Pettie	3,696	810	11⅝	...do	...	...	...
50	35	NE.	Morgan Wilson	3,610	1,000	4½	Oct. 23, 1915	...	([d])	69

T. 13 S., R. 31 E.

No.	Section.	Quarter.	Owner or designation.	Elevation.	Depth.	Diameter.	Date.	Height.	Flow.	Temperature.
51	8	SW.	Walter C. Wiley	...	400	4	Oct. 19, 1915	−33	...	...
52	17	NE.	Mr. Herald	3,640	...	...	...do	−30	...	...
53	17	NW.	Triangle Cattle Co.	...	550	5	...do	...	1	...
54	17	...	A. E. Palmer	...	...	4	...do	+ 5	30	84
55	17	SW.	...do	...	840	5	Oct. 18, 1915	+13	2	79
56	18	NE.	Sam L. Gray	...	610	4	...do	+ 8	3	83
57	18	SW.	R. B. Cornett	3,566	...	4	Dec. 29, 1913	+14	10	83
							Oct. 25, 1915	+24	6	83
58	19	NE.	Chas. Welch	3,604	550	5	Oct. 18, 1915	...	([d])	...
59	19	SW.	G. B. Barnett	3,592	840	4	Dec. 30, 1913	...	12	82
							Oct. 25, 1915	+26	8	82
60	20	NW.	A. E. Palmer	3,609	560	5	Oct. 19, 1915	+12	24	84
61[b]	20	NE.	Wm. Gregg	3,618	...	4	Dec. 30, 1913	+23	...	...
							Oct. 19, 1915	+11	45	84
62	20	NE.	Geo. B. Marshall	...	590	4	Oct. 19, 1915	+10	64	83
63	20	SW.	John Vest	3,609	660	4	Oct. 18, 1915	...	1	73
64	20	SE.	James Salyer	3,616	640	5	...do	+18	24	84
65	20	SE.	Mrs. Gordon Wharton	3,623	615	4	Oct. 19, 1915	+18	111	83
66	20	SE.	Walter Grant	3,626	...	5	...do	+27	136	83
67	21	SE.	Mr. Hedrick	...	550	4	Oct. 20, 1915	+ 9	58	80
68	21	SE.	...do	...	600	4	...do	+ 9	12	72
69	22	SW.	A. B. Hulsey	...	508	4	...do	−13	...	...
70	22	SW.	...do	...	...	4	...do	−11	...	...
71	27	SW.	Mr. Jennings	...	...	5	Oct. 20, 1915	...	...	...
72	27	SW.	...do	...	610	4	...do	−26	...	...
73	28	NW.	R. O. Merritt	3,637	673	4	...do	+26	164	82
74	28	NE.	J. C. Campbell	3,661	549	6⅝	Dec. 30, 1913	...	...	80
							Oct. 20, 1915	+12	51	82
75	28	...	Walter Grant	3,638	625	5	...do	+30	107	81
76[b]	29	NE.	G. E. Darsey	3,618	618	4	Dec. 30, 1913	+51	54	78
							Oct. 20, 1915	+26	13	79

[a] Estimated.
[b] For analysis of water see p. 17.
[c] Casing pulled and well filled up.
[d] Less than 1.
[e] Very small.

Records of wells in San Simon and Bowie areas ending in lower or artesian horizon—Continued.

T. 13 S., R. 31 E.—Continued.

No.	Location in township: Section.	Location in township: Quarter.	Owner or designation.	Elevation of mouth of well above sea level.	Depth.	Diameter of casing at top.	Measurements: Date.	Measurements: Height of water above (+) or below (−) surface.	Measurements: Flow per minute.	Measurements: Temperature of water.
				Feet.	Feet.	In.		Feet.	Galls.	°F.
77	29	SE.	G. E. Darsey		760	4	Oct. 20, 1915	+42	95	81
78	30	SW.	C. E. Smith						1	
79[a]	30	SW.	San Simon Townsite Co.		850	6				
80	30	SE.	James Hancock		1,008	5	Oct. 22, 1915		5	79
81	31	NW.	Mrs. Winslow		1,200	8⅝	do			
82	31	NW.	do			5	do		19	83
83	31	SW.	John Homrichausen		884	5	Oct. 23, 1915		36	84
84	31	SE.	Guy Pannel and Gordon Wharton.	3,624	850	5	Oct. 22, 1915		36	82
85[a]	33	NE.	F. J. Barnes	3,652	590	5	Dec. 30, 1913 Oct. 20, 1915	+29 +25	[b]200 144	80
86	33	SE.	M. T. Bruce		690	3	Oct. 12, 1915		21	81
87	33		do	3,645	663	5	do	+31	170	81
88	33	SE.	A. M. Bruce	3,645		5	do	+23	120	
89	33	SE.	J. M. Hall		660	5⅝	Oct. 4, 1915	+20	91	
90	34	NW.	W. F. Frye		830	5⅝	do	+ 4	36	
91	34	SW.	Mr. Hall	3,670	[c]600	4	do	+11	23	

T. 14 S., R. 30 E.

No.	Section.	Quarter.	Owner or designation.	Elevation.	Depth.	Diameter.	Date.	Height.	Flow.	Temperature.
92	1	SW.	A. L. Paschall	3,644	920	5	Oct. 23, 1915		2	81
93	2	SW.	H. O. Carr	3,661	987	8⅝	Sept. 29, 1915		([d])	
94	12	NE.	Frank Meade	3,649	1,040	5⅝	Oct. 21, 1915		} [e]45	82
95	12	NE.	do	3,649		9⅝	do		}	
96	12	NE.	do	3,649	880	7⅝	do		1	78
97	13	SE.	Mr. Russell	3,699	743	4	Oct. 15, 1915	+ 9	([d])	72

T. 14 S., R. 31 E.

No.	Section.	Quarter.	Owner or designation.	Elevation.	Depth.	Diameter.	Date.	Height.	Flow.	Temperature.
98	3	NE.	W. S. Smith	3,695	500		Oct. 4, 1915	− 3		
99	3	NE.	do	3,695	756	5⅝	do	− 3		
100	3	NW.	E. C. Adams	3,658	626	5	do	+24	95	80
101	3	SW.	F. J. Barnes		704	5	Oct. 17, 1915	+24	166	75
102	3	SE.	A. G. Pierce		650	6¼	Oct. 4, 1915		4	
103	3	SE.	do		580	6¼	do	+ 2	3	
104[a]	4	NE.	Stella E. Ebsen	3,639		5	Dec. 26, 1913 Oct. 17, 1915	+ 9 +13	17 23	 74
105	4	SW.	John W. Toles		570	5	do	+15	48	76
106	5	NW.	Mrs. Collier	3,628		5	Oct. 21, 1915		([f])	
107	5	SW.	Luther Thorstenberg	3,631	770	4	do		19	78
108	6	NW.	J. H. Hibler		640	5⅝	do		([d])	
109	6	NW.	Olan Hanum		900	4	Oct. 22, 1915		2	78
110	7	SW.	Chas. Tompkins		760	4	Oct. 15, 1915		45	77
111[a]	7	SE.	H. S. Chamberlain	3,659		4	Dec. 27, 1913	+30		
112	7	SE.	do	3,659		4	Oct. 15, 1915	+33	35	77
113[a]	8	NE.	Lee Adams		796	5	do		8	78
114	8	NE.	do		820	5	do			
115	8	NE.	do		800	5				
116	9	SW.	M. H. Butler		800	5	Oct. 15, 1915		46	80
117	9	SE.	San Simon Land & Water Co.	3,633	775	5⅝	Oct. 17, 1915		107	76
118	10	NE.	J. E. Somervell	3,674	603	5⅝	do	+23	222	80
119	10	NW.	E. A. Washburn	3,655	624	4	Oct. 13, 1915	+ 7	24	74
120	10	SE.	M. R. La Rue			6	Oct. 5, 1915		20	
121[a]	10	SE.	do		650	6¼	Oct. 13, 1915		260	78
122	11	SW.	J. A. Shaw	3,681	433	4	Oct. 5, 1915		25	76
123	11	SW.	do		730	5⅝	do	+ 2	1	72
124	13	NW.	R. B. Cornett		520	4	do	− 7		
125[a]	13	SW.	Eugene Belch	3,705	490	4	do	+13		80
126	13	SW.	do	3,705	530	4	do		3	76
127[a]	14	NW.	M. T. Bruce	3,678	440	4	Dec. 26, 1913 Oct. 5, 1915	+45 +20	122 60	 75
128	15	NW.	E. A. Washburn		822	9⅝	Oct. 14, 1915		206	79
129	15	NW.	do		790	9⅝	do	+36	274	80

[a] For analysis of water see p. 17.
[b] Estimated.
[c] Approximate.
[d] Less than 1.
[e] Combined flow.
[f] Small.

Records of wells in San Simon and Bowie areas ending in lower or artesian horizon—Continued.

T. 14 S., R. 31 E.—Continued.

No.	Location in township: Section.	Location in township: Quarter.	Owner or designation.	Elevation of mouth of well above sea level.	Depth.	Diameter of casing at top.	Measurements: Date.	Measurements: Height of water above (+) or below (−) surface.	Measurements: Flow per minute.	Measurements: Temperature of water.
				Feet.	*Feet.*	*In.*		*Feet.*	*Galls.*	°*F.*
130	15	SW.	E. A. Washburn	3,676		5⅝	Oct. 14, 1915		74	79
131	15	SW.	do	3,676	726	4	do		125	83
132[a]	16	SE.	do	3,674	715	4	do		31	79
133	17	NE.	Dr. J. P. Rice	3,657	830	4	Dec. 28, 1913	+38	55	
							Oct. 15, 1915	+16	18	84
134	17	NW.				5	do	+27		79
135	19	NW.	Wm. Homrichausen		1,140	5⅝	do		1	70
136	20	NE.	G. J. Purdy			4	do	+ 7	3	83
137	20		S. B. Morrow				do			
138	20	SE.?	F. W. Bartlett			4	do	+ 8	5	86
139	20	SW.	Mr. Foxworth	3,727	1,052	10	Oct. 9, 1915		1	
140	21	NE.	Will Buck		875	5	Oct. 15, 1915	+16		77
141	21	NE.	do	3,696	730	4½	do			84
142	21	SW.	Dr. W. N. Stewart		770	4	do	+ 7	4	
143	21	SE.	C. R. Anderson	3,706	800	4	Oct. 9, 1915	+11	34	85
144	22	NE.	J. D. Averill		620	5	Oct. 7, 1915	+10	28	78
145	22	NW.	Mr. Cox	3,694			Oct. 13, 1915	+ 8	9	80
146	22	SW.	C. E. Wharton	3,704	750	4	Oct. 9, 1915	+ 9	40	85
147	22	SW.	do	3,701	760	4	do		[b] 30	
148[a]	22	SE.	Mrs. S. M. McKinney	3,702	770	4	Dec. 27, 1913	+38		83
							Oct. 13, 1915	+17	120	
149[a]	23	NW.	Peter Jensen	3,692	705	5	Dec. 24, 1913		432	
							Oct. 7, 1915	+24	250	84
150	23	NW.	do		725	5⅝	do		250	
151[a]	23	SW.	do	3,711	750	5	do	+11		83
152[a]	23	SE.	Mrs. Lizzie Hammons		620	5	Oct. 16, 1915	+10	180	80
153	23	SE.	do	3,709	720	5⅝	Oct. 7, 1915	+ 9		80
154	23	SE.	do		580	5⅝	do	+ 9	90	79
155	24	NW.	Mrs. Hegie	3,698	590	5	Oct. 6, 1915	+18	87	77
156	25	NE.	Mrs. Frank Lewis	3,714	640	5⅝	Oct. 7, 1915	+17	134	80
157	25	NW.	Albert Jones	3,713		4	do	+12	65	80
158	25	NW.	do			5⅝	do	+ 9	60	78
159	25	SE.	J. L. Hill		660	5⅝	do	+13	137	83
160	26	NE.	H. O. Carr		800		Oct. 9, 1915			
161	26	NW.	do		735	5	do		22	81
162	26	NW.	do	3,720	920	4	do		[b] 25	84
163	26	NW.	do	3,724	800	5⅝	do		[b] 20	
164	26	SW.	Mr. Payne	3,742		5	Oct. 16, 1915	− 5		
165	27	NW.	A. S. McKinney		740	4	Oct. 9, 1915		3	83
166	27	SW.	J. J. Rhodes		885	5⅝	Oct. 16, 1915	−14		
167	28	NE.	A. Cummins		780	5	Dec. 27, 1913	+17	70	
							Oct. 8, 1915	− 5		
168	33	SE.	Verne A. Garrison		791		Oct. 2, 1915	[c]− 3		
169	34	NW.	Jeff D. Reagan		791		do	[d]−30		
170	35	NE.	J. S. McCrory	3,758	800	4	Oct. 16, 1915	−18		
171	35	SE.	Wm. Maude		707	6⅝	do	−35		

T. 14 S., R. 32 E.

No.	Section.	Quarter.	Owner or designation.	Elevation.	Depth.	Diameter.	Date.	Height of water.	Flow per minute.	Temperature.
172	18	NE.	E. E. Voglar		520	4	Oct. 5, 1915	[e]−36		
173	19	NW.	Arthur Starr	3,710	390	5⅝	Oct. 6, 1915		[b] 20	75
174	19	SW.	Dr. J. R. Kight	3,711	441	5⅝	Oct. 7, 1915		[f] 300	80
175	19	SW.	do	3,704	207	5⅝	Oct. 6, 1915		254	73
176			F. J. Graham		350	4	Oct. 5, 1915	− 6		
177	29	NW.	A. Olander		360	5⅝	do	− 7		
178	29	NW.	F. J. Graham		410	5⅝	Oct. 6, 1915	−23		
179[a]	29	SW.	A. Olander	3,725	350	4	Dec. 23, 1913		34	70
							Oct. 5, 1915	+ 5	17	
180	29	SE.	W. A. Paul		760	7⅝	Oct. 6, 1915	−18		
181	29	SE.	John Reeden		300					
182[a]	30	NW.	J. L. Hill		560	4	Oct. 7, 1915			
183	31	NW.	Mr. Minges	3,738	[d] 430	5	Oct. 16, 1915		20	78
184	32	NE.	Dr. J. R. Kight	3,744	409	5⅝	Oct. 6, 1915	− 5		

[a] For analysis of water, see p. 17.
[b] Estimated.
[c] When first drilled.
[d] Approximate.
[e] When first drilled; well now filled up.

Records of wells in San Simon and Bowie areas ending in lower or artesian horizon—Continued.

T. 15 S., R. 32 E.

No.	Location in township: Section.	Location in township: Quarter.	Owner or designation.	Elevation of mouth of well above sea level.	Depth.	Diameter of casing at top.	Measurements: Date.	Measurements: Height of water above (+) or below (−) surface.	Measurements: Flow per minute.	Measurements: Temperature of water.
				Feet.	*Feet.*	*In.*		*Feet.*	*Galls.*	°*F.*
185	4	......	H. F. Copeland	....	*a* 400	5	Oct. 29, 1915	−19	......	....
186	5	NW.	John Kirby	....	520	4	Oct. 7, 1915	− 3	......	....
187	5	NW.	.....do............	....	380	3	.....do........	....	......	....
188	5	NW.	.....do............	....	603	4	.....do........	*b*−12	......	76
189	6	SE.	C. N. McLarty............	....	572	4	.....do........	−32	......	....

a Approximate. *b* When first drilled; well now filled up.

FLOWING WELLS IN ARTESIA VALLEY.

Artesia Valley occupies an erosional trough in the Quaternary Lake beds in the lower part of the San Simon basin, at the eastern base of the Pinaleno Mountains. The valley is one-half to 2½ miles wide, trends northeast, and drains into the Gila Valley. The bottom of the valley is flat and from 25 to 100 feet below the general surface of the basin. In the vicinity of Artesia, where the valley is widest, there are several thousand acres of good farming land, a part of which is irrigated by water from flowing wells.

The artesian conditions in Artesia Valley are similar to those in the San Simon flowing-well area. The water is found in sand or "honeycomb" sandstone overlain by impervious clay, generally blue, but in some places red or white. The first flows are generally encountered between 200 and 400 feet from the surface and succeeding flows at different levels to depths of about 900 feet.

The wells range in depth from 400 to 900 feet and are generally 3 to 6 inches in diameter. Most of the wells are cased only in part, and some of them have only one joint of casing at the top. In many of the old wells wooden casing was used.

Between 30 and 40 wells were flowing in 1915. The flows ranged from only a few gallons to 150 gallons per minute. Many of the older wells that are cased only at the top have caved or filled with sand, so that the flow has diminished greatly or ceased entirely. Some of the larger and better constructed wells have been flowing at an undiminished rate for several years.

Few of the wells are fitted with valves, and consequently there is a large waste of water, especially during the times when the demands for irrigation are light. As the water contains considerable dissolved mineral matter the raising of the water level has caused heavy accumulations of alkali in the soil in the lower part of the settlement.

IRRIGATION.

FLOWING WELLS.

In the San Simon flowing-well area about 1,500 acres were irrigated by flowing wells in 1915. (See Pl. II.) Most of the irrigated lands are in the eastern and southern part of the flowing-well area, where the flows are large enough for irrigation on a commercial scale. North and west of San Simon the yield of the wells is generally too small except for the irrigation of gardens.

From some of the larger wells the water is run directly into the ditches, but the usual practice is to store it in earth reservoirs, from which it is run onto the land. In this way considerable water is lost by seepage and evaporation, but the entire flow of the wells is more completely utilized and a more effective irrigating stream is obtained.

In Artesia Valley about 800 acres is irrigated from flowing wells.

PUMPING.

In the San Simon area several pumping plants are in operation and others are being installed. The total acreage irrigated by pumping in 1915 was about 150 acres. The plants are located over deep wells outside of the flowing-well area, where the water does not reach the surface, and over flowing wells whose yield is insufficient for irrigation.

In the part of the Bowie area lying east and north of Bowie the water in deep wells rises near enough to the surface to be profitably pumped for irrigation. In 1915 a number of plants were in operation and about 300 acres was irrigated.

SUMMARY OF CONCLUSIONS.

1. Practically all the water in San Simon Valley is derived from the precipitation on the drainage basin; there is no considerable inflow of water from other basins.

2. In the San Simon and Bowie areas there are two distinct ground-water horizons; an upper horizon in the younger stream deposits and a lower or artesian horizon in the deposits below the dense clay of the lake beds.

3. In the San Simon area the ground water of the upper horizon is less than 100 feet below the surface throughout a large tract

extending along the axis of the valley. The supply has proved ample for watering stock, for domestic needs, and for the heavier demands of the railroad, and if it can be pumped economically it is probably large enough for considerable irrigation. It is doubtful, however, whether it would be profitable at present to pump this supply for irrigation. In the Bowie region the supply at the upper ground-water horizon is very scanty and it is generally necessary to sink to the lower horizon, even for small supplies.

4. In the lower ground-water horizon the water is under hydrostatic pressure, so that it rises in wells when the water-bearing beds are penetrated. In the San Simon flowing-well area the pressure is sufficient to cause this water to rise above the surface in wells. In the Bowie area the water is also under pressure and in some localities it rises close enough to the surface to be economically pumped for irrigation.

5. Measurements show that the head and yield of wells has decreased considerably in the two-year period between 1913 and 1915. This decrease is largely due to the filling of the uncased wells with sand and the caving of the walls of these wells, but it may in part be due to the increase in the number of wells and depletion of the artesian supply.

6. It is of the utmost importance for the future welfare of the valley that all wells be properly cased to the bottom with heavy casing and be fitted with valves which will be closed when the water is not needed. Faulty construction of wells and waste of artesian water will result in disaster, just as they have in other artesian basins.

7. The flowing-well waters are mostly of the sodium carbonate type, but they generally contain only small amounts of dissolved solids and are of good quality for irrigation and domestic use.

8. In the vicinity of Apache and Moore's Spur the ground-water supply is small and uncertain, but some water for stock and domestic purposes is obtained from shallow wells and springs. In the vicinity of Rodeo and in the central part of the valley north of Rodeo there is a considerable area in which the depth to the water table is less than 100 feet. In this area the supply is probably large, but on account of the lift that would be required it would probably not be profitable at present to pump it for irrigation.

9. All the waters analyzed from the Rodeo area are good irrigating and domestic waters.

AGRICULTURE.

By R. H. FORBES.

HISTORICAL NOTES.

San Simon Valley, like most other valleys of central and southern Arizona, contains traces of a crude prehistoric agriculture. Near the confluence of San Simon Creek with Gila River, above the village of San Jose, are the remains of an ancient ditch, several miles long, which served a large Indian town that was situated just east of Solomonsville. In the ruins of this town numerous artifacts of stone and pottery have been found. In the artesian district on the east slope of Graham Mountain small rectangles formed of man-handled stones mark the foundations of the primitive dwellings of an unknown race; and burial urns containing charred human remains and awls and needles of antelope and turkey bone have been dug up in this vicinity.

On the mesas north of the Gila, opposite its junction with San Simon Creek, there are considerable areas of level land, the stones from which have been collected in irregular rows to form numerous small plots of cleared ground. These may have been camp grounds, or possibly, during the summer rainy season, they may have been used for the culture of aboriginal crops, such as corn and beans. Corn, beans, and native cotton have been found in cliff dwellings on Bonita Creek, a few miles distant. All this is evidence that the region was formerly inhabited by more or less sedentary peoples, who must have supported themselves partly by hunting and partly by a primitive agriculture.

Civilized occupation of the region did not begin until the sixties of the last century, when a colony of Mexicans settled the village of San Jose, near the mouth of San Simon Creek, and irrigated their land with water from the Gila. They were followed by Americans, at Solomonsville, in 1870, and by subsequent colonies at Safford and in the Artesia district.

American cattlemen first grazed their herds in San Simon Valley about 1867, being attracted by profitable contracts to supply beef to army posts in southeastern Arizona. Overgrazing and erosion have so devastated the valley in recent years that it now sustains only a comparatively small number of cattle.

The discovery of artesian water at San Simon station, on the Southern Pacific Railroad, in 1910 gave a considerable impetus to the agricultural development of the surrounding district by artesian wells.

The lands now actually under cultivation in the entire San Simon Valley, exclusive of the part that is irrigated from the Gila, are roughly estimated to include, in the Bowie district and on the east slope of the Chiricahua Mountains, 500 acres, in gardens, orchards, and forage crops; in the Rodeo district, 800 to 1,000 acres, in grain sorghums, corn, and beans; in the San Simon district, 2,000 to 2,500 acres, in grain sorghums, sweet sorghums, alfalfa, corn, and winter grains; and in the Artesia district, 800 to 1,000 acres, in gardens, orchards, and forage crops.

SOILS.

The valley fill consists largely of heavy yellow and bluish clays laid down in a lake that occupied the basin in late geologic time. These lake beds are exposed along the Gila Valley and in the northern part of San Simon Valley. Beds of volcanic ash, which settled in the waters of the ancient lake, outcrop at a number of places in the Gila Basin. This material, which is locally but erroneously known as "gyp rock," is soft and easily worked and has been considerably used in the Gila Valley as a building stone.

Overlying the lacustrine deposits in many places are gravels and sands washed down from adjacent mountain sides. Detrital deposits of poorly sorted boulders, gravel, and sand extend as alluvial fans far out into the valley from the mouths of the steeper mountain canyons.

The soils of San Simon Valley thus consist of heavy impervious clays derived from lacustrine deposits, and sandy or gravelly loams derived from material washed down from adjacent mountain slopes.

By reason of the steep gradients and good drainage extensive accumulations of alkali salts do not occur in San Simon Valley. As the drainage basin contains large areas of granitic rocks, however, sodium carbonate is found in the soils and in the artesian waters of the district. One effect of this sodium carbonate, or black alkali, may be to make more difficult the cultivation of the valley bottom clay, which tends to become deflocculated, plastic, and impervious under its influence. The soils of the valley are nearly everywhere fertile under irrigation, but, like soils elsewhere in the semiarid Southwest, they are deficient in nitrogen and humus. There is a considerable area of marshy soil at San Simon Cienaga, where the combined drainage of Cave Creek and upper San Simon Creek has formed a body of black land rich in organic matter, derived from locally abundant vegetation.

VEGETATION.

The native vegetation of San Simon Valley is of high economic utility. Pine forests at higher altitudes, in the Chiricahua and Pinaleno mountains, have afforded local supplies of lumber for many years. A scattering growth of juniper, oak, and walnut below the pines supplies timber and posts. Sycamores and cottonwoods border the stream courses, and a stunted growth of mesquite, valuable for fuel and posts and for its nutritious pods, covers large areas in the valley bottom.

The valley was originally grassy. Extensive flats covered with sacaton occupied the flood plain, restraining the summer storm waters and effectually preventing erosion. With the advent of cattle, however, the sacaton was overgrazed, and erosion began along cattle trails and wheel ruts and continued until the valley is now drained throughout most of its length by deep and wide barrancas, which have permanently changed the surface. Sacaton pastures are therefore now in large part replaced by bare flats or playas, which, however, during the summer rainy season, produce an abundant crop of "red-root" forage, much relished by cattle. An annual growth of grama and six-weeks grasses covers the higher ground and still supports a considerable number of cattle. In favorable places there is a growth of other forage plants, such as succulent fruit-bearing opuntias, which are eaten by cattle; saltbushes; and even sotol, or Spanish bayonet, the sweet young flower stalks of which are eagerly eaten by range cattle. Alfileria has been introduced and affords winter feed.

On the whole, stockmen regard the San Simon Valley as brushy or "browse" country, rather than as typical grassland.

AGRICULTURAL POSSIBILITIES.

Aside from grazing the types of agriculture practiced or proposed within San Simon Valley are irrigation farming by surface water or by water from artesian wells, dry farming, dry farming supplemented by irrigation with flood water and pumped water, and dry farming supplemented by the use of the adjacent range for grazing.

IRRIGATION FROM STREAM FLOW.

In the Chiricahua Mountains small isolated areas are irrigated by mountain streams, whose effectiveness may hereafter be increased by means of small storage reservoirs. These high irrigated areas are well adapted to raising fruit, especially apples, pears, peaches, plums, prunes, grapes, and bush fruits, as well as grain, forage crops, and many kinds of vegetables. Such products find a ready market in adjacent mining camps, so that the cultivation of these small but well-watered areas is profitable.

ARTESIAN IRRIGATION.

Two distinct artesian districts have been developed within the valley. The older of these districts, which was discovered about 20 years ago, lies on the east slope of Graham Mountain, at an altitude of 3,500 to 4,000 feet. Most of the wells are south of Safford, in washes that lie below the mouths of mountain canyons. Their water supply is apparently derived from mountain run-off caught under the edges of uptilted clay strata, between which the water descends with accumulation of hydrostatic head. These wells yield black alkaline water, and some of them carry a high content of sulphates and common salt. These waters, through their use for irrigation, but more especially through the waste from uncapped wells, have caused the accumulation of injurious amounts of alkali in the soils of some areas. In this district, which is well above the general level, the air circulates freely, so that the cold air flows out and is replaced by warm air from lower levels. The season is therefore about three weeks earlier than in the lower-lying Gila Valley. The soils of this district are sandy loams, which are well adapted to gardening. Alfalfa and other legumes should be grown in this district, for the artesian waters used carry no sediments rich in organic matter and nitrogen, as do the muddy river waters used for irrigation in other parts of the region. Deciduous fruits may be grown here successfully, and also some subtropical fruits that resist frost fairly well, such as certain varieties of figs. Bees and poultry do well, and goats have been ranged in connection with general farming.

The San Simon artesian basin was discovered in 1910. It lies in the valley bottom on the Southern Pacific Railroad, at an altitude of about 3,600 feet. Its soils and climate are probably not so well adapted to fruit growing as some other parts of the valley, but the more abundant artesian and flood-water supplies are favorable to general farming.

Wheat and barley and both grain and forage sorghums grow well in this district, and Sudan grass thrives on even a scant supply of water. Certain varieties of Indian corn, such as Mexican June, do well, and so also does alfalfa, in places where sufficient water can be provided.

Most of the lands in this district must be grubbed and leveled, and reservoirs must be constructed to store good irrigating heads of water from the wells, which generally yield too small a flow to afford a direct supply for irrigation. The use of silos for storing succulent forage will materially assist in developing the live-stock industry in this district. Irrigation farming should as far as possible be carried on in conjunction with stock raising or vice versa. In this way the irrigated forage supplements the wild feed of the range, and the range supplies feeders for the irrigated forage as well as for supplementary wild feed at times of favorable rainfall.

DRY FARMING.

The somewhat uncertain and varying precipitation averages from 10 to 15 inches yearly, and therefore dry farming, if unassisted by supplementary water supplies, can hardly insure satisfactory crops. In unusually favorable seasons, such as the winters of 1904–5 and 1915–16, the rainfall is sufficient to make grain hay or even to mature a crop of wheat or barley.

A favorable succession of summer rains will also make such hardy, quick-growing crops as milo maize, feterita, tepary beans, pumpkins, and Sudan grass. After a few such favorable seasons speculative promotions of so-called dry-farming lands have led to the settlement of lands which later have been found to require a more certain and abundant water supply than is ordinarily afforded by direct rainfall.

Supplementary supplies in areas outside of artesian districts can be obtained occasionally by the use of flood waters and by pumping from wells. Storm waters from higher altitudes, particularly in summer, are diverted and used successfully by the Mexicans and Indians of the Southwest for irrigating quick-growing crops of corn, beans, melons, and squashes, and, especially with the help of small storage reservoirs, should be available in San Simon Valley where the topography is favorable.

In certain areas wells of moderate depth and good capacity may be pumped to advantage. On the edges of the artesian district the hydrostatic head brings deep-well waters nearly to the surface, so that they can be easily pumped. By the use of pumped water at critical times to start or save a crop the dry-land farmer may tide over periods when rainfall fails to afford an adequate supply.

In brief, it may be stated that at altitudes below 5,500 feet in San Simon Valley and elsewhere in Arizona dry farming must be supplemented by a water supply, either from storms, storage reservoirs, or wells.

FARM MANAGEMENT.

Though but few exact data are available upon which to base any very definite recommendations, certain suggestions may be of profit to the new farmer in this district. Where the water supply is comparatively abundant, as at Artesia, in the Chiricahua Mountains, and near San Simon, the farmer's problem is comparatively easy. He can grow a great variety of deciduous fruits, vegetables, and forage crops. But where only the rainfall, supplemented by a scanty supply of ground water, is available the problem becomes difficult and its successful solution requires careful management.

The home vegetable garden.—Of immediate importance to every pioneer family is the area, say about an acre, of fruit trees and garden that may be irrigated by water from the house well, pumped by a windmill or a small oil engine and stored in a small tank or reservoir to maintain an irrigating head. By means of this equipment the table may be supplied every month in the year with a variety of excellent vegetables—in spring and summer with asparagus, corn, beans, pumpkins, squashes, melons, cantaloupes, tomatoes, and deciduous fruits, such as peaches, apples, pears, grapes, and plums, and in winter with beets, cabbage, cauliflower, onions, turnips, radishes, lettuce, and spinach. Some of these products, such as Hubbard squashes, pumpkins, and dried fruits, will keep for a long time. Cabbage may be made into sauerkraut and fruits may be canned. Half the food supply of an ordinary family may thus be obtained from a well-tended vegetable garden that is properly planned, cultivated, and protected from insect pests.

Hardy trees for shade and ornament, such as tamarisks, oleasters, mulberries, cottonwood, and ash, may also be watered from the domestic water supply.

Grain and forage.—In a very wet winter and spring wheat, barley, and oats will make hay, but ordinarily they must be irrigated to make grain. The sorghum grains, such as milo maize, feterita, and Kafir corn, are drought resistant and mature good crops of grain with a minimum supply of water. Certain quick-growing varieties of Indian corn also, if planted early in July, will with necessary irrigation make successful crops.

Sorghum is a standard drought-resistant forage, and Sudan grass, which has been recently introduced, promises to become a hardy and valuable crop. Alfalfa requires abundant irrigation and is not well adapted to dry farming.

To some extent the grains and forages mentioned above may be sold as such, especially barley and baled hay, but new, rough roads, distant markets, and competition with older districts render it more profitable to utilize as far as possible the grain and forage for feeding live stock, for the raising of which the adjacent grazing ranges may be utilized.

Horses and mules.—Horses and mules raised in the adjacent Gila Valley and allowed to range on near-by mountain pastures are well known for stamina and for sound feet and legs. The forage and grain produced on a dry farm combined with range pasture produces excellent work and driving animals.

Beef cattle.—The forage and grain produced on farms in San Simon Valley should be profitably fed to cattle from adjacent ranges, or at least should be used to tide over times of drought and scarcity on the open range. In many thinly settled locations dry farms and grazing ranges will supplement each other profitably.

Dairy cows.—By means of cheaply constructed pit silos corn and sorghum can be converted into silage for feeding dairy stock, especially at times of drought, when succulent feed is not otherwise to be had. In semiarid districts in New Mexico that somewhat resemble San Simon Valley incomes are earned in this manner and by cooperative cream collecting and hauling.

Hogs.—Milo maize and feterita are a cheap and excellent ration for hogs, having been found superior to alfalfa for this purpose. These drought-resistant crops should therefore provide the dry-farm homestead with its meat supply and should afford a cash return.

Poultry.—Milo maize, feterita, and the miscellaneous seeds and green produce of a dry farm afford good feed for chickens and turkeys. Turkeys in particular are worthy the consideration of settlers in this district. They are native to the region and thrive not only on what may be grown for them but also on wild food, such as red-root weeds and grasshoppers. They command good prices also when they are ready for market.

Bees.—Many plants in the valley afford honey to bees in considerable quantity at certain seasons of the year. The mesquite yields excellent honey, and the mountain foothills during the summer rains carry much wild bloom.

SUMMARY.

In those areas of San Simon Valley that are more abundantly watered by stream flow and by artesian wells a great variety of deciduous fruits and vegetables, as well as grain and forage that may be converted into live-stock products, may be readily grown

In localities that must depend on rainfall supplemented by pumped reservoir or storm waters a greater diversity of methods and of products will be required for success in agriculture. Among the resources available to the pioneer dry-land farmer in this district are the home garden, which yields a great variety of fruits and vegetables; drought-resistant grain and forage, such as quick-growing varieties of Indian corn, milo maize, feterita, sorghum, and Sudan grass; and live stock, including horses, mules, cattle, dairy cows, hogs, and poultry. Pit silos are essential to success with live stock, especially dairy cows; and the adjacent grazing ranges should be utilized as a source of supplementary feed.