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THE MOHAVE DESERT REGION
CALIFORNIA

A GEOGRAPHIC, GEOLOGIC, AND HYDROLOGIC RECONNAISSANCE

BY

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PREFACE

By O. E. Meinzer

Among the duties of the United States Geological Survey are those of "determining the water supply of the United States, the investigation of underground currents and artesian wells, and the preparation of reports upon the best methods of utilizing the water resources." In the performance of this duty, the Geological Survey has investigated the water resources of 30 to 40 areas in the arid portion of the country. (See pl. 1.)

In addition to the usual appropriation for the investigation of water resources, on August 21, 1916, Congress passed an act authorizing the survey, marking, and protection of desert watering places, for which purpose the sum of $10,000 became available on July 1, 1917. With this money, supplemented by an allotment from the usual appropriation, four field parties were organized, and a survey was made during the year from July 1, 1917, to June 30, 1918, of about 60,000 square miles of the desert region in southeastern California and southwestern Arizona. Signs directing travelers to water were erected at 305 localities, 167 of them in California and 138 in Arizona. Maps were made in the field showing the location of the principal roads and watering places, and many samples of water were collected and analyzed in the water-resources laboratory of the Geological Survey. The maps, together with logs of the roads and brief notes on the watering places have been published as Water-Supply Papers 490–A to 490–D, Routes to desert watering places in California and Arizona.[1]

In connection with the survey of desert watering places a large amount of information was obtained in regard to the geography, geology, and hydrology of the region covered. This information, supplemented by data from other sources, has been used in the preparation of a series of four reconnaissance reports, each covering the part of the region studied by one of the survey parties. The large

[1] Brown, J. S., Routes to desert watering places in the Salton Sea region, Calif.: U. S. Geol. Survey Water-Supply Paper 490–A, pp. i–v, 1–86, pls. 1–7, 1920. Thompson, D. G., Routes to desert watering places in the Mohave Desert region, Calif.: U. S. Geol. Survey Water-Supply Paper 490–B, pp. i–vii, 1–4, 87–269, pls. 1–4, 8–18, 1921. Ross, C. P., Routes to desert watering places in the lower Gila region, Ariz.: U. S. Geol. Survey Water-Supply Paper 490–C, pp. i–iv, 1–4, 271–315, pls. 1–3, 19–22, 1922. Bryan, Kirk, Routes to desert watering places in the Papago country, Ariz.: U. S. Geol. Survey Water-Supply Paper 490–D, pp. i–vi, 1–4, 317–429, pls. 1–3, 16, 23–28, 1922.

size of the areas surveyed by each party and the requirements of the work of erecting signposts and collecting data for the guidebooks prevented the study of the regions in as detailed a manner as might be desired, but the reports contain a large amount of new and useful information on this little-known portion of the United States.

The present report on the Mohave Desert region, by David G. Thompson, is the last of these reports to be published.[2] It is based not only on the survey that was made in 1917 and 1918 but also on field work done in the region in 1919, 1920, and 1921. The report was completed by the author in May, 1924, but was not sent to the printer until 1928. The relief maps (pls. 9, 10, 11, 12, and 13) were printed in Water-Supply Paper 490–B in 1921, and have not been revised. Some information in regard to precipitation, stream discharge, water levels in wells, changes in roads, etc., in the period since the report was completed, has been added, but it has not been practicable to add information in regard to all recent developments in the region.

The Mohave Desert region has an area equal to the combined area of Massachusetts, Rhode Island, Connecticut, and New Jersey, but it would be difficult to conceive of two regions more strikingly different—one densely populated and teeming with industry, the other in large part virtually uninhabited. Almost equally striking, however, and in some respects of more practical importance is the contrast between this almost undeveloped desert region and the region just across the mountains to the west and southwest, including the valley of southern California and other valleys nearer the coast, with their exceedingly productive and valuable irrigated lands. As these better-watered valleys nearer Los Angeles have approached the limits of possible development, their enterprising inhabitants have looked more and more earnestly toward the Mohave Desert region and asked the question whether in its vast expanse, with its 50 desert valleys, each occupying a closed drainage basin of its own, there are not opportunities for making irrigation developments similar to those that have been so successful in the coastal region. Many attempts have already been made to develop irrigation districts in different parts of the region, in a few places with considerable success, as in Antelope Valley, but more commonly with complete failure. The interest in the possibilities of irrigation in this region is, however, unabated, and the United States Geological Survey is constantly

[2] The three reports previously published are Brown, J. S., The Salton Sea region, Calif., a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 497, xv, 292 pp., 19 pls., 1923; Ross, C. P., The lower Gila region, Ariz., a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 498, xiv, 237 pp., 23 pls., 1923; Bryan, Kirk, The Papago country, Ariz., a geographic, geologic, and hydrologic reconnaissance, with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 499, xviii, 432 pp., 27 pls., 1925.

receiving inquiries in regard to the ground-water conditions of one locality or another in the region.

In spite of this interest in the Mohave Desert region only very inadequate information has been available in regard to its water supplies. Its vast extent and scarcity of inhabitants and watering places has made any comprehensive and thorough survey of its water resources a formidable undertaking. Though necessarily based on deficient information in many respects, the present report is a more comprehensive and accurate description of the region and contains a more critical and reliable discussion of its water resources than has hitherto been published.

ANTELOPE VALLEY

Antelope Valley is one of the few areas in the Mohave Desert region in which irrigation has been successful to a considerable extent. The water supply of the valley was described by Johnson [79] in 1911, but since that time many new wells have been drilled. The writer collected information in the valley in December, 1918, December, 1919, January, 1920, and April and May, 1921.

The writer is indebted to Messrs. H. A. Brodie and L. S. Tudor, of the Southern California Edison Co.; Burt Cole, engineer for the Palmdale irrigation district; J. W. Scott, engineer for the Little Rock irrigation district; and Harry Austin, R. H. Orr, C. L. Mason, and N. S. Abbott for information in regard to wells, acreage under irrigation, and other valuable data. W. R. Parkhill and C. H. West, engineers of the Federal Land Bank of Berkeley, also kindly furnished data.

In addition to the report by Johnson cited above, several other published reports [80] contain brief data in regard to Antelope Valley. The writer has also been permitted to examine several unpublished reports by engineers in regard to the utilization of the surface waters of certain parts of the valley for irrigation.

LOCATION AND SETTLEMENTS

Antelope Valley lies in Los Angeles and Kern Counties, in the southwest corner of the Mohave Desert region (see pl. 7), and is bounded on the south and west by the high San Gabriel and Tehachapi Mountains. These ranges serve as barriers to the rain-producing winds that blow from the Pacific Ocean in winter, and for that reason the precipitation is so low that in most parts of the valley crops can

[79] Johnson, H. R., Water resources of Antelope Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 278, 1911.

[80] Davis, A. P., Report of progress of stream measurements for the calendar year 1896: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 4, pp. 402–405, 1897. Describes a stream-gaging station on Little Rock Creek and gives the estimated discharge of the creek for 1896.

Schuyler, J. D., Reservoirs for irrigation: Idem, pp. 711–715, 737. Describes proposed reservoirs of the Antelope Valley Water Co. and the Alpine (now called Harold) reservoir of the South Antelope Valley Irrigation Co.

Operations at river stations, 1897, Part II: U. S. Geol. Survey Water-Supply Paper 16, p. 193, 1898. Gives record of daily gage height at gaging station on Little Rock Creek for 1897.

Newell, F. H., and others, Report of progress of stream measurements for the calendar year 1897: U. S. Geol. Survey Nineteenth Ann. Rept., pt. 4, p. 527, 1899. Gives estimated monthly discharge of Little Rock Creek for 1897.

Operations at river stations, 1898, Part II: U. S. Geol. Survey Water-Supply Paper 28, p. 189, 1899. Gives record of daily gage height at gaging station on Little Rock Creek for 1898.

Newell, F. H., Report of progress of stream measurements for the year 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 4, p. 540, 1900. Gives estimated monthly discharge for Little Rock Creek for 1898.

Newell, F. H., Report of progress of stream measurements for the year 1899: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 4, pp. 470–471, 1901. Gives estimated monthly discharge of Little Rock Creek for 1899.

Johnson, H. R., Water resources of Antelope Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 278, 1911. Describes in considerable detail both the ground water and surface water supplies of the valley. Gives data in regard to 353 wells.

Tait, C. E., Irrigation resources of southern California: California Conservation Comm. Rept., pp. 322–324, 1912. Gives a brief outline of developments in the valley up to 1912.

Adams, Frank, Irrigation districts in California, 1887–1915: California Dept. Engineering Fifth Bienn. Rept., appendix B, pp. 10, 37–39, 91–93, 1917. (Originally printed as Bull. 2 of State Dept. Engineering, 1916.) Gives briefly the history of the different irrigation districts formed in the valley.

not be grown without irrigation. The more prominent topographic features of the region are shown on Plate 19 and on the relief maps, Plates 9 and 10.

The valley lies 40 miles north of Los Angeles, but the distance by railroad or highway is nearly twice as great, owing to the fact that high mountains necessitate a wide detour to the west. The line of the Southern Pacific Railroad that runs from Los Angeles to San Francisco by way of San Joaquin Valley crosses the valley from south to north, and the line of the Atchison, Topeka & Santa Fe Railway from Barstow to San Francisco crosses the northeast corner. The valley is also connected with Los Angeles by a good paved road, which is part of one of the roads that connects southern California with the Lincoln Highway between San Francisco and Salt Lake City.

The largest town is Lancaster, on the Southern Pacific Railroad near the center of the valley. The next in size is Palmdale, on the railroad 8 miles south of Lancaster, near the foot of the San Gabriel Mountains. The only other town on the railroad is Rosamond, 12 miles north of Lancaster. Lancaster and Palmdale are thriving towns, with hotels, good stores, and banks. Little Rock, 10 miles southeast of Palmdale; Del Sur, 9 miles west of Lancaster; and Fairmont, 19 miles west of Lancaster, are small communities, each with a post office and general store. Valyermo and Llano, each 20 miles southeast of Palmdale; Wilsona, about 20 miles northeast of Palmdale; Neenach, 28 miles northwest of Lancaster; Domino, 16 miles west of Rosamond; and Muroc, on the Atchison, Topeka & Santa Fe Railway, are post offices that serve scattered ranches.[81] All these communities are reached by automobile, and roads lead from the valley to desert towns lying to the north and east.

HISTORY OF IRRIGATION

Stock raising was probably the first agricultural activity of white men in this region. The first attempts at farming any large portion of the valley seem to have been made near the foot of the mountains along the south side of the valley, where the rainfall is somewhat greater than in the center of the valley. Some of the early settlers, especially those on the lands west of the Southern Pacific Railroad around Del Sur, Fairmont, and Neenach, tried to grow crops without irrigation. In years of abundant rainfall they seem to have been successful. For instance, it is said that 750 carloads of wheat was shipped from the valley in 1893,[82] most of it presumably from the region between Del Sur and Neenach. One man is said to have had 1,000 acres in wheat and barley. The following year, however, the rainfall was deficient, and the crop failed.

[81] Runnington post office, shown in Plate 9, and Casa Desierto post office, shown on Plate 10, are not listed in the 1928 edition of the Postal Guide and apparently have been discontinued.

[82] Farm, Field, and Fireside, vol. 17, No. 16, pp. 524–527, Apr. 21, 1894.

During the early nineties a wave of schemes of land settlement swept over the Western States, and in California conditions were made favorable by the passage in 1887 of a law known as the Wright Act. This law "sought to confer on farming communities powers of municipalities in the purchase or construction and the operation of irrigation works." [83] In Antelope Valley six irrigation districts were organized under the Wright Act between 1890 and 1895, known as the Neenach, Manzana, Amargosa, Palmdale, Little Rock Creek, and Big Rock Creek districts. The Little Rock Creek district is the only one that can be said to have been entirely successful, after a hazardous career, and the Big Rock Creek district is the only other one that still exists. Recently a new Palmdale district, which embraces in part the lands of the old Palmdale district, has been organized under a new law.

One of the most pretentious projects was located on Rock Creek (often called Big Rock Creek), then called Rio del Llano (river of the plain). This project was fostered by a paper devoted to farming interests, which proposed the establishment of a colony where the colonists would have an opportunity to build homes for themselves.[84] The plan seems to have been a bona fide scheme, which promised no great profits to the promoters, and the land with water rights was sold much cheaper than in neighboring districts. Before the land was obtained by the colony several hundred acres of fruit trees, grapes, and alfalfa had been brought to a productive state by a few ranchers, who used water from the creek. The promoters of the colony obtained 8,000 acres of land, all of which was quickly sold under contracts, and steps were taken to obtain an additional area of 10,000 acres, but this area was in litigation and was not immediately obtainable.

During the same period that the Rio del Llano colony had its inception other colonies were being started along the north foot of the mountains. The Alpine Springs colony was located on the site of the present Little Rock Creek district. It contained 1,300 acres, planted mostly with almonds and prunes.[85] At Manzana 1,500 acres was sold and planted, mostly in almonds,[86] and at Almendro, at the west end of the valley, it was planned to set out 800 acres in 1895, mostly in almonds. Probably at least 1,000 acres additional had been set out by private parties. It is probable that during this period areas aggregating from 12,000 to 15,000 acres were bought in different parts of the valley by prospective colonists who expected

[83] Adams, Frank, Irrigation districts in California, 1887-1915: California Dept. Eng., Fifth Bienn. Rept., appendix B, p. 8, 1917. This report was also published as California Dept. Engineering Bull. 2, 1916.

[84] The information on the early history of this colony is gathered from numerous articles in different numbers of Farm, Field, and Fireside, vols. 17-20, 1894-1897.

[85] Farm, Field, and Fireside, vol. 17, p. 828, June 23, 1894.

[86] Idem, pp. 521-524, Apr. 21, 1894.

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to set out orchards. Some idea of the magnitude of the developments may be obtained from the following quotation from Hinton:[87]

In the Antelope Valley proper, since April, 1889, some 10,000 acres have been brought under cultivation; this area can be readily increased to 25,000 acres. It is estimated that in all 50,000 acres are now under ditch. The surface supply is obtained from mountain streams, stored in three reservoirs, with a total capacity of 30,000,000 gallons.[88] The works include five dams, five headways, seven weirs, and six tunnels driven into the foothills. The main ditches are 50 miles in length, 5 feet wide at the top. There is an equal mileage of distributing and lateral ditches.

The colonization projects seem to have been started at what proved to be the most inopportune time in the history of the valley. During eight out of the eleven years from July 1, 1893, to June 30, 1904, the mean annual rainfall for the places at which precipitation records have been kept for a long period was considerably below the normal. (See table on p. 85 and pl. 6.) For two successive years, 1897–98 and 1898–99, the precipitation was the lowest yet recorded at several of the stations for which the records are given; the longest record covers a period of 50 years.

The colonists had hardly set out their orchards when they were hit by the unprecedented drought. The orchards on the west side of the valley, which depended almost entirely on rainfall for water, were the first to wither, but it was not long before Rock and Little Rock Creeks dwindled to a point where they did not carry enough water for the large acreage set out. Most of the settlers were forced to give up their new homes. A very few were able to continue on their places until years of more abundant rainfall. Tracts amounting to many hundreds of acres were abandoned, for in 1910 less than 5,000 acres was irrigated in the valley.

Mr. O. Lewis, of Little Rock, states that in the dry years of 1897–1899, as the flow of Little Rock Creek dwindled, family after family moved out until he was practically the only landowner left in the district. He installed a pumping plant in a well dug in the creek bottom and was thus able to keep his orchard from dying. After the drought had passed some of the settlers gradually drifted back, and eventually the Little Rock Creek district was placed on a sound basis. The original orchards were largely planted with almonds and olives, but these trees suffered greatly from the drought, and in the years since that period most of the orchards have been set out with pear trees and a smaller number of apple trees.

Since its beginning the Big Rock Creek Irrigation District has been divided into two parts, known as the East Side and the West Side, located respectively on the east and west side of Rock Creek Wash.

[87] Hinton, R. J., Progress report of irrigation in the United States, pt. 1, p. 50, U. S. Dept. Agr., 1891.
[88] About 90 acre-feet. Either the figure given by Hinton is wrong or the storage capacity was exceedingly small in comparison with the diversion works that had been built according to his statement.

When the lands were first colonized in 1894, the headquarters of the East Side were at Llano and of the West Side at Almondale.

In 1914 an attempt was made to rehabilitate the Rio del Llano project by a group of socialists, who established a cooperative colony. Several hundred members joined the colony, each contributing a certain amount of money. It was to be operated on ideal socialistic principles of equal division of work and of benefits accruing therefrom, and it was expected that the colony would eventually become nearly independent of the outside world. Internal troubles arose over the management of the colony. In the early part of 1918 most of the colonists were sent to Louisiana to form a new colony, and Llano was practically abandoned. In 1919 a large part of the area that was formerly irrigated was badly neglected.

Almondale was abandoned during the extreme drought of the nineties and has not been revived, but a community known as Longview has been established on some of the West Side lands, and several hundred acres of fruit trees are being irrigated. It is reasonable to believe that eventually the district may become as highly developed as the Little Rock Creek district.

The districts on the west side of the valley did not survive the drought of the nineties. It was found that the water supply that was to be used for irrigation was not sufficient except in seasons when the precipitation was above the normal, and the projects were abandoned. Hundreds of acres of almond and olive trees were allowed to die, but about 1,000 acres of trees at Manzana are still cultivated without irrigation and in some years produce good yields.

At about the time the Little Rock Creek Irrigation District was organized the South Antelope Valley Irrigation Co., later called the Palmdale Water Co., was organized as a private corporation, not under the Wright Act. This company also used water from Little Rock Creek, carrying it by open ditch to a natural depression, known as the Alpine or Harold Reservoir, about a mile south of Palmdale. Until recently no storage was provided on the creek. The Little Rock Creek district has used the flow of the stream only during the irrigation season, but the Palmdale Co. has stored some of the winter flow in the Harold Reservoir. This reservoir, however, has a capacity of only about 3,000 acre-feet, and in winter, when the run-off is greatest, much water has been lost. Recently the Palmdale Irrigation District has been organized. It covers practically the same territory that was served by the Palmdale Water Co., which has sold its holdings and water rights to the new district. The Palmdale district and the Little Rock Creek district joined on a project to build a concrete dam on Little Rock Creek with a view to impounding the greater part of the excess flow that is not diverted to the Harold Reservoir. In January, 1919, a bond issue of $580,000 was voted for this purpose.

In the Palmdale district about 700 acres has been irrigated, and in the Little Rock Creek district about 1,600 acres, practically all in pears or apples. When the new storage works are completed the plans provide for irrigating about 5,000 acres in the Palmdale district and about 3,000 acres in the Little Rock Creek district.[89]

While the southern margin of Antelope Valley has been developed by water from Rock and Little Rock Creeks, a large area in the central part has been developed by water from drilled wells. Early in the eighties it was discovered that flowing wells could be obtained in the lower part of the valley near Lancaster by drilling to depths of 200 to 500 feet.[90] The development of the ground-water resources at first was not rapid. Johnson's report gives a list of 353 wells that had been drilled up to January, 1909.[91] Only 23 wells are given in this list as being drilled during the 10-year period 1881 to 1890, but Hinton states that in 1890 more than 100 wells were in use, of which five were flowing wells.[92] Definite figures for the period since 1908, when the field work on Johnson's report was finished, are not available, but the rate at which wells have been drilled has apparently been somewhat greater than before 1908. One driller put down about 80 wells from 1912 to 1919, and another about 40 wells from 1917 to 1919. Other drillers have also put down a considerable number of wells. Probably at least 150 wells have been drilled since 1908, and the total number that have been drilled in the valley is not far from 500, but not all of these are now in use.

In the early years the land in the central part of the valley was devoted principally to cattle raising. Gradually, however, an increasing area was irrigated from wells. The water for irrigation was at first obtained almost entirely from flowing wells. Practically no pumping plants were used for irrigation prior to 1900. In the list of 353 wells given by Johnson less than 40 are indicated as equipped with pumping plants in 1908, including several that were used by railroads or for manufacturing. Since 1908 the number of pumping plants has increased greatly. In January, 1920, the Southern California Edison Co. was furnishing electric power to more than 200 pumping plants, and in addition there were 25 to 50 pumping plants operated by gasoline or oil engines.

The greatest development at first took place in the area of artesian flow because of the ease with which water could be obtained. In a large part of this area, however, there is so much alkali that the land

[89] The dam has been completed since the above statement was written, but no information is available as to the results of its use. All statements in this report are based on conditions as they were in 1919, unaffected by storage of water which has since taken place.

[90] Hinton, R. J., Progress report of irrigation in the United States, p. 50, U. S. Dept. Agr., 1891. Johnson, H. R., Water resources of Antelope Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 278, well No. 298, p. 86, 1911.

[91] Johnson, H. R., op. cit., pp. 70-88.

[92] Hinton, R. J., op. cit., p. 50.

is useless for crops. Nevertheless many wells were put down on land covered with alkali merely to get title to the land under the desert-land laws. At a number of places the settlers tried to grow crops, only to have them killed by alkali or by salt grass that got a better footing in the alkali soil.

The developments in recent years have been confined largely to raising alfalfa on land that lies near the margins of the area of artesian flow, where the alkali is not bad, and land that lies not more than a mile or two outside the area of artesian flow, where the pumping lift is not more than 50 feet. In the last few years a number of wells have been drilled higher up on the alluvial slope to be used in irrigating fruit orchards, which yield a sufficient return to warrant a high lift. The most notable development of fruit orchards has been between Palmdale and Little Rock and northwest of Palmdale, where several hundred acres of fruit trees, mostly pears, have been set out. Although some fruit trees are being grown in the alfalfa-producing region, fruit growing on a commercial scale is practically confined to the higher lands on the south side of the valley. In 1920 experiments were made in growing rice on the clay flat of Rosamond "Dry Lake" on the north side of the valley, but the results were not satisfactory.

In addition to the lands irrigated in Antelope Valley several hundred acres is under cultivation in mountain valleys that are tributary to the main valley. Near Valyermo 300 acres or more of pear and apple orchards are irrigated with water from Rock Creek and yield good returns. A few hundred acres is devoted to fruit and grain in Leonis Valley, a long, narrow valley drained by Amargosa Creek, west of Palmdale. The rainfall here is greater than in Antelope Valley and irrigation is not practiced. Some of the lands are naturally moist.

In the last few years the development of Antelope Valley has been rapid. In a report published in 1912 the area of irrigated land in the valley is given as 4,629 acres.[93] The following summary, compiled from information obtained by the writer from various sources in January, 1920, gives some indication as to the area irrigated in the valley in 1919.

[93] Tait, C. E., Irrigation resources of southern California: California Conservation Comm. Rept., p. 326, 1912.

Estimated area irrigated in Antelope Valley in 1919

Locality and source of water	Nature of crop	Area (acres)
Water supply from surface streams:		
Valyermo and Pallett ranches	Fruit	300
Llano	Fruit and alfalfa	300
Longview	Fruit	350
Little Rock	do	1,600
Palmdale	do	700
Water supply from wells:		
Electric pumping plants [a]	do	1,555
	Alfalfa	[b]6,855
Gasoline pumping plants and flowing wells	Fruit and alfalfa	300
		11,960

[a] The estimates of acreage irrigated by water from electrically driven pumping plants were obtained from H. S. Brody, district agent of the Southern California Edison Co., which furnishes power to probably 90 per cent of the pumping plants in the valley.

[b] Data received from Mr. N. S. Abbott, Lancaster, Calif., in December, 1924, show that the area of alfalfa irrigated as given in the above table may be too high. He stated that in 1919-20 the directors of the Alfalfa Growers Association of Antelope Valley made a careful survey and estimated the acreage then planted to be about 4,400 acres. He further stated that a careful compilation by L. S. Tudor, district agent of the Southern California Edison Co., showed an acreage planted to alfalfa in July, 1923, of 8,013 acres. Mr. Abbott stated that in recent years there had been a yearly increase in alfalfa acreage of about 1,000 acres.

The most rapid expansion probably occurred within the last year or two, to infer from shipments of certain products as given in the following table, furnished by the freight department of the Southern Pacific Railroad. Records for shipments prior to 1917 are not available.

Agricultural products shipped from stations in Antelope Valley, 1917–1919, in carloads

Station	Hay			Grain			Live stock			Deciduous fruit		
	1917	1918	1919	1917	1918	1919	1917	1918	1919	1917	1918	1919
Lancaster	333	809	1,479	2	2	3	54	73	63	8	3	1
Palmdale		17				3		10	5		72	102
Rosamond	2	20	57						1			
	335	846	1,536	2	2	6	54	83	69	8	75	103

The hay shipped from the valley is nearly all alfalfa. Most of it is shipped from Lancaster, and Rosamond ranks second. In addition to the shipments given in the table, an increasing tonnage of hay has been shipped to Los Angeles by motor truck. Mr. R. C. Hitte, of the Lancaster Feed & Fuel Co., estimates that in 1919 from 2,000 to 3,000 tons (equivalent to 180 to 270 carloads) was shipped by truck.[94]

About 80 per cent of the shipments of fruit consists of pears, and most of the remainder of apples. Practically all the fruit is shipped from Palmdale—that is, from the more elevated valley lands, where the orchards are irrigated from the mountain streams or where the

[94] Statistics furnished by the Southern Pacific Co. for shipments from 1920 to 1926 show that shipments of hay by railroad have decreased to almost nothing, apparently as a result of increasing shipments by automobile truck. The data are obviously of no value as an indication of agricultural production in the valley and hence have not been added to the table.

pumping lift is great. The small quantity of grain shipped comes principally from the dry-farm district between Del Sur and Neenach. In this connection the statement that 750 cars of grain was shipped in 1893 is of interest.

SOILS

A soil survey has been made of a large part of the Antelope Valley region.[95] The soils are composed essentially of detrital material washed into the valley from the mountains—that is, of fragments of granite, schist, gneiss, limestone, and volcanic and other rocks. On the alluvial slopes the materials range in coarseness from clay to sand, gravel, and boulders. In the lower part of the valley, around the playas, the soil contains a large amount of clay and silt and a proportionately smaller percentage of sand and gravel. The material that underlies the playas is practically all clay or silt.

Throughout the greater part of the alluvial slopes the soil seems to be fairly productive when provided with water, but on the lower land which surrounds the playas and extends for several miles from them the soil contains more or less alkali. Although alfalfa and other crops are grown in some places on the alkali soil, most of this land is not cultivated. In some places where low mounds of wind-blown sand are scattered over the surface alkali may not show at the surface, but when the land is leveled for irrigation alkali may later appear. This condition apparently exists only near the outer edge of the area of alkali soil, for elsewhere if there is much alkali it will rise to the surface of the sandy areas. The alkali in the soil in the lower part of the valley seems to be due principally to evaporation of ground water that has reached the surface by upward capillary movement.

As a result of the evaporation of the lakes that once existed in some of the closed basins of the Mohave Desert region common salt and other alkali salts were deposited with the clay and silt of the lake bottoms and the soils in such places, as well as the ground waters, are highly impregnated with alkali. This does not seem to have happened in Antelope Valley, for no extensive salt deposits have been found, and the water from wells drilled on or close to the playas is rather low in mineral matter. No data are available as to the depth to which the alkali extends. However, as it is due to evaporation, it is probably most abundant in the uppermost foot or two.

In the present investigation the boundary of the area of alkali soils was determined approximately at several places on the south side of the valley east and west of Lancaster. Where thus defined it agreed closely with the limit of the area in which flowing wells existed at the time of the investigation, which is shown on Plate 19, and doubt-

[95] Carpenter, E. J., and Cosby, S. W., Soil survey of the Lancaster area, Calif.: U. S. Dept. Agr. Bur. Soils Field Operations for 1922, advance sheets, 1926.

less the boundaries for the two areas are approximately the same throughout the valley. On this assumption it is estimated that the valley includes 75,000 to 100,000 acres in which the soil contains more or less alkali. In this area the cost of obtaining water from wells is less than in any other part of the valley, but unfortunately the topographic and soil conditions are not favorable to methods used to reduce alkali in other arid areas. In view of the fact that there is a vast acreage of land with better soil elsewhere in the valley much of the low land will doubtless remain uncultivated.

NATIVE VEGETATION

Many kinds of native plants grow in Antelope Valley, although the variety in any one locality is more or less restricted. The distribution of the different plant species is determined by a combination of factors that include variations in soil, moisture, and temperature. Hence there are plant zones the boundaries of which follow approximately the contour of the land.

The plant forms over most of the valley proper are desert shrub varieties, the large species being confined to the mountains or upper slopes of the valley. In the high mountains coniferous trees are found. These areas are included in national forests and are difficult of access, and hence these trees are used very little. The most noticeable treelike form in the valley is the Joshua tree, or giant yucca, which grows principally on the upper parts of the alluvial slopes and is rare below altitudes of 2,500 feet above sea level. The piñon or juniper is found in the upper part of the yucca zone and extends upward on the mountains. Between Fairmont and Neenach these two forms grow in greater abundance than has been observed by the writer at any other place in the Mohave Desert region. The yucca is the only large tree in the valley that can be easily obtained for fuel. It is composed of rather pithy material, however, which, although it gives much heat, burns out quickly. Deciduous trees are very rare in the valley, except where they have been planted by ranchers.

Some of the native plants are good indicators of the nature of the soil or the depth to ground water. Salt grass (*Distichlis spicata*) is one of the best of these indicators. It grows where the depth to ground water is shallow and also generally indicates some alkali in the soil. In some places in the alkali-soil area it is abundant; in others it is very sparsely distributed. Other types, commonly known as salt brush, grow in the alkali soil of the lower part of the valley. Mesquite trees, which are usually good indicators of shallow ground water, grow at places in the area of artesian flow and along the wash of Rock Creek southwest of Lovejoy Buttes.[96] Sagebrush

[96] Johnson, H. R., op. cit., p. 19.

(*Artemisia tridentata*) was observed on the intermediate part of the alluvial slope, the growth being particularly dense south and southwest of the Portland ranch, 6 or 7 miles west of Lancaster, at an altitude of about 2,400 feet above sea level. It is unusual to find this species growing at so low an altitude in the Mohave Desert region. There is probably no relation between the distribution of this plant and the shallow-water zone, but it is said to indicate good agricultural land. The creosote bush (*Covillea tridentata*), which is the dominant plant over most of the Mohave Desert region, is almost entirely absent throughout a large part of Antelope Valley and grows in abundance only around the borders of the valley.

PHYSICAL FEATURES

GENERAL FEATURES

Antelope Valley lies in a closed basin—that is, a basin which has no outlet for its surface streams. All the storm water either sinks into the ground or collects in the lower parts of the valley, where it is disposed of by evaporation.

The boundary of the drainage basin of the valley is shown on Plate 19. It is roughly triangular, like a huge arrowhead. On the south and southwest the valley is separated from a region that drains to the Pacific Ocean by the San Gabriel Mountains (on some maps named the Sierra Madre) and their westward extension—Sawmill Mountain and Liebre Mountain. The trend of these mountains is approximately N. 70° W. The San Gabriel Mountains are very steep and high. North Baldy, the highest peak in the divide of Antelope Valley, rises 9,389 feet above sea level, and several other peaks attain altitudes of more than 6,000 feet. The peaks of Sawmill and Liebre Mountains, however, are less than 6,000 feet above sea level.

On the northwest the valley is separated from the south end of San Joaquin Valley by the Tehachapi Mountains, the highest peak of which is Double Mountain, 7,950 feet above sea level. The trend of the Tehachapi Range is N. 65° E.

The divide between Antelope Valley and adjacent regions on the north and east is not so distinct as that formed by the San Gabriel and Tehachapi Mountains. In these directions the divide is marked in some places by low rock ridges or isolated buttes, but in other places it lies on slopes of alluvial material which have so gentle a grade that it is difficult to determine just where the divide is situated except by careful leveling or observation on the flood run-off. A large fan built out in front of Oak Creek, west of Mojave, slopes both southeastward toward Antelope Valley and northeastward to Fremont Valley, and the exact boundary between the two valleys is not known. It is probable that flood waters of Oak Creek at one time or another flow in both directions. The boundary north of the railroad between Bissel and Kramer is located with comparative accuracy. Topographic maps are not available for the east side of the valley, and it is not certain that the boundary of the basin from Kramer southward to the northern part of T. 6 N. is correct as it is represented in the map. South of T. 6 N. it is reasonably accurate, but at the extreme southeast corner of the basin a large alluvial fan has been built at the mouth of Sheep Creek, and it is impossible to determine accurately from the topographic map into which drainage basin that stream empties. The divide on the east and north is much lower than that on the southwest and northwest, the maximum altitude being not much over 3,500 feet above sea level.

Antelope Valley lies at a higher altitude than any of the valleys beyond the mountains that surround it, with one exception. The valley of Mohave River, on the east, is higher at its upper end than Antelope Valley, but toward the north it drops to an altitude between 2,100 and 2,200 feet. The lowest part of Antelope Valley is about 2,275 feet above sea level. The lowest part of Fremont Valley, to the north, is about 1,900 feet above sea level. The south end of San Joaquin Valley, which lies west of the Tehachapi Mountains, is only about 1,000 feet above sea level. San Fernando Valley and San Gabriel Valley, on the south side of the San Gabriel Mountains, do not reach altitudes of more than 1,000 feet.

The drainage basin of Antelope Valley includes topographic features of three principal kinds—mountains, alluvial slopes, and playas. The alluvial slopes and the playas form the valley proper. The alluvial slopes contain most of the area that is devoted to agriculture, but nearly all the water that is available for irrigation comes from the mountains.

The playas, usually called "dry lakes," occupy the lower parts of the valley and are nearly flat expanses underlain by clay or silt. The alluvial slopes are underlain by sand, gravel, and clay. They rise gradually from the playas and become steeper as they approach the mountains. From the upper limit of the alluvial slopes the mountains rise very steeply, and their sides are generally rough and rocky. The origin of the three kinds of features is described briefly in the following paragraphs. Their relation to the water resources of the valley will be discussed on subsequent pages.

MOUNTAINS

The San Gabriel Mountains and probably the Tehachapi Mountains have been raised to a great altitude by faulting—that is, they are huge blocks of the earth's crust that have been broken from the surrounding rocks and pushed up to a great height. This movement was probably very slow and it was probably accompanied by earthquakes. After being elevated, part of the mountains have been worn away by streams and other agents until now they are much dissected and very rugged.

Since the main mass of the San Gabriel Mountains and the western continuation of that range, the Sawmill and Liebre Mountains, were elevated, faulting of lesser magnitude has occurred along the north base of the range. The most obvious evidence of this later faulting is a succession of long, narrow valleys that have a northwesterly trend, separated from the main valley by narrow ridges. The outer ridge that adjoins the valley has been lifted up, or the valley behind it is a block that has dropped down. Several of these valleys stand out prominently on the relief maps (pls. 9 and 10); the most notable is the one occupied by Elizabeth and Hughes Lakes (Leonis Valley), which is drained by Amargosa Creek, Swartout Valley, and Lone Pine Canyon. The ditch of the Palmdale irrigation district from Little Rock Creek to the Harold Reservoir follows one of the valleys which is less prominently shown on the map but which is nevertheless a distinct valley. The Harold Reservoir also occupies one of these valleys. The direct road from Little Rock to Valyermo follows in a general way the fault line. Portal Ridge is a prominent ridge that separates Elizabeth and Leonis Valleys from the main valley. Careful observation shows less notable features that indicate the continuation of the fault line at other points along the north base of the San Gabriel Range.[97]

The succession of valleys and ridges or other features that indicate the fault zone can be traced northwestward and northward to San Francisco and beyond and southeastward through Cajon Pass and San Gorgonio Pass to the Salton Sea Basin. This long zone of faulting has been called the San Andreas rift. Movement along this rift farther northwest, particularly near San Francisco, caused the earthquake of April 18, 1906, which did so much damage in that city and elsewhere. There apparently was no movement along the San Andreas rift in Antelope Valley in 1906, but faulting along the rift has occurred in the region at least as recently as 1857.[98] Evidences of faulting are found at other places in the San Gabriel Range; the fault lines are approximately parallel to the San Andreas rift, but none of them are as continuous as the rift.

The origin of the rock hills on the north and east sides of Antelope Valley is somewhat obscure. There is evidence that the hills at the north end of the valley west of Rosamond have been faulted, but the extent of this faulting is not known. However, definite evidence of faulting has not been found in the hills on the east side. These hills are low, and their appearance suggests that they represent an old land surface that had been worn down nearly to a plain. They are now almost buried by alluvium.

[97] Lawson, A. C., and others, The California earthquake of April 18, 1906 (report of the State Earthquake Investigation Commission): Carnegie Inst. Washington Pub. 87, vol. 1, pp. 43-44, pls. 24-28, maps 7-10 in atlas, 1908.

[98] Idem, pp. 43, 52, 449.

ALLUVIAL SLOPES

Antelope Valley is underlain by a large amount of rock débris, which has been washed down from the surrounding mountains. By the process known as weathering the surface rocks of the mountains are being continually though slowly broken into fragments that range in size from mintue particles to boulders several feet in diameter. This débris is carried to the valley by the mountain streams. At flood stage the streams may carry very coarse material, including boulders a foot or more in diameter. In the mountains, where the grade of a stream is steep, its carrying power is great, but when the stream reaches the foot of the mountains its grade becomes less, the velocity of the water decreases, and it therefore drops some of its load. It deposits the coarsest material first and carries the silt and clay farthest.

Most of the débris is deposited in front of the mouth of the canyon, where the stream leaves the mountains, because the velocity of the stream usually decreases most rapidly at that place. It often happens that so much débris is deposited in the channel that the stream overflows on either side, giving rise to distributary streams, which also deposit sand and gravel. By this process a sloping fan-shaped plain, called an alluvial fan, underlain to great depths by coarse alluvium, is formed at the foot of the mountains. The fans built by several streams along the foot of the mountains may coalesce, forming a more or less continuous alluvial slope.

PLAYAS

If the mountain streams furnish enough water ponds or lakes may be formed in the lower parts of a closed basin. When the streams carrying débris flow into such a lake their velocity is further lessened and all material is dropped close to the shore, except the very finest silt or clay, which may remain in suspension for some time but finally settles to the bottom. In the Antelope Valley region, as in many other desert valleys, the rainfall is so slight and the evaporation is so great that not enough water is carried to the bottom of the valley to form a lake except after heavy rains in the mountains. The lake that is formed during great floods usually contains only a few inches of water which evaporates in a few weeks or months, leaving a bare, smooth flat of clay or silt which is locally known as a "dry lake" but which geologists call a playa.

There are several playas in the lowest parts of Antelope Valley, of which the largest are Rosamond, Rogers (Rodriguez), and Buckhorn Dry Lakes. It is probable that at one time all three formed a single large playa, but they are now separated by low sand dunes. There is also reason to believe that at an earlier period a perennial lake covered these playas. Along the Atchison, Topeka & Santa Fe Railway about 5 miles northeast of Muroc, in T. 10 N., R. 8 W., Rogers Dry Lake is separated from a smaller playa by a low ridge of gravel about 5 feet high which was evidently deposited in standing water as a beach ridge. A well-defined beach ridge, the top of which is 10 or 15 feet above the surface of the playa, was observed on the northeast side of Rosamond Dry Lake. At most places around Rogers Dry Lake there is a sharp rise of 1 to 6 feet or more from the clay flat to the surrounding land, suggesting a wave-cut cliff. These features may be due to wave action in a temporary lake formed by unusually heavy floods from the mountains, the lake disappearing after a few months or a year or two at the longest. Other higher and more prominent cliffs were observed from a distance by the writer on the north side of Rosamond Dry Lake, about 5 miles east of Rosamond. He did not have an opportunity to examine them closely, and as a fault, which might account for them, was observed in this locality only a mile or two farther west, it was not definitely established that they are wave-cut cliffs. The presence of a considerable thickness of blue clay, which is generally considered to indicate deposition under water, in wells in the lowest part of the valley (see p. 306) further suggests the existence of a lake.

It is known that in the Pleistocene epoch perennial lakes existed in other basins in the Mohave Desert region that now contain only playas,[99] and it is not improbable that further examination will show that a perennial lake once covered the playas in Antelope Valley. It is generally believed by geologists that these ancient lakes were due to slightly greater precipitation and less evaporation throughout the desert region than at present. If the difference in rainfall was sufficient to produce lakes in other parts of the Mohave Desert region, the rainfall in the San Gabriel and Tehachapi Mountains must have been sufficient to produce a perennial lake in Antelope Valley.

If a perennial lake did exist in Antelope Valley covering the area of the three playas mentioned, it probably overflowed northward into another basin, known as Fremont Valley, by a channel extending from the north end of Rogers Dry Lake along the west side of T. 11 N., R. 9 W. San Bernardino meridian. It has been stated that in the Pleistocene epoch Rogers Dry Lake drained to Mohave River.[1] The writer does not believe that this was the case. So far as is known, the lowest point in the divide on the east side of the playa is along the Atchison, Topeka & Santa Fe Railway a mile or two west of Kramer, where the altitude, according to levels run by the topo-

[99] Gale, H. S., Salines in the Owens, Searles, and Panamint Basins, southeastern California: U. S. Geol. Survey Bull. 580, pp. 251–323, 1914. Buwalda, J. P., Pleistocene beds at Manix, in the eastern Mohave Desert region: California Univ. Dept. Geology Bull., vol. 7, pp. 443–464, 1914. Thompson, D. G., Pleistocene lakes along Mohave River, Calif.: Washington Acad. Sci. Jour., vol. 11, pp. 423–424, 1921 (abstract of paper read before Geological Society of Washington, April 28, 1920).

[1] Free, E. E., The topographic features of the desert basins of the United States with reference to the possible occurrence of potash: U. S. Dept. Agr. Bull. 54, p. 45, 1914.

graphic branch of the United States Geological Survey, is slightly more than 2,500 feet above sea level.[2] At the north end of Rogers Dry Lake, however, the altitude of the divide between Antelope Valley and Fremont Valley, according to the Searles Lake topographic map, is less than 2,400 feet. The exact altitude is not known, but apparently it is not much over 2,300 feet. Unless there is a low point on the rim on the east side of Rogers Dry Lake not observed by the writer, it would be natural for any overflow to go northward. A very marked channel extends northward from the south side of T. 32 S., R. 38 E. Mount Diablo meridian, between Desert Butte and Castle Butte, to a playa in Fremont Valley. Where this channel is crossed on the road from Mojave to Atolia, near the north line of sec. 20, T. 32 S., R. 38 E., it is fully 500 feet wide and from 10 to 15 feet below the surrounding territory. It is apparently much too large to have been cut by the drainage from the territory that is now tributary to it and strongly suggests an outlet channel from Rogers Lake. About 4 miles farther southeast, almost due east of Desert Butte, on the lowest part of the divide, however, there is no noticeable channel of any sort. The conditions here are not clear, and the writer did not have opportunity to determine definitely whether or not an outlet existed at the north end of Rogers Dry Lake.

GEOLOGY

KINDS OF ROCKS

The rocks of the mountains and hills that form the border of Antelope Valley are as a rule not water-bearing or yield only meager supplies, whereas most of the deposits that underlie the valley yield water, some of them very freely.

The rocks which yield little or no water comprise (1) limestone, (2) granite and rocks of a similar nature, (3) metamorphosed rocks, such as slate, schist, and gneiss, and (4) volcanic rocks. These rocks are compact and hard and contain almost no pore spaces that can hold water. Practically the only water that is contained in them exists in fissures. The fissures are usually small and form only a small percentage of the entire rock mass, so that the quantity of water that these rocks can yield is very small.

The main water-bearing formation is the valley fill, which consists chiefly of the alluvial gravel, sand, and clay that underlie the greater part of Antelope Valley. These deposits are very porous and are capable of holding large quantities of water, but the pores in the clay are so minute that they yield their water very slowly.

The following brief notes on the rocks of the valley, based on observations by the writer, on previously published reports, or on personal communications from L. F. Noble and J. P. Buwalda, both

[2] Spirit leveling in California, 1896 to 1923, inclusive: U. S. Geol. Survey Bull. 766, p. 86, 1925.

of the United States Geological Survey, will be of value in interpreting conditions. Mr. Noble has studied in detail the geology in the vicinity of Little Rock and Valyermo, and Mr. Buwalda has studied the geology of the mountains on the west side of Antelope Valley.

DISTRIBUTION OF NON WATER-BEARING ROCKS

The rocks of the Tehachapi and San Gabriel Ranges and the hills on the east side of the valley consist principally of granite, together with some limestone and schist or gneiss. The rocks of the buttes on the north side of the valley and the buttes northeast of Rosamond are principally volcanic rocks with some sandstone. Although these rocks are more porous than the granite, they will yield little water and may be considered practically impervious.

The fill of the valley is probably underlain by crystalline or volcanic rocks. The chief evidence in support of this belief is the presence of such buttes as the Antelope or Fairmont Buttes, the Little Buttes, northeast of Fairmont, and Quartz Hill, northwest of Palmdale, which are composed of volcanic or granitic rocks. Hard rock has also been encountered in several wells in the valley. (See wells 24, 97, and 107 in table, p. 356, and map, pl. 19.) On the other hand, the depth to solid rock in some parts of the valley is great. A well was drilled for oil in sec. 11, T. 7 N., R. 12 W., to a depth of 2,000 feet, apparently without having reached bedrock. Shale struck at about 1,300 feet probably represents a consolidated phase of the valley fill.

Non water-bearing rocks practically surround and underlie the valley, forming an essentially water-tight basin in which lie the water-bearing beds. At two places and possibly elsewhere the rim of the basin is composed of porous materials, but it is evident that impervious rocks underlie them at no great depth. (See pp. 324–325.)

DISTRIBUTION OF WATER-BEARING FORMATIONS

The water-bearing formations may be separated into two divisions—those that occur in the mountains and hills and those that underlie the valley.

Small areas of water-bearing formations occur at several places in the mountains. Sandstone occurs at the extreme west end of the valley, near the junction of the Tehachapi Mountains and the northwest continuation of the San Gabriel Range. It is overlain by less consolidated beds of sand and gravel.[3] Other deposits of more or less consolidated gravel and sand cover a considerable area near the north base of the San Gabriel Mountains. Good exposures of them occur south of Valyermo post office, where they have been broken and tilted by faulting along the San Andreas rift zone.

[3] Johnson, H. R., op. cit., p. 25.

These sedimentary rocks belong to the group of water-bearing formations, but they are of little economic value. Around Valyermo they occur only in the mountains, where they are so dissected by steep valleys that the land is practically worthless for agriculture. They are separated from the water-bearing rocks of the valley by non water-bearing rocks. The water-bearing rocks in the hills at the west end of the valley occur under somewhat similar conditions, but they may continue out into the valley beneath the valley fill that forms the alluvial slope. Their outcrops cover small areas, however, and they are of no great value as sources of water. The water-bearing rocks of the mountains absorb more water during heavy rains than the less porous rocks, such as granite, but much of their water is later returned slowly to the surface through springs or seeps and is evaporated.

The notable water-bearing formation in Antelope Valley is the alluvium that underlies the valley. It is composed of gravel, sand, and clay washed down from the surrounding mountains. A study of well logs and of samples from wells indicates that the water-bearing beds that are penetrated in the wells are much like the materials that lie immediately below the surface and were deposited by processes that may be observed at the present time.

A peculiar type of water-bearing rock, locally called "honeycomb cement" or simply "cement," is encountered in many wells in the alluvium in Antelope Valley. It is so named because of its resemblance to artificial cement and because of its porous texture. According to Johnson [4] it is a limy hardpan, either in clay or in sand, which has a more or less cellular texture, apparently due to water dissolving out some of the constituent material.

Deposition of clay, either on a large playa or in a perennial lake, occurred for a long period in the lowest part of Antelope Valley, for a thick body of clay is encountered in wells north and northeast of Lancaster. Mr. Harry Austin states that in a well on the Morgan ranch, in the NE. ¼ sec. 3, T. 7 N., R. 12 W., blue clay was penetrated from a depth of 120 feet to 240 feet, practically without any change to coarser material. In a well in the SE. ¼ sec. 34, T. 9 N., R. 12 W., blue clay was struck at about 100 feet and was about 80 feet thick. Near Redman School blue clay is reached at a depth of about 265 feet and is about 200 feet thick.

CLIMATE

TEMPERATURE, WINDS, AND EVAPORATION

High temperatures are common in summer, the thermometer rising above 100° F. on many days each season and frequently reaching 110° or 115°. Records kept at Mojave, a few miles north of the north

[4] Johnson, H. R., Water resources of Antelope Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 278, p. 39, 1911.

side of the valley, for the 16-year period 1891 to 1906 give the maximum temperature as 115° F.[5] During this period the annual maximum was never below 105°, and for 7 out of the 16 years it was above 110°. The air usually cools rapidly after the sun sets, with the result that there is generally a large daily range of temperature, frequently amounting to 30° and sometimes to 45°. The summer evenings are nearly always delightfully cool, and the heat seldom prevents sleep.

The winter temperatures are somewhat higher than those in regions of the same latitude and altitude farther inland. The thermometer frequently rises to 60° or more in the day and usually drops only a few degrees below freezing at night, although it sometimes goes as low as 15° above zero or even lower. The lowest minimum temperature recorded at Mojave during the 16-year period mentioned above was 15°. It is said that on December 30, 1895, the temperature fell to 6° above zero near Lancaster.[6] The daily range is probably somewhat less in winter than in summer.

It is generally believed that along the foot of the mountains on the south side of the valley the winter temperature is usually several degrees higher and the summer temperature a few degrees lower than in the lower part of the valley. Mr. Dickey, who for a number of years has been in charge of large almond orchards at Manzana, in the west end of the valley, states that in many years freezing temperatures occur at Lancaster six weeks earlier than at Manzana.

Strong winds blow across the valley at times. Such winds frequently carry fine sand and clay, which gather into low dunes in some parts of the valley, principally on its east side. The fine sand is at times blown against young plants with such force that they are cut off as if by a knife, and it is necessary to protect newly sown alfalfa or other crops by windbreaks.

Data in regard to evaporation from a floating pan on Harold Reservoir are given on page 76.

PRECIPITATION

Records of precipitation have been kept for periods of 1 to 13 years at a number of places in the valley, as follows:[7] Monterio (Knecht's ranch), on Cottonwood Creek about 30 miles northwest of Lancaster; the Liebre ranch, about 30 miles west of Lancaster; the E. T. Earl ranch, about 5 miles southwest of Lancaster, in sec. 36, T. 7 N., R. 13 W.; Palmdale; Palmdale headworks, at head of ditch on Little Rock Creek; Valyermo, on Rock Creek, 20 miles southwest of Palmdale; Llano, 20 miles east and a little south of Palmdale, in sec. 21, T. 5 N., R. 9 W.; Fairmont; Manzano; and Lancaster. (See pp. 78–80.)

[5] Johnson, H. R., op. cit., p. 17.

[6] Idem. p. 17.

[7] The records w re compiled in 1920–21, and subsequent records have not been obtained.

The corrected long-term average annual precipitation of the stations in Antelope Valley has been calculated by the method described on page 83 and is given in the table on page 87.

The data in these tables must be used with some caution, for there are great differences between the indexes of the several control stations in some years, though for most of the years the differences are not great.

A study of the data on precipitation shows certain dominant features. (1) There is a distinct seasonal distribution of the precipitation, most of it coming in the winter; (2) the precipitation differs in different parts of the valley, being affected by topographic features, but in general it is least in the low central part of the valley and greatest in the high mountains; (3) the mean annual precipitation in most of the valley is less than 10 inches, an amount so small that irrigation is necessary for successful agriculture.

The seasonal distribution of the precipitation is very marked. According to the records from 70 to 85 per cent or more falls from November to March. The greatest precipitation usually occurs in January, February, and March.

The winter precipitation comes from storms that cover large areas. These storms move, in general, from the Pacific Ocean eastward. The precipitation from such storms is more or less steady, continuing from several hours to two or three days, and an inch or more may fall during a storm. Most of the precipitation in the valley is in the form of rain. Snow falls occasionally, but it usually melts within a few hours. In the high San Gabriel and Tehachapi Mountains much of the winter precipitation occurs as snow, which remains on the ground for longer periods.

The precipitation during the dry season is irregular. It usually occurs in thunderstorms in which the fall may be only a fraction of an inch, but occasionally the fall is very great in a short time. The summer rainfall is not of much value to crops, because it is so slight and irregular, and the severe thunderstorms may do more damage than good. As the greatest precipitation occurs in the winter, when the plants use a minimum quantity of water, the water must be stored either in the soil, in artificial surface reservoirs, or in the natural underground reservoir composed of the water-bearing sand and gravel that underlie the valley.

The records, as adjusted to the long-term period, for stations in and near the valley show that the mean annual precipitation differs considerably at different points, ranging from 18.10 inches at Monterio to 3.96 inches at Gray Mountain. It is a striking fact, however, that the mean annual precipitation is greater at stations high above sea level than at lower stations. The moisture-laden winds from the ocean, after passing over the mountains, descend to lower levels and, becoming warmer, can absorb more moisture, so that evaporation rather than precipitation takes place, or, if the air is still oversaturated, the rainfall becomes less and less at successively lower altitudes. Because of these conditions the rainfall at a given altitude in Antelope Valley is somewhat less than that at a corresponding altitude on the oceanward side of the mountains that border the valley.

Although in general the higher the altitude the greater the precipitation, this relation is not uniform for all parts of the basin. This discrepancy can best be shown by dividing the number of inches of the corrected long-term average annual precipitation for a given station by the altitude of the station in feet. The ratios thus obtained for all the stations in the basin and for the control stations around it are given in the last column of the table on page 87. These results show that the precipitation at the stations on the south side of San Gabriel Mountains and the west side of the Tehachapi Mountains (Bakersfield, Tejon ranch, Fort Tejon, Newhall, Los Angeles, and San Bernardino) is greater than at the corresponding altitudes in Antelope Valley or on the mountain slopes tributary to it, primarily because these stations are on the windward side of the mountains with respect to the moisture-bearing winds from the ocean.

Among the stations in Antelope Valley the rainfall per foot of altitude is greatest at Fairmont, and it decreases eastward and westward from that point. At the Liebre ranch, for instance, if altitude were the only factor affecting the rainfall, the average annual precipitation should be greater than at Fairmont, but in reality it is considerably less. On the east, the rainfall at Valyermo is likewise much less than at Fairmont, although the altitude is greater. The north side of the valley as a whole is much drier than the south side. These variations are probably due to local topographic features that influence the course of the rain-bearing winds from the ocean. Mr. William Dickey, of Manzana, states that the rain-bearing clouds at that place generally move from the southeast, and Mr. J. C. Knecht, of the Liebre ranch, states that the best rains there come from the south. On the other hand, near Little Rock the rain clouds generally come from the direction of the head of Soledad Canyon.

According to the theory that precipitation increases with altitude, the mean annual rainfall in the San Gabriel and Tehachapi Mountains should be considerably greater than is recorded at the nearest stations. If, for instance, the precipitation on North Baldy Peak bears the same ratio to the altitude as that at Valyermo, the mean annual precipitation at the summit would be about 28 inches. There is no means of determining the accuracy of this estimate, but it seems reasonable. The corrected long-term average annual precipitation in Little Bear Valley, in the San Bernardino Mountains, about 50 miles southeast of Antelope Valley, at an altitude of 5,200 feet, is 33.72 inches, and that at Bear Valley, a short distance farther southeast, at an altitude of 6,500 feet, is 36.18 inches. The ratio of precipitation to altitude at these points is greater than at Valyermo, but it is believed that the topographic conditions in the San Bernardino Mountains are more favorable for heavy precipitation than those in the region between North Baldy and Valyermo. It is considered that 30 inches is a fair figure to assume for the maximum average annual precipitation on the leeward side of the highest part of the San Gabriel Mountains. For most of the north side of the mountains it would be much less than that amount. On this basis the average annual precipitation for the entire area between Valyermo and North Baldy would be about 20 inches.

RUN-OFF

In the drainage basin of Antelope Valley perennial streams are found only in the mountains. Where the streams emerge from their mountain canyons upon the alluvial slopes most of the water is absorbed. It is only during the flood run-off following heavy rains that the streams flow very far down into the valley. Occasionally some of the water may flow to the playas (dry lakes) in the lower part of the valley, from which it disappears principally by evaporation.

Rock Creek and Little Rock Creek, which rise in the high San Gabriel Mountains, are the two largest streams in the valley. Cottonwood Creek, which rises in the Tehachapi Mountains, is probably next in size. These creeks are all mountain streams with steep grades. Amargosa Creek, which drains Leonis Valley, is probably perennial for part of its course. It is not a typical mountain stream but flows in a flat-bottomed alluvium-filled valley in which it has cut a narrow trench 10 to 20 feet deep with nearly vertical walls. This trench has been cut recently, probably as a result of uplift along the San Andreas rift. Several minor streams at the extreme west end of the valley are said to have a small perennial flow. Oak Creek, which rises in the Tehachapi Mountains, is said to be a perennial stream of fair size, but where it emerges from the mountains it is on the summit of a large alluvial fan that slopes both northeast and southeast, and it is not known whether the surface run-off goes to Antelope Valley or to Fremont Valley. Similar conditions exist in the extreme southeastern part of the valley, at the mouth of Sheep Creek Canyon.

Stream-flow measurements have been made on Rock and Little Rock Creeks. Daily gage-height readings were made on Little Rock Creek during 1896–1899, from which the run-off for these years has been computed.[8] The monthly discharge is given in the following

[8] U. S. Geol. Survey Water-Supply Paper 300, pp. 402–405, 1913.

table. The run-off year is considered as extending from October 1 to September 30. Inasmuch as the run-off for July, August, and September is small the records can be compared without great error with the precipitation records, which are given for years beginning July 1.

Monthly discharge of Little Rock Creek for 1896–1899

[Drainage area, 65 square miles]

Month	Acre-feet	Month	Acre-feet
1896		1897–98—Continued	
January	1,144	January	373
February	1,070	February	389
March	3,332	March	371
April	470	April	364
May	110	May	319
June	30	June	0
July	12	July	0
August	12	August	10
September	30	September	6
The period ª	6,210	The year	2,930
1896–97		1898–99	
October	61	October	0
November	89	November	0
December	234	December	0
January	879	January	318
February	2,894	February	245
March	4,187	March	472
April	6,284	April	268
May	2,189	May	166
June	399	June	119
July	22.1	July	12
August	12.3	August	12
September	11.9	September	12
The year	17,300	The year	1,620
1897–98		1899	
October	338	October	0
November	411	November	0
December	350	December	61

ª The record for October, November, and December, 1895, is lacking.

The record is complete for the three years 1896–97, 1897–98, and 1898–99. Reference to the average precipitation indices for these years in the table (p. 85) shows that in the first year, when the run-off was 17,300 acre-feet, the precipitation in the region was about 113 per cent of the long-time average but that in the other two years it was less than half of the average. A gaging station has been maintained on San Gabriel River near Azusa, Calif., from which complete records of run-off from a drainage area of 222 square miles are available from 1896 to 1926. This drainage area comprises part of the same mountain range as that drained by Little Rock Creek but lies on the Pacific slope of the range, where the rainfall is materially higher. The annual variation, however, should be roughly comparable in the two areas. The run-off during the 3-year period 1897 to 1899 on San Gabriel River was 34 per cent of the mean for the 31-year period ending September 30, 1926. On this basis the average annual run-off of Little Rock Creek would be approximately 21,000 acre-feet, or 323 acre-feet to the square mile.

Measurements of the discharge of Rock Creek have been made regularly since January 17, 1923. The monthly summaries of the records are given in the accompanying table.[9] The gaging station is in the NE. ¼ sec. 20, T. 4 N., R. 9 W., about a quarter of a mile south of the boundary line of the Angeles National Forest and about 1¾ miles southeast of Valyermo. It is above the point where Pallett Creek discharges into Rock Creek. A number of miscellaneous measurements have also been made on Pallett Creek and Rock Creek below the regular station.[10]

Monthly discharge of Rock Creek near Valyermo, January, 1923, to September, 1926

[Drainage area, 23 square miles]

1923	Acre-feet
January 17–21	391
February	844
March	1, 060
April	1, 210
May	1, 010
June	827
July	664
August	453
September	372
The period	6, 830
1923–24	
October	409
November	412
December	430
January	324
February	258
March	244
April	702
May	612
June	305
July	183
August	149
September	155
The year	4, 180

1924–25	Acre-feet
October	170
November	145
December	206
January	217
February	174
March	230
April	508
May	486
June	294
July	148
August	184
September	142
The year	2, 860
1925–26	
October	143
November	159
December	186
January	188
February	245
March	414
April	4, 680
May	2, 810
June	1, 520
July	922
August	534
September	376
The year	12, 200

The precipitation was below normal in both the years 1923–24 and 1924–25, as is indicated by the fact that precipitation indices at Los Angeles, San Bernardino, Bakersfield, and Tejon ranch ranged from only 43 to 87 per cent of the normal in 1923–24 and from 51 to 83 per

[9] Daily records are given in U. S. Geol. Survey Water-Supply Paper 570, pp. 82–83, 1928; Water-Supply Paper 590, pp. 84–85, 1928; Water-Supply Paper 610 (in press); and Water-Supply Paper 630 (in preparation).

[10] The records of these miscellaneous measurements are contained in Water-Supply Papers 591, p. 295, 1925; 610 (in press); 630 (in preparation).

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cent in 1924–25. The discharge of Rock Creek in these years was undoubtedly far below the true average. In 1925–26, when the run-off was 12,200 acre-feet, the precipitation was 127 per cent of the normal at San Bernardino and 113 per cent at Los Angeles, but only 90 per cent at Bakersfield and 67 per cent at Tejon ranch. A comparison of concurrent records on Rock Creek and San Gabriel River indicates that the mean run-off of Rock Creek for the 3-year period ending September 30, 1926, was approximately 45 per cent of the long-term mean. On this basis the average annual run-off of Rock Creek would be approximately 14,500 acre-feet, or 630 acre-feet to the square mile.

Amargosa Creek, which drains Leonis Valley, is a perennial stream, but no data are available in regard to its discharge. Its drainage basin, of about 40 square miles, differs considerably from those of any of the other perennial streams, and the flow of the creek is probably affected accordingly. The highest point in the basin is more than 5,000 feet above sea level, but the slopes are on the whole much more gentle than those in the basins of Rock and Little Rock Creeks. The bottom of the valley is wide, nearly flat, and underlain by a considerable thickness of alluvial material or of disintegrated rock that is capable of absorbing much of the rain. The water table beneath much of the land in the bottom of the valley is so close to the surface that the soil is more or less moist, and evaporation takes place. Although the precipitation in Leonis Valley is doubtless as great as in any other part of Antelope Valley that lies at the same altitude, the run-off per square mile is probably not more than half as great as in the basins of Rock and Little Rock Creeks.

Estimates of the run-off of several streams in the Tehachapi Mountains were given to the writer by Mr. John C. Knecht, foreman of the Liebre ranch, and by Messrs. Leeds & Barnard, consulting engineers in charge of the construction of a reservoir on the ranch. These estimates lead to the conclusion that the total annual flow of all the streams in the Tehachapi Mountains from Oak Creek southward, which drain an area of about 65 square miles, is about 2,500 acre-feet. The run-off per square mile of Cottonwood Creek and probably of Oak Creek is believed to be somewhat greater than the average of the other streams. However, an examination of these two creeks by F. C. Ebert, hydraulic engineer, of the United States Geological Survey, and the writer showed that the run-off to the square mile is doubtless much less in the Tehachapi Mountains than in the basins of Rock Creek and Little Rock Creek. The Tehachapi Mountains are much lower than the San Gabriel Mountains and have much less precipitation. The surface slope over a large part of the southwest end of the mountains is much less than that in the Little Rock Creek and Rock Creek basins. In addition it is believed that a considerable

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area in the mountains at the west end is underlain by porous rocks, which absorb much of the rain, whereas in the two main drainage basins at the east end of the valley the rocks are mostly granite, which is incapable of absorbing much of the rain.

East of Rock Creek there is an area of about 45 square miles of mountainous country tributary to Antelope Valley that reaches altitudes as great as 8,000 feet. The principal drainage basin in this region is Swartout Valley, drained by Sheep Creek. It is believed that the region is sheltered from the rain-bearing winds by high mountains, such as North Baldy and Old Baldy, and that the precipitation is not as great as in the basins of Rock and Little Rock Creeks. The run-off per square mile from this region is perhaps only half as much as that from the two basins west of it.

Between Rock and Little Rock Creeks there is an area of about 20 square miles of mountainous country. This region is not very high, and its run-off per square mile is very much less than that in the Little Rock Creek basin.

Between Little Rock Creek and Amargosa Creek is another area drained by several intermittent or ephemeral streams. Most of this drainage is prevented from reaching the valley proper by a long, low ridge that lies north of the valley, along the San Andreas fault line. Some of it reaches the natural depression occupied by the Harold Reservoir and another small basin to the east. Farther east most of the run-off is absorbed by porous material in the fault valley, producing ciénaga conditions in an area where much of the water evaporates. It is believed that there is a small flow from the ciénaga lands into the main part of Antelope Valley. The run-off per square mile from this area is small. Several short intermittent or ephemeral streams drain the north slopes of Sawmill and Liebre Mountains, and the run-off from this area likewise is small.

Fairmont, the point in the valley at which the greatest average annual precipitation is recorded according to the table on page 87, is situated at the northwest end of Portal Ridge. The streams that drain Portal Ridge are short, and the contribution per square mile from this ridge is not great.

The average annual run-off from all parts of the mountainous area that surrounds Antelope Valley is roughly estimated, on the basis of the fragmentary information above given, to be about 75,000 acre-feet.

GROUND WATER

IMPORTANCE OF GROUND-WATER SUPPLY

About 80 per cent of the land at present irrigated in Antelope Valley receives its water supply from wells. (See p. 326.) The total area of land in the valley that is level enough to be farmed is about

500,000 acres. Ground water—that is, water recovered by means of wells—is contained in the alluvial deposits that underlie practically the whole of this large area, but in about half of the area the depth to water is so great that under present economic conditions the water can not be profitably pumped for irrigation. It is estimated that in about 275,000 acres the depth to the water table is not more than 150 feet. Under present economic conditions in southern California, however, only products that bring high cash returns per acre, such as apples, pears, and other fruits, can be raised where the pump lift is greater than 100 feet.

The ultimate limiting factor, however, is not the depth to the water table, but the quantity of water that is available. A great volume of water is stored in the alluvial deposits that underlie the valley, but if enough water were pumped from this ground-water reservoir to irrigate 275,000 acres the water level would soon be lowered so far that pumping for irrigation would be unprofitable. In the long run pumping must not exceed intake.

OCCURRENCE OF GROUND WATER

The water that is pumped for irrigation in Antelope Valley occurs in the alluvial deposits—clay, sand, and gravel. The mountains and hills that surround the valley are composed of rocks that are practically impervious to water. These rocks form a basin which is nearly water-tight and which contains a great accumulation of porous alluvial deposits that are capable of holding a large volume of water. A part of the water that falls as rain on the alluvial deposits or that is carried by the mountain streams upon these deposits sinks into them and becomes ground water. The alluvium is essentially a great underground reservoir in which the run-off from the mountains is stored.

It is believed by some people that the ground-water supply of the valley comes from some distant source, such as the Sierra Nevada, north of the valley. In particular it has been said that the water comes from Mount Whitney, 125 miles north of Lancaster, and other high mountains that are tributary to Owens Valley, reaching Antelope Valley by underground channels that are supposed to exist in the rocks which lie between that region and Antelope Valley. Despite efforts made in the previous report by the Geological Survey [11] to correct these mistaken ideas as to the source of the water supply, the erroneous notions have persisted and are still advocated by some persons. It is therefore considered necessary to point out again why they are fallacious.

[11] Johnson, H. R., Water resources of Antelope Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 278, pp. 59-61, 1911.

Practically all the run-off on the west side of the high Sierra is carried by Kings, Kaweah, Tule, and Kern Rivers and other streams into San Joaquin Valley. That on the east side is carried to Owens Valley and farther south to Indian Wells Valley and Fremont Valley. Each of these valleys is inclosed by rocks that are as impervious as those that surround Antelope Valley. The water table is 100 to 300 feet lower in Fremont and Indian Wells Valleys than in Antelope Valley. (See pp. 162, 217.) Therefore, even if the rocks between the basins were permeable the ground water in Antelope Valley would drain into Fremont Valley rather than receive any acquisition from that valley or from Indian Wells Valley. It is true that the water table in Owens Valley is several hundred feet higher than in Antelope Valley, but there is no way for water from Owens Valley to reach Antelope Valley unless it follows channels that penetrate the solid rock mass of the Sierra Nevada. It is inconceivable that fissures or other channels sufficiently large to carry water to Antelope Valley could exist in the granitic rocks that compose the Sierra, parallel to the trend of the range, without the coexistence of fissures in other directions that would permit the leakage of the water to the lower lands on the east, or to San Joaquin Valley on the west, which is more than 1,000 feet below Antelope Valley.

Similarly, the valleys that lie south and east of Antelope Valley are lower than this valley, so that if the rocks that surround the valley were not impervious, the movement of water would be away from it and not toward it. It is obvious that there can be no contribution of any consequence to the ground-water reservoir of Antelope Valley from sources outside of its drainage basin. Essentially all of its supply comes from the rain and snow that fall within the boundaries of its own basin.

Much of the water is absorbed by the alluvium and sinks downward until it reaches a level below which the alluvium is completely saturated, all the interstices between the rock particles being filled with water. If a hole is sunk into this zone of saturation water will flow into the hole, making it a well. The upper surface of the zone of saturation is called the water table.

The water table is not a horizontal surface. Its shape is governed by the nature and structure of the alluvium, the source of the water, the areas of discharge, and other conditions. Well data indicate that the water table is nearly horizontal in the central part of Antelope Valley but that it rises gradually toward the mountains. It is highest in the alluvial fans near the mouths of the canyons from which emerge such streams as Rock Creek and Little Rock Creek. (See pp. 336–338 and figs. 11 and 13.)

The water table is highest beneath the upper parts of the principal alluvial fans because the greatest supply of water is added to the ground-water reservoir where the principal streams pour out from the mountain canyons upon the porous gravel. The body of ground water seeks to reach a uniform level and moves from these upper levels toward the central part of the valley. Its movement through the alluvium is very slow, and consequently the water table does not quickly become a level surface. If there were no precipitation in any part of the valley for a number of years, so that there would be no addition to the ground water, it would have an opportunity to reach an equal level throughout the valley, and the water table would become practically horizontal. As a result of precipitation, however, a new supply of water is added each year, and as the greatest addition occurs on the fans of such streams as Little Rock Creek the water table stands highest in such places. During the dry summer the ground water of the alluvial fans moves slowly toward the center of the valley and the water table beneath the upper parts of the fans falls, only to rise again when the ground-water supply is replenished by the heavy rains of the following winter. Fluctuations of the water table are discussed further on pages 326–335.

ARTESIAN CONDITIONS

In the lower parts of Antelope Valley, the beds near the surface are composed of clay and silt, which act as a nearly water-tight cover over the underlying water-bearing beds and tend to prevent the water from rising to the surface. These beds extend for some distance up the alluvial slopes, confining the ground water under them. As the water table is higher beneath the alluvial slopes than in the bottom of the valley it exerts hydrostatic pressure on the water beneath the confining beds. If a well is drilled through the confining beds to the water-bearing beds the water will rise in the well under hydrostatic pressure. If the well is in the lower part of the valley the water may rise high enough to overflow at the surface, producing a flowing well, or if the casing is extended upward the water may rise to a level several feet above the surface. If the well is drilled on the alluvial slope a short distance above the lowest part of the valley, the water may rise in the well but not high enough to reach the surface. The conditions that give rise to wells of either kind are called artesian conditions. The conditions that result in flowing wells are shown in Figure 11.

Many flowing wells have been obtained in Antelope Valley, some of which yield large quantities of water without pumping. Wells near Rosamond Dry Lake are reported to flow at the rate of 100 miner's inches (about 2 second-feet, or 900 gallons a minute). In a well drilled for the Southern Pacific Co. at Oban, 5 miles north of Lancaster, the water rose 22.5 feet above the surface upon its completion in 1910. Artesian conditions in the valley are described in some detail in Water-Supply Paper 278.

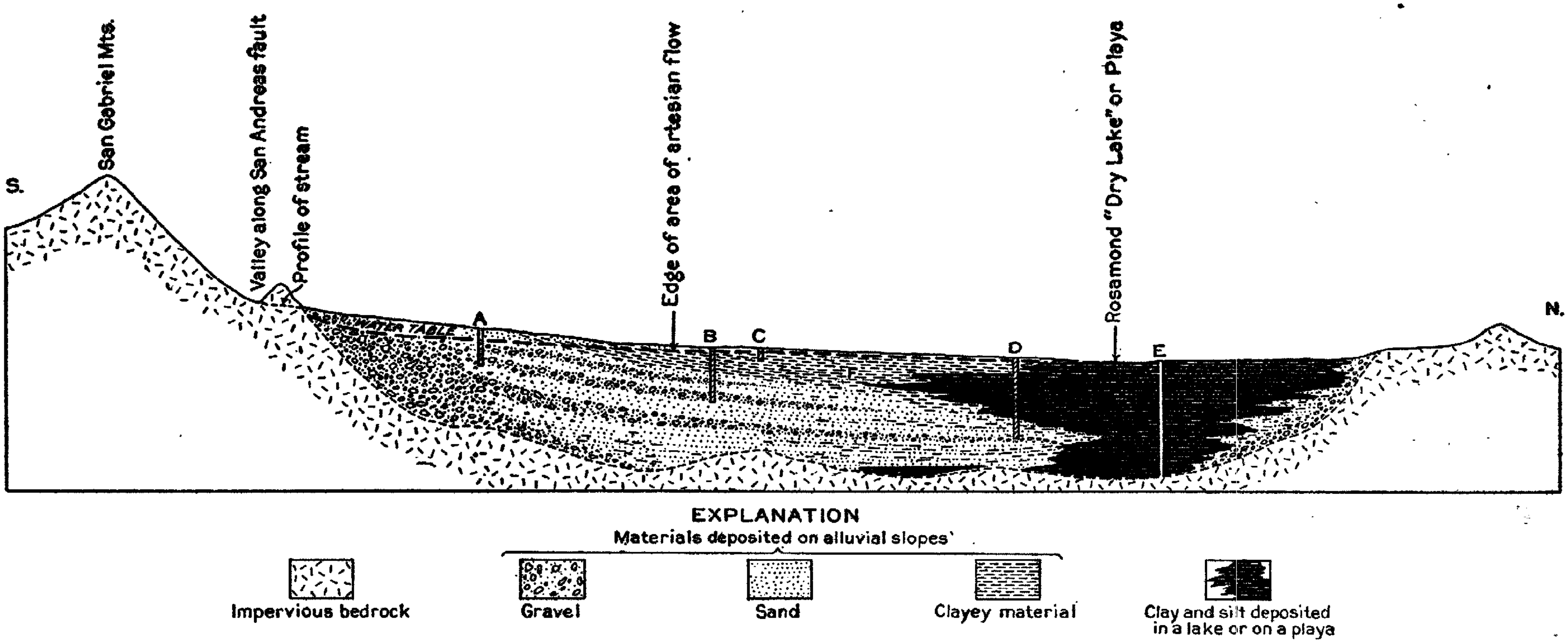

FIGURE 11.—Diagrammatic section across Antelope Valley from south to north, showing occurrence of ground water. Heavy dashed line is water table. The bed of clayey material, F, is relatively impervious and holds the water beneath it under pressure. A is an ordinary pump well. B is a flowing well near the edge of the area of artesian flow, penetrating gravel below the playa clay. C is a shallow well in the area of artesian flow, but it will not flow because it does not reach a water-bearing bed below F. D is a flowing well that obtains its supply from a deep gravel bed. E is a dry hole, drilled to bedrock entirely through silt and clay too impervious to yield any water

In Plate 19 the approximate boundary of the area of artesian flow is given. In part of the region two lines are shown—one the boundary as it was in 1909, as shown on the map in Water-Supply Paper 278, and the other the boundary as indicated by data obtained by the writer in December, 1919, and January, 1920. There is some uncertainty as to the original boundary northwest of Lancaster, for several wells that were represented on the map in Water-Supply Paper 278 as being situated in the area of artesian flow are said never to have flowed. The position of the boundary in the winter of 1919–20 was not determined for the entire area.

The water level in artesian wells is subject to fluctuations, like that in other wells. If the pressure is weak the well may cease to flow during the summer and begin to flow again in the fall or winter. If the pressure is strong the only evidence of fluctuation may be a slight decrease in the volume of flow.

QUANTITY OF GROUND WATER AVAILABLE

The alluvium-filled basin of Antelope Valley has already been likened to a surface reservoir. In any surface reservoir there is discharge by surface outflow, underground leakage, or evaporation, and the same is true of a ground-water reservoir. During a long period of years the average annual inflow into the ground-water reservoir, which may be called the recharge, will be about equal to the average annual discharge. Although there may be minor fluctuations from season to season, if the average inflow is greater than the quantity used for economic purposes and that lost by leakage in various ways, the reservoir will overflow, and if it is less the reservoir will be drained. The most desirable condition is that as much water be used as possible without exceeding the average annual recharge.

GROUND-WATER RECHARGE

SOURCES

The conditions that affect the recharge of the ground-water reservoir may best be summarized by the following quotation from Meinzer:[12]

> Contributions to the underground supply are made at the localities where the following three conditions exist: (1) The formations lying between the surface and the water table are not water-tight; (2) the water from rain or snow is applied in sufficient quantity to percolate to the water table without being entirely absorbed by the capillary pores of the dry zone between the surface and the water table; and (3) the water table is not already at the surface. These three conditions are provided most fully on the upper parts of the alluvial fans, where water is poured from the mountains upon gravelly deposits through which it can percolate freely to the water table. They are largely wanting in the

[12] Meinzer, O. E., Geology and water resources of Big Smoky, Clayton, and Alkali Spring Valleys, Nev.: U. S. Geol. Survey Water-Supply Paper 423, pp. 78–79, 1917.

mountains, where nearly impervious bedrocks are near the surface, and in the lower parts of the valley, where the soil is too tight to admit water freely and where over large areas the water table is so near the surface that water is being discharged from the valley fill instead of being taken in.

Contributions to the water in the valley fill are made by (1) the perennial streams that flow out of the larger canyons; (2) the floods discharged at long intervals from the canyons which are normally dry; (3) the underflow of some of the canyons; (4) the rain that falls in the valley; and (5) water discharged underground from openings in the bedrocks.

CONTRIBUTIONS FROM RUN-OFF

The water that is carried by the streams from the mountains out upon the alluvial slopes is disposed of in two ways—some of it percolates to the water table and replenishes the ground-water supply, and the remainder evaporates before it reaches the water table. As Antelope Valley is a closed basin no water is carried away from the valley on the surface. However, in wet years considerable surface water may reach the playas, where it evaporates without getting below the surface.

The largest contribution to the ground water comes from the perennial streams, most of it from Rock Creek and Little Rock Creek (see fig. 13) and less from Amargosa Creek and several streams at the west end of the valley. Although the run-off from Sheep Creek is probably considerable, the position of the alluvial fan upon which it empties is such that a large part of the water, either surface or underground flow, goes eastward toward Mohave River and does not reach Antelope Valley.

The run-off from more than half of the mountainous area is not carried by perennial streams but by streams that flow only after rains. The flow from these streams largely sinks beneath the surface, but most of it goes to wet the soil and is evaporated or taken up by plants before it reaches the water table. In ordinary years the contribution to the ground-water reservoir by these intermittent or ephemeral streams is very small, but in exceptionally wet years they may furnish an appreciable amount of ground water. About 7,000 acre-feet of the flow of the perennial streams was used in 1919 for irrigation and was not available for recharge except as it percolated downward after it had been applied to the irrigated land. (See p. 326.)

CONTRIBUTIONS FROM UNDERFLOW

The coarse water-bearing alluvium extends some distance up the canyons and fills them to considerable depths. Surface water may enter the alluvium several miles above the mouth of the canyon, percolate down the canyon, and reach the main ground-water reservoir without again appearing at the surface. Evidence of the existence of this underflow is seen about a mile above the mouth of the canyon of Little Rock Creek, where the Little Rock Irrigation District has built a low concrete dam that presumably reaches bedrock. At times when the creek is dry for a long distance above and below the dam a small pool of water stands just behind the dam and a considerable stream flows continually from this pool into the irrigating ditches.

Measurements made by J. B. Lippincott in June, 1896, near the place where the submerged dam was later built showed that at that time the water was percolating through the gravel at the rate of about 2.16 feet an hour, or 3.53 miles a year.[13] The submerged dam is 368 feet wide and 11 feet 8 inches high. If the cross section through which the water percolates were equal to that of the dam and the rate of flow were that given above, the underflow in one year would be a little less than 2,000 acre-feet. As the dam extends above the creek bed, the cross section of the underflow is probably not as great as that of the dam, but, on the other hand, the season of 1895–96, when the measurements were made, was unusually dry.

It is probable that a considerable quantity of water is discharged as underflow by Rock Creek. The lower mile of its canyon is filled with coarse alluvium, which must contain a large quantity of water. Attempts have been made at various times to recover some of this underflow by a tunnel driven through solid rock to a point near the place where the road from Little Rock to Valyermo crosses the creek, where it is turned under the gravels. The yield from this tunnel is said to be about 100 miner's inches (about 1,500 acre-feet a year), but the underflow has never been developed to its full capacity.

There is probably some underflow in the canyons of Oak, Cottonwood, and Amargosa Creeks. It is said that in the summer water ceases to flow at the surface in Cottonwood Canyon as far upstream as Knecht's ranch, 6 miles or more above the mouth of the canyon. Much of it sinks into the alluvium and continues downstream as underflow. The exact conditions in Oak Canyon are not known, but it is understood that most of the surface flow enters the alluvium some distance above the mouth of the canyon. In January, 1920, practically no water was flowing in Amargosa Creek where it emerges from the pass at the east end of Portal Ridge, although a stream was flowing farther up the canyon. It is probable that most of the run-off from Swartout Valley, east of Rock Creek, enters the alluvium of the main part of the valley as underflow, for Sheep Creek is shown on the topographic map as an intermittent stream, and the alluvial deposits extend for some distance up the canyon.

CONTRIBUTIONS FROM PRECIPITATION IN THE VALLEY

Some of the rain that falls on the valley may percolate to the water table. The rainfall on the valley lands is low, and the quantity that falls in a single storm is ordinarily not great. The lower part of the

[13] Schuyler, J. D., Reservoirs for irrigation: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 4, p. 714, 1897.

valley is largely underlain by a clayey soil which absorbs water very slowly, and most of the rain that falls on such soil remains near the surface until it evaporates. Furthermore, in most of the area in which flowing wells exist the water table is so close to the surface that discharge rather than absorption is the dominant process. Outside the area of artesian flow the soil is more permeable, and percolation may occur. A large part of the precipitation that enters the soil is, however, taken up by the yuccas and other plants that cover the alluvial slopes. After exceptionally heavy storms some of the precipitation doubtless reaches the zone of saturation.

CONTRIBUTIONS FROM BEDROCK

The rock formations in the mountains are nearly impervious, and the quantity of water that enters them is so small that any contribution to the ground-water reservoir by percolation from this source is probably negligible. The only region where there might be much percolation is on the south side of the valley, where faulting has produced a series of valleys, some of them undrained, behind Portal Ridge and the low hills that form a continuation of this ridge toward the east. Although the surface material of Portal Ridge consists of comparatively loose, porous soil, exposures at several points indicate that solid rock occurs at no great depth. It has been suggested that the faulting might have so greatly shattered the rock ridges that separate the valleys along the fault line from the main part of the valley that water from these closed valleys could percolate into the alluvium of the main valley. The very fact, however, that ciénagas are found at several points in the fault valley and especially the presence of Elizabeth and Hughes Lakes constitute evidence that there is not much seepage, for otherwise the lakes and ciénagas would be drained.

CONCLUSION

It has been estimated that the total run-off from the mountain areas into Antelope Valley averages about 75,000 acre-feet a year. A large part of the run-off from perennial streams is added to the ground-water supply, but only small quantities of water from the ephemeral streams and from rainfall in the valley reach the water table. It is roughly estimated that from all sources an average of about 50,000 acre-feet a year is added to the ground water.

GROUND-WATER DISCHARGE

The contributions to the ground-water supply are about balanced during a period of years by losses from the ground-water reservoir. The natural losses occur chiefly in three ways—by evaporation where the water is brought to the surface in springs or by capillary action; by transpiration by plants; or by percolation out of the basin through underground passages. Moreover, water is withdrawn from the ground-water reservoir through flowing wells and by pumping. Estimates of the amount of discharge by the different processes would serve as a basis for estimating the quantity available for irrigation.

DISCHARGE FROM SPRINGS

A number of springs exist in the drainage basin of Antelope Valley. Many are in the mountains on the south and west sides of the valley, but the water from these mountain springs does not come from the main ground-water reservoir beneath the valley, and hence their discharge does not represent a loss from the main ground-water supply.

Several springs discharge water from the main ground-water reservoir. The Willow Springs, about 8 miles west of Rosamond, which probably form the largest group of springs in the valley, are estimated to flow about 100 acre-feet a year. Other springs are Buckhorn Springs, about 12 miles east of Rosamond; Lovejoy Springs, about 16 miles east of Palmdale; and Moody Spring, about 20 miles east of Palmdale.

DISCHARGE FROM SOIL AND PLANTS

To determine accurately the area in which discharge by evaporation is occurring, it would be necessary to make numerous borings with a soil auger or to measure shallow wells to find where the water was close enough to the surface to be within the limit of capillary rise. The writer did not have opportunity to do this work. Studies in other regions of the desert, however, have shown that certain surface conditions are fairly reliable evidence of discharge by evaporation, and some of these conditions are present in Antelope Valley.

Where evaporation has continued for a long time deposits of alkali may be seen at the surface. The alkali was held in solution in the ground water, and as the result of long-continued evaporation the mineral matter has been left on the surface as a deposit.

The presence of the water table within a few feet of the surface is also shown by certain plants which are found almost exclusively in areas where the water table is near the surface. One of the most reliable of these plant indicators is salt grass (*Distichlis spicata*). Where salt grass is the predominating vegetation the depth to water is usually not more than 8 feet. Such plants discharge ground water. The plant roots reach down to the capillary fringe and perhaps even to the water table and draw up the water, giving it off into the air through pores in the leaves, a process known as transpiration.

The presence of alkali on the surface and of salt grass shows that discharge of ground water by evaporation and transpiration is taking place at a number of places, involving a large acreage in the lower part of Antelope Valley. It is noteworthy that evidence of such discharge is found at many places within the area of artesian flow but with minor exceptions is generally absent outside of that area. There is, therefore, some suggestion that the discharge is related to the artesian conditions. However, the fact that the indications of discharge are not everywhere present in the area of artesian flow raises a question as to whether the loss is from the artesian supply or only from the surface zone that is separated from the artesian aquifers by relatively impervious clay. If it is a loss from the artesian aquifers it will probably be reduced as the head on them is lowered by an increase in the use of water for irrigation. On the other hand, if it is a loss from the surface zone no great reduction may result with greater use of water, and conceivably it may increase; for the water level may be raised by additional return seepage from irrigation which the underlying clay will prevent from reaching the artesian aquifer.

On the south side of Lovejoy Buttes, about 15 miles east of Palmdale, the water table is close to the surface and there is evidence of discharge, but the area of discharge is not great. Salt grass was observed at a number of places in Leonis Valley, in the fruit valley between the Harold Reservoir and Little Rock Creek, and at other places, but at these places the discharge is not from the ground-water reservoir of the main part of the valley.

In experiments in Owens Valley Lee [14] found that when the water table was at the surface the evaporation and transpiration from a salt-grass area in one year was about 62 inches and that the evaporation decreased at a nearly uniform rate with the depth of the water table and ceased entirely at a depth of about 7½ feet. Climatic records indicate that the evaporation is fully as high in Antelope Valley as in Owens Valley. The total area in Antelope Valley in which there is discharge by evaporation and transpiration is unknown, but from the writer's observations it is considerable, and there must be a substantial loss of ground water by these processes.

PERCOLATION OUT OF THE BASIN

North of Rogers Dry Lake, the divide between Antelope Valley and Fremont Valley is not very high above the dry lake, and although rock hills are present on both sides, the divide for a distance of about a mile is probably composed of alluvium. If a perennial lake ever covered Rogers Dry Lake it may have overflowed at this point into Fremont Valley.

At Muroc the water table is lower than it is farther south in the valley, and at the north end of the playa, as nearly as can be deter-

[14] Lee, C. H., The determination of safe yield of underground reservoirs of the closed basin type: Am. Soc. Civil Eng. Trans., vol. 78, pp. 181–196, 1915; An intensive study of the water resources of a part of Owens Valley, Calif.; U. S. Geol. Survey Water-Supply Paper 294, pp. 53–64, 1912.

mined in several wells, it is still lower, indicating that the water table slopes toward the north. In the vicinity of Redman School, in T. 8 N., R. 10 W., where the altitude is more than 2,300 feet the water rises to the surface. In December, 1917, it flowed several feet above the ground in a test hole for potash (well 6 in table on p. 348 and pl. 19) drilled on Rogers Dry Lake near the center of sec. 20, T. 9 N., R. 9 W., where the altitude is about 2,275 feet above sea level. The depth to water in the Atchison, Topeka & Santa Fe Railway well at Muroc is about 33 feet and the altitude of the ground about 2,285 feet; the altitude of the water table is about 2,255 feet. In well 4, in the northeast corner of the NW. ¼ sec. 6, T. 19 N., R. 9 W., the depth to water is about 90 feet, and it is about the same in well 3, in northeast corner of sec. 34, T. 11 N., R. 9 W. As nearly as can be determined the altitude of the surface at these wells is not much over 2,300 feet, and the altitude of the water table is probably between 2,210 and 2,240 feet. These conditions are shown in Figure 5. The slope of the water table toward the north seems to indicate that the water is percolating northward under the alluvium into Fremont Valley.

The water table in Fremont Valley is much lower than in Antelope Valley. The depth to water in well 55 (see pl. 16 and table on p. 222), about 2 miles east of Desert Butte, in T. 12 N., R. 10 W., in January, 1920, measured 199 feet. The surface at this well is believed to be not more than 2,375 feet above sea level and the altitude of the water table not more than 2,175 feet. The water table in wells northwest of this well is even lower. (See fig. 5.) It is therefore evident that a rock barrier exists below the alluvial surface at the divide which acts as a submerged dam holding up the water table in Antelope Valley but which may allow some ground water from Antelope Valley to waste underground into the valley to the north.

The boundary of the drainage basin at the northwest corner of the valley is formed by an alluvial fan that has been built out in front of the canyon of Oak Creek, and at the southeast corner of the valley it is formed by a similar fan in front of the canyon of Sheep Creek. In each region, however, the water table, as shown by depth to water in wells, is higher than it is in the lower part of the valley, indicating that the ground water moves toward the lower level in the valley and not out of the drainage basin.

QUANTITY OF WATER USED FOR IRRIGATION

Estimates of total consumption of water for irrigation in Antelope Valley, from both surface and underground sources, are summarized in the accompanying table. The figures for quantity of water applied in irrigation, commonly called duty of water, are based on information given by a number of ranchers. They are average figures and do not represent extreme quantities used on different tracts of land.

Estimate of water used for irrigation in the drainage basin of Antelope Valley, 1919

Source of supply and locality	Area (acres)	Principal crop	Quantity applied in irrigation (acre-feet per acre)	Total consumption of water (acre-feet)
Supply obtained from wells				
Electric power plants mostly near Palmdale	1,555	Fruit	1⅓	2,100
Electric power plants mostly near Lancaster	6,855	Alfalfa	4	27,400
Gasoline power plants	300	do	4	1,200
Supply obtained from streams:				
Little Rock district	1,600	Fruit	1⅓	2,100
Palmdale district	700	do	1⅓	900
Longview	350	do	1⅓	500
Llano	150	do	1⅓	200
	150	Alfalfa	4	600
Valyermo and Pallett ranches	300 (?)	Fruit	(a)	3,100
	11,960			38,100

[a] Total quantity used is based on statement of estimated continuous flow diverted during irrigation season.

The water obtained from flowing wells for irrigation is not included in the above estimates, but the quantity is probably not great. Where the flowing wells have sufficient head to yield supplies adequate for irrigation without pumping, the soil generally contains so much alkali that not much land is under cultivation. Much artesian water, however, is wasted. This waste probably amounts to several thousand acre-feet a year.

According to the data presented above, in 1919 about 31,000 acre-feet of ground water was pumped annually for irrigation, and about 7,000 acre-feet was obtained from streams. Some of the water, however, percolated downward and returned to the water table, so that the net draft on the ground-water reservoir was not as great as stated.

FLUCTUATIONS OF THE WATER TABLE

ANNUAL FLUCTUATIONS

The water table rises during or shortly after the rainy season. The rise is generally greatest on the higher portions of the alluvial fans near the mouths of the mountain canyons, where the water is added to the alluvium in the rainy season faster than it can move through the sand and gravel to lower levels, and it is least in the lower central part of the basin. The nature and amount of these seasonal fluctuations are illustrated by measurements made in four wells at approximately monthly intervals from November, 1915, to November, 1916, by E. W. Martin, of Little Rock, which are given on page 327. The fluctuations are shown graphically in Figure 12. All these wells are in or near the wash of Little Rock Creek, near the point where it emerges from its mountain canyon upon the alluvial slope.

Water levels in wells near Little Rock Creek

[Measurements by E. W. Martin]

Date	Depth to water below reference point (feet)			
	Littleton well [a]	Kellerman well [b]	Keyes well [c]	Holloway well [d]
1915				
Nov. 6	33.3	52.6	13.5	15.4
Dec. 2	43.3	[b] 54	Dry.	15.7
1916				
Jan. 4	35	[b] Dry.	1.6	10.7
Feb. 1	21.8	26.3	([c])	10.5
Mar. 17	20.7	28.3	0	10.7
Apr. 3	19.3	27.4	----------	10.3
May 2	18	32	2	11
June 6	23	40	5	14
July 1	23	45	10	15
Aug. 1	30	50	13.5	15.5
Sept. 8	23.8	52	Dry.	16.5
Nov. 6	37	47	Dry.	15.3

[a] Littleton well (No. 139 on pl. 19), in southeast corner SW. ¼ NW. ¼ sec. 14, T. 5 N., R. 11 W. A drilled well 1.3 feet in diameter, about 43 feet deep. Reference point for measurements, top of casing 1.5 feet above ground. On Jan. 9, 1920, the depth to water, measured by the writer, was 39.8 feet below the reference point.

[b] Kellerman well (No. 140), approximately in NE. ¼ SW. ¼ sec. 14, T. 5 N., R. 11 W., about 75 feet from bank of Little Rock Creek. The well is dug 54 feet deep. It was nearly dry on Dec. 2, 1915, and completely dry on Jan. 4, 1916. Reference point, nail in curb about 18 inches above surface of ground.

[c] Keyes well (No. 141), near northeast corner of sec. 22, T. 5 N., R. 11 W., close to bank of creek. Reference point is a piece of pipe that projects from curb about 15 inches below surface of ground. Well could not be measured Feb. 1, 1915, because of high water in creek. Well is 14 feet deep.

[d] Holloway well (No. 142), near northwest corner of sec. 23, T. 5 N., R. 11 W., close to bank of creek. Reference point, surface of ground.

The measurements were made during a year of unusually heavy rainfall, and hence both the high and low water levels were probably higher than during normal years. Nevertheless they show the general fluctuation, the water being highest in the winter or early spring and lowest in the late summer or fall. The marked rise in the Keyes well between December 2 and January 4 was due to heavy rains in the later part of December. From 6 to 8 second-feet of water was flowing in the creek at that time. The well is close to the creek bank and practically within the canyon, being dug in the alluvium that fills the canyon. It responds very quickly to the flow of the stream. In contrast to it is the Kellerman well, which on January 4 was dry. It is farther from the stream channel, and the water that percolated through the alluvium from the stream had not reached the well. Water ceased flowing in the stream as far as the Littleton well about April 11. Annual fluctuations are shown by somewhat less detailed observations on a number of wells, the records of which are given on pages 364–371.

Ranchers in different parts of the valley have observed fluctuations of the water table in the different seasons of the year. A. C. Whidden stated that on his ranch in secs. 9 and 16, T. 7 N., R. 13 W., the difference between the maximum and minimum height of the water table is about 12 feet.

The water table reaches its highest and lowest levels in different parts of the valley at different times, but in general it is highest late in winter or in spring just before irrigation is begun and lowest in the late summer or fall, near the end of the irrigation period, when

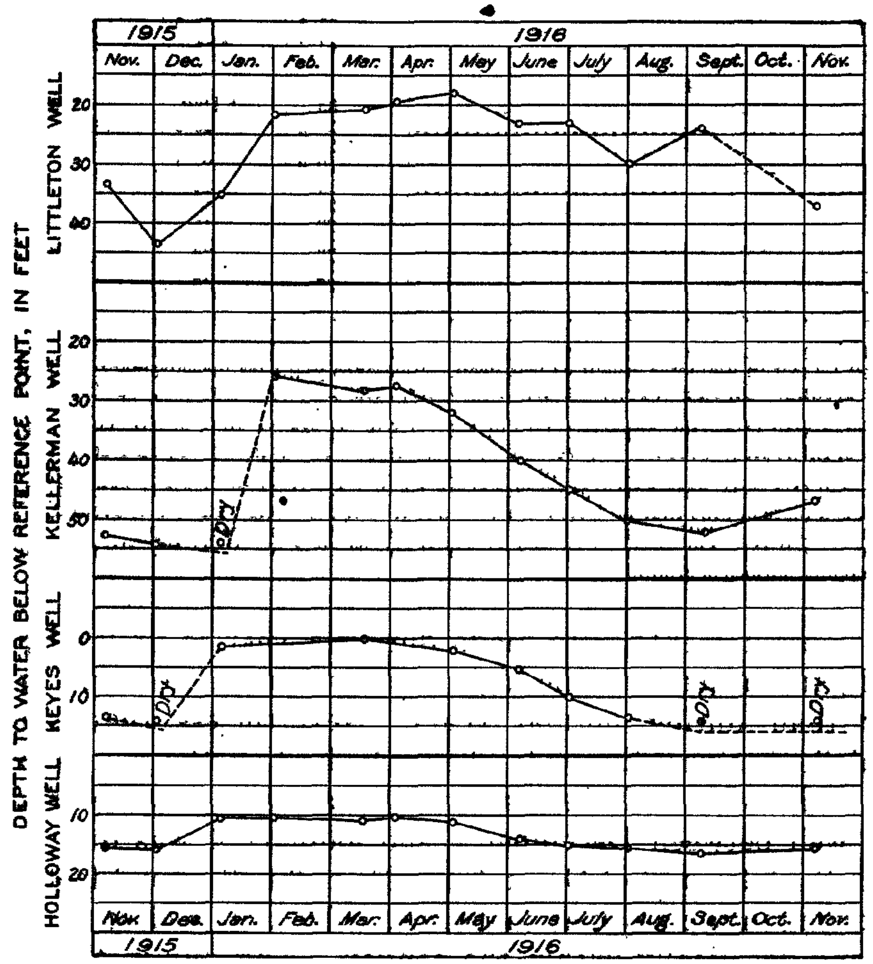

FIGURE 12.—Fluctuation of water table in wells near Little Rock Creek, Antelope Valley, November, 1915, to November, 1916

the heavy pumping produces some of the change in level. There are, however, exceptions to this statement.

E. B. Wargren, whose ranch is in the SW. ¼ NE. ¼ sec. 21, T. 7 N., R. 12 W., stated that the water in his well reaches its lowest level and begins to rise about the later part of September. A. Z. Wilson stated that at his ranch in the southeast corner of sec. 2, T. 7 N., R. 11 W., the water begins to rise in the pump pit in June, although at the same time the pumping lift apparently continues to increase and the yield decreases for several weeks. The apparent rise in the water table is evidently due to the return seepage of water from irrigation. Such a condition has been observed in other irrigated regions. This seepage water may be prevented from reaching the principal water-bearing bed by impervious layers. In support of the theory that this rise is due to seepage from the surface Mr. Wilson gave the following evidence. A reservoir a few hundred feet from Mr. Wilson's well does not hold water readily. When the reservoir was filled the water seeped out, and in one week the water in Mr. Wilson's pump pit rose 2 feet. In a well at the reservoir the water rose 4 feet. It subsided in both wells after the reservoir was empty. A. C. Whidden stated that in his wells in secs. 9 and 16, T. 7 N., R. 13 W., the lowest level is reached during July and the water begins to rise during the later part of that month, while the pumping is the neighborhood is as heavy as at any time. The conditions here are probably similar to those cited by Mr. Wilson. In the wells near the mouth of Rock Creek Canyon the lowest level was not reached until December—that is, later than in most parts of the valley. This lag may be partly accounted for by the fact that no wells are pumped within a radius of several miles, and hence the effect of reduced pumping is eliminated.

SECULAR FLUCTUATIONS

Fluctuations before 1920.—In addition to its annual fluctuations the water table moves slowly up and down during longer and more irregular periods, owing chiefly to series of wet and dry years. Heavy pumping tends to lower it.

The testimony of well owners in the valley as to whether there has been any marked change in the water table during recent years is to a certain extent conflicting. Some stated definitely that there has been a gradual lowering of the water level; others stated that they have noticed no change; and a few stated that the water level in 1919 was higher than during the preceding few years. Many well owners did not know whether the water level in their wells had changed and apparently had not given the matter any thought, although it really is of much importance. Usually the pumps are installed in such a manner that the depth to water can not be readily observed. If the water rises the owner has no indication of the fact, nor even if it falls, unless the drop is so great as to reach the suction limit or is revealed by a great increase in his power bill or a decrease in the discharge of the pump. Even if any of these indications are observed they are sometimes attributed to mechanical trouble in the pump and not to a lowering of the water level. The desirability of measuring the depth to the water level, from time to time, can not be too strongly urged on the owner.

Several well owners have observed that the water in pump pits rose earlier or to a higher level than in past years. The return seepage of irrigation water causes a rise of the ground water in the upper beds while at the same time the level of water in the beds that yield the strongest supply may still be low. In a dry season irrigation is often begun earlier than in normal years and more water is applied to the land. It would therefore not be surprising that in a a dry year like 1919 the level of the water in the upper beds would rise earlier or to a higher level than during normal years. On the whole, the information from well owners indicates a lowering of the water table both within and outside the area of artesian flow.

The proprietor of the hotel at Rosamond stated that in 1919 the water was about 2 feet lower in his well (No. 21) than in 1918. The depth to water, as measured by the writer on January 12, 1920, was 25 feet below the top of the casing, about 8 inches above the ground. This well probably is No. 69 in Water-Supply Paper 278, for which the depth to water was given as 15 feet. If not the same well it is very close to that well, and evidently the water table has dropped. A few hundred feet south of it a well at an old saloon, which is said to have been owned formerly by a Mr. Simpson and to be the well designated No. 267 in Water-Supply Paper 278, was dry in January, 1920, at a depth of 19 feet below the surface. The depth to water in 1909 was given as 16 feet. This well apparently has been partly filled up.

The Southern Pacific Railroad has a flowing well (No. 37) at Oban, in the NE. ¼ sec. 21 or NW. ¼ sec. 22, T. 8 N., R. 12 W., which is so arranged that the water rises naturally into an elevated tank for supplying engines. F. M. Worthington, division superintendent of the railroad, stated in a letter that in 1910 the water in this well rose 22 feet 6 inches above the surface of the ground, in 1918 it rose 19 feet, and in 1920 it rose 17 feet 6 inches. He did not say whether the tests were made at approximately the same time each year, but presumably the height given for each year is the maximum height at which the water stood at any time during that year. The railroad also has a well at Lancaster in which the water stood at the surface when drilled in 1914 and 2 feet below the surface in 1920.

Mr. L. M. Huntington, superintendent of the P. D. Gaskill ranch, in the SW. ¼ sec. 35, T. 8 N., R. 13 W., stated that in 1919 the water in the well (No. 20) was about 8 feet lower than in previous years. This year was the first in which it was necessary to prime the pumps. When the well is not being pumped the water stands about 22 feet below the surface. On the map in Water-Supply Paper 278 this place is shown as inside the area of artesian flow. If this map was correct when made, the drop in the water level since 1909 would be more than 22 feet, but there is some question whether this part of the region was within the area of artesian flow. Two wells in the section that adjoins the Gaskill ranch on the south, Nos. 88 and 89 in

Water-Supply Paper 278, were indicated on the map in that report as flowing wells, but in the table on pages 74 and 75 of that report the depth to water is given as 7 and 7¾ feet, respectively, and they are both referred to as "nonflowing artesian" wells. Mr. Huntington stated that the depth to water in well 89 (in Water-Supply Paper 278), owned by F. A. Ingersoll, is now 22 feet. Evidently the water table in this well has dropped considerably.

Mr. A. C. Whidden, owner of the Portland ranch, in the NE. ¼ sec. 16 and the N. ½ sec. 9, T. 7 N., R. 13 W., stated that, as far as he could determine, the water table dropped on the average about 1 foot a year in the nine years prior to 1920. It was not possible to measure his wells (Nos. 51, 52, and 53), but there is evidence that the drawdown increases each year. It has become necessary to prime the pumps earlier in the year than formerly.

Mr. Harry Austin, who has drilled many wells in the valley, stated that wells 42*a* to 42*c* (in Water-Supply Paper 278), in the N. ½ sec. 2, T. 7 N., R. 13 W., ceased flowing for the first time in 1919. On the Reese Snowden ranch, in the NW. ¼ sec. 11, a short distance south of the wells mentioned above, the depth to water in a well 225 feet deep (No. 56) was 3 feet 8 inches when measured on January 16, 1920. In Water-Supply Paper 278 wells on this ranch and also wells farther west were noted as flowing wells. Evidently the area of artesian flow has been reduced in size in this vicinity.

Mr. H. A. Prendel, whose well (No. 62) is in the SW. ¼ NE. ¼ sec. 24, T. 7 N., R. 13 W., stated that his well began to flow later in the fall of 1919, the flow was smaller than usual, and the pumping lift during the irrigation season was apparently greater. The maximum drawdown on the vacuum gage during the pumping season in 1928 was equivalent to 22 inches of mercury. In 1919 it was 23 inches, which indicates a difference in the water level of about 1 foot. In previous years the water rose high enough to begin flowing usually in October, but in 1918 it did not flow until the later part of November, and in 1919 not until the early part of December. About 1916 the well was changed so that the discharge pipe was about 4 feet above ground, and at that time it flowed from 10 to 15 gallons a minute. When visited by the writer on January 10, 1920, it flowed at the same level not more than 2 gallons a minute. This well is near the edge of the area of artesian flow. Mr. Prendel stated that when he came to the region about 1910 a well (No. 61) about half a mile west of his place flowed 5 or 6 miner's inches. On January 10, 1920, the water stood in this well about 6 inches below the surface. This well is evidently No. 247 in Water-Supply Paper 278. The well when measured by the writer was 211 feet deep.

Mr. E. B. Wargren, whose ranch is in the SW. ¼ NE. ¼ sec. 21, T. 7 N., R. 12 W., stated that when his well (No. 69) was drilled in

1914 the water barely flowed at the surface. In January, 1920, it was about 3 feet below the surface.

On January 14, 1920, the depth to water in an 8-inch well (No. 67) on the E. T. Earl ranch, near the northwest corner of sec. 36, T. 7 N., R. 13 W., as measured by the writer, was 79 feet below the floor of the pump house. Mr. J. A. White, superintendent of the ranch, stated that in April, 1918, the depth to water in a 16-inch well only a few feet from the 8-inch well was 72 feet. As the water in both wells is considered to stand at practically the same level it was about 7 feet lower in 1920. It should be noted, however, that the higher level was recorded in April, when the water table is probably at its maximum level, and perhaps in January, 1920, the water had not yet reached its highest point. Mr. White stated that in 1918 the 16-inch well was pumped dry several times. In 1919, however, the pump yielded more water. The low level of the water in 1918 was attributed to the effect of an earthquake. Although this may have been the cause it is more likely that the real cause was a lowering of the water table, which rose again in 1919.

Mr. Donald Graham, resident manager of the Guy C. Earl ranch, in the NW. ¼ sec. 35, T. 7 N., R. 13 W., stated that the drawdown of his wells during the irrigation season has gradually increased. As indicated by a vacuum gage in 1913, it was equivalent to 20 inches of mercury (about 23 feet) and in 1919 to 26 inches (about 29 feet), which is an average drop of about 1 foot a year.

The depth to water in well 48, near the center of sec. 14, T. 7 N., R. 14 W., as measured by the writer on December 18, 1919, was 147 feet below the top of the casing, which is about 1 foot above the surface. This is evidently well 35 of Water-Supply Paper 278, in which the depth to water is given as 120 feet.

Mr. J. L. Meder stated that on his brother's ranch, in the NE. ¼ NW. ¼ sec. 13, T. 7 N., R. 12 W., the crops were originally irrigated from flowing wells (No. 74) without pumping, but it is now necessary to pump. The wells still flow in the winter but not as much as formerly.

The depth to water in a well (No. 85) on the J. B. Nourse ranch, at the southwest corner of sec. 12, T. 7 N., R. 11 W., as measured by the writer on January 15, 1920, was 13 feet below the surface. This is well 77 of Water-Supply Paper 278 and flowed when it was drilled in 1906. Mr. Nourse believes that the pumping lift has increased in the last four years, basing his statement on his yearly power consumption since he began using electricity. In 1916 Mr. Nourse lowered his pump 8 or 9 feet.

Mr. A. Z. Wilson, whose ranch is in the southeast corner of sec. 2, T. 7 N., R. 11 W., stated that the water table in the summer is now about 10 feet lower than when he settled in the valley in 1907. One of his wells (No. 84), when it was drilled in July, 1907, flowed about 6 miner's inches. The well has flowed every winter until the season of 1919–20, but the flow was less each year. On January 15 the well had not begun to flow, and Mr. Wilson did not believe it would flow. Soon after the well was drilled a centrifugal pump was installed, being set at the ground level. It has since been necessary to lower the pump, setting it in a 12-foot pit. The writer was informed that it has been necessary to lower the pumps in several other wells in the vicinity of the Roosevelt School, but he did not have an opportunity to obtain detailed information in regard to conditions in that part of the valley.

Mr. Grant Frakes for several years irrigated about 5 acres of alfalfa in sec. 30, T. 8 N., R. 10 W., from a flowing well (No. 45) without pumping. For the last three years the flow has ceased during part of the summer. In 1919 there was no flow from about July 1 to about November 1. The flow from this well was originally about 25 miner's inches.

Mr. Charles Eberts, who has installed and repaired many pumps in the valley and hence has been in a position to observe conditions in different parts of it, expressed the opinion that the water table had been lowered from 3 to 10 feet in the six years ending in 1919, although the water in the upper alluvial beds had risen several feet in some wells, owing to the return seepage from irrigation.

Several other persons reported that the pumping lift had increased 10 to 12 feet since their wells were drilled. Two of these wells are situated several miles east of Lancaster, in the Roosevelt district, and two others about 4 miles southeast of Palmdale, in a region of comparatively new development.

Some of the lowering is doubtless due to deficient precipitation in the four years prior to 1919, but most of it is apparently due to the draft on the supply for irrigation. It is manifestly impossible for so great a quantity to be pumped from the ground-water reservoir without affecting the water table. The consumption has increased more or less regularly in recent years. The several years of deficient precipitation have had a cumulative effect in reducing the recharge in proportion to the discharge, for not only has the recharge each year been less than in normal years but the consumption has been greater for a given area because in dry years irrigation is usually begun earlier than in normal years.

Fluctuations in 1920–1926.—After the writer's investigation in January, 1920, it was realized that periodic measurements of the depth to water in a number of wells were necessary to determine the true nature of fluctuations of the water table. Unfortunately funds were not available to permit observations as frequently as desirable, but a considerable number of measurements have been made which yield valuable information. Mr. N. S. Abbott, a citizen of Lancaster who has installed many pumps in the valley, has measured about 25 wells from two to five times a year since 1921. The writer expresses his appreciation of the service thus rendered by Mr. Abbott. Beginning in October, 1924, measurements of the same wells have been made twice a year by F. C. Ebert or H. G. Troxell, of the United States Geological Survey. These observations have been made early in the spring, when the water table is about at its highest point, and in the fall, when it is about at its lowest point. The records of depth to water are given on pages 364–371. The locations of the wells, with numbers corresponding to those in the tables, are shown on Plate 19.

To judge from observations in other investigations in which automatic recorders were used to obtain a continuous record of water levels, the seasonal rise or fall of the water level may be interrupted by fluctuations as pumps on other wells are stopped or started. Furthermore, the lowest and highest levels reached each season are affected by several factors that vary from year to year, such as amount of precipitation and its time of occurrence. The difference in precipitation from year to year may affect the water level directly in so far as it affects recharge of the ground-water reservoir; and indirectly in that pumping for irrigation may be necessary earlier or later in some years than in others. Because of these variable conditions, it is unlikely that the water level reaches its lowest or highest level at exactly the same time each year. It is highly desirable that automatic water-level recorders be installed on several observation wells to obtain continuous records of the movement of the water level, from which the highest and lowest points reached each year can be determined.

All the wells show more or less seasonal fluctuation, the water level being lower in summer than in winter. The amount of fluctuation ranges from a few inches in wells 48 and 163, to 41 feet in well 160. Several of the wells have a seasonal range of more than 10 feet, notably Nos. 59, 61, 155a, 160, and 169. These are all near wells that are pumped regularly during the irrigation season, and the great lowering of the water level in them in the summer is obviously due to pumping of the near-by wells. There is no conclusive evidence of any definite trend from 1921 to 1925. In the summer of 1926, however, lower water levels were observed in every well for which the records are complete than at any previous time during the period of the observations with the exception of well 48. Furthermore, in 8 out of 17 wells measured in 1927, including well 48, the water level was lower than in any previous year.

The difference between the lowest level in the summer of 1926 and the previous lowest level ranged in different wells from 0.6 foot to

12.8 feet. In three wells it was between 5 and 10 feet, in six wells it was between 1 and 5 feet, and in four wells it was 1 foot or less. The difference between the low levels of 1927 and those of 1926 was mostly less than 1 foot.

It appears that only a moderate decline in the water level occurred in 1926 and 1927, and this is believed to be due in part to some increase in draft and in part to deficient precipitation.

RECENT DEVELOPMENTS OF GROUND WATER

Many new wells have been drilled in different parts of Antelope Valley since the first report on the water resources of the valley was published.[15] As a result of the drilling of some of these wells conditions were revealed that had not been previously known. The trend of the new developments in different parts of the region is given briefly in the following pages.

In the central part of the valley the new developments have taken place largely around the border of the area of artesian flow, either extending a short distance inside the boundary of the area or reaching a mile or two away from it. In this territory alfalfa is the principal crop. Few new wells have been drilled in the interior of the area of artesian flow doubtless because it is not adapted to alfalfa. The greatest lift observed by the writer where water was pumped for alfalfa was about 70 feet, in the northwestern part of T. 8 N., R. 13 W., but throughout most of the valley water for alfalfa is not pumped more than 50 feet. The land rises more gradually toward the east and west than toward the south, and it is perhaps for this reason that more new wells have been drilled around the east and west margins of the flowing-well area. A large number of wells have been drilled west, northwest, and north of Esperanza School. Many have been drilled 4 or 5 miles east and southeast of Lancaster, and a large number within a radius of several miles of the Roosevelt and Redman Schools. The depth to water directly east of the flowing-well area is nowhere very great.

The depth to water in the well of William H. Brooks (No. 89), in the SE. ¼ sec. 10, T. 7 N., R. 10 W., is only 25 feet. In well 91, in the NW. ¼ sec. 20, T. 7 N., R. 9 W., belonging to W. T. Graham, it is about 80 feet. This is nearly at the eastern limit of the irrigable area, for rock hills rise beyond it. Few wells seem to have been drilled southwest of Lancaster, probably because the land rises more rapidly in that direction, and the pumping lift increases rapidly. In the lower part of the valley most of the wells drilled years ago were only 4, 6, or 8 inches in diameter. At many places new wells of larger diameter have been drilled to replace the old ones.

[15] Johnson, H. R., Water resources of Antelope Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 278, 1911.

Many new wells have been drilled northeast of Palmdale and between that town and Little Rock. In Water-Supply Paper 278 only a few wells were shown in and near Palmdale, and these were used principally only for domestic purposes or manufacturing. The depth to water was supposed to be too great to permit the use of the wells for irrigation. In recent years several wells have been drilled between Palmdale and Little Rock in which the depth to water was found to be much less than was supposed. The depth to water in the upper part of the alluvial fan of Little Rock Creek is slight near the mouth of the canyon of the creek and increases for some distance to the northwest, north, and northeast of the mouth of the canyon. In well 39, the Littleton well, a few feet northwest of the bridge over Little Rock Creek, in the NW. ¼ sec. 14, T. 5 N., R. 11 W., the depth to water on January 9, 1920, was 38 feet. (See p. 327 for data on fluctuations of the water level in this well.) The depth to water increases for some distance to the northwest, north, and northeast. West of Little Rock Creek, in the NE. ¼ sec. 9, T. 5 N., R. 11 W., the depth to water in well 138, belonging to Robert Stuart, is reported to be about 90 feet. In well 111, owned by John Boyle, in the southeast corner of the SW. ¼ sec. 32, T. 6 N., R. 11 W., the depth to water is said to be about 100 feet. In well 110, near the southwest corner of the NW. ¼ sec. 31, T. 6 N., R. 11 W., owned by Carl W. Lorenz, the depth to water is reported to be 146 feet, and in well 101, in Palmdale, just east of the Palmdale Inn, owned by the Palmdale Land Co., the depth to water as measured by the writer on January 7, 1920, was 245 feet.

Not only does the depth to water increase northwestward from the mouth of the canyon of Little Rock Creek, but it also increases to the north and northeast, for some distance. The depth to water in well 107, in the SE. ¼ sec. 21, T. 6 N., R. 11 W., owned by George B. Otis, is reported to be about 165 feet, and in other wells near this the depth to water is nearly as great. It is worthy of note that granite was struck in this well at a depth of about 300 feet. So far as is known rock was not reached in any other wells in this vicinity. On the Rowland ranch, in sec. 14, T. 6 N., R. 11 W., about 5 miles north of the Littleton well, the depth to water is reported to be 117 feet. In the well of E. W. Martin (No. 143), in the NW. ¼ sec. 12, T. 5 N., R. 11 W., about a mile northeast of well 39, the depth to water when drilled in August, 1918, was 86 feet. The depth to water in well 16, in the NW. ¼ sec. 28, T. 6 N., R. 10 W., owned by J. Hintermann, is said to be 125 feet. About 1½ miles northeast of this the depth to water in well 117, in sec. 22, owned by Mr. Bowland, is said to be about 75 feet. Many other wells have been drilled east and southeast of Palmdale, but these need not be discussed in detail.

The water table is so close to the surface near the mouth of the canyon of Little Rock Creek apparently because so much water is poured out onto the gravel and absorbed near the head of the alluvial fan. The water after it reaches the saturated zone does not move rapidly toward the lower part of the basin, and the result is a piling up, so to speak, of the water near the mouth of the canyon. If no water were added to the ground water beneath the fan for several years, it would have an opportunity to spread out and reach a uniform level. Because the water table stands so much higher under the alluvial fan of Little Rock Creek it is probable that during a period of extra dry years the water level will drop more in that locality than in the lower part of the valley, where the water table is more nearly level. It is also possible that the water table would return to or nearly to the original level in a single winter of exceptionally heavy and advantageously distributed rainfall.

The influence of discharge from the water table of Little Rock Creek in building up the water level beneath its fan are shown in three profiles in Figure 13. Profile B extends along a line almost due north from the mouth of Little Rock Creek, and shows how the water table beneath the alluvial cone rises more than 400 feet above its level in the lower part of the valley. Along profile A, which extends from the mouth of the creek northwestward through Palmdale, the water table slopes rather steeply for some distance from the mouth of the cone. In this profile the water table in well 96 is represented to be slightly higher than in well 101. This may be due partly to inadequate data in regard to the altitude of the surface at the wells. However, it is also probably due in part to the fact that there is a buried rock ridge, of which Quartz Hill is a part, which acts as a barrier to the northward movement of water, so that the water stands at a higher level behind it than at corresponding altitudes farther to the east and west. Profile C extends along a line extending from the San Gabriel Mountains northward through Palmdale—that is, it is between the mouths of Little Rock and Amargosa Creeks.[16] In contrast to the other two profiles, which extend from the mouth of Little Rock Creek, profile C shows that the water table does not rise steeply near the mountains but has only a gradual slope, with little doubt because there is no important contribution to the ground-water reservoir in this part of the valley.

The recent development of the ground-water supply on the upper part of the alluvial slope, between Palmdale and Little Rock, has been due in a large measure to the high returns received from the pear and apple orchards in the Little Rock irrigation district, where the water supply is obtained from Little Rock Creek. The prices

[16] The contour interval on the Elizabeth topographic map, on which the surface profile is based, is so large that the valley occupied by the Harold Reservoir is not shown.

received for the fruits produced in these orchards are sufficient to justify high pumping lifts, much greater than can be borne in alfalfa growing. The lands nearer the mountains that are irrigated by ground water are therefore devoted almost entirely to pear and apple orchards. In the four or five years prior to 1919 several hundred acres of trees had been set out, and in 1919 the oldest were

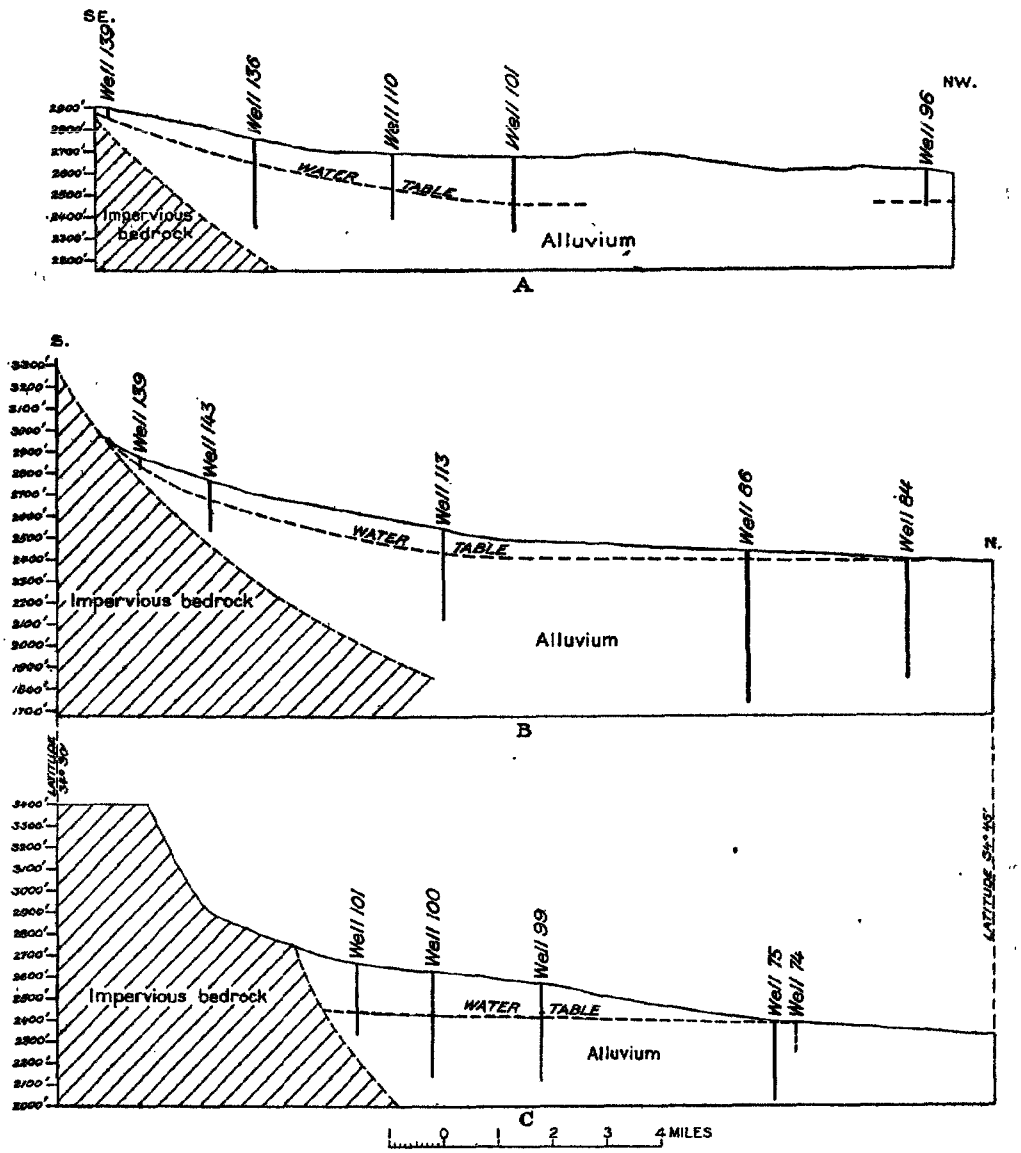

FIGURE 13.—Sections showing effect of discharge from Little Rock Creek, Antelope Valley, in building up the water table. A, Profile from mouth of Little Rock Creek northwestward through Palmdale; B, profile northward approximately along longitude 118°; C, profile along a line from north to south through Palmdale

just reaching the bearing stage. The pumping lifts in this part of the valley range from 100 feet to as much as 160 feet.

Conditions similar to those on the fan on Little Rock Creek probably exist on the fan of Rock Creek, but fewer data are available in regard to the latter region. The lift in well 145, in the Longview colony, owned by G. C. Chase and believed to be in sec. 25 or 26, T. 5 N.,

R. 10 W., is reported to be about 50 feet. The only other information obtained was in regard to wells nearer Lovejoy Buttes. The depth to water in well 120, in the S. ½ sec. 28, T. 6 N., R. 9 W., owned by E. E. Reinsberg, was reported to be about 28 feet. Farther north, near the south side of the buttes, the water stands very close to the surface, producing a ciénaga around Lovejoy Springs. One well near the springs, owned by Alexander Stewart, flows, and in another the depth to water is only 2 feet.

The nearness of the water table to the surface in this vicinity is evidently due to the presence of the Lovejoy Buttes, which act as a barrier behind which the water is held, for north of the buttes the depth to water is much greater. J. C. McGowan reports that in his well (No. 94), in the SE. ¼ SW. ¼ sec. 34, T. 7 N., R. 9 W., the depth to water is 100 feet. In the well of Aaron C. Huff (No. 121), near the northwest corner of sec. 18, T. 6 N., R. 8 W., the depth to water is 165 feet. The barrier apparently continues as a buried rock ridge eastward from the Lovejoy Buttes toward Gray Mountain, for data collected in 1917 by G. A. Waring, of the United States Geological Survey, show that the water table in secs. 13 and 14, T. 6 N., R. 8 W., was only 30 to 50 feet below the surface. (See wells 122–125, pp. 358–359.) Additional data are presented in a recent report on water for irrigation in Upper Mohave Valley,[17] which adjoins Antelope Valley on the east. On Plate 1 of that report, contours of the water table show that the water table is higher immediately south of Gray Mountain than to the east. Apparently a part of the ground water that comes from the flow of Sheep Creek is held back by the rock hills in the vicinity of Mirage Dry Lake and is diverted westward along the south side of the buried ridge between Gray Mountain and the Lovejoy Buttes. If this is true, the depth to water along the south side of T. 6 N., R. 8 W., would not be very great.

Northwest of Palmdale the distance between the flowing-well area and the foot of the mountains is short and the land rises rapidly. Accordingly, the depth to water increases rapidly from the flowing-well area toward the mountains. In well 98, owned by W. R. Cowan, in the southeast corner of the NE. ¼ NE. ¼ sec. 4, T. 6 N., R. 12 W., only 3 miles from the flowing-well area, the depth to water was 150 feet when the well was drilled in 1914. The pumping lift in this well was estimated by the driller to be 180 feet when the yield was 30 miner's inches (270 gallons a minute). In well 67, on the E. T. Earl estate, in the northwest corner of sec. 36, T. 7 N., R. 13 W., the depth to water, as measured by the writer on January 14, 1920, was 79 feet.

[17] McClure, W. F., and others, Report on the utilization of Mojave River for irrigation in Victor Valley, Calif.: California Dept. Engineering Bull. 5, pp. 54–55, pl. 1, 1918.

South of Quartz Hill, in sec. 6, T. 6 N., R. 12 W., no good wells have been obtained. Well 97, near the northeast corner of the NE. ¼ sec. 1, T. 6 N., R. 13 W., south of Quartz Hill, struck hard rock at 77 feet. Water was found at 76 feet, but the quantity is small, and it was estimated by the driller that the well would not pump more than 5 or 6 miner's inches (45 to 54 gallons a minute). In well 96, about 1½ miles southwest of this, probably in the SW. ¼ sec. 2, T. 6 N., R. 13 W., on the ranch of Dr. W. Winnard, hard rock was struck at about 125 feet. The water stood about 130 feet from the surface when the well was completed in January, 1920. The quantity was said to be only enough for domestic use. About half a mile northwest of Doctor Winnard's well hard material was struck in well 95, on the place of Fred Godde, at a depth of 137 feet. Water was found at 96 feet, and when drilling was finished it stood at about that depth. The quantity available is apparently not great.

It is not certain whether the material called "rock" in the Winnard and Godde wells is granite, or other unweathered igneous rock, or whether it is material derived from the weathering of such rocks, which has been cemented together. At any rate, it apparently is not very porous and does not yield much water. It is also perhaps significant that there is no stream in this locality like Little Rock Creek which might pour out a large quantity of water to build up the water table.

There has been practically no development by irrigation in the west or northwest part of the valley. In January, 1920, the writer observed only one or two ranches that were irrigated west of the road between Del Sur and Willow Springs. This condition is due largely to the fact that the depth of water increases toward the mountains. The depth to water in well 30, near the northeast corner of sec. 30, T. 8 N., R. 13 W., as measured by the writer on January 16, 1920, was 56 feet. The depth to water in well 26, owned by R. A. George, near the southeast corner of sec. 14, T. 8 N., R. 14 W., is reported by the driller to have been 90 feet when the well was finished in August, 1918. According to the report by Johnson,[18] the depth to water in a well in the NW. ¼ sec. 6, T. 8 N., R. 14 W., is 140 feet. In the same report the depth to water in a well (No. 25 on pl. 19) in sec. 10, T. 8 N., R. 16 W., is given as 200 feet. The depth to water in a well 2½ miles west of that well, in sec. 6 of the same township (well 24, pl. 19), is given as only 94 feet. The reason for this difference is not known, but it is believed that in the well where the depth to water is only 94 feet the supply comes from a local bed which is perched above the main water table. This belief is supported by information supplied by C. H. Windham in

[18] Johnson, H. R., Water resources of Antelope Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 278, p. 70, well 9, 1911.

regard to a well drilled for oil (No. 23, pl. 19) on the Liebre ranch, approximately near the center of sec. 27, T. 9 N., R. 17 W. Water was not encountered in this well until a depth of 530 feet was reached, and it rose within about 400 feet of the surface but could be bailed down. According to the topographic map this well is not more than 300 feet above the well in sec. 6, T. 8 N., R. 16 W., and yet the altitude of the water table is apparently lower than in the well on lower ground. Normally it would be more likely that the water table would be higher nearer the mountains. It has been shown earlier in this report that there is no great contribution to the water table by streams at the west end of the valley, and for this reason it is not surprising that the depth to water is great, for there is no "piling up," so to speak, of the water such as occurs on the alluvial fan of Little Rock Creek.

Several wells have been drilled west and northwest of Willow Springs, but so far as is known none of them have been used for irrigation. Mr. Fred M. Hamilton, owner of Willow Springs, states that in well 15, drilled by him in the SE. ¼ SE. ¼ sec. 1, T. 9 N., R. 14 W., water was struck at 67 feet and rose within 57 feet of the surface. In well 13, on the place of John Lane, in the NE. ¼ sec. 4 of the same township, the first water was struck at 275 feet. Another water-bearing bed was struck at 550 feet, and the water rose within 250 feet of the surface. On Mr. Naquin's place, in the NW. ¼ sec. 8, T. 9 N., R. 13 W., north of the lava butte that lies east of Willow Springs, the depth to water in well 16 is said to have been 47 feet.

A number of wells have been drilled on the nearly level lands that lie between the lava buttes north of Rosamond (called the Rosamond Buttes), Soledad Mountain, and hills north of the Atchison, Topeka & Santa Fe Railway. So far as can be determined from the topographic maps the region is a part of the Antelope Valley drainage basin, but the ground-water conditions are probably not comparable with those in the main part of the valley. It is likely that the depth to impervious non water-bearing rocks is at no place very great, and the topography is such that there is no source for any large contribution to the ground-water supply. Besides the rainfall in the immediate region, the only other possible contribution may be a part of the run-off from Oak Creek.

Near the southwest corner of sec. 24, T. 10 N., R. 12 W., the depth to water in an 8-inch well (No. 10) owned by I. J. Sopp, is about 40 feet, and the total depth of the well is 75 feet. The well is equipped only with a windmill and is used for irrigating a small patch of alfalfa. Another well (No. 11), on the D. H. Walker ranch, in the NW. ¼ NE. ¼ sec. 26 of the same township, is reported to yield 30 miner's inches, with a lift of about 90 feet. The water is used to irrigate 20 acres of apple trees. A well (No. 9) on the place of R. A. Canning, near the northwest corner of sec. 18, T. 10 N., R. 11 W., is 150 feet deep, and the depth to water is about 50 feet. The well is equipped with a windmill, and the water is used to irrigate about 5 acres of fruit trees and a small patch of alfalfa. On the place of Mr. Rathbun, in sec. 34, T. 11 N., R. 11 W., in well 8, which is 300 feet deep, the depth to water is reported to be 70 feet. Rock was struck within 60 feet of the top, and the water comes in from crevices. The yield is small, estimated at about 100 barrels in 24 hours. In another well (No. 7) owned by Mr. Rathbun, probably in sec. 4, T. 10 N., R. 11 W., the depth to water is reported to be 70 feet. The total depth is 200 feet. The yield of this well is also small. It is reported that the water in both of Mr. Rathbun's wells is slightly salty. Other wells are located in this region, but no information was obtained in regard to them.

Several wells have been drilled at the north end of Rogers "Dry Lake," but not much information was obtained in regard to them. Well 3, on the place of H. M. Meckley, in the NE. ¼ sec. 34, T. 11 N., R. 9 W., is 260 feet deep, and the depth to water is reported to be 90 feet. With the pump running to its full capacity this well is said to have yielded 35 miner's inches with a 2-foot drawdown. The owner believes that the well will furnish 65 miner's inches if equipped with a larger pump. E. F. Edinburgh has a well (No. 4) in the northeast corner of the NW. ¼ sec. 6, T. 10 N., R. 9 W., which is 280 feet deep. The depth to water is 90 feet. The well had not been tested when the information was obtained by the writer in December, 1917. The depth to water in well 5, owned by the Atchison, Topeka & Santa Fe Railway, at Muroc, is only about 30 feet. Although definite information is not available in regard to the relative altitude of the ground surface at Muroc and at the wells at the north end of the "dry lake," it is believed that the water table is lower at the north end of the lake than at any other place in the valley, and that there is percolation northward into Fremont Valley. (See p. 325.)

The possible contribution to the water table from precipitation in the region around the north end of Rogers Dry Lake is small. It is not definitely known whether the deposits underlying the playa are all clay or silt, and therefore so impervious that ground water from the main part of the valley can not move to beds that underlie the north end of the playa. However, in well 6, drilled near the center of sec. 20, T. 9 N., R. 9 W., on the playa, as a test for potash, water-bearing gravel, which yielded a strong flow of water, was struck at a depth of less than 145 feet. It is quite probable that there is free communication between the water-bearing beds at the north end of the "dry lake" and those beneath the main part of the valley.

QUALITY OF WATER

Analyses of several samples of water are published in Water-Supply Paper 278 (p. 57), and analyses of 6 samples collected by the writer are given in the accompanying table. In addition, in Water-Supply Paper 278 (pp. 70–89) the total solids as determined by conductivity measurements are given for samples from 180 other wells. These analyses indicate that water suitable for domestic use and irrigation can be obtained from deep wells almost anywhere in the valley. All but two of the 12 waters analyzed are classed as either fair or good for domestic use, boilers, and irrigation. The total dissolved solids range from 158 to 766 parts per million, but only two samples contained more than 330 parts. The water which contained 766 parts per million (No. 69) was obtained from a shallow well only 15 feet deep, and alkali is abundant on the surface a short distance from the well. It is hard but not unsuitable for drinking or irrigation.

Analyses of ground waters in Antelope Valley, Calif.

[Parts per million]

No. on pl. 19 [a]	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Carbonate radicle (CO_3)	Bicarbonate radicle (HCO_3)	Sulphate radicle (SO_4)	Chloride radicle (Cl)	Nitrate radicle (NO_3)	Total dissolved solids at 180° C.
6	Dec. 13, 1917	27	0.21	6.1	1.9	[b] 94	9.1	158	71	6.2	0.78	301
59	Jan. 10, 1920	39	.07	36	8.3	[b] 27	.0	150	9.5	16	33	255
65	Jan. 10, 1920	35	.06	46	11	[b] 48	.0	150	88	28	12	346
69	Jan. 14, 1920	40	.07	157	23	75	.0	364	127	77	61	766
86	Jan. 13, 1920	23	.07	21	2.2	[b] 29	1.7	107	19	10	.50	158
148	1908	45	.86	5.7	1.8	154	9.6	325	55	29	.0	460
149	1908	52	.84	5.1	6.2	102	19	196	54	65	.64	330
150	1908	16	.08	40	7.0	54	.0	176	44	25	7.0	283
151	1908	39	.05	36	12	41	.0	146	31	18	30	267
152	1908	39	.07	23	3.7	25	6.0	96	25	5.5	1.7	161
([c])	1908	25	.25	44	9.1	54	.0	155	101	19	-------	312
([d])	Dec. 13, 1917	46	.06	9.3	1.7	[b] 82	.0	164	59	8.6	.48	281

[a] For additional data see corresponding map number in table on pp. 348–363.
[b] Calculated.
[c] Not numbered on map. Willow Springs, sec. 11, T. 9 N., R. 14 W.
[d] Not numbered on map. Buckhorn Springs, sec. 27, T. 9 N., R. 10 W.

Analysts: No. 6 and Buckhorn Springs, A. T. Geiger; Nos. 59, 65, 69, and 86, M. D. Foster; Nos. 148–152 and Willow Springs, Walton Van Winkle.

Of the 185 samples from wells listed in Water-Supply Paper 278 only 19 contained more than 300 parts per million of total solids and only 2 contained more than 500 parts per million. In general, the water obtained from shallow wells is more highly mineralized than that from deeper wells. This is especially true in the area of artesian flow, where the water table is so close to the surface that more or less alkali has been deposited at and near the surface as the result of evaporation. The concentration of alkali in the soil may extend down a number of feet, or surface water containing alkali may seep into the well. The water from deep wells near and on the playas is nearly as good as that from wells some distance from them, despite the presence of alkali at the surface. Water that contained only 301 parts per million of solids was obtained at a depth of less than 150 feet in a well (No. 6) drilled as a test for potash near the center of sec. 20, T. 9 N., R. 9 W., on Rogers Dry Lake. This drilling did not penetrate any beds of salt or gypsum.

WELL CONSTRUCTION

Drilling in Antelope Valley is done by the hydraulic rotary and the mud-scow or California methods.

In the fine deposits that underlie the lower parts of the alluvial slopes the hydraulic rotary method is commonly used. The hole is not cased until it is drilled the entire depth or until the diameter is reduced. To prevent caving before the casing is inserted the water that is forced into the hole is laden with mud, which fills the porous alluvium and acts as a lining. Unperforated casing is usually inserted to a depth of 50 feet or more, and perforated casing of small diameter in the rest of the well. The casing is perforated before it is inserted.

In the coarse bouldery deposits that underlie the upper parts of the alluvial slope the mud-scow method is used. A sand bucket or mud scow, consisting of a long iron pipe with a sharpened edge, is commonly used for both loosening and removing the material, but if large boulders are encountered the drilling may be done with a heavy iron bit. To prevent caving the casing must be driven down as the hole progresses and is perforated after it is inserted in the well. It may be perforated throughout, but usually it is perforated only where good supplies of water were struck when the hole was drilled. If because of inaccurate measurements the casing is perforated a little too high or too low, the water supply may be much less than if the measurements were carefully made.

If the water is under artesian pressure and the casing is perforated for most of its length, the pressure at different horizons may be different and the water from one bed may be forced into another. In several wells 500 to 600 feet deep the water level stood 5 to 15 feet or more above the level of the water in wells only half as deep.

Most of the wells that were drilled during the early development of the valley were only 6 or 8 inches in diameter. In recent years most of them have been 10 or 12 inches, and a few as large as 16 inches. One reason for the larger wells has been the increase in the use of deep-well turbine pumps.

PUMPING PLANTS

Three general types of pumps are used in Antelope Valley. In the upper parts of the alluvial slopes, where the lift is great, reciprocating or cylinder pumps are much used. They are especially adapted to pumping rather small supplies of water for fruit orchards. In the lower parts of the alluvial slopes, where the lift is not great, and especially in the area of artesian flow centrifugal pumps of both horizontal and vertical types have been used to a great extent, the pumps usually being set in pits. In the last few years the drop of the water table has made it necessary to lower a number of the centrifugal pumps, and this required the deepening of the pump pits. To avoid additional expense from this trouble many of the well owners have installed deep-well turbine centrifugal pumps, which are placed in the well casing at any desired depth. These pumps are also well adapted to use where the lift is great, as in the fruit-raising districts.

Probably 90 per cent of the irrigation wells are pumped by electricity, most of the rest being too far from the transmission lines to warrant the expense of connecting them. Practically all the plants that are not operated by electricity are run by internal-combustion engines that use the cheaper grades of fuel known as "tops" and distillate.

CONSERVATION OF WATER SUPPLY

The information presented in this report shows that the available water supply is not sufficient to irrigate all the tillable land in the valley; but it is believed that the safe yield of the ground-water reservoir has not yet been reached. Nevertheless, conservation of the water supply is necessary if the maximum use of the water is to be obtained. In some other areas, notably the Santa Ana and San Gabriel Basins, the ground-water supply has been increased by a process called water spreading, which consists of spreading the flood water over a large territory, thus increasing the area of the surface where percolation may occur.[19] In Antelope Valley most of the run-off is spread naturally over the alluvial fans, so that the benefits to be attained by artificial spreading probably would not be great. Possibly some of the water that occasionally reached the playas, where it is evaporated, might be added to the ground-water reservoir by spreading.

Losses of ground water may be reduced by reducing the natural losses and the waste through wells. The natural loss by evaporation and transpiration probably will be reduced as increased pumpage causes the water level to be lowered. This condition will also reduce somewhat the loss by percolation out of the basin, if there is any. One very practical means of increasing the irrigation supply is by eliminating needless waste from flowing wells, many of which are allowed to flow freely throughout the year, although no use is made of the water. (See pl. 18, *B*.) This waste amounts to at least

[19] Lee, C. H., Subterranean storage of flood water by artificial methods in San Bernardino Valley, Calif.: California Conservation Comm. Rept., pp. 339–399, 1913. Tait, C. E., Preliminary report on conservation control of flood water in Coachella Valley, Calif.: California Dept. Eng. Fifth Bienn. Rept., appendix D, pp. 23–27, 1917.

several thousand acre-feet a year. The water thus wasted is probably to a large extent lost permanently, because much of the water is dissipated by evaporation and transpiration and probably only a very small part of it returns to the ground-water reservoir. Other uneconomic results of this waste have been pointed out in the report by Johnson.[20] When wells are allowed to flow freely the pressure head in near-by wells is reduced, and it may become necessary to install pumps. The waste of water increases the alkali in the soil.

Doubtless some water may be saved by a careful study of the distribution and application of water to the crops. Several reports on the elimination of waste in water applied in irrigation have been published by the United States Department of Agriculture or State experiment stations.[21] The quantity of water required for a unit area may be reduced by the growth of crops that require less water than alfalfa. Deciduous fruit trees require much less water than alfalfa, but it is said that the climatic conditions in the lower parts of the valley differ so greatly from those in the Palmdale and Little Rock fruit districts that fruit grown in the lowlands can not compete with the choice fruit produced on the higher lands to the south. The truth of this statement can best be determined by actual experimentation, and several persons on the lowlands are raising small orchards.

RECORDS OF WELLS

Detailed data in regard to many wells in Antelope Valley are given in the following table. The well numbers in the first column correspond to those on Plate 19.[22] Most of the wells listed have been drilled since the publication of Water-Supply Paper 278, but a few which are listed in that report, and which are mentioned specifically in the text of the present report, are included in the table. The reader is referred to Water-Supply Paper 278 for data in regard to many wells drilled prior to 1909. Some wells in the valley are not listed in either report.

The well data were obtained from a number of sources. The information in regard to about one-third of the wells was obtained from drillers' logs, which did not give information in regard to the pumping plants. Some of the data were reported by the owners of the wells or by other persons. The data obtained from so many sources are of various degrees of accuracy. In the tables so far as possible the

[20] Johnson, H. R., op. cit., pp. 66-67.

[21] Etcheverry, B. A., Increasing the duty of water: California Univ. Coll. Agr. Exper. Sta. Circ. 114, 1914. Smith, G. E. P., Use and waste of irrigation water: Arizona Univ. Coll. Agr. Exper. Sta. Bull. 88, 1919. Fortier, Samuel, Irrigation of alfalfa: U. S. Dept. Agr. Farmers Bull. 865, 1917. Adams, Frank, Robertson, R. D., Beckett, S. H., Hutchins, W. A., and Israelsen, O. W., Investigations of the economical duty of water for alfalfa in Sacramento Valley, Calif., 1910-1915: California Dept., Eng. Fifth Bienn. Rept., appendix C, 1917; also printed as California State Dept. Eng. Bull. 3.

[22] Owing to a necessary rearrangement of the well numbers after Plate 19 was drawn, certain numbers have been omitted from the map.

source of the data has been indicated by means of footnotes. In general, the information in regard to the depth to water can be considered of value only for the few places where the date of measurement is given, in order that the relation of the water level at the time of measurement to the seasonal fluctuation may be known. In the drillers' records of a number of wells that apparently are located within the area of artesian flow the depth to water is given as several feet below the surface. It is probable that the depth given is the depth at which shallow ground water not under artesian pressure was struck and that at greater depths water under artesian pressure probably rose to the surface, but this fact was not stated in the records. In many places the depth to water is based on measurements made several years ago, and the water level has since changed considerably.

Records of wells in and near Antelope Valley, Calif.

No. on map (pl. 19)	Location				Owner or name	Depth of well (feet)	Diameter of well (inches)	Type of casing and depth at which it is perforated
	Quarter	Section	T. N.	R. W.				
1	SW	24	(b)	(b)	C. C. Conklin	337	12	
2	(?)	35(?)	12	10	(?)	[c] 378	10	
3	NE	34	11	9	H. M. Meckley	260	10	
4	NW	6	10	9	E. F. Edinburgh	280	10	
5	NW.(?)	31(?)	10	9	Atchison, Topeka & Santa Fe Railway (Muroc station).	218	12½	
6	(?)	20	9	9	California Kali Co.	150(?)		
7	(?)	34(?)	11	11	—— Rathbun	300		
8	(?)	4(?)	10	11	do	200		
9	NW	18	10	11	R. A. Canning	150		
10	SW	24	10	12	I. J. Sopp	75	8	
11	NE	26	10	12	D. H. Walker	(?)	16	
12	N½	12	11	12	George A. Arper	(?)		
13	NE	4	9	14	John Lane	550	12	
14	SW	2	9	14	L. A. Turner	155	7	
15	SE	1	9	14	F. M. Hamilton(?)	186		
16	NW	8	9	13	—— Naquin	(?)	12	
17	NE	14	9	14	John Hammond	100		
18	NW	29	9	13		[c] 54	42	
19	SE	31	9	13	Arden Dairy	443	12	12-inch screw casing, 0–118 feet; 10-inch perforated stovepipe casing, 117–443 feet.
20	SW	34	9	13	P. D. Gaskill	420 350	8 10	
21	NW	21	9	12	W. S. Webb	[c] 89	6	
22	SE	16	9	12	Mitchell, Erickson & Johnson	254	14	14-inch screw casing, 0–84 feet; perforated stovepipe casing, 71–251 feet.
23	(?)	27(?)	9	17	C. H. Windham	1,395		

[b] Well 1 is in T. 32 S., R. 37 E. Mount Diablo base and meridian. All other townships are located with respect to the San Bernardino base and meridian.
[c] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.

No. on map (pl. 19)	Water level: Above (+) or below (−) surface or reference point [a] (feet)	Water level: Date of measurement	Method of lift	Yield (gallons per minute): Flow	Yield: Pump	Yield: Date of measurement	Date of completion of well	Remarks
1	−242		Deep-well cylinder					In drainage basin of Fremont Valley.
2	[c]−199	Feb. 6, 1920	Cylinder					In drainage basin of Fremont Valley. Reference point for measurement, top of pump support, 1 foot above surface.
3	−90		Vertical centrifugal		[d] 305		1915	Pit dug 90 feet. Estimated capacity of well, 65 inches.
4	−90				[e] 40		1915	Sandy clay, 0-100 feet; good water-bearing gravel, 100-280 feet.
5	[f]−33	Dec., 1913	Deep-well cylinder		[f] 110	Dec., 1913	1913	Used for locomotives.
6	+4	Dec. 13, 1917		(?)			Dec., 1917	Test hole for potash. Artesian flow obtained at about 125 feet. For analysis see p. 343.
7	−70		Hand		Small.			Struck rock at about 60 feet. Water a little salty.
8	−70				Small.			Water a little salty.
9	−52		Windmill		Small.			
10	−40		do		Small.		1910	
11	−90		Deep-well turbine		270			In drainage basin of Fremont Valley.
12	−400							
13	−250							Water struck at 275 feet and rose to 250 feet.
24	−145							
15	−57							Water struck at 67 feet and rose to 57 feet.
16	−47							
17	(?)							Pump cylinder is 86 feet from surface.
18	[c]−53.1	Jan. 16, 1920	None					Dug well. Reference point for measurement, top of curb 6 inches above surface.
19	[g]−63		[h]		[i] 765		Apr., 1917	Two wells pumped together; pump set at 22 feet. Drawdown in 1919 was 24 inches on vacuum gage.
20	−22		Centrifugal		1,125		Oct., 1915	
21	[c]−25.0	Jan. 12, 1920	Windmill		Small.			Reference point, top of casing, 8 inches above surface. See p. 364 for additional measurements of depths to water.
22	(?)		[h]		[i] 450		June, 1917	
23	−400							Drilled for oil. Water struck at about 530 feet; rose to 400 feet; stands at 400 feet.

[a] Depth to water is from surface unless a specific reference point is described in the column of "Remarks."
[c] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.
[d] Capacity of pump. Capacity of well believed to be greater.
[e] No pumping test had been made when data were collected. The figure is estimated by driller or owner.
[f] Measurements of depth to water, yield, and other data furnished by Atchison, Topeka & Santa Fe Railway.
[g] Data furnished by driller. Although the reported depth to water is probably that at the time of completion it is not always clear from the driller's log whether it was that figure or the depth at which water was first struck, later rising under artesian pressure.
[h] Data obtained from the drillers' records in January, 1920. Although pumps may have been installed on many of the wells at that time the record did not so state.
[i] Estimated by driller, generally before installation of pump.

Records of wells in and near Antelope Valley, Calif.—Continued

No. on map (pl. 19)	Location				Owner or name	Depth of well (feet)	Diameter of well (inches)	Type of casing and depth at which it is perforated
	Quarter	Section	T. N.	R. W.				
24		6	8	16	W. M. Fisher	(?)	8	
25		10	8	16	O. Caldwell	200+		
26	SE	14	8	14	R. A. George	252	16	8-inch screw casing, 0–146 feet; 6½-inch perforated stovepipe casing, 146–252 feet.
27	SW	6	8	13	J. Narod	301	8	Screw casing, 0–119 feet; perforated stovepipe casing, 119–301 feet.
28	NE	6	8	13	Gust Rottman	100	14	
29	SW	8	8	13	—— Brooks	350		
30	NE	30	8	13	—— Martin (?)	[a] 314	8	
31	NW	2	8	13	F. A. Ingersoll	336	6	
32	NW	2	8	13	L. M. Huntington	420	6	
33	NW	6	8	12	Mrs. M. Webber	334	10	
34	NW	4	8	12		(?)	12	
35	NE	4	8	12		(?)	10	
36	NE	4	8	12		[a] 56	6	
37	NW	22(?)	8	12	Southern Pacific Railroad (Oban siding).	371	6	
38	NW	22(?)	8	12	La Grande (?)	(?)	4	
39	SW	22	8	12	C. H. Lippincott	330	6	
40	NE. (?)	34(?)	8	12		(?)		
41	SW	28(?)	8	11	T. P. Breslin	272	10	Screw casing, 0–44 feet; perforated stovepipe casing, 38–272 feet.
42	SW	34	8	11	Hahn	200	10	Screw casing, 0–47 feet; perforated stovepipe casing, 41–200 feet.
43	NW	18	8	10	Harvard Ranch No. 1	295	12	Screw casing, 0–76 feet; perforated stovepipe casing, 69–293 feet.
44	SW	19	8	10	S. D. Longwell	283	6	6-inch screw casing, 0–62 feet; 4¾-inch perforated stovepipe casing, 51–283 feet.
45	NE. (?)	30	8	10	Grant Frakes	(?)	6	
46	NE	31	8	10	—— Hall	302	10	Screw casing, 0–64 feet; perforated stovepipe casing, 52–302 feet.
						350	6	
47	SW	32	8	10	John Demuth	772	6	
						200	6	

[a] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.

No. on map (pl. 19)	Water level: Above (+) or below (−) surface or reference point (feet)	Water level: Date of measurement	Method of lift	Yield (gallons per minute): Flow	Yield: Pump	Yield: Date of measurement	Date of completion of well	Remarks
24	−94							Well No. 2 in Water-Supply Paper 278.
25	−200							Well No. 4 in Water-Supply Paper 278.
26	[g] −90						Aug., 1918	Struck "tufa rock" at 165 feet, which reached to bottom.
27	[g] −72		(h)		[i] 450		Nov., 1914	Pumping lift about 70 feet.
28	−56		Deep-well turbine		360			
29	−50		Turbine		630			
30	[c] −56.1	Jan. 16, 1920	None					Reference point, top of casing, 2 feet above surface.
31	−22		Vertical centrifugal		675			Drawdown 26 inches on vacuum gage.
32	−18		do		675			Drawdown 26 inches on vacuum gage; pump set at 22 feet.
33	−14		(h)		450		Nov., 1914	
34	Flowing.	Jan. 12, 1920		(?)				Capped, but water coming up around casing.
35	Flowing.	do		[j] 25		Jan. 12, 1920		Plug knocked out and water wasting.
36	[c] −5.3	do	None					Reference point top of casing level with surface.
37	[k] +17.6		do	(?)				See p. 330. Probably same as well 228 in Water-Supply Paper 278.
38	[l] +4	Jan. 12, 1920		[j] 270		Jan. 12, 1920		Probably same as well 271 in Water-Supply Paper 278.
39	At surface.[m]	do	None	(?)			Oct., 1915	
40	Flowing.	do	do	[j] 20		Jan. 12, 1920		Poorly capped.
41	[n] −4			(h)	[i] 450		Dec., 1914	
42	[n] −10		(h)		[i] 450		June, 1914	Estimated lift 35 feet when pumping 450 gallons per minute.
43	[g] Flowing.		(h)		[i] 720		May, 1916	
44	[g] −9		(h)		[i] 270		Mar., 1918	
45	+2	Jan. 16, 1920	None	(?)				Did not flow from July to Oct., inclusive, 1919. See p. 333.
46	[g] −10.5		(h)		[i] 630		June, 1914	
47	−7	1907	Vertical centrifugal		630	Jan., 1920	1907	Three wells pumped together. In summer yield is estimated to be only 450 gallons per minute. In the 772-foot well the water under greatest pressure is cased off.
	−40	1907					1907	
	−12	1917					1917	

[c] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.

[g] Data furnished by driller. Although the reported depth to water is probably that at the time of completion it is not always clear from the drillers' log whether it was that figure or the depth at which water was first struck, later rising under artesian pressure.

[h] Data obtained from the drillers' records in January, 1920. Although pumps may have been installed on many of the wells at that time the record did not so state.

[i] Estimated by driller, generally before installation of pump.

[j] Estimated by the writer.

[k] Reported by Southern Pacific Railroad in letter dated June 2, 1920.

[l] Water flows with considerable force at a height of 4 feet above surface. Will rise much higher.

[m] On the drillers' record the depth to water is given as 4½ feet. This is probably the depth at which water was struck. When the well was visited in January, 1920, water was leaking out at surface.

[n] Depth to water as given in driller's record. This is probably depth at which water was struck and not that at which it stood on completion of drilling, as the well is within the area of artesian flow.

Records of wells in and near Antelope Valley, Calif.—Continued

No. on map (pl. 19)	Location				Owner or name	Depth of well (feet)	Diameter of well (inches)	Type of casing and depth at which it is perforated
	Quarter	Section	T. N.	R. W.				
48	NW	14	7	14	George Marigold (?)	[c] 152	5	
49	SE	5	7	13	G. F. Weld	450	16	16-inch screw casing, 0–116 feet; 10-inch perforated stovepipe casing, 104–450 feet.
50	NW	3	7	13	Charles Pemberton [e]	400	12	12-inch screw casing, 0–75 feet; 10-inch perforated stovepipe casing, 69–400 feet.
51	NW	9	7	13	A. Whidden	501	18	18-inch stovepipe casing, not perforated, 0–118 feet; 10-inch perforated stovepipe casing, 110–500 feet.
52	NE	9	7	13	do	502	16	16-inch stovepipe casing, not perforated, 0–113 feet; 10-inch perforated stovepipe casing, 100–500 feet.
53	NE	16	7	13	do	250 500	6 6	
54	NE	17	7	13	G. C. Earl	600 270	8 10	Casing, not perforated, 0–275 feet; 6-inch perforated casing, 275–600 feet. Casing, not perforated, 0–100 feet; 8-inch perforated casing, 100–270 feet.
55	NW	11	7	13	R. O. Snowden	350	12	12-inch screw casing, 0–80 feet; 10-inch perforated stovepipe casing, 70–350 feet.
56	NW	11	7	13	do	225 500	6	
57	NE	10	7	13	J. C. Clark	500	12	
58	N. ½	2	7	13	R. Riddell			
59	SE	15	7	13				
60		13(?)	7	13				
61	NE	23	7	13		[c] 211	7	
62	NE	24	7	13	H. A. Prendel	450	6	6-inch screw casing, 0–168 feet; 4⅝-inch perforated stovepipe casing, 168–450 feet.
63	SW	24	7	13	M. L. Berry	300		
64	NW	35	7	13	G. C. Earl	541	16	
65	NW	35	7	13	do	400	8	
66	SE	26	7	13	E. T. Earl estate	501	16	16-inch stovepipe casing, not perforated, 0–140 feet; 10-inch perforated stovepipe casing, 130–501 feet.

[c] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.
[e] Formerly owned by L. P. Burgess.

No. on map (pl. 19)	Water level: Above (+) or below (−) surface or reference point (feet)	Water level: Date of measurement	Method of lift	Yield (gallons per minute): Flow	Yield: Pump	Yield: Date of measurement	Date of completion of well	Remarks
48	[c] −147	Dec. 18, 1919	Windmill					Probably well No. 35 in Water-Supply Paper 278. See p. 364 for additional measurements of depth to water.
49	[g] −60		([h])		720		Mar., 1917	
50	[p] −32	Jan. 16, 1920	Deep-well turbine		[i] 675		Aug., 1918	Estimated lift 60 feet when pumping 675 gallons per minute.
51	[g] −45		do		[q] 1,625	Oct. 8, 1920	June, 1919	Lift 90 feet when pumping 1,625 gallons per minute.
52	[g] −33		do		[c] 1,625		Dec., 1918	
53	−10		Vertical centrifugal		[c] 630		1912	Two wells connected.
54	{−23, −27}		do		[c] 1,000			Two wells pumped together. Drawdown 26 inches on vacuum gage.
55	[g] −16		([h])		[i] 900		Jan., 1917	Two wells of same diameter, depth, etc.
56	[r] −3.75	Jan. 16, 1920	(?)				1918 (?)	Depth to surface water, 7.5 feet. Two wells connected. See p. 311.
57	−25		Deep-well turbine		720		July, 1914	Pumping lift, 47 feet; pump set at 67 feet.
58								Ceased flowing in 1919. See p. 331. Same as wells 42a to 42c in Water-Supply Paper 278.
59	[c] +3	Jan. 10, 1920	None	25		Jan. 10, 1920		Water wasting. See p. 364 for additional measurements of depth to water. For analysis see p. 343.
60	+6			250				Water wasting. Probably same as well 252 in Water-Supply Paper 278.
61	[c] −1.7	Jan. 10, 1920						Reference point for measurement top of casing, 1.1 feet above surface. Said to have flowed 50 gallons per minute in 1910. Same as well No. 247 in Water-Supply Paper 278. See p. 365 for additional measurements of depth to water.
62	[c] +4	do	Horizontal centrifugal	[c] 2	315		1915	Drawdown 23 inches on vacuum gage. See p. 331.
63	−28		Vertical centrifugal					Pump set at 28 feet; must be primed.
64	−53	April, 1916	Deep-well turbine		[s] 315		Nov., 1915	Estimated lift to surface 66 feet. Lift above surface 33 feet.
65	−85 −95	Spring, 1913 Summer, 1919	Deep-well cylinder		90		1912–13	Two wells 6 feet apart, each same depth, diameter, etc.; separate pumps run by same motor. For analysis see p. 343.
66	[g] −58		Deep-well turbine		900		Aug., 1919	

[c] Measured by writer. Unless otherwise stated all other figures on total or depth to water were reported by the owner, driller, or other person.
[g] Data furnished by driller. Although the reported depth to water is probably that at the time of completion it is not always clear from the driller's log whether it was that figure or the depth at which water was first struck, later rising under artesian pressure.
[h] Data obtained from the drillers' records in January, 1920. Although pumps may have been installed on many of the wells at that time the record did not so state.
[i] Estimated by driller, generally before installation of pump.
[p] Reported by W. R. Parkhill, of Federal Land Bank of Berkeley. Driller's log gives depth to water as 26 feet, indicating a probable drop since well was drilled.
[q] Result of weir measurement by Southern California Edison Co.
[r] Depth to water in 225-foot well measured by W. R. Parkhill, Federal Land Bank of Berkeley.
[s] Measured by pump manufacturer.

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Records of wells in and near Antelope Valley, Calif.—Continued

No. on map (pl. 19)	Location				Owner or name	Depth of well (feet)	Diameter of well (inches)	Type of casing and depth at which it is perforated
	Quarter	Section	T. N.	R. W.				
67	NW	36	7	13	E. T. Earl estate	466	8	
67a	NW	36	7	13	....do	460	16	
68	SE	16	7	12	(?)	------	------	
69	NE	21	7	12	E. B. Wargren	350	6	6-inch screw casing, 0–100 feet; 5-inch perforated stovepipe casing, 100–350 feet. See p. 331.
70	NE	21	7	12	—— Mason	254	8	Screw casing, 0–60 feet; perforated casing, 53–254 feet.
71	NE	21	7	12	C. E. Marble	301	10	10-inch screw casing, 0–63 feet; perforated stovepipe casing, 51–301 feet.
72	SE	11	7	12	Mott and Martin	300	8	8-inch screw casing, 0–79 feet; perforated casing, 69–300 feet.
73	NW	23	7	12	R. G. Donovan	153	8	Unperforated casing, 0–52 feet; perforated casing, 40–153 feet.
74	NW	13	7	12	—— Meder	------	------	
75	SE	13	7	12	J. L. Meder	363	12	Screw casing, 0–102 feet; perforated stovepipe casing, 102–363 feet.
76	NW	6	7	11	C. F. Nelson	302	12	Screw casing, 0–82 feet; perforated stovepipe casing, 70–300 feet.
77	SW	6	7	11	Oliver Miller	430	4½	
78	SW	18	7	11	C. Crapinell	300	10	10-inch screw casing, 0–80 feet; 6½-inch perforated stovepipe casing, 60–290 feet.
79	NW	30	7	11	—— Burris	298	10	Screw casing, 0–98 feet; not perforated, 0–98.4 feet; perforated stovepipe casing, 96–298 feet.
80	SE	32	7	11	Big Ten Ranch	550	6	
81	NE	16	7	11	W. W. Wurzburger	303	10	
82	SE	2	7	11	M. E. Felt	282	6	Casing, not perforated, 0–82 feet; perforated stovepipe casing, 70–279 feet.
83	NE	2	7	11	J. O. Eggen	301	10	Screw casing, 0–70 feet; perforated stovepipe casing, 60–300 feet.
84	SE	2	7	11	A. Z. Wilson	250 550	6 6	

No. on map (pl. 19)	Water level: Above (+) or below (−) surface or reference point (feet)	Water level: Date of measurement	Method of lift	Yield (gallons per minute): Flow	Yield: Pump	Yield: Date of measurement	Date of completion of well	Remarks
67	[a] −78.9	Jan. 14, 1920	Deep-well cylinder		100		Sept., 1914	Reference point for measurement, cement floor of pump house. Two wells, same depth, diameter, etc., together yield 200 gallons per minute.
67a	−72		Deep-well turbine		550		Jan., 1915	See p. 332.
68	+3.5			50–100				Water wasting.
69	−3	Jan., 1920	Horizontal centrifugal		450		Feb., 1914	Originally flowed. See p. 331. For analysis see p. 343.
70	[g] −20		([h])				Mar., 1916	
71	[g] −10		([h])		[i] 450		Mar., 1915	
72	[g] −13		([h])		[i] 450		Jan., 1918	
73	[g] −16		([h])		[i] 180		Feb., 1911	
74	Flows.							Does not flow as strong as formerly. See p. 332.
75	−21	Jan., 1920	([h])		1,625		Jan., 1920	Has 2 other wells 240 and 550 feet deep.
76	Flows.[k]		Deep-well turbine		[j] 200		Sept., 1919	
77	Flows.	Jan., 1920	Horizontal centrifugal	15	450		1905(?)	Originally flowed about 50 gallons per minute. Drawdown estimated at 20 feet.
78	[g] −32		([h])		[i] 675		Dec., 1917	
79			([h])				Feb., 1916	
80	(?)		Centrifugal		540			Depth of pit 65 feet.
81	[g] −25		([h])		[i] 450		Apr., 1916	
82	[g] −14		([h])				June, 1916	
83	[g] −12		([h])		[i] 540		June, 1916	
84	See remarks.		Vertical centrifugal		800		July, 1907	550-foot well originally flowed 50 gallons per minute. Ceased flowing in 1919. See p. 332. Pumping yield of both wells in winter about 800 gallons per minute; in summer about 550 gallons per minute. 250-foot well not perforated to 100 feet; 550-foot well not perforated to 240 feet.

[a] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.
[g] Data furnished by driller. Although the reported depth to water is probably that at the time of completion it is not always clear from the driller's log whether it was that figure or the depth at which water was first struck, later rising under artesian pressure.
[h] Data obtained from the drillers' records in January, 1920. Although pumps may have been installed on many of the wells at that time the record did not so state.
[i] Estimated by driller, generally before installation of pump.
[j] Estimated by the writer.
[k] In the driller's log the depth to water is given as 10 feet. Apparently water was first struck at this depth and later rose to the surface, for the well is said to have flowed before the pump was installed.

Records of wells in and near Antelope Valley, Calif.—Continued

No. on map (pl. 19)	Location: Quarter	Location: Section	Location: T. N.	Location: R. W.	Owner or name	Depth of well (feet)	Diameter of well (inches)	Type of casing and depth at which it is perforated
85	SW	12	7	11	J. B. Nourse	610	6	Casing not perforated, 0–240 feet.
85a	SW	12	7	11	do.	203	8	
86	SW	23	7	11	George A. Niller	330 710	8 6	Screw casing, 0–200 feet; perforated stovepipe casing, 200–330 feet. Screw casing, 0–376 feet; perforated stovepipe casing, 376–710 feet.
86a	SW	23	7	11	do.			
87	NE.(?)	11	7	11	George Edwards	225	8	
88	NW	10	7	10	C. A. Cleary	400	8	8-inch screw casing, 0–90 feet; perforated stovepipe casing, 80–400 feet.
89	SE	10	7	10	W. H. Brooks	300	10	
90	NE	32	7	10	C. S. Jones	350	10	10-inch screw casing, 0–120 feet; 8¼-inch perforated stovepipe casing, 110–250 feet.
91	NW	20	7	9	W. T. Graham	(?)	12	
92	E. ½	20	7	9	S. G. Bay	401	12	12-inch casing, not perforated, 0–105 feet; 8¼-inch perforated stovepipe casing, 100–400 feet.
93	E. ½	28	7	9	H. L. Graham	278	10	10-inch screw casing, 0–126 feet; 8½-inch perforated stovepipe casing, 120–278 feet.
94	SW	34	7	9	J. C. McGowan	158	12	
95	NW.(?)	2	6	13	Fred Godde	137	12	
96	SE.(?)	2(?)	6	13	W. L. Winnard	171	12	
97	NE	1	6	13	E. T. Earl estate	100	5⅝	
98	NE	4	6	12	W. R. Cowan	303	10	Casing, not perforated, 0–178 feet; perforated stovepipe casing, 174–303 feet.
99	SW	1	6	12	J. L. Davidson	451	12	Screw casing, 0–184 feet; perforated stovepipe casing, 168–448 feet.
100	SE	13	6	12	H. C. Fertig	490	10	Screw casing, 0–260 feet; perforated stovepipe casing, 252–489 feet.
101	NE	26	6	12	Palmdale Land Co.	[a] 344	6	
102	SW	6	6	11	F. Junquist	445	10	Casing, not perforated, 0–147 feet; perforated stovepipe casing, 140–445 feet.
103	NE	6	6	11	—— Copple	350	12	
104	SE	8	6	11	Orr & Baker	450	10	
105	NW	10	6	11	E. T. Earl estate	445	16	16-inch screw casing, 0–165 feet; 10-inch perforated stovepipe casing, 445 feet.
106	SE	20	6	11	C. L. Mason	260	12	
107	SE	21	6	11	G. B. Otis	502		

[a] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.

No. on map (pl. 19)	Water level: Above (+) or below (−) surface or reference point (feet)	Water level: Date of measurement	Method of lift	Yield (gallons per minute): Flow	Yield: Pump	Yield: Date of measurement	Date of completion of well	Remarks
85	[e] −13.5	Jan. 15, 1920	Horizontal centrifugal				1907	Reference point for measurement, 13.5 feet below joint in standpipe, 0.5 feet above surface. Well flowed when first drilled. See p. 332.
85a	[e] −19.2	do						Reference point for measurement, top of casing level with ground. See p. 365 for additional measurements of depth to water.
86			Vertical centrifugal		900		Feb., 1910	Two wells pumped together. Depth to water in pit 30.0 feet below floor, Jan. 15, 1920. For analysis see p. 343.
86a	[e] −39.5	Jan. 13, 1920						Dug well. See p. 365 for additional measurements of depth to water.
87	[e] −17.0	Jan. 15, 1920					1919	Reference point for measurement, top of 10 by 12 inch frame, 1 foot above surface. Depth to surface water in pit 19.8 feet.
88	[g] −24		([h])		[i] 540		Apr., 1919	
89	−25							Pumping lift 50 feet.
90	[g] −91		([h])		[i] 675			
91	−80		Deep-well cylinder		450			
92	[g] −78		([h])				June, 1914	
93			([h])				May, 1914	Struck rock at bottom.
94	−100		Deep-well cylinder		450		1913	Drawdown 10 feet.
95	−95		([h])		Small.		Jan., 1920	
96	−130				Small.		Jan., 1920	Struck rock at 122 feet.
97	[g] −76		None		[i] 50		Aug., 1919	Struck rock at 77 feet.
98	[g] −150		([h])		[i] 270		Aug., 1914	Estimated lift 180 feet when pumping 270 gallons per minute.
99	[g] −130		([h])		[i] 540		May, 1917	
100	[g] −172		Deep-well turbine		[i] 360		Sept., 1915	
101	[e] −245.5	Jan. 7, 1920	None					Same as well No. 152 in Water-Supply Paper 278. Reference point for measurement top of cement floor of pump house.
102	[g] −92		([h])		[i] 400		March, 1915	
103	See remarks.		Deep-well turbine		675			Depth to water 120 feet when pumping.
104	−103		do		675			
105	−78		do		630		Feb., 1915	
106	−159		Deep-well cylinder		135		June, 1915	Principal water-bearing strata 227–260 feet.
107	−165		Air lift		[m] 225	Oct. 26, 1917		Granite reported to have been struck at 300 feet.

[e] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.
[g] Data furnished by driller. Although the reported depth to water is probably that at the time of completion it is not always clear from the driller's log whether it was that figure or the depth at which water was first struck, later rising under artesian pressure.
[h] Data obtained from the drillers' records in January, 1920. Although pumps may have been installed on many of the wells at that time the record did not so state.
[i] Estimated by driller, generally before installation of pump.
[m] Weir measurement by C. E. Tait.

Records of wells in and near Antelope Valley, Calif.—Continued

No. on map (pl. 19)	Location				Owner or name	Depth of well (feet)	Diameter of well (inches)	Type of casing and depth at which it is perforated
	Quarter	Section	T. N.	R. W.				
108	SW	28	6	11	George Coffman	260	12	
109	SE	28	6	11	C. Sigfriedson	237	12	
110	NW	31	6	11	C. W. Lorenz	105	12	Stovepipe casing, perforated at 212–215, 250–261, and 301–304 feet.
111	SW	32	6	11	J. Boyle	495	16	Stovepipe casing, perforated at 158–168, 188–196, 214–222, 224–248, and 258–268 feet.
112	SE	32	6	11	J. F. Jacobs	410	12	Perforated at 158–172 and 290–302 feet.
113	SE.(?)	14	6	11	P. A. Rowland	425	12	
114	NW	24	6	11	F. W. Comstock	(?)	(?)	
115	W. ½	18	6	10	J. M. Schissler	(?)		
116	NW	28	6	10	J. Hintermann	175		
117	(?)	22	6	10	—— Bowland (?)	181		
118		21 (?)	6	9	Alexander Stewart	(?)		
119	NW.(?)	22	6	9	Mrs. A. Stewart	180	14	
120	NW	28	6	9	E. E. Reinsberg	(?)	12	
121	NW	18	6	8	A. C. Huff	215	9	
122	NE.(?)	14	6	8	W. W. Kent	(?)		
123	NW.(?)	13	6	8	J. S. Barton	(?)		
124	SE	14	6	8	E. Malcom	(?)		
125	SE	14	6	8	A. H. Tidd	(?)		
126	SE	13	6	8	J. O. W. Anderson	(?)		
127	SE.(?)	23	6	8	S. W. Moore	(?)		
128	NE	36	6	8				
[a] 129	SW	5	6	7	M. B. Charles			
[a] 130	NE	3	6	7	W. M. Gray	392		

[a] Located in Mirage Valley drainage basin. Data from C. E. Tait, Bureau Public Roads and Rural Engineering, U. S. Department Agriculture. Most of these data, with those in regard to other wells not listed in this report, are given in Report on the utilization of Mojave River for irrigation in Victor Valley, Calif.: California Dept. Engineering Bull. 5, 1918.

No. on map (pl. 19)	Water level: Above (+) or below (−) surface or reference point (feet)	Water level: Date of measurement	Method of lift	Yield (gallons per minute): Flow	Yield (gallons per minute): Pump	Yield (gallons per minute): Date of measurement	Date of completion of well	Remarks
108	−63		Windmill					Water said to have been struck first at 126 feet, rising to 63 feet. Perforated in gravel at 220 feet.
109	−7.3		None					Water struck at 140 feet; rose to 73 feet; cased to 196 feet.
110	−146		Deep-well cylinder		180			Pumping lift 175 feet.
111	−100		Deep-well turbine		600		May, 1917	See p. 366 for additional measurements of depth to water.
112	See remarks.		Deep-well cylinder		315		Nov., 1916	Lift 112 feet.
113	[e] −117		Deep-well turbine		450			Water rose a few feet when struck.
114	(?)		Deep-well cylinder		150			
115	(?)		(?)		450			Depth probably not more than 250 feet.
116	−125		Windmill					
117	−75				675			
118	Flows.			(?)				Near Lovejoy Springs. Combined flow of well and springs is about 60 gallons per minute. Depth to water in another well near by only 2 feet.
119	−17		Turbine		630			Drawdown 90 feet. Struck bedrock at 175 feet.
120	−28		(?)		720			
121	−165		Windmill		[f] 90			
122	[g] −33							Dug.
123	[g] −29							Do.
124	[g] −33							
125	[g] −48							Do.
126	[g] −56							
127	[g] −57							
128	[g] −112							
[w] 129	[c] −40.8	Dec. 16, 1919						Reference point top of curb. Depth to water measured 36 feet on Feb. 16, 1918. Well No. 253 in California Dept. Eng. Bull. 5, p. 90.
[w] 130	−16							Water struck at 165 feet; said to have overflowed. Water also found at other depths. Well No. 248 in California Dept. Eng. Bull. 5.

[c] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.
[e] Data furnished by driller. Although the reported depth to water is probably that at the time of completion it is not always clear from the driller's log whether it was that figure or the depth at which water was first struck, later rising under artesian pressure.
[f] Estimated by driller, generally before installation of pump.
[g] From data collected by G. A. Waring, U. S. Geological Survey, in August, 1917.
[w] Located in Mirage Valley drainage basin. Data from C. E. Tait, Bureau Public Roads and Rural Engineering, U. S. Department Agriculture. Most of these data, with those in regard to other wells not listed in this report, are given in Report on the utilization of Mojave River for irrigation in Victor Valley, Calif.: California Dept. Engineering Bull. 5, 1918.

Records of wells in and near Antelope Valley, Calif.—Continued

No. on map (pl. 19)	Location				Owner or name	Depth of well (feet)	Diameter of well (inches)	Type of casing and depth at which it is perforated
	Quarter	Section	T. N.	R. W.				
[w] 131	NW	11	6	7	K. McDonald	25	48	
[w] 132	NE	30	6	7	P. Showers	295	12	
[w] 133	SW	27	6	7	H. M. Engebritson	151	See remarks.	
134	SE	12	5	12	G. S. Lindley	[c] 180	8	
135	NW	5	5	11	C. K. Cook	[c] 403	12	Stovepipe casing, perforated at 175–179, 191–197, 205–225, 249–255, and 270–295 feet.
136	SW	4	5	11	Will McAdam	399	16	
137	SE	4	5	11	J. A. Martin and B. H. Martin	373	16	
138	NE	9	5	11	Robert Stuart	223	12	
139	NW	14	5	11	—— Littleton	[c] 44.3	16	
140	SW	14	5	11	—— Kellerman	54	(?)	
141	NE	22	5	11	—— Keyes	14		
142	NW	23	5	11	—— Holloway	(?)		
143	NW	12	5	11	E. W. Martin	226	12	Stovepipe casing, perforated at 96–104, 114–122, 128–158, 198–208 feet.
144	SE	21	5	10	H. J. Hammond	30	36	
145	SW	23	5	10	G. C. Chase	69		
[v] 146	NE	9	5	7	O. W. Jessup	351	6	
[w] 147	SW	12	5	7	De Moville and Rowley	415		
[x] 148	NW	26	9	12	John Mosby	165	4	
[x] 149	NE. (?)	14	8	12	S. J. Morford	300	5	
[x] 150	NE	10	7	13	C. N. Post	360	4	
[x] 151	NW	22	7	13	—— Vysette	227	2¾	

[c] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.

[u] Weir measurement by C. E. Taft.

[v] From data collected by G. A. Waring, U. S. Geological Survey, in August, 1917.

[w] Located in Mirage Valley drainage basin. Data from C. E. Tait, Bureau Public Roads and Rural Engineering, U. S. Department Agriculture. Most of these data, with those in regard to other wells not listed in this report, are given in Report on the utilization of Mojave River for irrigation in Victor Valley, Calif.: California Dept. Engineering Bull. 5, 1918.

[x] The data for wells Nos. 148 to 152, inclusive, are taken from Water-Supply Paper 278. They are included principally for use in the discussion on quality of waters.

No. on map (pl. 19)	Water level: Above (+) or below (−) surface or reference point (feet)	Water level: Date of measurement	Method of lift	Yield (gallons per minute): Flow	Yield (gallons per minute): Pump	Yield (gallons per minute): Date of measurement	Date of completion of well	Remarks
[w] 131	[i] −21.5	Feb. 21, 1918						Dug. Well No. 246 in California Dept. Eng. Bull. 5.
[w] 132	−80		Jack pump					Well No. 216 in California Dept. Eng. Bull. 5.
[w] 133	−135		do		[e] 10		1915	Dug 140 feet. 10-inch hole at bottom drilled 16 feet. Well No. 217 in California Dept. Eng. Bull. 5.
134	−4		Vertical centrifugal		[e] 180			In small valley along San Andreas fault line. No sand or gravel. Drawdown 15 feet; recovers in 5 hours.
135			Deep-well cylinder		[i] 360			First water struck at 145 feet.
136	[e] −88.9	Jan. 9, 1920	do		720		Jan., 1916	Reference point for measurement hole in casing head in pit, 3.5 feet below floor.
137	−84							Pumping lift said to be 115-120 feet.
138	−90		Deep-well turbine		360		1913	Pumping lift 109 feet.
139	[e] −39.8	Jan. 9, 1920	None					See pp. 327 and 366 for other measurements.
140								See p. 327 for measurements of depth to water.
141								Do.
142								Do.
143	−86		Deep-well cylinder		180		Aug., 1918	First water struck at 77-foot level, but later dropped to 86 feet.
144	−20		Windmill		Small			Dug well.
145	−42				75			
146	See remarks.		Deep well cylinder					Depth to water variously reported at 250 to 280 feet. Well No. 210 in California Dept. Eng. Bull. 5.
[v] 147	−315		None					Well No. 213 in California Dept. Eng. Bull. 5. In Mirage Valley drainage basin.
[x] 148	Flows(?)							Well No. 265 in Water-Supply Paper 278. For analysis, see p. 343.
[x] 149	Flows(?)							Well No. 270 in Water-Supply Paper 278. For analysis, see p. 343.
[x] 150	Flows(?)							Well No. 51 in Water-Supply Paper 278. For analysis, see p. 343.
[x] 151	Flows(?)							Well No. 253 in Water-Supply Paper 278. For analysis, see p. 343.

[e] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.
[i] Estimated by driller, generally before installation of pump.
[v] From data collected by G. A. Waring, U. S. Geological Survey, in August, 1917.
[w] Located in Mirage Valley drainage basin. Data from C. E. Tait, Bureau Public Roads and Rural Engineering, U. S. Department Agriculture. Most of these data, with those in regard to other wells not listed in this report, are given in Report on the utilization of Mojave River for irrigation in Victor Valley, Calif.: California Dept. Engineering Bull. 5, 1918.
[x] The data for wells Nos. 148 to 152, inclusive, are taken from Water-Supply Paper 278. They are included principally for use in the discussion on quality of waters.

Records of wells in and near Antelope Valley, Calif.—Continued

No. on map (pl. 19)	Location: Quarter	Location: Section	Location: T. N.	Location: R. W.	Owner or name	Depth of well (feet)	Diameter of well (inches)	Type of casing and depth at which it is perforated
[a] 152	([b])	8	7	11	Ben. W. Hahn	350	5	
153	SE	30	7	10	J. L. Stone	532	14	14-inch double stovepipe casing, 0–140 feet; 10-inch perforated galvanized-iron casing, 130–492 feet.
154	SW	27	7	11	Robert B. Campbell	401	16	16-inch double stovepipe casing, 0–116 feet; 10-inch perforated galvanized-iron casing, 110–400 feet.
155	SW	5	7	10	Chris Larris	404	16	16-inch double stovepipe casing, 0–81 feet; black-iron perforated casing, 73–403 feet.
155-a	SW	5	7	10	do			
156	NW	21	6	11	Moller & Serritsler	350	12	12-inch screw casing, 0–199 feet; 4-inch perforated galvanized casing, 188–348 feet.
157	NE	20	9	13	Harry White	350	12	12-inch double stovepipe casing, 0–101 feet; perforated casing, 88–348 feet.
158	NW	11	8	13	—— Nebecker	452	16	16-inch double stovepipe casing, 0–99 feet; perforated 10-inch casing, 90–450 feet.
159	NW	30	7	11	E. A. Merritt	281	10	10-inch double stovepipe casing, 0–99 feet; perforated 8¼-inch galvanized-iron casing, 89–279 feet.
160	NE. (?)	2	7	11	—— Rice			
161	(?)	8	8	10				
162	SW	9	8	10	J. M. Hamilton	25±		
163	NE	24	8	14				
164	NE	30	8	13				
165	SE	20	7	13	—— Doll (?)			
166	SE	32	7	12	—— Lord			
167	NE	34	7	12				
168	SE	12	6	11	Harper & Paramore			
169	SW	10	7	11	C. B. Sharp			
170	NE	31	7	10				
171	SE	14	7	10	—— Adair			

[a] The data for wells Nos. 148 to 152, inclusive, are taken from Water-Supply Paper 278. They are included principally for use in the discussion on quality of waters.
[b] The exact location of this well is not given in Water-Supply Paper 278 and it is not shown on the map.

No. on map (pl. 19)	Water level: Above (+) or below (—) surface or reference point (feet)	Water level: Date of measurement	Method of lift	Yield (gallons per minute): Flow	Yield (gallons per minute): Pump	Yield (gallons per minute): Date of measurement	Date of completion of well	Remarks
[m] 152	Flows(?)							Well No. 146 in Water-Supply Paper 278. For analysis, see p. 343.
153	[g] —76		([h])		[i] 1,125		Apr. 3, 1920	
154	[g] —62		([h])		[i] 1,350		Mar. 25, 1921	
155	[g] —23		([h])		[i] 1,350		Mar. 4, 1921	Total lift 75 feet when pumping 1,350 gallons a minute.
155-a	[c] —28.9	May 29, 1921						See p. 366 for additional measurements of depth to water.
156	[g] —135		([h])		[i] 675		Feb. 17, 1921	
157	[c] —37.2	May 30, 1921	([h])		[i] 675		Nov. 30, 1920	See p. 367 for additional measurements of depth to water.
158	[g] —23		([h])				July 27, 1920	
159	[g] —44		([h])		[i] 585		May 15, 1920	
160	[c] 20.0	May 29, 1921						Do.
161	[a] 14.5	Aug. 21, 1921						Do.
162	[c] 11.25	May 29, 1921						See p. 368 for additional measurements of depth to water.
163	[c] 79.0	May 30, 1921						Do.
164	[a] 65.2	Oct. 3, 1921						Do.
165	[a] 39.9	Oct. 4, 1921						See p. 369 for additional measurements of depth to water.
166	[a] 116.1	Oct. 4, 1921						Do.
167	[a] 123.6	Oct. 4, 1921						Do.
168	[a] 113.0	Oct. 8, 1921						See p. 370 for additional measurements of depth to water.
169	[c] 19.0	May 29, 1921						Do.
170	[c] 81.2	May 29, 1921						Do.
171	[c] 62.05	May 29, 1921						See p. 371 for additional measurements of depth to water.

[a] Measured by writer. Unless otherwise stated all other figures on total depth or depth to water were reported by the owner, driller, or other person.

[g] Data furnished by driller. Although the reported depth to water is probably that at the time of completion it is not always clear from the driller's log whether it was that figure or the depth at which water was first struck, later rising under artesian pressure.

[h] Data obtained from the drillers' records in January, 1920. Although pumps may have been installed on many of the wells at that time the record did not so state.

[i] Estimated by driller, generally before installation of pump.

[m] The data for wells Nos. 148 to 152, inclusive, are taken from Water-Supply Paper 278. They are included principally for use in the discussion on quality of waters.

[c] Measured by N. S. Abbott.

Measurements of depth to water in wells in Antelope Valley, Calif.

Well 21; W. S. Webb, owner; NW. 1/4 sec. 21, T. 9 N., R. 12 W.

[Well equipped with windmill, behind hotel at Rosamond. Reference point, top of casing 8 inches above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1920	*Feet*		1925	*Feet*	
Jan. 12	25.0	D. G. Thompson.	May 5	28.4	F. C. Ebert and H. G. Troxell.
			Oct. 6	29.9	Do.
1921			1926		
May 30	26.2	D. G. Thompson and N. S. Abbott.	Jan. 9	30.0	N. S. Abbott.
Oct. 3	28.6	N. S. Abbott.	May 13	29.5	F. C. Ebert.
1922			Aug. 25	32.0	N. S. Abbott.
Feb. 7	26.2	Do.	Oct. 15	[a] 32.0	F. C. Ebert.
1924			1927		
Oct. 23	29.4	F. C. Ebert and H. G. Troxell.	Jan. 19	30.0	N. S. Abbott.
			May 9	[a] 31.0	F. C. Ebert.
			Oct. 27	[b] 32.9	Do.

Well 48; George Marigold, owner (?); southeast corner NW. 1/4 sec. 14, T. 7 N., R. 14 W.

[Reference point, top of casing and few inches above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1919			1924		
Dec. 18	147.0	D. G. Thompson.	Nov. 15	146.2	N. S. Abbott.
1921			1925		
Apr. 30	146.5	D. G. Thompson and F. C. Ebert.	Feb. 17	145.7	Do.
Oct. 14	147.1	N. S. Abbott.	May 6	146.8	F. C. Ebert and H. G. Troxell.
1922			June 8	145.9	N. S. Abbott.
Jan. 1	146.5	Do.	July 21	146.3	Do.
Apr. 30	147.4	Do.	Oct. 6	146.7	F. C. Ebert.
May 24	146.5	Do.			
Oct. 26	147.0	Do.	1926		
1923			Jan. 9	145.8	N. S. Abbott.
Feb. 24	146.3	Do.	May 16	145.5	F. C. Ebert.
July 11	146.6	Do.	Aug. 30	146.6	N. S. Abbott.
1924			Oct. 15	146.8	F. C. Ebert.
Jan. 19	146.3	Do.	1927		
Mar. 28	146.05	Do.	Jan. 20	146.	N. S. Abbott.
July 4	146.3	Do.	May 9	146.3	F. C. Ebert.
Oct. 22	147.0	F. C. Ebert and H. G. Troxell.	Oct. 26	148.0	Do.

Well 59; owner unknown; SE. 1/4 sec. 15, T. 7 N., R. 13 W.

[Opposite ranch of Mr. Bonnefeux. Well inclosed above surface with sewer pipe. Reference point, top of sewer pipe about 5 feet above top of casing and surface of ground until 1924; thereafter top of casing. In 1924 well was plugged by débris at a depth of about 7 feet, but when high enough the water was able to percolate through the débris.]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1920			1923		
Jan. 10	([c])	D. G. Thompson.	July 11	22.1	N. S. Abbott.
1921			1924		
Apr. 30	17.5	D. G. Thompson and F. C. Ebert.	Oct. 20	[e] 3.4	Do.
			Oct. 22	[f] 2.5	F. C. Ebert and H. G. Troxell.
May 30	10.4	D. G. Thompson and N. S. Abbott.	1925		
Oct. 2	13.7	N. S. Abbott.	Jan. 22	([c])	N. S. Abbott.
			May 5	([g])	F. C. Ebert and H. G. Troxell.
1922			July 7	([g])	N. S. Abbott.
Jan. 21	([c])	Do.	Oct. 6	([g])	F. C. Ebert.
Apr. 30	15.1	Do.	1926		
May 24	([c])	Do.	Jan. 9	([c])	N. S. Abbott.
Oct. 26	6.1	Do.	Aug. 30	([g])	Do.
Nov. 20	([c])	Do.	1927		
1923			Jan. 20	([c])	Do.
Feb. 25	([d])	Do.			
May 14	16.9	Do.			

[a] Pumping very slowly.
[b] Not pumping.
[c] Flowing.
[d] Flowing about 40 gallons a minute.
[e] Measured from top of casing (?).
[f] Sewer pipe broken up. Reference point, top of casing about 5 feet lower than original reference point.
[g] Water below débris plug.

Measurements of depth to water in wells in Antelope Valley, Calif.—Continued

Well 61; owner unknown; NE. ¼ sec. 23, T. 7 N., R. 13 W., probably near southeast corner

[Reference point, originally top of casing 1.1 feet above surface of ground until some time prior to Oct. 22, 1924, when top of casing was broken off level with surface of ground. Measurements prior to 1924 have been corrected to present reference point by subtracting 1.1 feet from the observed reading. Well plugged with débris at a depth of 21.5 feet, but in winter water rises above plug]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1920			1925		
Jan. 10	0.6	D. G. Thompson.	Jan. 22	4.0	N. S. Abbott.
			May 6	18.5	F. C. Ebert and H. G. Troxell.
1921					
Apr. 30	19.2	D. G. Thompson and F. C. Ebert.	July 17	(g)	N. S. Abbott.
			Oct. 6	19.9	F. C. Ebert.
May 30	13.0	D. G. Thompson and N. S. Abbott.	1926		
Oct. 2	12.5	N. S. Abbott.	Jan. 9	4.4	N. S. Abbott.
			May 13	24.2	F. C. Ebert.
1923			Aug. 30	(g)	N. S. Abbott.
Feb. 25	2.5	Do.	Oct. 15	20.3	F. C. Ebert.
May 14	15.6	Do.			
July 11	22.2	Do.	1927		
			Jan. 20	5.7	N. S. Abbott.
1924			May 9	(h)	F. C. Ebert.
Sept. 29	20.5	Do.	Oct. 26	17.0	Do.
Oct. 22	9.6	F. C. Ebert and H. G. Troxell.			
Nov. 15	8.8	N. S. Abbott.			

Well 85a; J. B. Nourse, owner; SW. ¼ sec. 12, T. 7 N., R. 11 W.

[Unused well a few feet from well equipped with pump. Reference point, top of casing, level with surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1920			1922		
Jan. 15	19.2	D. G. Thompson.	Feb. 8	20.3	N. S. Abbott.
			May 3	j 34.9	Do.
1921					
Apr. 27	i 29.3	Do.	1924		
May 29	i 28.8	D. G. Thompson and N. S. Abbott.	Oct. 23	(j)	F. C. Ebert and H. G. Troxell.
Aug. 21	i 31.6	N. S. Abbott.			
Oct. 2	26.3	Do.			

Well 86a; George A. Niller, owner; SW. ¼ sec. 23, T. 7 N., R. 11 W.

[Dug well at house. Reference point, three notches cut in south side of curb, 1.7 feet above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1920			1924		
Jan. 13	39.5	D. G. Thompson.	Oct. 23	38.2	F. C. Ebert and H. G. Troxell.
1921			1925		
May 29	37.6	D. G. Thompson and N. S. Abbott.	May 6	37.5	Do.
Aug. 21	(k)	N. S. Abbott.	Oct. 6	38.3	F. C. Ebert.
Oct. 2	(k)	Do.			
			1926		
1922			May 13	(l)	Do.
May 23	38.3	Do.			

g Water below débris plug.
h Plugged and dry at 21.5 feet.
i Well 10 feet to south running.
j Pump installed in well.
k Dry at 40.5 feet.
l Filled in and dry at 33 feet.

Measurements of depth to water in wells in Antelope Valley, Calif.—Continued

Well 111; J. Boyle, owner; SW. ¼ sec. 32, T. 6 N., R. 11 W.

[Reference point, bottom of pump base, level with surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1919			1925		
September	114	J. Boyle.	May 5	137.1	F. C. Ebert and H. G. Troxell.
1921			Oct. 7	140.7	F. C. Ebert.
August	119	Do.	1926		
1921			May 12	[m] 136.5	Do.
Feb. 12	118.1	N. S. Abbott.	Oct. 16	([n])	Do.
1924			1927		
Oct. 24	134.5	F. C. Ebert and H. G. Troxell.	May 10	[o] 147.0	Do.
			Oct. 26	([p])	Do.

Well 139; Littleton well, on north side of road a short distance west of bridge over Little Rock Creek near town of Little Rock, probably near southwest corner of NE. ¼ NW. ¼ sec. 14, T. 5 W., R. 11 W.

[Reference point, top of casing 1.5 feet above surface of ground. See p. 327 for additional measurements]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1920			1924		
Jan. 9	39.8	D. G. Thompson.	Oct. 24	([r])	F. C. Ebert and H. G. Troxell.
1921			1925		
Apr. 29	35.2	D. G. Thompson and F. C. Ebert.	May 5	([s])	Do.
Oct. 9	36.4	N. S. Abbott.	Oct. 7	([s])	F. C. Ebert.
1922			1926		
Jan. 5	38.35	Do.	May 12	[t] 32.65	Do.
Oct. 21	35.3	Do.	Oct. 16	36.4	Do.
1923			1927		
July 14	34.1	Do.	May 10	23.7	Do.
1924					
July 16	[q] 44.4	Do.	Oct. 26	32.4	Do.

Well 155a; Chris Laras, owner; SW. ¼ sec. 5, T. 7 N., R. 10 W.

[Abandoned well 25 feet north of pumping plant. Reference point, top of casing about level with surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1924		
May 29	28.9	D. G. Thompson and N. S. Abbott.	Nov. 13	25.3	N. S. Abbott.
Aug. 21	33.45	N. S. Abbott.	1925		
Oct. 1	35.6	Do.	Feb. 10	25.3	Do.
1922			May 6	[v] 46.7	F. C. Ebert and H. G. Troxell.
Feb. 8	21	Do.			
May 23	[u] 34.4	Do.	Aug. 12	[v] 49.9	N. S. Abbott.
Sept. 8	[u] 40.1	Do.	Oct. 6	[v] 46.4	F. C. Ebert.
Oct. 30	23.8	Do.	1926		
1923			Jan. 4	24.4	N. S. Abbott.
Feb. 26	23.1	Do.	Mar. 17	27.5	Do.
May 13	[u] 36.9	Do.	May 13	[w] 46.3	F. C. Ebert.
July 12	[u] 43.4	Do.	Aug. 16	[x] 54.4	N. S. Abbott.
Oct. 10	31.1	Do.	Oct. 16	[y] 34.4	F. C. Ebert.
Dec. 12	23.5	Do.			
1924			1927		
Apr. 12	63.7	Do.	Jan. 18	26.8	N. S. Abbott.
July 8	45.1	Do.	May 9	[w] 52.2	F. C. Ebert.
Oct. 23	28.5	F. C. Ebert and H. G. Troxell.	Oct. 27	35.8	Do.

[m] Pump pulled.
[n] Pumping.
[o] Pumping in the vicinity.
[p] New pump set, could not measure.
[q] Well cleaned out.
[r] Well dry at 44.5 feet.
[s] Well dry.
[t] Little Rock Reservoir filled; considerable water wasted down Little Rock Creek.
[u] Pump running near by.
[v] Well 25 feet to the south being pumped.
[w] Well to the south being pumped.
[x] Although the fact is not indicated in the record, a pump near by was probably running at the time this measurement was made.
[y] Near-by pumps not operating.

Measurements of depth to water in wells in Antelope Valley, Calif.—Continued

Well 157; Harry White, owner; NE. ¼ sec. 29, T. 9 N., R. 13 W.

[Reference point, top of casing level with surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1924		
May 30	37.2	D. G. Thompson and N. S. Abbott.	Dec. 31	37.4	N. S. Abbott.
Oct. 3	37.85	N. S. Abbott.	1925		
1922			Feb. 10	37.4	Do.
Jan. 21	36.6	Do.	May 5	40.4	F. C. Ebert and H. G. Troxell.
Apr. 29	36.0	Do.	May 8	40.9	N. S. Abbott.
May 24	36.6	Do.	July 21	41.8	Do.
Oct. 17	38.5	Do.	1926		
1923			Jan. 9	38.5	Do.
Apr. 30	40.2	Do.	May 13	40.55	F. C. Ebert.
July 10	40.2	Do.	Aug. 20	42.8	N. S. Abbott.
Aug. 8	40.4	Do.	Oct. 15	42.3	F. C. Ebert.
1924			1927		
Apr. 13	40.1	Do.	Jan. 19	41.0	N. S. Abbott.
July 4	40.4	Do.	May 9	43.1	F. C. Ebert.
Oct. 23	38.7	F. C. Ebert and H. G. Troxell.	Oct. 27	43.0	Do.

Well 160; Mr. Rice, owner, formerly owned by Mr. Chapman; southeast corner NE. ¼ (?) sec. 2, T. 7 N., R. 11 W. Old well 50 feet north of pumping plant. Reference point, 1921-22, top of curb, level with surface of ground. After July, 1923, top of casing about 1 foot above curb

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1924		
May 29	20.0	D. G. Thompson and N. S. Abbott.	Nov. 13	7.2	N. S. Abbott.
Aug. 21	26.9	N. S. Abbott.	1925		
Oct. 1	17.6	Do.	Feb. 10	5.9	Do.
1922			May 6	[h] 44.8	F. C. Ebert and H. G. Troxell.
Feb. 7	([e])	Do.	Aug. 12	[h] 55.6	N. S. Abbott.
Oct. 30	6.6	Do.	Oct. 6	12.7	F. C. Ebert.
1923			1926		
Feb. 26	2.7	Do.	Jan. 5	6.6	N. S. Abbott.
May 13	25.0	Do.	Mar. 17	11.9	Do.
July 12	([i])	Do.	May 13	[aa] 37.9	F. C. Ebert.
Oct. 10	[h] 20.0	Do.	Aug. 20	[h] 66.5	N. S. Abbott.
1924			Oct. 16	29.2	F. C. Ebert.
Jan. 10	0.00	Do.	1927		
Mar. 7	15.4	Do.	Jan. 18	8.5	N.S. Abbott.
July 8	[h] 41.2	Do.	Oct. 27	30.7	F. C. Ebert.
Oct. 23	15.0	F. C. Ebert and H. G. Troxell.			

Well 161; owner unknown; dug well in sec. 8, T. 8 N., R. 10 W.

[At abandoned shack on west side of road to Buckhorn Springs and Muroc. Reference point not reported]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1924		
Aug. 21	14.5	N. S. Abbott.	Jan. 10	12.4	N. S. Abbott.
Oct. 1	14.0	Do.	Mar. 7	16.4	Do.
1922			July 8	17.1	Do.
Feb. 7	12.3	Do.	Nov. 13	13.3	Do.
Apr. 21	14.5	Do.	1925		
May 23	13.0	Do.	Feb. 10	15.2	Do.
July 20	15.7	Do.	Aug. 10	17.8	Do.
Oct. 30	13.7	Do.	1926		
1923			Jan. 4	15.7	Do.
Feb. 26	13.9	Do.	Mar. 17	16.0	Do.
May 13	15.4	Do.	Aug. 16	19.9	Do.
July 12	16.4	Do.	1927		
Oct. 10	15.2	Do.	Jan. 18	16.6	Do.
Dec. 12	14.8	Do.			

[e] Flowing.
[f] Well 10 feet to south running.
[g] Pump running near by.
[h] Although the fact is not indicated in the record, a pump near by was probably running at the time this measurement was made.
[i] Pump removed; new reference point, top of casing about 1 foot above surface of ground.
[aa] Pump 50 feet away running.

Measurements of depth to water in wells in Antelope Valley, Calif.—Continued

Well 162; J. M. Hamilton, owner; NW. ¼ SW. ¼ sec. 9, T. 8 N., R. 10 W.

[A shallow well, with no perforations in casing. Reference point, top of casing about 1.8 feet above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921					
May 29	11.25	D. G. Thompson and N. S. Abbott.	Oct. 23	12.5	F. C. Ebert and H. G. Troxell.
Aug. 21	12.9	N. S. Abbott.	Nov. 13	12.4	N. S. Abbott.
Oct. 1	11.4	Do.	1925		
1922			Feb. 10	12.2	Do.
Feb. 7	11.3	Do.	May 6	11.9	F. C. Ebert and H. G. Troxell.
Apr. 29	10.6	Do.			
July 20	11.3	Do.	Aug. 10	12.6	N. S. Abbott.
Oct. 30	11.8	Do.	Oct. 6	12.8	F. C. Ebert.
1923			1926		
Feb. 26	11.6	Do.	Jan. 4	12.6	N. S. Abbott.
May 13	11.6	Do.	Mar. 17	12.5	Do.
July 12	11.9	Do.	May 13	12.45	F. C. Ebert.
Oct. 10	12.0	Do.	Aug. 16	13.4	N. S. Abbott.
Dec. 12	11.7	Do.	Oct. 16	13.4	F. C. Ebert.
1924			1927		
Jan. 10	11.8	Do.	Jan. 18	13.2	N. S. Abbott.
Mar. 7	11.6	Do.	Mar. 9	12.8	F. C. Ebert.
July 8	12.0	Do.			

Well 163; owner unknown; probably near northeast corner of NE. ¼ sec. 24, T. 8 N., R. 14 W.

[Well with windmill at corral of cattle camp. Reference point, top of casing about 3 inches above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1925		
May 30	79.0	D. G. Troxell and N. S. Abbott.	Feb. 11	78.5	N. S. Abbott.
Oct. 3	78.8	N. S. Abbott.	May 5	78.8	F. C. Ebert and H. G. Troxell.
1922			June 8	78.85	N. S. Abbott.
Jan. 5	[a] 80.2	Do.	July 21	79.2	Do.
May 24	79.4	Do.	Oct. 6	79.5	F. C. Ebert.
Oct. 17	79.1	Do.	1926		
			Jan. 9	79.0	N. S. Abbott.
1923			May 13	79.1	F. C. Ebert.
July 10	78.85	Do.	Aug. 25	79.9	N. S. Abbott.
			Oct. 15	81.0	F. C. Ebert.
1924					
July 27	78.9	Do.	1927		
Oct. 20	78.95	Do.	Jan. 19	79.7	N. S. Abbott.
Oct. 22	79.1	F. C. Ebert and H. G. Troxell.	May 9	79.5	F. C. Ebert.
			Oct. 27	80.3	Do.

Well 164; owner unknown; probably in NE. ¼ sec. 30, T. 8 N., R. 13 W.

[About 1,000 feet west of a well owned by H. L. Martin, which stands near road. Reference point, top of casing, 6 inches above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			Oct. 22	59.9	F. C. Ebert and H. G. Troxell.
Oct. 3	65.2	N. S. Abbott.			
1922			Feb. 11	56.9	N. S. Abbott.
Jan. 6	55.4	Do.	May 5	61.5	F. C. Ebert and H. G. Troxell.
Apr. 30	59.8	Do.			
May 24	59.7	Do.	June 8	61.9	N. S. Abbott.
Aug. 23	61.6	Do.	July 21	64.3	Do.
Oct. 17	59.3	Do.	Oct. 6	62.4	F. C. Ebert.
1923			1926		
Mar. 20	57.0	Do.	Jan. 9	58.5	N. S. Abbott.
July 10	59.0	Do.	May 13	62.3	F. C. Ebert.
July 26	62.4	Do.	Aug. 25	66.7	N. S. Abbott.
Aug. 9	62.6	Do.	Oct. 15	65.4	F. C. Ebert.
1924			1927		
July 4	62.6	Do.	Jan. 19	60.9	N. S. Abbott.
Oct. 20	59.3	Do.	May 9	65.0	F. C. Ebert.
			Oct. 27	66.2	Do.

[a] Pumping.

Measurements of depth to water in wells in Antelope Valley, Calif.—Continued

Well 165; Mr. Dall, owner (?); occupied by Mr. Krubsack; northeast corner SE. ¼ sec. 29, T. 7 N., R. 13 W.

[Dug well. Reference point, nail in curb about 3 feet from top of box]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1923		
Oct. 4	39.9	N. S. Abbott.	Feb. 25	39.5	N. S. Abbott.
			July 10	40.1	Do.
1922			1924		
Jan. 21	39.6	Do.	Jan. 10	39.7	Do.
May 24	39.7	Do.	Oct. 22	(a)	F. C. Ebert and H. G. Troxell.
Oct. 26	39.95	Do.			

Well 166; Mr. Lord, owner; NE. ¼ SE. ¼ sec. 32, T. 7 N., R. 12 W.

[Reference point, hole drilled in pump base, about 1 foot above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1925		
Oct. 4	116.1	N. S. Abbott.	Feb. 19	118.0	N. S. Abbott.
			May 5	118.1	F. C. Ebert and H. G Troxell.
1922					
Feb. 8	115.3	Do.	June 8	118.6 [a]	N. S. Abbott.
May 21	115.3	Do.	Aug. 12	118.4	Do.
Oct. 26	116.6	Do.	Oct. 6	119.5	F. C. Ebert.
			Dec. 29	119.2	N. S. Abbott.
1923			1926		
May 13	116.4	Do.	May 13	119.5	F. C. Ebert.
July 11	116.8	Do.	Aug. 25	121.3	N. S. Abbott.
			Oct. 15	121.6	F. C. Ebert.
1924			1927		
Mar. 28	116.5	Do.	Jan. 20	120.8	N. S. Abbott.
July 16	[b] 117.8	Do.	May 9	121.5	F. C. Ebert.
Oct. 22	118.5	F. C. Ebert and H. G. Troxell.	Oct. 26	124.0	Do.
Nov. 15	118.4	N. S. Abbott.			

Well 167; Mr. Morrion, owner (?); SE. ¼ NE. ¼ sec. 34, T. 7 N., R. 12 W.

[Reference point, hole in casting resting on well]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1925		
Oct. 4	123.6	N. S. Abbott.	June 8	125.9	N. S. Abbott.
			Aug. 12	126.7	Do.
1922			Oct. 6	127.2	F. C. Ebert.
Feb. 8	121.7	Do.	Dec. 29	126.9	N. S. Abbott.
May 21	122.5	Do.			
Oct. 26	125.1	Do.	1926		
			May 12	126.7	F. C. Ebert.
1923			Aug. 25	133.4	N. S. Abbott.
May 13	123.5	Do.	Oct. 15	128.5	F. C. Ebert.
July 11	124.5	Do.			
			1927		
1924			Jan. 20	130.0	N. S. Abbott.
July 16	125.4	Do.	May 9	128.5	F. C. Ebert.
Oct. 22	127.0	F. C. Ebert and H. G. Troxell.	Oct. 26	130.7	Do.
Nov. 14	126.1	N. S. Abbott			
1925					
Feb. 19	126.6	Do.			
May 5	125.5	F. C. Ebert and H. G. Troxell.			

[a] Well dry.
[b] Windmill running.

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Measurements of depth to water in wells in Antelope Valley, Calif.—**Continued**

Well 168; Harper & Paramore, owners; southeast corner SE. ¼ sec. 12, T. 6 N., R. 11 W.

[Reference point, top of casing 6 inches above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1924		
Oct. 8	113.0	N. S. Abbott.	Nov. 14	114.0	N. S. Abbott.
1922			1925		
Feb. 12	112.6	Do.	Feb. 27	114.6	Do.
Oct. 21	116.6	Do.	June 9	115.6	Do.
			Nov. 4	116.9	Do.
1923					
May 13	111.7	Do.	1926		
July 12	112.8	Do.	Jan. 4	117.4	Do.
			Aug. 20	117.0	Do.
1924					
Feb. 16	112.9	Do.	1927		
July 15	113.9	Do.	Jan. 17	120.6	Do.

Well 169; C. B. Sharp, owner; SW. ¼ sec. 10, T. 7 N., R. 11 W.

[Well is 300 feet northeast of house. Reference point, top of casing]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1924		
May 29	19.0	D. G. Thompson and N. S. Abbott.	Nov. 13	8.0	N. S. Abbott.
Oct. 2	18.5	N. S. Abbott.	1925		
			Feb. 10	6.1	Do.
1922			May 6	26.6	F. C. Ebert and H. G. Troxell.
Feb. 8	1.7	Do.			
Oct. 30	8.0	Do.	Aug. 12	34.2	N. S. Abbott.
1923			1926		
Feb. 26	2.9	Do.	Jan. 5	6.5	Do.
May 13	20.1	Do.	Mar. 17	11.0	Do.
July 12	27.9	Do.	May 13	([cc])	F. C. Ebert.
Oct. 10	21.7	Do.	Aug. 23	47.0	N. S. Abbott.
1924			1927		
Apr. 12	24.8	Do.	Jan. 18	9.7	Do.
July 8	33.2	Do.			
Oct. 23	13.7	F. C. Ebert and H. G. Troxell.			

Well 170; owner unknown; near northwest corner NE. ¼ sec. 31, T. 7 N., R. 10 W.

[Reference point, top of casing, about 2.5 feet above surface of ground]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1924		
May 29	81.2	D. G. Thompson and N. S. Abbott.	Nov. 14	85.5	N. S. Abbott.
Aug. 2	82.5	N. S. Abbott.	1925		
Oct. 2	82.0	Do.	Feb. 10	84.8	Do.
			May 6	[ee] 87.3	F. C. Ebert and H. G. Troxell.
1922					
Jan. 23	81.2	Do.	June 9	[a] 87.9	N. S. Abbott.
May 1	83.0	Do.	July 17	[a] 89.2	Do.
Aug. 30	[a] 85.1	Do.	Oct. 6	89.4	F. C. Ebert.
Oct. 21	[a] 85.4	Do.	Oct. 30	89.0	N. S. Abbott.
1923			1926		
May 8	[a] 84.1	Do.	Jan. 4	87.0	Do.
July 12	[a] 85.9	Do.	Mar. 16	87.3	Do.
July 14	[dd] 85.4	Do.	May 13	89.9	F. C. Ebert.
Oct. 8	85.2	Do.	Aug. 16	94.8	N. S. Abbott.
Dec. 12	84.6	Do.	Oct. 15	[ee] 93.9	F. C. Ebert.
1924			1927		
Apr. 12	83.7	Do.	Jan. 17	90.2	Do.
July 10	87.3	Do.	May 9	[ee] 94.8	Do.
Oct. 23	86.7	F. C. Ebert and H. G. Troxell.	Oct. 27	96.1	Do.

[a] Pump running near by.
[cc] Well covered. Could not measure.
[dd] Pump not running.
[ee] Well 100 feet to north being pumped.

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Measurements of depth to water in wells in Antelope Valley, Calif.—Continued

Well 171; Mr. Adair, owner; SE. ¼ SE. ¼ sec. 14, T. 7 N., R. 10 W.

[Reference point, top of cement pump base level with surface of ground. No pump in well]

Date of measurement	Depth to water below reference point	Measured by	Date of measurement	Depth to water below reference point	Measured by
1921			1924		
May 29	62.05	D. G. Thompson and N. S. Abbott.	Nov. 13	64.1	N. S. Abbott.
Aug. 21	62.2	N. S. Abbott.	1925		
Oct. 2	62.3	Do.	Feb. 10	63.8	Do.
Dec. 30	62.3	Do.	May 6	64.5	F. C. Ebert and H. G. Troxell.
1922			June 9	64.8	N. S. Abbott.
May 1	63.4	Do.	Sept. 10	65.5	Do.
Sept. 2	62.7	Do.	Oct. 6	65.6	F. C. Ebert.
Oct. 17	62.8	Do.	Oct. 30	65.4	N. S. Abbott.
1923			1926		
May 8	62.9	Do.	Jan. 4	64.8	Do.
July 12	63.1	Do.	Mar. 15	64.9	Do.
Oct. 8	63.3	Do.	May 13	65.65	F. C. Ebert.
Dec. 7	63.2	Do.	Aug. 16	66.9	N. S. Abbott.
			Oct. 16	67.4	F. C. Ebert.
1924					
Feb. 16	63.05	Do.	1927		
Apr. 12	63.4	Do.	Jan. 17	66.3	N. S. Abbott.
July 9	64.0	Do.			
Aug. 12	64.1	Do.	May 9	67.6	F. C. Ebert.
Oct. 23	64.3	F. C. Ebert and H. G. Troxell.	Oct. 27	([1])	Do.

[1] Well 10 feet to south running.

MOHAVE RIVER BASIN

The drainage basin of Mohave River is one of the largest in the Mohave Desert region. Agricultural development has been greater in this basin and the prospects for future development are also greater than in any other basin of the region except, perhaps, Antelope Valley. Several projects to irrigate large areas in the basin have been proposed, but so far none of them have been completed. A number of reports, published and unpublished, have been made upon these different projects. The most comprehensive report is Bulletin 5 of the California State Department of Engineering, "Report on the utilization of Mohave River for irrigation in Victor Valley, Calif.," by W. F. McClure, J. A. Sourwine, and C. E. Tait. This report, like most of the others, considers principally problems concerned in the utilization of the surface flow of the river.

The basin contains several large areas where conditions are favorable to agricultural development, separated by less favorably situated areas. The physical and geologic conditions are such that there seems no doubt that the development of either the surface or ground-water supply in one part of the basin will affect the development in areas farther downstream. No report, so far as the writer is aware, has given more than passing consideration to the effect of developments in one part of the drainage basin on developments in another part. In the following pages attention is called to some of these problems,