Ground-Water Conditions in the Avenal-McKittrick Area Kings and Kern Counties California

By P. R. WOOD *and* G. H. DAVIS

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1457

Prepared in cooperation with the U.S. Bureau of Reclamation

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1959

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The U.S. Geological Survey Library has cataloged this publication as follows:

Wood, Perry Rowley, 1920–

Ground-water conditions in the Avenal-McKittrick area, Kings and Kern Counties, California, by P. R. Wood and G. H. Davis. Washington, U.S. Govt. Print. Off., 1959.

iv, 141 p. maps, diagrs., tables. 24 cm. (U.S. Geological Survey. Water-supply paper 1457)

Part of illustrative matter folded in pocket.

Prepared in cooperation with the U.S. Bureau of Reclamation.

Bibliography: p. 62–64.

1. Water, Underground—California—Kern Co. 2. Water, Underground—California—Kings Co. I. Davis, George Hamilton, 1921– joint author. II. Title: Avenal-McKittrick area, Kings and Kern Counties, California. (Series)

For sale by the Superintendent of Documents, U.S. Government Printing Office Washington 25, D.C.

CONTENTS

ILLUSTRATIONS

[Plates in pocket]

TABLES

GROUND-WATER CONDITIONS IN THE AVENAL-McKITTRICK AREA, KINGS AND KERN COUNTIES, CALIFORNIA

By P. R. Wood and G. H. Davis

ABSTRACT

The Avenal-McKittrick area consists of about 850 square miles on the southwest side of the San Joaquin Valley, extends southeastward from the towns of Avenal and Kettleman City to the Elk Hills. Except for about 16,000 acres in several isolated localities, the area is uninhabited desert most of the year, although extensive grazing is carried on during winter and spring. The area includes Kettleman and Antelope Plains, Antelope and McLure (also known as Sunflower) Valleys, and the area south of Tulare Lake.

The geologic units of the area are classed as consolidated rocks and unconsolidated deposits. The first group includes consolidated non-water-bearing rocks and semiconsolidated rocks of Jurassic to Pliocene age which in general contain connate water of poor quality; locally at shallow depth fresh water is present in them. Most of the formations contain fold- and fault-induced fractures, and these openings probably convey small quantities of water to the adjacent unconsolidated deposits. The second group consists of unconsolidated to loosely consolidated water-bearing deposits of continental origin which supply nearly all the water pumped from wells. These deposits include the structurally deformed Tulare formation of late Pliocene and Pleistocene(?) age and the alluvium of Pleistocene and Recent age, which in most places unconformably overlies the Tulare. Both units are composed of generally poorly sorted silty materials containing lenticular bodies of sand and gravel derived from the Coast Ranges and deposited by streams on extensive alluvial fans. The alluvium is only moderately permeable, and, although the water-bearing properties of the Tulare are little known, it probably is also only moderately permeable. Lacustrine and flood-basin sediments of Pleistocene and Recent age, present in the bed of Tulare Lake and along Buena Vista Slough, consist of nearly flat-lying well-stratified silt, clay, and fine sand which generally are poorly permeable.

The alluvium and the Tulare formation range in thickness from a few feet along the western border of the valley to several thousand feet beneath the valleys and plains. However, because of comparatively late structural deformation in the area, the deposits vary considerably in thickness for short distances. Over the crests of buried anticlines the deposits thin considerably, and along the flanks and in adjoining synclinal troughs they thicken rapidly.

Recharge to the unconfined and semiconfined bodies of ground water may be by seepage loss from streams, by deep penetration of imported water applied for irrigation in excess of plant requirements, by losses of imported water through irrigation canals and ditches, and by deep penetration of rainfall. However, seepage loss from intermittent streams draining the Coast Ranges

probably is the chief source of recharge. Poorly defined drainage channels that extend generally eastward across the area suggest that little water escapes as surface outflow. Inasmuch as annual precipitation averages less than 12 inches, deep penetration of rainfall is a significant source of recharge only during infrequent years of exceptionally large precipitation.

Although the general movement of ground water is northeastward from recharge areas along the western border of the valley toward Buena Vista Slough in the trough of the valley, the movement is interrupted or deflected in several places by northwestward-trending anticlinal structures, principally those underlying the Pyramid, Kettleman, and Lost Hills. Movement is restricted in the narrow Dagany and Avenal Gaps and the area between the Kettleman and Lost Hills. Local pumping depressions have developed in McLure and Antelope Valleys.

Of the 344 wells that were investigated in the field in 1951 and 1955, only 95 were used as irrigation wells in the autumn of 1955. Short-term drawdown and recovery tests made by the Pacific Gas and Electric Co. indicate that the yields ranged from about 100 to 1,700 gpm (gallons per minute). Specific capacities ranged from 2 to 120 gpm per foot of drawndown. The depths of irrigation wells ranged from about 100 to 1,700 feet.

Irrigation pumpage by electrically powered pumps increased steadily from about 13,000 acre-feet in 1947 to about 25,000 acre-feet in 1953. From 1953 to 1956 the annual pumpage remained nearly constant, about 25,000 acre-feet. The total for the 10-year period was about 200,000 acre-feet.

In areas of large withdrawals water levels have undergone steady and marked declines. For the period 1936–53 the levels at Devils Den ranch declined a maximum of about 100 feet; for the period 1951–56 levels in Antelope Valley declined a maximum of 40 feet; and for the period 1947–54 levels in McLure Valley declined 60 to 120 feet. In the areas of little ground-water development east of Avenal Gap and throughout most of Kettleman and Antelope Plains, water levels remained essentially unchanged to 1955, the date of this report.

The stream waters tributary to the Avenal-McKittrick area differ greatly in both chemical character and mineral content. They were divided into two general types on the basis of their chemical character. The waters of Avenal and Polonio Creeks are characterized by a comparatively lower mineral content and proportionally less sulfate but more magnesium than the waters of Bitterwater, Media Agua, and Carneros Creeks. These differences in mineral content are related to the lithology of the rocks in the respective drainage areas. The waters in which the concentration of sulfate is relatively low were derived from areas underlain predominantly by marine sediments of Cretaceous age and sedimentary, igneous, and metamorphic rocks of the Franciscan formation of Jurassic and Cretaceous age. The waters characterized by a high proportion of sulfate were derived from areas underlain chiefly by marine and continental sedimentary rocks of Tertiary and Quaternary age.

The ground waters of the area are fairly consistent in chemical character but differ greatly in mineral content. The typical waters are of sodium sulfate composition or are sulfate waters of intermediate cation composition. Locally, sodium chloride waters are present. The mineral content of ground waters in the area ranges from 477 to 7,040 ppm (parts per million), hardness ranges from 30 to 3,020 ppm, and boron from 0.3 to 11 ppm. The high sodium content of the ground waters in comparison to that of the stream waters evidently is the result of cation exchange with the sediments.

In most of the area the ground waters are of doubtful to unsuitable quality for irrigation. Further detailed studies of soil salinity and quality of ground water, and exploration and testing of undeveloped parts of the area will be required to determine whether ground-water supplies or ground-water storage can be utilized effectively in conjunctions with imported surface-water supplies.

INTRODUCTION

LOCATION AND GENERAL FEATURES OF AREA

The Avenal-McKittrick area of this report includes that part of the west side of the San Joaquin Valley which extends southeastward from the towns of Avenal and Kettleman City to the northern border of Elk Hills and west from the axial trough of the valley, marked by Buena Vista Slough and the southwestern margin of the dry bed of Tulare Lake, to the foothills of the Coast Ranges on the west. It also includes parts of Kettleman Hills and Reef Ridge-Pyramid Hills, outliers of the Coast Ranges, and Kettleman Plain and McLure (Sunflower) Valley—the valley between these outliers and the Coast Ranges proper. The location and general features of the area are shown on plates 1 and 2 and figure 1.

The area is about 70 miles long by an average of 12 miles wide and includes about 850 square miles. Of this total about 700 square miles is underlain by unconsolidated alluvial deposits; the rest consists of hilly and mountainous country underlain by consolidated and semiconsolidated rocks of marine and continental origin. The greater part of the area is in Kern County; the remainder extends north into the southern part of Kings County.

The area is readily accessible to automobiles by way of U.S. Highway 466 and State Highways 33 and 41 (pl. 1). The only railroad is the McKittrick branch of the Southern Pacific, which provides freight service from Bakersfield to the oil-producing districts near the town of McKittrick.

Avenal, founded after the discovery of oil in the Kettleman Hills in 1928, had a population of 3,982 in 1950 and is the largest town in the area. Lost Hills, a small community in the east-central part of the area, is the only other town. Other settlements include combination service stations and eating places at Kecks Corner, Blackwells Corner, North Belridge, and South Belridge, and an unnamed station at the intersection of State Highways 33 and 41. The agricultural population is concentrated chiefly on the Devils Den ranch, in McLure Valley, and in Antelope Valley. People employed by the oil industry generally live in small company-owned communities or isolated dwellings near the producing oil fields.

Except for the irrigated areas in McLure Valley, Antelope Valley, and Kettleman Plain (pl. 3) the greatest part of the Avenal-McKittrick area is an uninhabited desert during most of the year. Only in the winter and early spring when the native pasture greens as a result of winter rains is there appreciable agricultural activity.

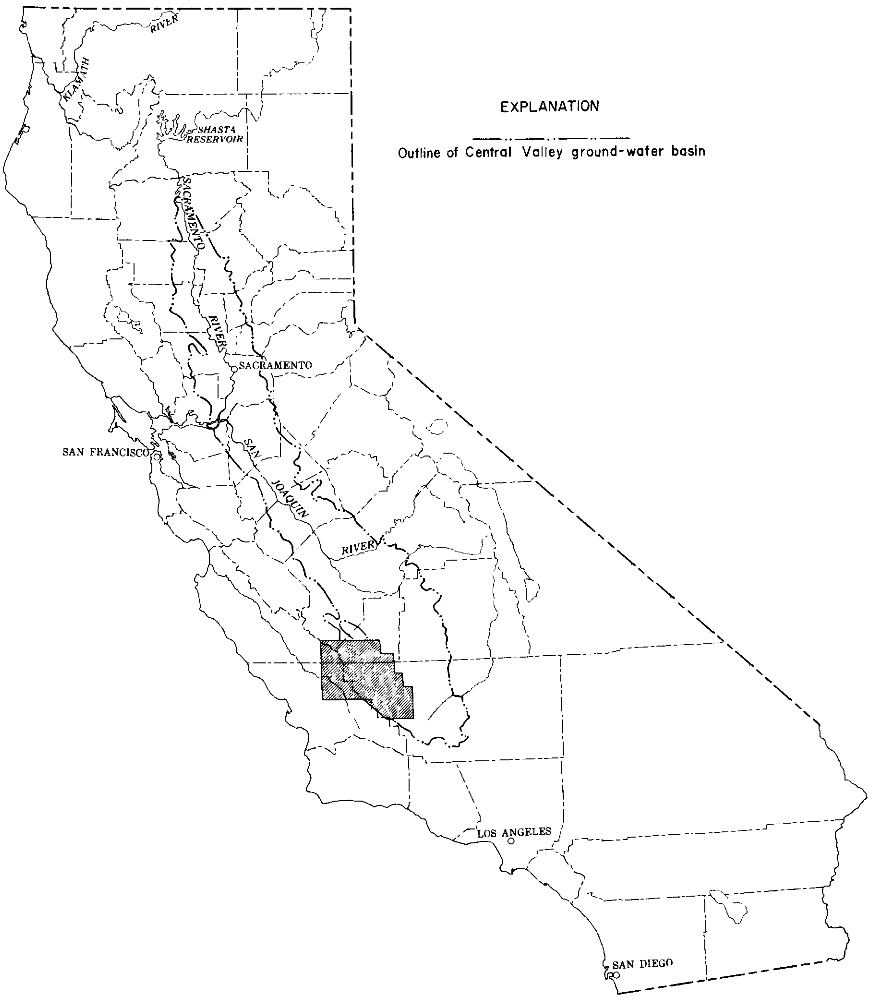


FIGURE 1.—Map of California showing area covered by this report.

Sheep and cattle graze the area as long as the forage lasts and are moved out of the area as summer approaches.

SCOPE AND PURPOSE

The investigation in the Avenal-McKittrick area was begun by the U.S. Geological Survey in 1951 with Federal funds provided for general ground-water investigations in the Central Valley. This work was discontinued late the same year. In autumn 1955 the investigation was resumed and carried to completion with funds supplied by the U.S. Bureau of Reclamation for the purpose of evaluating ground-water conditions along the western slope of the San Joaquin Valley in the service area of the proposed Avenal Gap unit of the Central Valley project.

The objectives of the ground-water study included: (1) an inventory of wells and springs; (2) collection of available drillers' logs, electric logs, water-level records, and chemical analyses of surface and ground waters; (3) an estimate of irrigation pumpage from records of power consumption; (4) a compilation of the available geologic mapping and study of well logs to determine the geologic features that relate to the occurrence and movement of ground water; (5) a study of the chemical quality of surface and ground waters with special consideration of their suitability for irrigation and the utilization of ground-water storage capacity; (6) tabulation of well records, water-level measurements, pumpage estimates, chemical analyses, and selected well logs; and (7) preparation of a report outlining the results of the study.

Accordingly, the purpose of this report is to present and to interpret the available data on the geology, ground-water hydrology, and chemical quality of the ground waters of the water-bearing deposits of the Avenal-McKittrick area. Almost no hydrologic work had been done in the area before this investigation. This report presents all the hydrologic information available on the area as of 1955.

Much of the information on wells in the area north of U.S. Highway 466 was collected in 1951 by the Geological Survey. During 1955 the area north of U.S. Highway 466 was reinvestigated, additional well information was collected, and the well inventory was extended south to the northeastern border of Elk Hills.

Most of the chemical analyses in tables 8 and 9 were made by the Geological Survey; the water samples were collected by the California Department of Water Resources.

The topographic base map is a polyconic projection compiled at a scale of 1:62,500 by the Topographic Division of the Geological Survey from the latest available quadrangle maps of the area. This base was reduced to a scale of 1:125,000 for the preparation of plates 1, 3, and 5.

The geology shown on plate 1 was compiled from published and unpublished sources as shown on the inset source map. Titles of papers and publications in which the papers appear can be found in the list of references at the end of the report. Modifications were made of the contact between the alluvium and the older rock units in most of the valley areas, especially south of U.S. Highway 466 and in the Lost Hills, North Belridge, and South Belridge, on the basis of interpretation of topographic maps and uncontrolled aerial mosaics.

The investigation was started under the supervision of J. F. Poland, district geologist of the Geological Survey in charge of ground-water investigations in California, and completed under the supervision of G. F. Worts, Jr., district geologist since July 1956. G. H. Davis was in charge of the investigation. Fieldwork in 1951 was done by P. R. Wood, M. E. Cooley, and R. S. Stone.

CLIMATE

The Avenal-McKittrick area and adjoining foothills are characterized by hot summers, mild winters, and low precipitation, most of which falls during the winter. Precipitation data from seven stations of the U.S. Weather Bureau in or near the area of investigation are summarized in tables 1 and 2. Coalinga station formerly was in the town of Coalinga, altitude 663 feet, about 16 miles northwest of Avenal. In January 1942 the station was moved to its present location at the airport, altitude 675 feet, about 1 mile north of Coalinga. Kettleman station, altitude 502 feet, is at the Kettleman station of the Pacific Gas and Electric Co., about 6 miles northeast of Avenal. Angiola, altitude 205 feet, is in the San Joaquin Valley near the Angiola station of the Atchison, Topeka, and Santa Fe railroad, about 40 miles east of Avenal. Dudley station, no longer in operation, was at the Dudley pump station (24/18–22E), altitude 595 feet, in the Pyramid Hills near McLure Valley, about 14 miles south of Avenal. Antelope Valley station, no longer in operation, was at the Antelope pump station, altitude 1,205 feet, near the northwest end of Antelope Valley. Middlewater station, altitude 803 feet, is at the Middlewater pump station (28/20–10N), about 11 miles southwest of the town of Lost Hills. Buttonwillow station, altitude 295 feet, is at the headquarters of the Buena Vista water-storage district (29/23–14L), about half a mile north of Buttonwillow.

TABLE 1.—*Seasonal precipitation (July 1 to June 30), in inches, at seven stations in or near the Avenal-McKittrick area*

[Data from U.S. Weather Bureau monthly and seasonal precipitation records]

Season	Coalinga	Kettleman station	Angiola	Dudley	Antelope Valley	Middle-water	Button-willow
1899–1900	--------	--------	7. 77	--------	--------	--------	--------
1900–01	--------	--------	8. 57	--------	--------	--------	--------
1901–02	--------	--------	5. 02	--------	--------	--------	--------
1902–03	--------	--------	3. 15	--------	--------	--------	--------
1903–04	--------	--------	4. 50	--------	--------	--------	--------
1904–05	--------	--------	7. 22	--------	--------	--------	--------
1905–06	--------	--------	9. 99	--------	--------	--------	--------
1906–07	--------	--------	8. 13	--------	--------	--------	--------
1907–08	--------	--------	6. 76	--------	--------	--------	--------
1908–09	--------	--------	11. 99	--------	--------	--------	--------

TABLE 1.—*Seasonal precipitation (July 1 to June 30), in inches, at seven stations in or near the Avenal-McKittrick area—Continued*

Season	Coalinga	Kettleman station	Angiola	Dudley	Antelope Valley	Middle-water	Button-willow
1909–10			7.01				
1910–11			8.89				
1911–12			3.49		8.35	6.51	
1912–13	3.42		4.12	3.76	4.94	4.29	
1913–14	10.87		7.20	8.59	10.88	7.56	
1914–15	11.84		11.68	11.99	15.52	10.30	
1915–16	8.37		7.93	7.05	10.55	6.50	
1916–17	5.05		5.06	4.22	7.71	5.79	
1917–18	9.05		6.16	9.73	12.09	8.25	
1918–19	5.59		7.72	4.73	6.50	5.26	
1919–20	5.78		6.46	5.44	8.89	5.12	
1920–21	5.67		6.46	5.72	6.97	3.42	
1921–22	9.62		8.84	8.14	11.51	7.73	
1922–23	5.25		6.97	4.97	7.70	2.85	
1923–24	4.06		4.79	3.44	3.79	3.41	
1924–25	4.64		6.96	5.36	4.69	3.10	
1925–26	7.53		5.50	8.44	7.70	4.88	
1926–27	8.34		9.68	7.67	10.51	6.07	
1927–28	3.43		6.66	7.15	5.18	4.56	
1928–29	4.66		6.17	2.98	6.55	2.46	
1929–30	5.28		4.94	5.03	6.77	4.81	
1930–31	7.20		7.67	[1] 6.25	6.43	3.68	
1931–32	6.35		8.65	5.45	11.24	6.52	
1932–33	4.62		6.15	[1] 5.47	8.88	5.04	
1933–34	5.23		4.11	5.30	4.52	1.69	
1934–35	11.23		12.45	10.58	13.58	7.62	
1935–36	8.20		8.19	7.30	9.14	3.48	
1936–37	9.36		11.08	12.31	16.30	6.95	
1937–38	13.29		12.36	10.33	15.76	7.60	
1938–39	4.73		6.55	[1] 4.67	5.93	3.57	
1939–40	7.28		8.49		9.92	4.09	
1940–41	14.83		12.59		20.00	8.20	
1941–42	7.63	5.61	8.22		10.20	6.04	7.28
1942–43	6.98	6.79	9.14			7.87	[1] 8.12
1943–44	6.85	5.69	5.36			4.58	[1] 4.18
1944–45	5.07	3.24	6.74			4.11	4.34
1945–46	5.41	4.20	[1] 7.40			4.26	3.86
1946–47	4.47	4.18				3.28	4.17
1947–48	4.23	4.00				2.43	3.01
1948–49	5.27	4.09	4.72			4.06	4.29
1949–50	5.28	4.61	4.23			3.81	3.35
1950–51		4.51	4.01			3.44	4.37
1951–52	10.44	7.36	9.46			7.13	7.10
1952–53	5.26	3.87	7.20			4.15	5.13
1953–54	6.92	6.59	6.29			5.13	5.03
1954–55	8.65	6.35	6.78			5.49	4.09
Average	[2] 6.98	[3] 5.07	[4] 7.28	[5] 6.74	[6] 9.31	[7] 5.16	[8] 4.88

[1] Estimated.
[2] 1912–13 to 1954–55.
[3] 1941–42 to 1954–55.
[4] 1899–1900 to 1954–55.
[5] 1912–13 to 1938–39.
[6] 1911–12 to 1941–42.
[7] 1911–12 to 1954–55.
[8] 1941–42 to 1954–55.

TABLE 2.—*Average monthly precipitation (inches) at seven stations in or near the Avenal-McKittrick area*

[Data from U.S. Weather Bureau annual summaries]

	Coalinga (1912–50)	Kettleman station (1942–50)	Angiola (1899–1950)	Dudley (1911–35)	Antelope Valley (1911–42)	Middle-water (1911–50)	Button-willow (1942–50)
January	1. 26	0. 76	1. 43	1. 32	2. 02	0. 95	0. 99
February	1. 58	1. 31	1. 41	1. 22	2. 09	1. 09	1. 02
March	1. 15	1. 13	1. 31	1. 00	1. 51	. 87	. 93
April	. 55	. 53	. 63	. 45	. 62	. 39	. 43
May	. 24	. 14	. 32	. 45	. 19	. 25	. 23
June	. 08	. 07	. 05	. 09	. 09	. 05	. 03
July	. 06	Tr.	. 01	. 01	. 04	. 04	. 03
August	Tr.	Tr.	. 01	. 03	. 02	. 01	Tr.
September	. 06	. 04	. 15	. 06	. 10	. 06	. 15
October	. 25	. 14	. 35	. 29	. 30	. 30	. 25
November	. 46	. 31	. 55	. 59	. 60	. 33	. 48
December	1. 24	. 97	1. 11	. 91	1. 60	. 83	. 75

The west side of the San Joaquin Valley lies in a rain shadow of the Coast Ranges. Moisture-laden air moving eastward from the Pacific Ocean is cooled while passing over the mountainous country west of the valley, resulting in condensation of water vapor followed by precipitation, mostly in the mountains. Consequently, when the air masses have passed over the mountains and descend to cross the San Joaquin Valley, they contain less moisture, and only a relatively small amount of rain falls on the valley floor. The orographic effect of the mountains is shown by the records of precipitation stations in the Coast Ranges and in the San Joaquin Valley. For example, Priest Valley, altitude 2,400 feet, in the Coast Ranges about 22 miles west of Coalinga, has a 56-year average precipitation of 19.56 inches. Parkfield, altitude 1,700 feet, in the Coast Ranges about 18 miles southwest of Avenal, has a 47-year average of 14.40 inches. In the Avenal-McKittrick area, Antelope Valley, altitude 1,205 feet, has a 30-year average of 9.31 inches, and Buttonwillow, altitude 295 feet, has a 14-year average of 4.88 inches.

Precipitation in the drainage basins tributary to the Avenal-McKittrick area falls almost entirely as rain. Rainfall very often occurs as heavy downpours in a small part of a drainage basin, with only light showers or no rain falling in other parts of the basin. Again, precipitation may occur as a gentle rain over a large part of the area. Ordinarily the rainfall does not last long, and during heavy downpours runoff generally is rapid. At most places soils are loose and poorly developed, and vegetation is scanty, consisting mostly of sparse grasses, brush, and weeds. Because of their loose texture the soils probably retain a large proportion of the precipitation resulting from gentle rains or showers.

Precipitation records given in tables 1 and 2 show the seasonal (July 1 to June 30) and monthly distribution and intensity of the rainfall in different parts of the area. The seasonal precipitation for the period of record at seven stations in or near the Avenal-McKittrick area is summarized in table 1. From the records of average monthly precipitation presented in table 2, it can be computed that nearly 75 percent of the precipitation occurs during the four months from December through March.

Table 3 shows the monthly temperatures at six stations in or near the Avenal-McKittrick area. Midsummer temperatures often exceed 110°F, and extremes as high as 116°F have been recorded at Middlewater station. In the winter the temperatures often drop below 32°, and lows of 15° to 20° are not uncommon. The temperatures given in table 3 show that July is the hottest month; average monthly temperatures range from 82° to 85°. January is the coldest month; average monthly temperatures range from 44° to 46°. The mean annual temperature is about 64°. The average number of frost-free days ranges from 195 to 300. Because of the clearness of the air, radiation is rapid; the difference between day and night temperatures frequently is 40° or more.

TABLE 3.—*Average temperatures (° F) at six stations in or near the Avenal-McKittrick area*

[Data from U.S. Weather Bureau annual summaries]

Month	Coalinga (1912–50)	Kettleman station (1942–50)	Angiola (1899–1945)	Dudley (1911–35)	Middlewater (1911–50)	Buttonwillow (1942–50)
January	45.7	46.2	44.3	46.5	46.1	45.4
February	50.6	50.5	49.5	52.5	50.7	49.8
March	54.8	55.3	54.3	56.0	55.3	55.5
April	60.8	61.7	60.9	61.7	61.6	62.6
May	67.5	68.5	69.0	68.7	69.0	69.5
June	75.6	75.3	75.5	77.4	76.9	75.5
July	82.1	83.0	82.2	85.4	84.6	82.5
August	80.0	80.4	80.0	84.2	82.7	79.8
September	73.7	76.3	72.8	75.6	76.4	74.4
October	64.7	66.1	63.2	66.3	66.1	64.6
November	54.5	55.7	51.9	56.2	55.7	53.5
December	46.9	47.7	45.2	47.7	48.1	48.3
Average annual	63.1	63.9	62.4	64.8	64.4	63.5

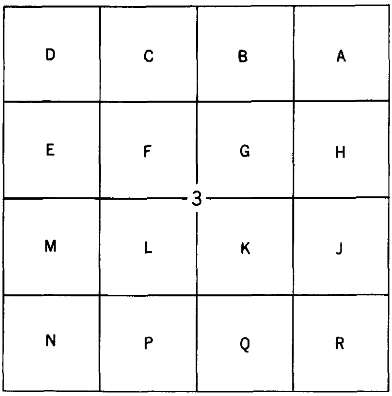
ACKNOWLEDGMENTS

The collection of data for this report and the success of the investigation were made possible to a great extent by the cooperation of public agencies, private companies, and individuals. The U.S. Bureau of Reclamation furnished many electric logs, a few drillers' logs, and most of the chemical analyses of surface waters. The California Department of Water Resources furnished most of the chemical analyses of spring and well waters, some miscellaneous

water-level measurements, and a few drillers' logs. Data on water levels, pumpage, and results of pumping-plant tests, which made possible quantitative estimates of irrigation pumpage, were furnished by the San Joaquin Division of the Pacific Gas and Electric Co. The Tidewater Associated Oil Co. supplied miscellaneous water-level measurements, chemical analyses, and drillers' logs of water wells at Reef, Temblor, and Carneras oil pump stations. The California Division of Mines made available unpublished geologic maps and furnished copies of the geologic map of California (preliminary uncolored edition) compiled by C. J. Kundert (1955). Acknowledgment also is due the many individuals, well drillers, and ranchers who furnished basic data and other information.

WELL-NUMBERING SYSTEM

The well-numbering system used in California by the Geological Survey shows the locations of wells according to the rectangular system for the subdivision of public land. For example, in the number 27/21–3A1, which was assigned to a well in the town of Lost Hills, the part of the number preceding the slant indicates the township (T. 27 S.), the part between the slant and the hyphen shows the range (R. 21 E.), the part between the hyphen and the letter indicates the section (sec. 3), and the letter following the section number indicates the 40-acre subdivision of the section as shown in the accompanying diagram.



Within each 40-acre tract wells are numbered serially, as indicated by the final digit of the number. Thus, well 27/21–3A1 is the first well to be listed in the NE¼NE¼ sec. 3, T. 27 S., R. 21 E. As all the Avenal-McKittrick area is in the southeast quadrant of the Mount Diablo base and meridian, the foregoing abbreviation of township and range is sufficient.

Objects other than wells have been described by a location number similar to a well-location number but without the final digit.

For example, an oil well in the NE¼NE¼ sec. 15, T. 24 S., R. 18 E., near Avenal Gap, may be described as being in 24/18–15A.

PHYSIOGRAPHY

TOPOGRAPHY AND DRAINAGE

The Avenal-McKittrick area for the most part lies in the Great Valley geomorphic province as defined by Jenkins (1938) but includes Kettleman Hills, Kettleman Plain, Reef Ridge-Pyramid Hills, and McLure Valley of the Coast Ranges province of Jenkins (1938).

The part of the San Joaquin Valley south of Tulare Lake is for all practical purposes a basin of interior drainage (Davis and others, 1959, p. 18). There the drainage is poorly integrated; the streams flow toward the valley trough and thence northward by way of Buena Vista Slough to Tulare Lake bed. Formerly, water collected in Tulare Lake and overflowed northward to the San Joaquin River during periods of exceptionally heavy runoff when the lake surface reached an elevation of as much as 210 feet above sea level. At present most of the lake bed has been reclaimed and is under cultivation; the northwestern part contains the lake which is confined by dikes and levees.

All the streams in the area are intermittent and flow only during periods of heavy rainfall. In periods of average rainfall virtually all the runoff from these streams is absorbed by permeable alluvial-fan deposits before reaching the valley trough.

SAN JOAQUIN VALLEY

The surface of the San Joaquin Valley is characterized by several types of topography which may be grouped into four geomorphic units (Davis and others, 1959, p. 16): Dissected uplands, low plains and fans, river flood plains and channels, and overflow lands and lake bottoms. The first, second, and fourth units are recognized in the Avenal-McKittrick area. Their general extent is shown on the inset map on plate 1.

DISSECTED UPLANDS

The dissected uplands (idem) are underlain chiefly by the moderately deformed Tulare formation, slightly warped old stream deposits, and alluvium. This geomorphic unit has several low, deeply eroded hills or ridges which protrude through the relatively smooth alluvial plains. These hills include Kettleman, Lost, and Elk Hills, the low hills and much dissected surface near North Belridge and west of South Belridge. Elsewhere, the dissected uplands include low hills underlain chiefly by deformed sediments of continental origin along the eastern margin of the Temblor Range and the upper, more dissected parts of alluvial fans bordering deformed marine sediments of the Coast Ranges.

Kettleman Hills are an elongate group about 28 miles long and 5 miles wide which rise sharply several hundred feet above the low plains and fans on the west side of the San Joaquin Valley. They consist of three northwestward-trending anticlinal structures—North Dome, Middle Dome, and South Dome—which form a chain that is nearly parallel to the trend of the Diablo Range (pl. 1; fig. 2). The hills attain a maximum altitude of 1,366 feet above sea level near the north end and gradually decrease in height and ruggedness toward the south where they merge almost imperceptibly into the low plains a few miles east of Devils Den ranch.

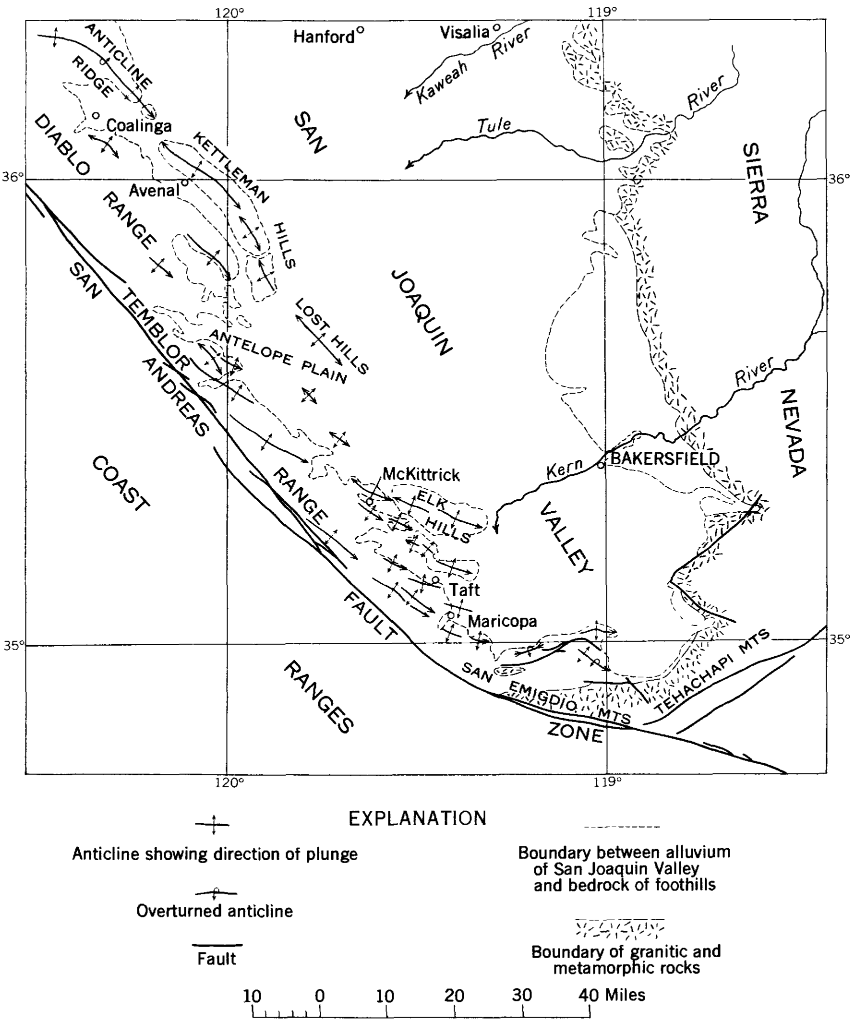


Figure 2.—Sketch map showing location of anticlines in Avenal-McKittrick area and vicinity, California.

Most of the trunk streams are consequent and flow down the slopes roughly at right angles to the trend of the hills and the strike of the strata, but many of the tributary streams are more or less parallel to the strike of the strata and form nearly right angles with the trunk streams.

Around the periphery of Kettleman Hills the dissected uplands include a band of deformed continental deposits and older alluvium about 2 miles in width. West of Kettleman Plain they include a discontinuous band of deformed continental deposits that overlie marine sediments of Tertiary age of the Diablo Range, and the higher parts of the alluvial fans that border the continental and marine sediments.

Lost Hills, about 4 miles southeast of the South Dome of Kettleman Hills, form a low ridge rising above Antelope Plain. These hills have a northwestward trend and are about 8 miles long and more than a mile wide. The maximum relief is near the center of the hills which stand about 80 feet above the adjacent Antelope Plain and about 125 feet above the main San Joaquin Valley to the northeast. The southwestern slope is very gentle, but the northeastern slope is steep and has been dissected to a depth of about 100 feet by the headward erosion of several streams. Lost Hills were so named because, though easily seen from the east, they appear to be lost when viewed from the west, where the slight eastward rise is hardly apparent.

Several small northeastward-trending streams have cut transversely across the hills and have an uninterrupted flow from Antelope Plain to the San Joaquin Valley. Lost Hills is the surface reflection of an underlying anticline (fig. 2) which extends northwestward through the Kettleman Hills to Anticline Ridge in the Diablo Range northeast of Coalinga.

The low hills known locally as the Antelope Hills, which are about 4 miles west of North Belridge, rise above the plains to the west only at the north end, where local relief is as much as 50 feet. To the east and southeast these hills blend into a slightly arched, much dissected northwestward-trending surface that is characterized by a local flattening on the west and a steepening on the east where it blends into the low plains. Although several poorly defined drainage courses extend northeastward across this surface, most of the dissection has been accomplished by local stream gullying on the eastern slopes. This dissected, slightly hilly area is the surface reflection of an anticlinal fold underlying the North Belridge oil field (fig. 2). A similar anticlinal fold underlies the South Belridge oil field, which is a few miles to the south. Its topographic expression is slight, although a rise in altitude can be observed from the east.

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About 4 miles west of South Belridge a hilly area, known locally as Bacon Hills, rises above a dissected surface which is crudely elliptical in outline. The drainage courses of Carneros and Chico Martinez Creeks, which drain much of the mountainous country to the southwest, are deflected northward and southward, respectively, around the Bacon Hills. One unnamed stream maintains a course across the area, and much dissection has been accomplished by local gullying in the poorly consolidated continental deposits. The Bacon Hills and the small isolated outcrops of continental deposits to the northwest indicate the location and trend of an underlying anticlinal structure that has been drilled successfully for oil.

Elk Hills, which form the southern border of the Avenal-McKittrick area and a relatively narrow group of northwestward-trending hills northeast of McKittrick Valley (pl. 1), are underlain by deformed continental deposits. They lie along the north side of a wedge of west-northwestward-trending foothills that adjoin the east flank of the Temblor Range. The hills are the surface expression of an anticlinal fold and are isolated from the foothills to the south by Buena Vista and McKittrick Valleys which are the surface expression of a northwestward-trending syncline (Woodring and others, 1932, p. 41).

The Elk Hills are crudely elliptical in outline, having a length of about 17 miles and a maximum width of almost 6 miles. They are separated from the much narrower range of hills north and northwest of McKittrick by the narrow northeastward-trending stream gap traversed by the Southern Pacific railroad. The hills rise to an altitude of 1,551 feet above sea level, about 1,000–1,200 feet above the floor of the San Joaquin Valley. They are drained by many-branched ephemeral streams, and the terrain is characterized by gentle slopes and smoothly rounded hills.

LOW PLAINS AND FANS

The belt of coalescing alluvial fans of low relief that lie between the dissected uplands and the Coast Ranges on the west and the nearly flat surface of the valley trough on the east have been called the "low plains and fans" by Davis and others (1959, p. 21–23). Land-surface altitudes in this area decline from about 1,000 feet above sea level on the west to about 200 feet on the east, and, except for trenching by the major streams, local relief is generally less than 10 feet and in most places less than 5 feet. The relatively smooth surfaces of the low plains and fans are interrupted in several places by low hills which are surface expressions of Coast Range folds. These low hills serve to subdivide the low plains and fans into several natural units, as follows: Kettleman Plain, McLure Valley, Antelope Valley, Antelope Plain, and the western slope of the valley east of Lost Hills (pl. 1).

Kettleman Plain is a relatively narrow, northwestward-trending valley occupying a deep alluvium-filled synclinal trough between the Kettleman Hills and the Kreyenhagen Hills (pl. 1), which are formed by a chain of structural ridges along the eastern border of the Diablo Range.

McLure Valley, also known locally as Sunflower Valley, occupies a shallow northwestward-trending alluvium-filled basin of structural origin between the Pyramid Hills and Avenal Ridge, the southernmost spur of the Diablo Range (pl. 1). At its lower end McLure Valley is connected to Kettleman Plain by an alluvium-floored outlet, known as Dagany Gap, which is less than a mile wide and apparently was cut by Avenal Creek. Avenal Gap is a similar alluvium-floored plain, nearly half a mile wide, which separates the Middle Dome and South Dome of the Kettleman Hills; it also appears to have been cut by Avenal Creek. Avenal Creek follows a course across McLure Valley, passes through Dagany Gap, trends northeastward across Kettleman Plain, eastward across the uplift of the Kettleman Hills through Avenal Gap, and debouches onto an alluvial fan along the west side of the San Joaquin Valley. Old residents report that in the past Avenal Creek occasionally has followed an alternate course around the south end of Kettleman Hills instead of through Avenal Gap.

Antelope Valley occupies a shallow northwestward-trending basin-like depression, probably of structural origin, between the southernmost spur of the Diablo Range (Avenal Ridge) and the north end of the Temblor Range (pl. 1). In the western and northwestern parts of the valley, alluvial deposits have been laid down and form alluvial fans built for the most part by Polonio and Franciscan Creeks. The east end of the valley broadens to form Antelope Plain, where Packwood and Bitterwater Creeks are the principal sources of the alluvium.

Antelope Plain is a gently sloping alluvial surface covering an extensive area along the west side of the San Joaquin Valley. In general, the plain extends from the south end of the Kettleman Hills to the northeastern border of Elk Hills and from Lost Hills to the Temblor Range. It includes most of the unit of low plains and fans of this report.

OVERFLOW LANDS AND LAKE BOTTOMS

The unit of overflow lands and lake bottoms includes a narrow strip of land west of Buena Vista Slough. Buena Vista Slough trends northwestward for a distance of about 50 miles from the Kern River near the east tip of Elk Hills, to Sand Ridge at the south end of Tulare Lake bed (pl. 1). The western boundary of these lands is formed by Elk Hills and the adjacent low plains and fans along the west side of the valley. Throughout much of its extent the slough is contained within levees and serves chiefly as a wasteway for excess flood waters being discharged from the Kern River and from Buena Vista Lake. The soils in the bed of Tulare Lake and the Buena Vista Slough area consist principally of heavy, poorly permeable clays.

COAST RANGES

The mountainous country that forms the western border of the San Joaquin Valley is the easternmost tier of a series of northwestward-trending mountain ranges that make up the Coast Ranges physiographic province of Jenkins (1938) and is traversed by the San Andreas fault zone (fig. 2). According to Taliaferro (1951, p. 142) this series of mountain ranges evolved as a result of several episodes of folding and faulting of geosynclinal sediments of Mesozoic and Tertiary ages during late Tertiary time. The Avenal-McKittrick area includes the east flank of the Temblor Range and part of the easternmost hills that comprise the Diablo Range.

The Diablo Range extends from Carquinez Straits at San Francisco Bay southeastward along the western border of the San Joaquin Valley and terminates at Avenal Ridge, which is a rugged east-southeastward-plunging anticlinal feature that forms the divide between McLure and Antelope Valleys (pl. 1). Other prominent salients or spurs of the Diablo Range that project toward the San Joaquin Valley include Reef Ridge and the Pyramid Hills. The Kreyenhagen Hills form a long foothill belt between Reef Ridge and the Kettleman Plain and are considered a structural part of the Diablo Range.

The Temblor Range is the dominant feature of the region. It is separated both topographically and structurally from the Diablo Range by Antelope Valley. The range has an echelon relationship to the Diablo Range at its north end and merges with the eastward-trending San Emigdio Mountains which form the southern border of the San Joaquin Valley (fig. 2). The Temblor Range has a southeasterly trend and preserves a broadly even summit line which reaches its greatest altitude, 4,332 feet above sea level, about 8 miles west of McKittrick. The northeast slope descends in a series of irregular tiers of structurally controlled hills, the lowest of which merge gently into the fans of the San Joaquin Valley.

The smaller streams draining the northeastern slopes of the Coast Ranges commonly flow in a northeasterly direction almost at right angles to the structurally controlled ridges. Larger streams commonly flow for some distance parallel to the structurally controlled longitudinal ridges and then turn sharply across them to lose their identity where they debouch on the alluvial plains beyond.

GEOLOGIC FEATURES

PREVIOUS WORK

The geologic history and structure of the San Joaquin Valley are intimately related to geologic events in the Sierra Nevada and southern Coast Ranges. Major events in the geologic history of the area since Late Cretaceous time were summarized in tabular form by Davis and others (1959). More detailed discussions of this subject may be found in papers by Anderson and Pack (1915), Hoots (1929), Matthes (1930), Reed (1933), Piper and others (1939), Woodring and others (1940), and Taliaferro (1943). An excellent summary of the stratigraphy and structure of the valley was presented by Hoots and others (1954). More detailed discussions of these subjects may be found in California Division of Mines Bulletin 118 (1943), pt. 3.

Papers outlining the structure and stratigraphy of oil fields in the Avenal-McKittrick area, notably the Kettleman Hills, Lost Hills, Pyramid Hills, Devils Den, Blackwells Corner, Antelope Hills, North Belridge, McDonald Anticline, Cymric, and Elk Hills oil fields have been presented in "Summary of Operations—California Oil Fields" (1919–56), published quarterly by the California Department of Natural Resources, Division of Oil and Gas.

GENERAL GEOLOGY

The following geologic summary of the San Joaquin Valley is taken with only slight modification from Davis and others (1959).

Although the full thickness of the sedimentary fill in the San Joaquin Valley is not known from drilling, several lines of indirect evidence indicate that the valley is an asymmetrical trough, the axis of which lies close to the western border of the valley. Vaughan (1943, p. 68) concluded, from geophysical evidence, that granitic and metamorphic rocks of the tilted Sierra Nevada fault block continue westward beneath the valley to the flanks of the Coast Ranges. Wells penetrating granitic and metamorphic rocks along the east side of the valley and as far west as the topographic trough (May and Hewitt, 1948, pl. 10) confirm this hypothesis. The fact that wells of equal or greater depths on the west side of the valley do not penetrate basement rocks is further confirmation of the asymmetrical character of the valley. Published geologic sections (Hoots, 1943, p. 266; de Laveaga, 1952, p. 120; Hoots and others, 1954, pl. 6; Davis and others, 1959, pl. 2) and interpretations (Hoots and others, 1954, p. 113–129 and pl. 5) based on the records of many hundreds of wells drilled for oil present a picture of an asymmetrical valley in which the basement rocks beneath the surface continue westward at increasing depths and with little structural disturbance to the flanks of the Coast Ranges.

During the Cretaceous and throughout much of the Tertiary periods, the San Joaquin Valley was the site of marine deposition, although nonmarine beds of Tertiary age are known to interfinger with marine deposits in several oil fields in the southern part of the valley. The youngest marine rocks are sediments of the Etchegoin and San Joaquin formations of middle Pliocene and late Pliocene age, respectively, which are exposed in the core of the Kettleman Hills and which form extensive outcrops along the southwestern margin of the valley. These marine sediments nearly everywhere are overlain by semiconsolidated and unconsolidated fluvial and lacustrine deposits of late Pliocene to Recent age.

The sedimentary units penetrated in the oil wells thin to the east and pinch out against the westward-dipping basement rocks of the Sierra Nevada block. In the southern part of the valley, rocks of Cretaceous and early Tertiary age thicken to the west, attaining their maximum thickness in the Coast Ranges.

During late Tertiary and Quaternary time, sedimentation in large part was confined to the present valley trough, although locally great thicknesses of deposits of these ages are exposed along the western margin of the valley.

The Diablo Range and the Temblor Range, which mark the western border of the San Joaquin Valley, are the easternmost of a series of northwestward-trending mountain ranges that make up the southern Coast Ranges. They are composed chiefly of sharply folded and intricately faulted marine sedimentary rocks of Mesozoic and Tertiary ages. The Diablo Range, although anticlinal in general, is not a single fold but rather an assemblage of folds, many of which are more or less oblique to the general structural trend. Its core is composed of folded and contorted sedimentary, igneous, and metamorphic rocks of the Franciscan formation of Jurassic and Cretaceous age. In the Avenal-McKittrick area the main salients or subsidiary structural features of the Diablo Range that trend toward the San Joaquin Valley are the echelon folds expressed topographically as the Kettleman Hills, Lost Hills, and others (fig. 2).

The Temblor Range forms the southwestern border of the San Joaquin Valley and merges with the eastward-trending San Emigdio Mountains which form the southern border of the valley. The range is composed of tightly folded sedimentary rocks chiefly of Tertiary age. Although its structure is complex throughout, the complexity increases toward the south, where a series of east-southeastward-trending anticlinal ridges and synclinal valleys extend out into the San Joaquin Valley.

Although the Coast Ranges have been established throughout a long interval of geologic time, they owe their present form largely to tectonic movements which resulted in deformation of marine sediments of late Tertiary age and continental deposits of late Tertiary and Quaternary age that border the valley. According to Hoots and others (1954, p. 128) the orogeny that produced most of the folding, faulting, and mountain building took place in middle Pleistocene time. In the Avenal-McKittrick area most if not all the anticlinal folds were formed or at least underwent the greater part of their present structural deformation at that time. Sedimentary deposits of the foothills and mountain areas forming the western border of the valley underwent pronounced uplift and compression which produced a complex pattern of tightly folded, overturned, and thrust-faulted anticlinal structures. Hoots and others (1954, p. 128) report that:

> Although it is certain that anticlines of the San Joaquin basin developed most of their present character and structural relief during the mid-Pleistocene orogeny, there is considerable evidence that some and possibly most of them began to develop as early as late Miocene or early Pliocene time, and experienced additional growth as broad, gentle folds during later Pliocene and early Pleistocene time.

In the Avenal-McKittrick area the anticlinal structures formed during this orogeny have warped the continental deposits of late Tertiary and Quaternary age at Kettleman Hills, Lost Hills, the hills west of North Belridge and South Belridge, and Elk Hills, where older sediments have been brought to the surface and exposed in topographic highs. These anticlinal structures commonly are flanked by structural depressions that contain continental deposits that were laid down subsequently.

The chief significance of these structural features is their effect on the quality of ground water. In general, the structural highs are areas where connate marine waters are found at relatively shallow depth, and the structural depressions contain maximum thicknesses of continental deposits that contain water of relatively good quality.

GEOLOGIC UNITS AND THEIR WATER-BEARING PROPERTIES

The geology shown on plate 1 is a compilation of work done by others (p. 5). On the basis of these earlier studies, the geologic units of the Avenal-McKittrick area were divided into two principal groups: (1) consolidated rocks, which include the Franciscan formation and ultramafic rocks, undifferentiated, of Jurassic and Cretaceous age, and sedimentary rocks, undifferentiated, of Cretaceous and Tertiary age; and (2) unconsolidated to loosely consolidated deposits that include the Tulare formation of Pliocene and Pleistocene(?) age, old stream deposits of Pleistocene age, and alluvium and flood-basin sediments of Pleistocene and Recent age.

The consolidated rocks are poorly permeable to impermeable. Locally, the sedimentary rocks contain connate water of poor chemical quality. The unconsolidated deposits supply nearly all the water pumped from wells. Of the unconsolidated deposits the Tulare formation and the alluvium are the most permeable and are tapped by most of the wells in the area. Collectively, the unconsolidated deposits range in thickness from a few feet along the contacts with older rocks to several thousand feet beneath Kettleman Plain and Tulare Lake. In general they are thickest in synclinal troughs and thinnest on the flanks or over the crests of anticlines.

CONSOLIDATED ROCKS

The consolidated rocks have been mapped in detail by previous workers who have identified them as follows: The Franciscan formation of Jurassic and Cretaceous age; the Panoche formation of Late Cretaceous age; the Tejon formation, Avenal sandstone, and Kreyenhagen shale of Eocene age; the Temblor sandstone, McLure shale member of the Monterey shale, and Reef Ridge shale of Miocene age; and the Jacalitos, Etchegoin, and San Joaquin formations of Pliocene age. In this report and on the geologic map (pl. 1) these formations have been divided into three groups: The Franciscan formation and ultramafic rocks, undifferentiated, undifferentiated sedimentary rocks of Cretaceous age, and undifferentiated sedimentary rocks of Tertiary age.

The Franciscan formation consists of a heterogeneous assemblage of sedimentary, volcanic, and locally metamorphosed rocks that have been intruded by mafic and ultramafic igneous rocks. Irregular masses and dikelike bodies of serpentine associated with this series of rocks probably are an alteration product by the ultramafic intrusive rocks. As shown on the geologic map (pl. 1) the Franciscan locally is separated from the marine sedimentary rocks of Cretaceous and Tertiary age by steeply inclined faults. Thus, its thickness and lateral extent are not known. However, studies made in other parts of the Coast Ranges, where the Franciscan is better exposed, indicate that this series of rocks forms the basement upon which a large part of the Cretaceous and later sediments were deposited.

The Cretaceous rocks, which attain their maximum thickness in the Coast Ranges, consist of a thick monotonous sequence of arkosic sandstone, conglomerate, sandy shale, thin impure limestone, and organic shale. They dip steeply toward the valley and wedge out against the basement complex of the Sierra Nevada near the east edge of the San Joaquin Valley where they are overlapped by continental deposits. At depth beneath the valley they contain connate saline waters unsuitable for any present agricultural purpose.

The marine sediments of Tertiary age attain a thickness of at least 15,000 feet near the western border of the valley and, like the Cretaceous rocks, thin eastward and wedge out against the basement complex of the Sierra Nevada where they too are overlapped by younger continental deposits. The rocks of early Tertiary age consist chiefly of shale, in large part organic, and conspicuous sandstone strata, whereas the rocks of late Tertiary age consist chiefly of sand containing abundant volcanic detritus and silt with some sandstone and conglomerate.

The consolidated rocks are generally of low permeability and transmit little water. Most contain fractures induced by folding and faulting; these openings probably convey small quantities of water to the adjacent unconsolidated deposits or yield small amounts of water to a few wells. Many of the small springs in creeks and ravines along the east side of the Coast Ranges evidently serve as outlets for ground water contained in such fracture systems.

Water wells drilled through the unconsolidated deposits into the underlying consolidated rocks usually are plugged back to beds in the Tulare formation or younger deposits because of the poor quality of the water at depth. Therefore, in these areas, except locally, it is unlikely that formations older than the Tulare would be tapped as a source of fresh-water supply.

UNCONSOLIDATED ROCKS

The unconsolidated deposits have been mapped by previous workers as the Tulare formation of Pliocene to Pleistocene(?) age; older alluvium, stream-terrace deposits, and old fan deposits of Pleistocene age; and younger alluvium, lake sediments, and basin deposits of Pleistocene and Recent age. In this report and on the geologic map (pl. 1), these deposits have been divided into four groups: The Tulare formation, old stream deposits of Pleistocene age, alluvium of Pleistocene and Recent age which includes younger and older alluvial deposits exposed on and underlying the valley floors, and flood-basin deposits approximately equivalent in age to and interfingered with the alluvium underlying Tulare Lake bed and Buena Vista Slough. The stratigraphic and structural relations and the general lithologic character of the unconsolidated deposits beneath Kettleman and Antelope Plains and Antelope and McLure Valleys are shown on plates 1 and 2.

The Tulare formation has been mildly folded; the old stream deposits have been uplifted, dissected, and locally tilted gently; and the youngest materials comprising the alluvium and flood-basin sediments are almost undisturbed. Except for the fine-grained flat-lying flood-basin deposits, all these units are similar lithologically. Hence, only along the valley margins where there has been uplift and erosion is it possible to distinguish between them. In the subsurface it is virtually impossible to recognize these distinctions, which are based largely on structural deformation and physiographic position rather than on lithologic features. Accordingly, except locally, no attempt was made to distinguish the units on the detailed geologic sections presented on plate 2.

TULARE FORMATION

The Tulare formation consists chiefly of unconsolidated continental deposits along the western border of the San Joaquin Valley that have been mapped by previous workers. Information concerning the surface extent of the Tulare was compiled from several sources as shown on the inset source map (pl. 1). Stewart (1946) mapped the Tulare along the west side of Kettleman Plain, where it rests comformably on semiconsolidated marine sediments and forms the highest parts of the Kreyenhagen Hills. Woodring and others (1940) showed that in the Kettleman Hills outcrops of the Tulare formation form a nearly continuous rim of intricately dissected deposits that in most places rest conformably on semiconsolidated marine sediments of the San Joaquin formation, which is exposed in the core of the hills. Woodring and others (1932) mapped the Tulare exposed in the Elk Hills along the southern border of the area. Exposures of the Tulare formation along the crest of the Temblor Range in the Bitterwater Creek area were mapped by English (1921). Other exposures along the western border of the valley were mapped by Arnold and Johnson (1910) and English (1921). Unpublished mapping by many oil-company geologists was compiled by Kundert (1955) for the geologic map of California.

The dissected uplands forming Lost Hills, the hills west of North and South Belridge, and other isolated outcrops protruding through Quaternary alluvium near the western border of the valley probably are underlain chiefly by the Tulare formation, which has been arched and uplifted along the northwestward-trending anticlines (fig. 2). On the geologic map of California (Kundert, 1955) most of these areas have been shown as Pliocene to Pleistocene nonmarine deposits, although older alluvial deposits, which are difficult to distinguish from the Tulare formation, may make up many of the exposures in these areas. However, because of the similarity between the Tulare and the older alluvial deposits and because of the lack of detailed geologic mapping in the dissected areas, they are shown on the geologic map (pl. 1) as the Tulare formation.

Discontinuous exposures of the Tulare formation in the foothills and along the east flanks of the Coast Ranges extend from a point several miles north of Corral Hollow Creek in San Joaquin County to Wheeler Ridge at the south end of the valley. In the synclines, however, the Tulare is covered by unknown thicknesses of alluvium.

The Tulare formation was named by F. M. Anderson (1905), p. 181–182), but a type locality was not designated. The Kettleman Hills have been regarded as the type locality, and Woodring proposed that the section on La Ceja (north of area shown on pl. 1) on the east side of North Dome be designated the type locality (Woodring and others, 1940, p. 13). Woodring placed the base of the Tulare just above the youngest widespread marine deposits comprising the upper *Mya* zone of the San Joaquin formation. At the type locality there is no evidence of a major discontinuity at this horizon, and the boundary represents a change from marine to continental deposition. The change is not abrupt, however, because continental deposits occur below the contact, and a few marine strata are found in the basal part of the Tulare formation. Although the Tulare conformably overlies the San Joaquin formation in the Kettleman Hills, it rests unconformably on sediments of Pliocene age and on older formations along much of the eastern border of the Diablo and Temblor Ranges (Woodring and others, 1940, p. 14).

Stratigraphic studies, based on electric-log data from many oil fields, indicate that the Tulare formation rests unconformably on the truncated edges of marine sedimentary rocks of Pliocene and Miocene age. Although the absence of diagnostic fossils has hindered the correlation of the Tulare beyond the type locality in the Kettleman Hills, its locality has been extended by other workers to the north and south on the basis of lithologic similarity and stratigraphic position.

As defined by Woodring, the Tulare formation includes those continental beds in the Kettleman Hills that have been deformed or tilted at an angle to their original plane of deposition. At those places along the valley margin where the alluvium and old stream deposits overlie the Tulare with angular unconformity, the contact is established readily. However, at many places along the valley border the dips increase westward so gradually that the contact between the alluvium and the Tulare formation is difficult to identify. Because of the similar lithology of the alluvium and the Tulare, their contact beneath the valley floor is virtually impossible to recognize in well logs.

The exposed thickness of the Tulare formation ranges from a few tens of feet along the western margins of the valley to about 3,500 feet in the Kettleman Hills. Because the Tulare is overlapped by alluvium and old stream deposits, its full thickness probably is not exposed. The available information on the thickness and depth to the base of the Tulare in several parts of the Avenal-McKittrick area and the source of the information are summarized in table 4. After studying the structural relations in the Kettleman Hills-Reef Ridge areas, Woodring and others (1940, pl. 51) postulated that the Tulare, which is overlain by 1,000 to 1,500 feet of alluvium, reaches a maximum thickness of about 5,000 feet in the syncline beneath Kettleman Plain (pl. 1). Near Avenal Gap the Tulare thins to about 3,800 feet, and southeast of Devils Den ranch, where it is exposed at the land surface, the Tulare has a maximum thickness of about 3,000 feet.

Although the interpretation given by Woodring suggests that the Tulare formation thins toward the southeast both in the Kettleman Hills and in the syncline west of the hills, the formation probably continues in a southeasterly direction for a considerable distance beneath the alluvium of Antelope Plain. Its depth, thickness, and lateral extent in this area are little known. Although its thickness, depth, and lateral extent east of the Kettleman Hills-Lost Hills upwarp are little known, information shown in table 4 indicates that the Tulare thickens rapidly east of the Lost Hills anticline and reaches a maximum of about 2,000 feet in the Trico gas field in the central part of the San Joaquin Valley about 15 miles west of Delano. West and southwest of Lost Hills the thickness and depth to the base of the Tulare (table 4) are well known only where structural highs have been drilled for oil. In these areas the Tulare has been uplifted and structurally deformed, and unknown thicknesses may have been removed from the crests of the folds by subsequent erosion. The thickness and depth of Tulare deposits in synclinal troughs adjacent to the structural highs generally are not well known, owing to the fact that few exploratory oil wells have been drilled in structural depressions.

Lithologically the Tulare formation is similar to the alluvium now being deposited along the west side of the valley. The formation generally consists of poorly sorted predominantly silty materials containing lenses of coarse sand and gravel and locally thin beds of argillaceous limestone, marl, and marly silt. The fine-grained beds are loose to semiconsolidated; the gravels locally are cemented by either calcium carbonate or gypsum to form resistant strata of conglomerate. Not all the sediments are of fluvial origin. Strata of diatomaceous clay, such as that near the base of the formation in the Kettleman Hills, and a widespread diatomaceous clay in the Mendota-Huron area, which was described in detail by Davis and others (1959, p. 76) and Frink and Kues (1954), represent lacustrine deposits, as do possibly some of the well-sorted fine sand and thin-bedded silt, clay, and limestone. Most of the formation consists of

TABLE 4.—*Thickness and depth to the base of the Tulare formation in the Avenal-McKittrick area*

[Where practicable reported thicknesses are arranged from north to south and from west to east]

Location	Thickness (feet)	Depth to base (feet)	Source of information
Kreyenhagen Hills	3,000±	3,000±	Stewart (1946, p. 105).
Kreyenhagen Hills, southern part.	2,000±	2,000±	Arnold and Anderson (1910, p. 149).
Kettleman Plain, about 3.5 miles northwest of Avenal.	5,000±	6,300±	Woodring and others (1940, pl. 51, sec. *A–A'*).
Kettleman Plain, about 7.5 miles southwest of Avenal.	5,000±	6,500±	Woodring and others (1940, pl. 51, sec. *B–B'*).
Kettleman Plain, about 4 miles northwest of Avenal Gap.	3,800±	4,000±	Woodring and others (1940, pl. 51, sec. *C–C'*).
Antelope Plain, about 1.5 miles southeast of Devils Den ranch.	2,800±	2,800±	Woodring and others (1940, pl. 51, sec. *D–D'*).
Kettleman Hills, west side, northern North Dome.	1,700	--------	Woodring and others (1940, p. 14).
Kettleman Hills, west side, southern North Dome.	2,600	--------	Do.
Kettleman Hills, east side, southern North Dome.	1,700	--------	Do.
Kettleman Hills, central Middle Dome.	3,500	--------	Do.
Kettleman Hills, South Dome	2,400	--------	Do.
Blackwells Corner oil field	400–900±	700–1,600±	Karmelich (1951, pl. IV, sec. *C–C'*).
Lost Hills oil field, crest of anticline in highest part of hills.	200±	--------	Ayars (1939, p. 82).
Lost Hills oil field, Tidewater Associated Oil Co., Taylor 1 (26/20–1E).	1,100±	--------	Do.
Trico gas field (24/23–17, 18), about 18 miles northeast of Lost Hills.	2,000±	--------	Wagner (1952, p. 133).
Antelope Hills oil field (28/20–6)	800±	1,200±	Woodward (1942, pl. 2, sec. *A–A'*).
North Belridge oil field	200±	--------	Dooley (1952, p. 205).
North Belridge oil field	600±	--------	Wharton (1943, p. 502).
McDonald anticline oil field (28/20–18, 20).	500–600	600–700	Ritzius (1954, pl. IV, sec. *B–B'*).
South Belridge oil field (28/20–24, 28/21–19); thickness and depth increases in an easterly direction away from crest of structure.	500–1,100	850–1,400	Ritzius (1950, pl. V, sec. *C–C'*).
South Belridge oil field (29/21–3, 12); thickness and depth increases in a southeasterly direction parallel to plunge of structure.	500–1,100	800–1,300	Ritzius (1950, pl. III, sec. *A–A'*).
Cymric oil field (29/21–22, 26)	1,000–1,500	1,300–1,800	Peirce (1947, pls. IV and V, secs. *A–A'* and *B–B'*).
Elk Hills oil field	875–2,950	--------	Woodring and others (1932, p. 25).

reworked sedimentary materials derived from older rocks in the Coast Ranges. Pyroclastic materials are abundant in the lower part of the formation in the Kettleman Hills (Woodring and others, 1940, p. 13) and may be abundant elsewhere.

As few wells are known to penetrate the Tulare formation in the Avenal-McKittrick area, its water-bearing properties are not known. However, except in the basal part where brackish connate water may occur, it probably contains water similar in quality to that yielded by wells tapping the alluvium. The subsurface section of the Tulare consists chiefly of discontinuous, lenticular, and commonly elongated bodies of poorly sorted silt, sand, and gravel probably laid down for the most part on extensive alluvial fans by intermittent streams. In general, the deposits become progressively coarser toward their source area in the Coast Ranges. Because of their predominantly fine-grained poorly sorted character and their moderate degree of consolidation, the deposits on the average probably are only moderately to poorly permeable.

OLD STREAM DEPOSITS

The old stream deposits of this report include remnants of old dissected stream-terrace and alluvial-fan deposits that lie above the floors of present streams and valleys. These deposits in the Kreyenhagen Hills-Reef Ridge areas and in the Kettleman Hills were mapped as older alluvium by Stewart (1946) and by Woodring and others (1940), respectively. These remnants may correspond or be equivalent to a part of the great thicknesses of older alluvium and younger alluvial deposits beneath the valley floors, which together have been termed the alluvium in this report. Although the old stream deposits in other parts of the Avenal-McKittrick area have not been mapped, they occur in and near the foothills of the Coast Ranges at several levels above the present stream courses.

The old stream deposits in the Kettleman Hills consist of dissected alluvial deposits generally 25 to 150 feet above the present stream beds. They are composed chiefly of silty sand that encloses occasional lenses or stringers of coarse sand and gravel. The gravel layers consist chiefly of subrounded cobbles and granules of volcanic rocks, brown sandstone, and red, green, and black chert.

The old stream deposits in the Kreyenhagen Hills-Reef Ridge area generally are less than 15 feet thick. They consist chiefly of boulders, gravel, and sand that have been deposited on stream terraces 25 to 150 feet above present stream channels.

As nearly all the old stream deposits shown on the geologic map (pl. 1) occur above the zone of saturation, they are not a source of ground-water supply.

ALLUVIUM

The unit shown as alluvium on the geologic map (pl. 1) includes principally the younger alluvium, whose surface actively receives deposition during the infrequent periods of runoff, and the older alluvium, which in large part is concealed beneath the younger deposits and in small part is exposed around the valley margins and locally in areas where dissection has occurred. The alluvium also is defined to include alluvial-fan deposits around the valley margins and minor areas of dune sand beneath Dudley Ridge and Sand Ridge (pl. 1) at the south end of the Tulare Lake bed.

The alluvium underlying much of the Avenal-McKittrick area consists of a poorly sorted heterogeneous complex of silt and sand enclosing lenses and tongues of coarse sand and gravel. The deposits are coarsest near the mountains and grade into fine materials in the valley. These deposits are lithologically similar to those of the Tulare formation, although as pointed out by Reiche (1950, p. 9) in a discussion of the foothill area along the west side of the San Joaquin Valley west of Tracy, they generally are somewhat coarser, looser, and cleaner than those of the Tulare formation. The character and thickness of the alluvium in Kettleman Plain, McLure Valley, and Antelope Valley are shown on plate 2 and by representative drillers' logs in table 10.

Although the maximum thickness of the alluvium is unknown, sections presented by Woodring and others (1940, pl. 51) show the alluvium extending to depths as much as 1,500 feet beneath Kettleman Plain. There the deposits rest on the Tulare formation which is of similar composition and lithology. In McLure Valley the continental deposits, chiefly alluvium but possibly including part of the Tulare formation, rest unconformably on semiconsolidated marine sediments at depths of 300 to 400 feet below the land surface (pl. 2). Similarly drillers' logs of water wells in Antelope Valley reveal from 200 to 700 feet of continental deposits overlying consolidated rocks of marine origin (pl. 2).

The alluvium of the Avenal-McKittrick area presumably was laid down by intermittent streams of the Coast Ranges under conditions similar to those of the present time. A downstream decrease in carrying power has been and is at present the principal cause of deposition. All the streams tributary to the area have flatter gradients in the valley areas than in their mountain watersheds. Accordingly, much of the load, including most of the coarse detritus, is carried to and deposited in the valley areas. Loss of flow by seepage to ground water further decreases the carrying power of the streams in the valleys.

In general the streams drop the coarsest part of their load where they issue from the mountains; progressively finer grained materials carried by the streams are deposited farther out on the valley floor. Thus, in the lower areas streams of this type tend to build up sloping plains more or less semicircular in outline with their highest points or apexes near the confined channels from which the streams emerge. Because the surfaces formed by this type of deposit generally have the form of part of a low nearly flat cone, they are called alluvial cones or fans.

The streams generally build up their channels in periods of flood; when they overflow their banks the velocity of the current is checked, and part of the suspended load is deposited near the edge of the channels to form raised banks that are natural levees. When the bottoms of the channels have been built above the adjacent parts of the fans, the streams tend to break out, to take lower courses, and in turn to build them up. Consequently, the principal channels or distributaries on the surfaces of the fans change course frequently as they become choked with alluvial debris in a relatively short time. When the water subsides, erosion takes place and channels may be cut into the surface of the fans for some distance below the mouths of the confined channels. During subsequent periods of flood, new channels are formed, and the gravel beds of the abandoned channels gradually become covered with poorly assorted alluvium deposited by lesser distributaries, sheetfloods, and rill wash; hence, the alluvial-fan deposits as a whole ultimately develop into a thick mass of poorly sorted material containing a branching network of moderately assorted gravel. These deposits grade laterally into the thick sequence of younger and older alluvium underlying the extensive plains and valleys.

East of the Kettleman and Lost Hills the alluvium is in gradational contact with the flood-basin sediments. In most places the contact between the 2 geologic units is poorly defined, and at depth the 2 units interfinger over a relatively wide area.

The alluvium is composed of unconsolidated to loosely consolidated silt and sand, enclosing lenses of sand and gravel which in large part are saturated with water. Because the coarser deposits for the most part are poorly sorted, their permeability is only moderate. In general the alluvial-fan deposits, which are very poorly sorted, have a lower permeability than the younger and older alluvium beneath the extensive plains and valleys. In addition, the deeper and older alluvial deposits, which are more compacted and locally cemented, have a lower permeability than the shallower and younger deposits, which are loosely consolidated.

Most of the 344 water wells investigated in the Avenal-McKittrick area in 1951 and 1955 obtained their supply from the alluvium. The wells ranged in depth from about 100 to 1,700 feet and averaged about 400 feet. For the irrigation wells, yields of more than 1,500 gpm (gallons per minute) were uncommon; the average was about 600 gpm (table 7).

FLOOD-BASIN SEDIMENTS

The flood-basin sediments include the lake sediments and other fine-grained materials deposited under sluggish floodwater or lacustrine environments in Tulare Lake and Buena Vista Slough in the trough of the San Joaquin Valley (pl. 3). They are composed chiefly of silt, clay, and fine sand deposited in the still waters of shallow lakes or by sluggish, slow-moving floodwaters. Except near former shorelines where they interfinger with beach-sand and alluvial-fan deposits, the lake sediments consist chiefly of layers of relatively impermeable silt and clay.

The sediments along Buena Vista Slough are composed chiefly of relatively impermeable layers of clay and sandy clay, interbedded with moderately to poorly permeable sand layers. Because of their fine-grained character, the flood-basin sediments generally are poorly permeable and are tapped only by a few stock wells.

GROUND-WATER CONDITIONS

OCCURRENCE, RECHARGE, AND MOVEMENT

In the Avenal-McKittrick area the unconsolidated continental deposits of late Tertiary and Quaternary age constitute the principal source of ground-water supply. The water-bearing deposits consist chiefly of the alluvium and in part the Tulare formation and are substantially more permeable than the consolidated rocks of marine origin that make up the mountainous country west of the valley. The consolidated rocks in general are barriers to ground-water movement and thus form the western boundary and the base of the ground-water body in this part of the San Joaquin Valley.

Ground water generally occurs either under unconfined (water-table) or confined (artesian) conditions. The water table, or surface of an unconfined-water body, is the upper surface of the zone saturated with water under hydrostatic pressure; it is the level at which the hydrostatic pressure is equal to atmospheric pressure. Above it is the capillary fringe, the lower part of which also may be saturated, but with water at less than atmospheric pressure. Confined water is contained in aquifers overlain by materials of sufficiently low permeability to hold water in the aquifer under artesian pressure. Even the least permeable confining beds in the area permit slow, perhaps inperceptible, movement into or out of confined aquifers. On the other hand, owing to differences in horizontal and vertical permeability, water bodies that generally are considered to be unconfined may react to fluctuations in pressure due to pumping in much the same manner as confined-water bodies, but the amplitude of such fluctuations will be less.

Because of the heterogeneous character of most unconsolidated alluvial deposits, confinement in them is commonly a matter of degree, and the time element must be considered. In most alluvial deposits there is enough hindrance to the vertical movement of ground water

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between separate aquifers that differences in head between the aquifers exist during periods of heavy pumping. During periods of little draft, the head in all the aquifers may recover to a level common with water table. Such conditions of occurrence commonly are called semiconfined, to indicate that, although the aquifers are subject to pressure effects over short periods, the head adjusts to equilibrium with the water table over long periods of time and under steady-state conditions.

In most of the Avenal-McKittrick area, ground water occurs under unconfined or semiconfined conditions in heterogeneously assorted alluvium. Although confined water has not been recognized in most of the Avenal-McKittrick area, it may occur in the topographic trough of the valley. During a ground-water study made in 1905–07 Medenhall and others (1916, pl. 1) outlined the area of flowing wells in the valley. At that time the western boundary of the artesian area, south of Tulare Lake, closely approximated the eastern border of the Avenal-McKittrick area. Several wells drilled along the southwestern border of Tulare Lake basin in the Kettleman City area before 1921 reportedly discharged small quantities of water of poor quality. Well 25/21–22H1, near Buena Vista Slough, was drilled to a depth of 649 feet before 1919 and reportedly had a small flow of water that was too highly mineralized for agricultural use. In July 1951 the water level in the well stood 39.9 feet below the land surface; in November 1955 the casing was open to a depth of 615 feet, and the water level was 66.8 feet below the land surface; and on May 24, 1956 the water level was 62.2 feet below the land surface. The lowering of the water level in this well between July 1951 and November 1955 probably was the result of long-continued heavy withdrawals of water, in excess of replenishment, from confined deposits in the trough of the valley.

The ultimate source of the ground-water recharge in the Avenal-McKittrick area is precipitation that falls on the valley floor and on the eastern slopes of the Coast Ranges bordering the valley. Replenishment to ground water occurs by seepage loss from streams, by deep penetration of rainfall, by losses of imported water from irrigation canals and ditches, and by deep penetration of the imported water applied for irrigation in excess of plant requirements.

Seepage loss from intermittent streams draining the Coast Ranges probably is the chief source of recharge to the ground water. Although most of the streams maintain fairly well-defined drainage channels for some distance east of the valley margins, only the largest maintain drainage courses that reach the axial trough of the valley. The poor definition of the drainage channels indicates that little water leaves the area by surface outflow. Except in times of exceptional floods, most of the surface runoff from the streams is lost by seepage into the moderately permeable alluvial deposits over which they flow. Because there are few precipitation stations in the drainage basins tributary to the Avenal-McKittrick area and because there are no gaging stations on the streams, no quantitative estimates of recharge to ground water have been made. However, the tributary drainage basins are small and have meager rainfall. Therefore, it is believed that the mean annual runoff from the basins and recharge to ground water are relatively small.

Deep penetration of rainfall may be a significant source of recharge to the ground-water body when there is ample rainfall. However, in the Avenal-McKittrick area rainfall averages much less than 12 inches per year, which for practical purposes may be considered the lower limit of precipitation below which little deep penetration of rainfall occurs (Blaney, 1933, p. 89). Thus, except for years when rainfall is in excess of about 12 inches (table 1), rainfall is not a significant source of recharge to ground water.

As importations of water to the Avenal-McKittrick area are minor under present development, deep penetration of irrigation water and losses from irrigation canals and ditches represent only minor sources of ground-water recharge.

Plate 3 shows the locations of all water wells investigated and water-level contours for the autumn of 1955. Also shown are the areas irrigated in 1955 and in certain prior years. The altitudes of the water levels in wells were determined from depth-to-water measurements made in October and November 1955, and the water-level contours were drawn from these data. Water-level contours are not shown for much of the area south of U.S. Highway 466 because of the scarcity of wells in which water-level measurements could be made. Where possible, the shape and slope of the ground-water surface are shown by water-level contours drawn at 10-foot intervals. In McLure and Antelope Valleys the water-level contours were drawn at 50-foot intervals because of the relatively steep gradients in these areas.

Contours drawn on the surface of the water body show its configuration in much the same way that topographic contours show the shape of the land surface. Ground-water movement is always in the downslope direction and at right angles to the contours. Thus, the contours show the direction of ground-water movement and hence indicate the areas of recharge and discharge.

Except for local pumping depressions, the contours on plate 3 show that in 1955 ground water was moving out of the several valleys through gaps or broad valley mouths and thence eastward toward the San Joaquin Valley. The details of the occurrence and movement of ground water are discussed by subareas of general extent in the following pages. The subareas comprise Kettleman

Plain, McLure Valley, the subarea east of Avenal Gap, Antelope Valley, and Antelope Plain and the area east of Lost Hills. Although these subareas are not completely separated hydrologically one from the other, their generalized extent is shown in figure 3.

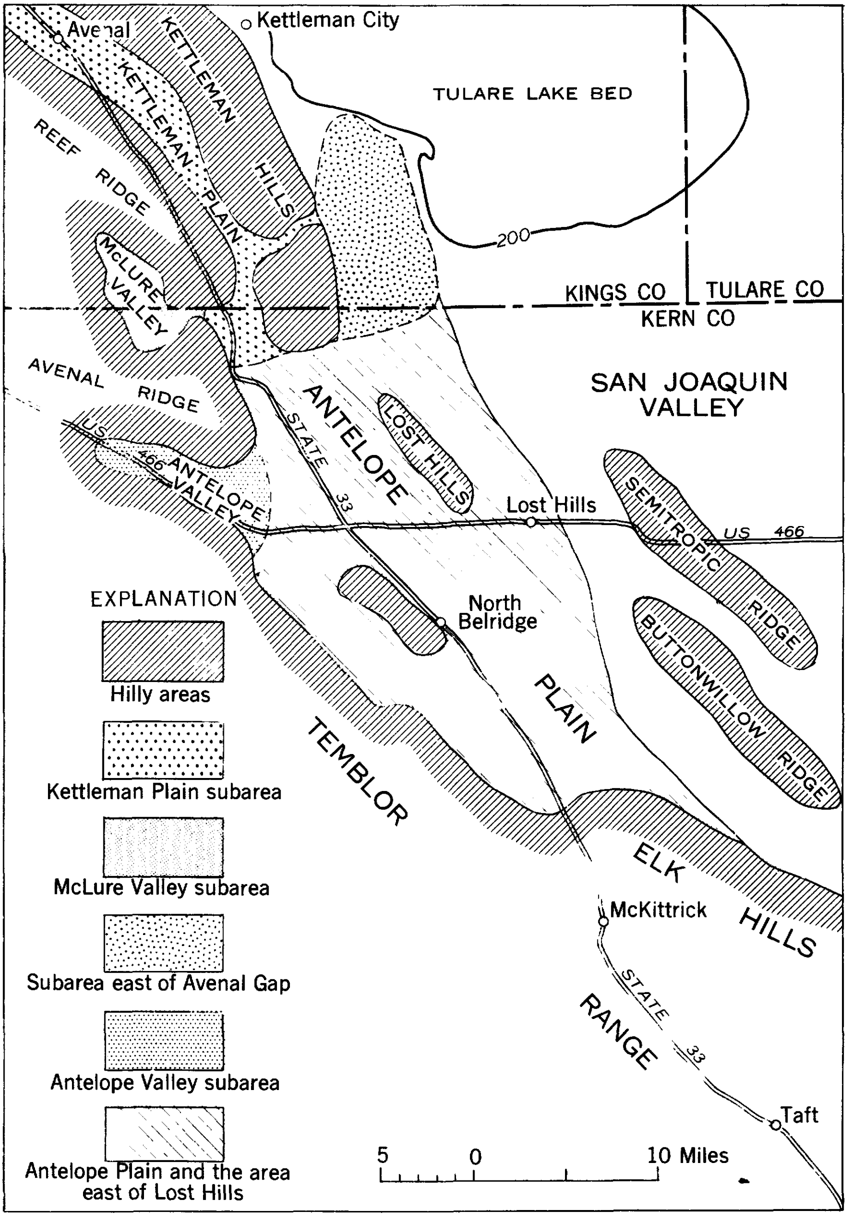


FIGURE 3.—Sketch map showing generalized hydrologic units in the Avenal-McKittrick area and vicinity, California.

KETTLEMAN PLAIN

The Kettleman Plain subarea includes all of Kettleman Plain, Avenal Gap, and the arm of Antelope Plain that extends northward between the southwestern part of Kettleman Hills and that part of Pyramid Hills south of Dagany Gap.

Occurrence and movement.—Ground water in the Kettleman Plain subarea occurs in continental deposits, including the alluvium and the Tulare formation, that range in thickness from a few feet to several thousand feet as shown on geologic sections *A–A*' and *B–B*' (pl. 1). These deposits consist chiefly of unconsolidated to slightly consolidated, generally poorly sorted, predominantly silty materials containing lenses and stringers of poorly sorted sand and gravel that yield water to wells. In the irrigated part of Kettleman Plain (south and west of Avenal Gap and east of Dagany Gap) the depths of irrigation wells range from 500 to 1,432 feet (table 7). Short-term drawdown and recovery tests made by the Pacific Gas and Electric Co. indicate that the yields of wells in the southern part of Kettleman Plain and in the north end of Antelope Plain ranged from less than 300 to about 1,400 gpm and averaged about 800 gpm. Specific capacities [1] ranged from 6 to 21 gpm per foot of drawdown and averaged about 14 gpm per foot of drawdown.

Although data regarding depths, perforated intervals of rock, and materials penetrated during drilling are not available for many of the wells in this area, drillers report that it is difficult to obtain wells of high yield and that many wells do not yield sufficient water for irrigation purposes and consequently are never completed.

A possible explanation for poorly productive or nonproductive wells in the southern part of this subarea may be seen on geologic sections *B–B*' and *C–C*' (pl. 1). These sections show that beneath much of the irrigated area the alluvium ranges in thickness from a few tens of feet to about 800 feet and overlies semiconsolidated rocks of marine origin. These semiconsolidated rocks generally yield little water to wells, and deep wells that tap them probably receive most of their water supply from the overlying alluvium. The geologic sections also show that the Tulare formation underlies the east edge of the irrigated area and much of the alluvial slopes to the east. The easternmost wells in the vicinity of the Devils Den ranch (25/19–7M) may receive part of their water supply from the Tulare formation. If wells were drilled east of the area irrigated in 1955, they might be expected to yield moderate quantities of water, principally from water-bearing beds in the Tulare formation.

[1] Specific capacity of a well is the ratio of the yield to the drawdown and generally is expressed in gallons per minute per foot of drawdown.

In the northern part of Kettleman Plain, scattered water-level measurements made in the autumn of 1955 indicate that north of Reef pump station the ground-water surface sloped about 10 feet per mile, generally in a southeasterly direction toward Avenal Gap (pl. 3). From well 23/18–29E1 southeastward to well 24/18–11L1, a distance of about 4½ miles, the altitude of the water surface decreased about 6 feet—an average gradient of less than 1½ feet per mile. The reason for this pronounced flattening of the hydraulic gradient is not known, because of the lack of water-level control in the intervening area.

At the west end of Avenal Gap the contours for 1955 indicate that ground water moving southward may have divided, part moving southward toward Devils Den ranch and part moving eastward through Avenal Gap. In the western part of Avenal Gap, west of well 24/19–17P1, the water table may have sloped nearly 50 feet per mile. In the central part of the gap the slope flattened to about 20 feet per mile. At the east end of the gap, between wells 24/19–10P1 and 11G1, the gradient steepened to nearly 70 feet per mile. The steep water-level gradients at both ends of Avenal Gap indicate that the cross-sectional area of the alluvial fill is less at the ends of the gap than in the central part, thereby restricting subsurface flow and accounting for the steep gradients.

In the southern part of Kettleman Plain, south of Avenal Gap, there has been much irrigation development from deep wells (pl. 3). Scattered water-level measurements in this area in 1955 indicated that ground water moved generally toward a pumping depression centered in sec. 6, T. 25 S., R. 19 E. Too few water-level measurements were available to show more than the general shape of this depression, which is outlined by the 370-foot contour east of Dagany Gap. Before the present irrigation development began, ground-water discharge from McLure Valley eastward through Dagany Gap may have divided—part may have moved northward toward Avenal Gap and part southeastward beneath Antelope Plain. The contours for 1955 indicate that all ground-water discharge through Dagany Gap was intercepted by local pumping for irrigation.

Fluctuations.—Periodic water-level measurements are not available for most of Kettleman Plain, especially in the irrigated area near Devils Den ranch. However, the scanty water-level data available, chiefly measurements made during pump-efficiency tests by the Pacific Gas and Electric Co., indicate that a marked decline of water levels has occurred since pumping for irrigation began before 1936.

In 1936 the pumping levels in wells 24/18–25H1 and 24/18–25J2, both about 3 miles north of Devils Den ranch, were reported to be 133 and 125 feet below the land surface, respectively. In February

1946, well 24/18–25J2 was pumping from a depth of 162 feet and in May 1949 from 198 feet. A pump-efficiency test made at well 24/18–25J2 in October 1950 reported a nonpumping depth to water of 137 feet, but no pumping measurement was made. No further tests were made on the wells in 24/18–25, but well 25/19–6D1, about 1.5 miles south of well 24/18–25J2 and at an altitude about 35 feet higher, was tested in 1950, 1951, and 1953. In October 1950 the nonpumping depth to water was 159 feet and the pumping level 172 feet. In April 1952 the nonpumping and pumping levels were 179 and 205 feet, respectively. A test in August 1953 reported the pumping level to be 286 feet. Although pumping water-level measurements are inferior to nonpumping measurements as indicators of water-level trends, the measurements cited above indicate a decline in water levels of more than 100 feet between 1936 and 1953 in the irrigated area north of Devils Den ranch.

Water-level fluctuations in the northern part of Kettleman Plain are shown on plate 4 by the composite hydrograph of wells 23/18–29E1 and 29E2 at Reef pump station. The graph, constructed from water-level measurements made at times when the wells were being repaired, indicates that between 1910 and 1955 the water level declined only about 10 to 12 feet. The large fluctuations of water levels in 1928 and 1929 probably indicate that the water level was affected by pumping in the companion well.

McLURE VALLEY

Occurrence and movement.—Ground water in McLure Valley occurs in the alluvium, which ranges in thickness from a few tens of feet to about 400 or 500 feet (geologic sections *B–B'* and *b–b'*, pls. 1 and 2) and which at most places rests unconformably upon the truncated edges of the undifferentiated sedimentary rocks of Tertiary age. The alluvium consists largely of poorly sorted silty materials which contain lenses and tongues of gravel and clayey gravel. Wells used for irrigation range in depth from 150 to 628 feet.

Short-term drawdown and recovery tests made by the Pacific Gas and Electric Co. indicate that the yields of wells ranged from 200 gpm near Dagany Gap to more than 1,000 gpm in the northern part of the irrigated area. Specific capacities ranged from 12 to 100 gpm per foot of drawdown and averaged about 35 gpm per foot.

Water-level contours (contour interval 50 feet) shown in McLure Valley are based on water-level measurements made in October 1955. The contours indicate that ground water moved across the valley in an easterly and northeasterly direction toward a pumping depression west of Dagany Gap. Near the eastern margin of the valley a fault (shown on pls. 1 and 3 and geologic sections *B–B'* and *b–b'*, pls. 1 and 2, respectively), which brings the relatively impermeable sedimentary rocks of Tertiary age close to the land surface, apparently acts as a ground-water barrier. Although few data regarding the effectiveness of this supposed barrier are available, local residents report that test wells drilled east of the fault in secs. 18, 19, and 20, T. 24 S., R. 18 E., obtained very little water. If, as suggested here and as shown on geologic section *b–b'* (pl. 2), the fault forms a ground-water barrier, then ground water moving eastward and northeastward across the valley is impeded by the fault. In the western and northwestern parts of the valley, ground water approaching the barrier would move down gradient along the barrier in a southeasterly direction toward the ground-water depression created by heavy pumping for irrigation in the well field just west of Dagany Gap. In the southern and southwestern parts of the valley, ground water would move down gradient along the barrier northward into the pumping depression.

Before the development of the well field west of Dagany Gap, ground water rose to the surface near the upstream end of the gap and was discharged as a series of sluggish springs, known locally as Alamo Solo springs, near the center of sec. 2, T. 25 S., R. 18 E. Arnold and Johnson (1910, p. 102) reported that during their investigation in the summer and autumn of 1908 the surface of the ground in the area adjacent to the gap was more or less moist and covered with efflorescent salts. Mr. Joseph Barker, who has lived on a ranch (25/18–3P) near the gap for many years, reported that the springs ceased flowing shortly after pumping for irrigation was started west of the gap. The presence of rising water before pumping probably was due to a combination of the thinning of deposits on the east side of the fault, produced by uplift of consolidated rocks, and the narrowing of the alluvium in Dagany Gap—the combination causing a marked decrease in the cross-sectional area of the alluvium through which ground water could discharge from McLure Valley.

Under present conditions, however, ground water probably does not discharge from McLure Valley to Antelope Plain through Dagany Gap. The altitudes of the water levels in the pumping depression west of Dagany Gap ranged from 452 feet in well 25/18–3M5 to 412 feet in well 24/18–33Q4. The altitudes of the water levels in wells in the irrigated area north and south of Devils Den ranch ranged from 332 to 375 feet. The altitudes of the water levels in three wells in Dagany Gap ranged from 508 to 537 feet. Thus, the water levels in 1955 in the alluvium in Dagany Gap stood more than 100 feet higher than the water levels in either of the adjoining areas. The higher altitudes of the water levels in Dagany Gap strongly indicate that a ground-water divide existed in the gap in 1955 owing to heavy pumping west of the fault which has caused a reversal of the ground-water gradient in the western part of the gap.

Fluctuations.—Hydrographs of wells 24/17–25H1, 24/18–30D1, and 24/18–30B1, presented on figures 4, 5, and 6, respectively, were compiled from pumping and nonpumping water-level measurements made by the Pacific Gas and Electric Co. They show that the water levels in McLure Valley declined almost steadily during the period 1946–53, and that recovery during the nonpumping season was negligible. The standing-water level declined about 84 feet in well 24/17–25H1 (fig. 4) from September 1946 to October 1952 and rose about 20 feet from October 1952 to October 1953. The standing level declined about 120 feet in well 24/18–30D1 (fig. 5) from October 1947 to October 1954 and declined about 98 feet in well 24/18–30B1 (fig. 6) from October 1948 to October 1954. The brief recovery recorded from October 1952 to October 1953 in wells 24/17–25H1 and 24/18–30D1 may indicate that pumping for irrigation in the northern part of McLure Valley was less than that in prior years, or it may indicate local recovery due to recharge from Avenal Creek, which crosses the valley near these wells.

Ground water in McLure Valley is replenished largely by seepage losses from Avenal and Cottonwood Creeks, which drain the hills and the mountains west and northwest of the valley. These intermittent streams are usually dry or nearly dry, except during the rainy season from December to March. In most years nearly all the streamflow is lost by seepage to ground water and by evaporation along the poorly defined drainage courses before they reach Dagany Gap.

SUBAREA EAST OF AVENAL GAP

The fans and low plains south of Tulare Lake bed and east of the South Dome of Kettleman Hills and the gap constitute the subarea east of Avenal Gap.

Occurrence and movement.—Ground-water conditions in the area are not well known because there has been little development of ground-water supplies. Consequently, well logs, water-level measurements, and other hydrologic data are meager. In general, ground water of inferior quality occurs in an undetermined thickness of alluvium (alluvial-fan deposits) east of Avenal Gap.

The water-level contours (pl. 3) suggest that the ground-water surface slopes in a northeasterly direction toward Tulare Lake bed under a gradient of about 2 feet per mile. The principal source of ground-water recharge in this subarea evidently is subsurface outflow of ground water from Avenal Gap. However, because of heavy pumping for irrigation in McLure Valley and at Devils Den ranch, the ground-water outflow from Avenal Gap probably will decrease

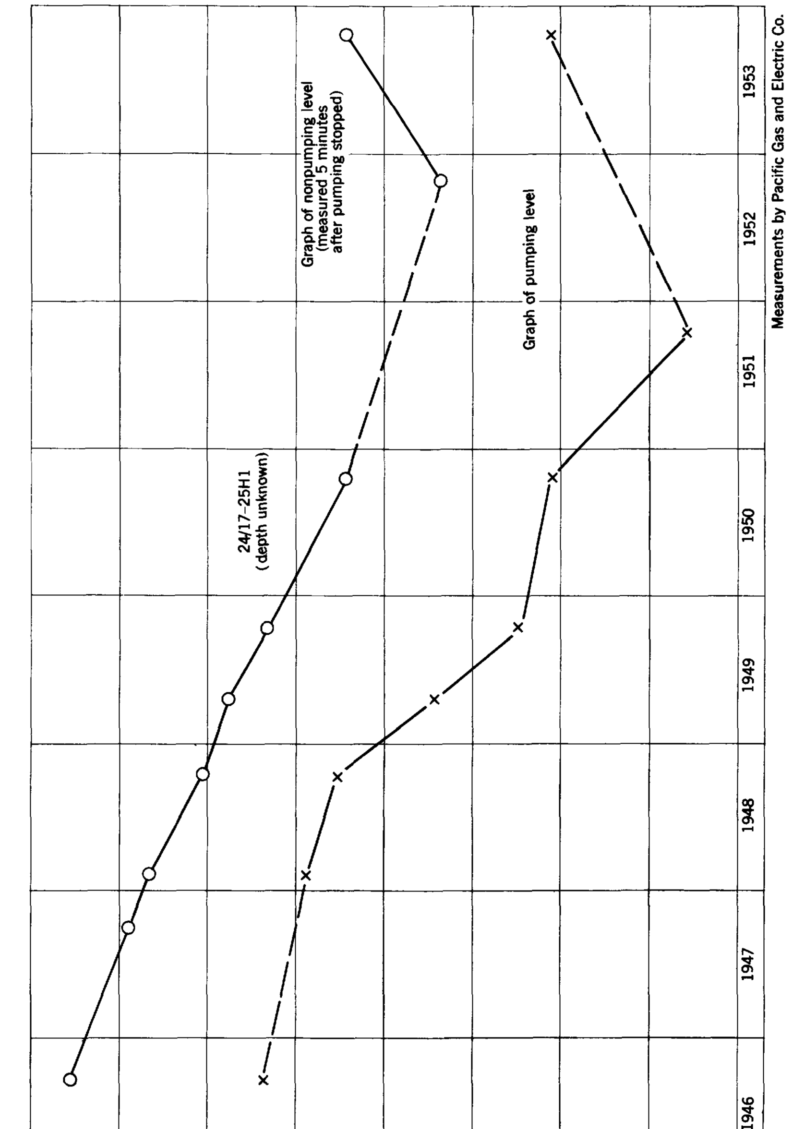


FIGURE 4.—Hydrograph of well 24/17-25H1 in McLure Valley.

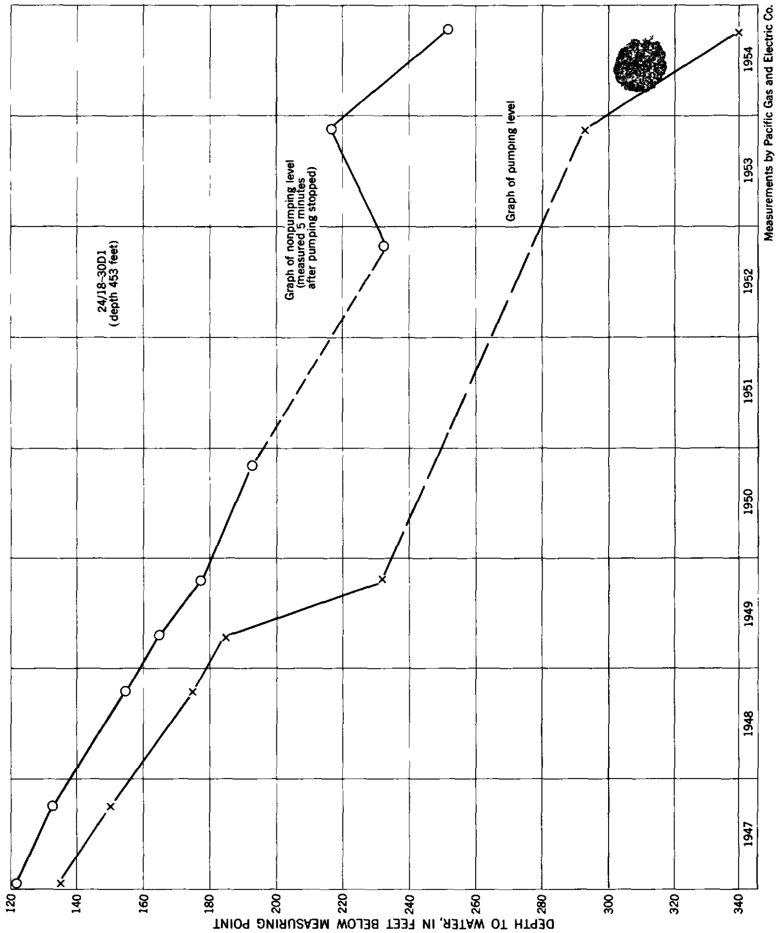


FIGURE 5.—Hydrograph of well 24/18-30D1 in McLure Valley.

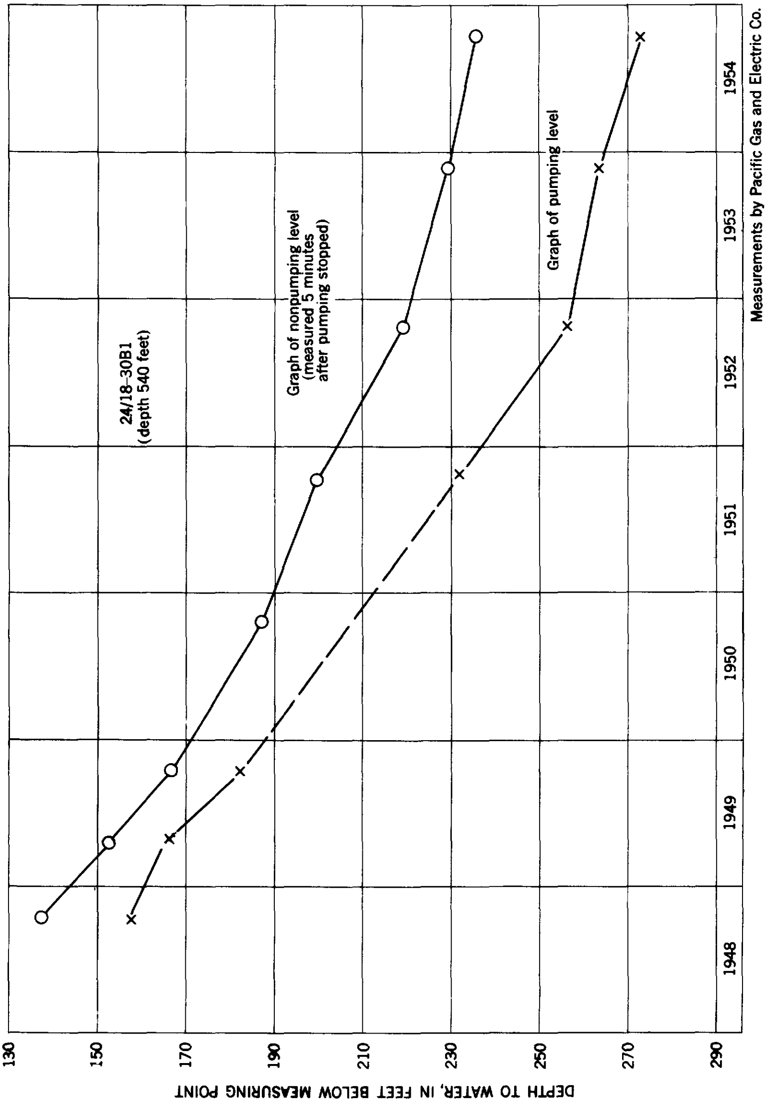


FIGURE 6.—Hydrograph of well 24/18-30B1 in McLure Valley.

with time. The contours for 1955 indicate that ground water draining through the alluvium in the northern part of Kettleman Plain may have constituted the principal source of supply to the alluvium in Avenal Gap. However, in time it is likely that the ground-water depression created by pumping in the southern part of Kettleman Plain will expand sufficiently to intercept part or all of the ground water that otherwise would discharge through the gap.

Because of the poor quality of ground water (p. 56–57) east of Avenal Gap, most of the water used for irrigation is imported through an unlined canal from sources east and northeast of the area of investigation. Some of the water is diverted from Tulare Lake and some is pumped from a well field near the Tule River north of Angiola (shown on the U.S. Geological Survey Alpaugh and Taylor Weir quadrangle maps).

Fluctuations.—Little is known about the fluctuations of water levels in this subarea. Water-level measurements made in October 1955 and in May 1956 in unused large-diameter gravel-packed wells 24/19–2Q1 and 12N1 indicate that the water levels fluctuated less than 0.5 foot in well 2Q1 and about 2 feet in well 12N1. Water-level measurements made in old stock wells 24/19–12G1 and 24/20–9K1 are shown in the following table. The measurements in the 2 unused irrigation wells and the 2 old stock wells suggest that there has been little change in water levels in this subarea in the years 1951–56.

Well	Water level (in feet below land surface); datum for—		
	June 1951	October 1955	May 1956
24/19–12G1	77. 8	--------	76. 8
24/20–9K1	32. 9	33. 2	33. 1

ANTELOPE VALLEY

Occurrence and movement.—Ground water in Antelope Valley occurs in alluvium which unconformably overlies sedimentary rocks of Cretaceous and Tertiary age. The thickness and lithologic character of the alluvium as interpreted from drillers' logs of wells are shown on geologic sections *c–c'* and *d–d'* (pl. 2), which show that the alluvial deposits are composed mostly of silt, clay, and gravel. They range in thickness from a few tens of feet near the valley margins to about 300 feet in the central part of the valley. Their saturated thickness in autumn 1955 ranged from about 60 feet in well 26/18–14R1 to about 120 feet in well 26/17–11R1 and averaged about 100 feet. Wells used for irrigation range in depth from 185 to 1,200 feet (table 7).

Short-term drawdown and recovery tests made in 1951 by the Pacific Gas and Electric Co. indicate that the yield of wells ranged from 160 to 700 gpm and averaged less than 350 gpm. At that time pumping drawdowns ranged from 20 to 70 feet and averaged about 40 feet. Specific capacities ranged from 4 to 23 gpm per foot of drawdown and averaged about 10 gpm per foot. Because of decreasing yields since that time, pumps of smaller capacity and electric motors of less horsepower have been installed on many of the wells.

Water-level measurements made in irrigation wells during October 1955 indicate that, because of heavy pumping for irrigation, a steep cone-shaped depression has formed. The deepest depression is near well 26/18–22G1, in which the water level was 439 feet above sea level. Water-level contours (pl. 3) indicate that in the western part of the valley between wells 26/17–11F1 and 26/18–18F3 the gradient was about 25 feet per mile to the east-southeast. Between wells 26/18–18F3 and 16E1 the gradient steepened to about 120 feet per mile; between wells 26/18–16E1 and 22G1, near the center of the cone-shaped depression, it flattened to about 50 feet per mile. North and east of well 26/18–22G1 the gradient was between 50 and 60 feet per mile toward the depression, and to the south it was about 90 feet per mile. Thus, the contours show that in 1955 there was no ground-water discharge to Antelope Plain from Antelope Valley; rather, the gradient was reversed and ground water was moving westward into the pumping depression from beneath the west side of Antelope Plain.

The difference in water levels between wells 26/18–18F4 and 26/18–18G1, 51 feet in a distance of less than 500 feet, suggests either a marked reduction in thickness of the water-bearing deposits or a concealed fault that forms a ground-water barrier. The geologic map (pl. 1) indicates 2 known faults in the consolidated rocks to the south, either or both of which may extend northward beneath the alluvium and between the 2 wells.

Fluctuations.—Although no periodic water-level measurements are available for Antelope Valley, measurements made by the Geological Survey in June 1951 and May 1956 indicate a general decline of water levels during the period. Comparison of depth to water in 12 wells measured in 1951 and 1956 show a rise of water level in only 1 well, 26/18–14R2; in all other wells there were declines, ranging from 2.3 feet in well 26/18–11K1 to 40.1 feet in well 26/18–14N1. The average decline for the 12 wells was about 14 feet, or nearly 3 feet per year.

ANTELOPE PLAIN AND AREA EAST OF LOST HILLS

Antelope Plain and the western slope of the San Joaquin Valley east of Lost Hills include the greater part of the valley lands in the Avenal-McKittrick area. Despite the large size of the area, little information is available regarding ground-water conditions. This area is characterized by low rainfall, ground water of inferior quality, no imported surface-water supplies, and high concentrations of salts in the soil and subsoil. Accordingly, there has been little agricultural development in this vast area. For the most part the land is used only for grazing, and that only during the winter and spring. Records are available on the industrial wells drilled to supply water to widely scattered oil-pumping stations; otherwise, the few wells in the area are mostly stock wells drilled many years ago for which little or no information is available.

Occurrence and movement.—In Antelope Plain and the western slope of the valley east of Lost Hills, ground water occurs in the alluvium and in the underlying Tulare formation. Because of the similarity of the lithology of these units, they are virtually indistinguishable in the subsurface. In general the water-bearing deposits consist of lenses and stringers of sand and gravel enclosed in predominantly poorly sorted silty materials.

Wells in Antelope Valley penetrate more coarse water-bearing material than do the wells in Antelope Plain. Thus, the average grain size decreases valleyward with increasing distance from the source of the deposits. However, just east of the southern part of Antelope Plain, wells in the axial trough of the San Joaquin Valley yield large quantities of water from sands deposited by the Kern River. Some of these sands probably extend into the Avenal-McKittrick area, but their westerly extent is not known.

The data on the thickness of the water-bearing deposits, chiefly from electric logs of oil-test wells, suggests that sediments in most of the Antelope Plain area contain waters of high conductivity. These waters are presumably of marine origin and are within less than 1,000 feet of land surface. Locally, however, particularly near Lokern, northeast of the Elk Hills, and near the Junction pump station in the northern part of Antelope Plain, the waters of high specific conductance are found at greater depths.

The electric log of an oil well drilled in sec. 26, T. 29 S., R. 22 E., about 2 miles southwest of Lokern, recorded reasonably fresh water in continental deposits to a depth of about 1,500 feet. Between about 1,500 and 2,000 feet the deposits contained water of progressively higher conductivity, which was apparently transitional between the fresher water above and the marine water below.

Electric logs of several oil tests drilled in secs. 27 and 28, T. 26 S., R. 19 E., about 2 miles east of Junction pump station, indicate that fresh waters overlie highly conductive waters with only a thin transitional zone at about 1,300 to 1,400 feet below land surface.

Because of the scarcity of hydrologic data, little is known about the movement of ground water in much of Antelope Plain. Although the general movement of ground water is in a northeasterly direction from recharge areas along the western border of the valley toward Buena Vista Slough in the trough of the San Joaquin Valley, it probably is interrupted or deflected in several places by southeastward-trending anticlinal structures, such as the Lost Hills. The water-level contours for 1955 (pl. 3) suggest that in the northern part of Antelope Plain ground water moved in a northeasterly direction between the south end of the Kettleman Hills and the north end of the Lost Hills toward Buena Vista Slough. The gradients were about 17 feet per mile between wells 25/19–25B1 and 25/20–19G1, about 28 feet per mile between wells 25/20–19G1 and 25/20–15Q1, and about 21 feet per mile between wells 25/20–19G1 and 25/20–4C1.

The Lost Hills anticlinal structure probably acts at least as a partial barrier to the northeasterly movement of ground water. The presence of gypsite deposits along the west side of Lost Hills (Ver-Planck, 1952, p. 53) suggests that at an earlier geologic time the barrier effect of the Lost Hills anticlinal structure may have caused ground water to rise to or nearly to the land surface.

Fluctuations.—The hydrographs presented on plate 4 are based on miscellaneous water-level measurements in wells 25/19–20Q1–3 at Temblor pump station and in wells 27/20–34G1 and 34P1–2 at Carneras pump station; they show the water-level fluctuations in the northern and southern parts of Antelope Plain, respectively. The hydrograph of well 25/19–20Q1 at Temblor pump station shows that the water level rose about 55 feet from 1928 to 1941 and then declined about 60 feet to 1951. However, it is possible that the exceptionally high water level recorded in September 1941 may have been an error. The relatively flat graphs for wells 27/20–34G1 and 34P1–2 at Carneras pump station suggest that there has been very little depletion of ground water in storage in this part of the area.

Periodic measurements made in a well near the center of sec. 22, T. 26 S., R. 21 E. (possibly well 26/21–22G2), by the U.S. Bureau of Reclamation between January 1945 and September 1954 show that annual water-level fluctuations in the area east of Lost Hills ranged from less than a foot in 1946 and 1947 to a maximum of 7.6 feet in 1950. Depths to water of 49 feet in February 1954 and 53 feet in September 1954 showed an annual fluctuation of at least 4 feet in that year.

PUMPING

Pumping for irrigation in the Avenal-McKittrick area began in the middle 1930's, when a small area in Kettleman Plain in sec. 25, T. 24 S., R. 18 E., and an area west of Dagany Gap in McLure Valley were placed under irrigation. Since that time the number of wells and the acreage irrigated have increased until in 1955 there were 75 wells in the area supplying water to about 11,400 acres (table 5) of irrigated crops. In addition, about 4,600 acres east of Avenal Gap (pl. 3) was irrigated by ground and surface water imported from areas east and northeast of the Avenal-McKittrick area.

TABLE 5.—*Approximate acreage of irrigated lands in the Avenal-McKittrick area*

[Acreage compiled from crop survey made by the Geological Survey in autumn 1955; areas shown on pl. 3]

Area	Gross acreage irrigated in years before 1955	Acreage irrigated in 1955
McLure Valley	4, 400	4, 000
Irrigated part of Kettleman Plain	5, 300	5, 300
Irrigated area east of Avenal Gap	[1] 5, 100	[1] 4, 600
Antelope Valley	2, 300	1, 900
Area east of Lost Hills	200	200
Total	17, 300	16, 000

[1] Water supply imported from east of the Avenal-McKittrick area.

The extent of lands irrigated before and during 1955, chiefly in McLure and Antelope Valleys and near Devils Den ranch, is shown on plate 3. Other areas where ground water was pumped for irrigation include a small area southeast of Kettleman City near the southwest margin of Tulare Lake bed, an area of about 200 acres about 3.5 miles north of Lost Hills, and an area of 50 to 60 acres near Buena Vista Slough about 2.3 miles east of Lost Hills. Some of these small areas were irrigated by water pumped by natural-gas engines and others by water pumped by electric motors. No attempt was made to calculate the pumpage for these small isolated areas because of the difficulty of obtaining records. In estimating the total pumpage in the Avenal-McKittrick area, however, little error is introduced by omitting these areas because of their limited extent.

In the McLure Valley and Devils Den ranch areas before 1946, nearly all ground water used in the area was pumped by gasoline and diesel engines. As no accurate records were kept of the amount of fuel used for pumping or of the yearly acreage of each type of crop irrigated, no estimates of pumpage could be made for the period before installation of electric motors.

In Antelope Valley pumping for irrigation began in 1947 and increased rapidly so that, by 1951, 25 irrigation wells were supplying water for about 2,000 acres of irrigated crops. In 1955, 28 irrigation wells supplied water for about 1,900 acres of land. Before 1951 nearly all the pumps were driven by gasoline and diesel engines, and, as no accurate records were kept of the amount of fuel used for pumping of the yearly acreage of each type of crop irrigated, estimates of pumpage could not be made. Since 1951 most of the water used has been pumped by electric plants for which power records are available.

The estimated annual pumpage for irrigation for the 10-year period 1947–56 is shown in table 6. These data were compiled largely by E. J. Griffith, commercial, industrial, and agricultural supervisor, Pacific Gas and Electric Co., Fresno, Calif., and were made available through the cooperation of V. C. Redman, division sales manager, San Joaquin Power Division, Pacific Gas and Electric Co.

The annual pumpage, in acre-feet, was derived from total power consumption per customer per year divided by an average figure for kilowatt hours per acre-foot for each customer as determined from pumping-plant efficiency tests for that customer for the same year. Because one customer operated wells in both McLure Valley and the Devils Den area, it was impossible to subdivide the power consumption and pumpage into the respective subunits.

TABLE 6.—*Estimated ground-water pumpage (in acre-feet) by electric plants in the Avenal-McKittrick area, 1947–56*

[Pumpage for agricultural year beginning April 1 and ending March 31; data chiefly from Pacific Gas and Electric Co.]

Year	McLure Valley-Devils Den ranch area [1]	Antelope Valley [1]	Total
1946–47	13, 000		13, 000
1947–48	15, 000		15, 000
1948–49	14, 000		14, 000
1949–50	16, 000		16, 000
1950–51	17, 000	4, 000	21, 000
1951–52	18, 000	5, 000	23, 000
1952–53	19, 000	6, 000	25, 000
1953–54	19, 000	5, 000	24, 000
1954–55	20, 000	5, 000	25, 000
1955–56	18, 000	[2] 5, 000–6, 000	23, 000–24, 000
Total	169, 000	About 30, 000	About 200, 000

[1] Before 1946 in the McLure Valley-Devils Den ranch area and before 1951 in Antelope Valley, most of the ground water was pumped by gasoline engines.
[2] Based on estimate of 2.5 to 3 feet per acre applied to about 2,000 acres of irrigated land.

Table 6 shows that the amount of ground water pumped by electric plants for irrigation increased steadily from about 13,000 acre-feet in 1946–47 to about 25,000 acre-feet in 1952–53. Thereafter the total yearly pumpage in the Avenal-McKittrick area was about 25,000 acre-feet.

Pumpage for domestic and stock use is negligible compared to that for irrigation. It probably is within the limits of error involved in the estimates of pumpage for irrigation, and therefore no attempt was made to estimate the pumpage for these minor uses. Because pumpage for a few isolated areas and the pumpage by a small number of diesel- and gas-powered pumps have been omitted, the yearly totals since 1951 in table 6 may be considered a conservative approximation of the total yearly pumpage for all uses in the Avenal-McKittrick area.

GEOCHEMISTRY OF NATURAL WATERS

The ground waters of the Avenal-McKittrick area are fairly consistent in chemical character but differ markedly in concentration of mineral constituents. These differences are related in part to differences in the chemical quality of the waters of the streams that issue from the Coast Ranges, but they are governed largely by physical and chemical changes that occur after the water has percolated to the water table and has moved through the containing deposits. Such differences in quality are helpful in determining the sources and occurrence and in tracing the movement of ground water. Moreover, a knowledge of the areal and vertical extent of bodies of water of inferior quality is essential for detailed studies of utilization of ground-water supplies.

When rain falls upon the earth it carries with it in solution chemicals that are present in the atmosphere, chiefly the normal gaseous constituents nitrogen, oxygen, and carbon dioxide; in areas near the oceans, chlorides and sulfates of sodium, magnesium, calcium, and potassium from the sea water are also carried by the rain. Carbon dioxide, especially, increases the solvent power of the rainwater, and the moment water enters the soil its chemical and solvent activities begin and continue until it returns to the atmosphere or flows to the ocean. Part of the precipitation runs off directly to streams but most enters the soil zone, in part to become ground water, in part to return directly to the atmosphere as evaporation or transpiration, and in very small part to be retained as water of hydration of clays. That water which enters the soil acquires additional carbon dioxide and reacts chemically with the soil and rock particles with which it comes in contact.

Figure 7, reproduced from Davis and others (1959, p. 168, fig. 5), shows the principal stages of the geochemical cycle as it relates to the waters of the Central Valley of California. The water is traced from the ocean to the atmosphere as vapor, to the earth's surface as precipitation, to the soil and thence in part to the ground water, and finally back to the atmosphere in the form of vapor or to the ocean as streamflow or ground-water discharge.

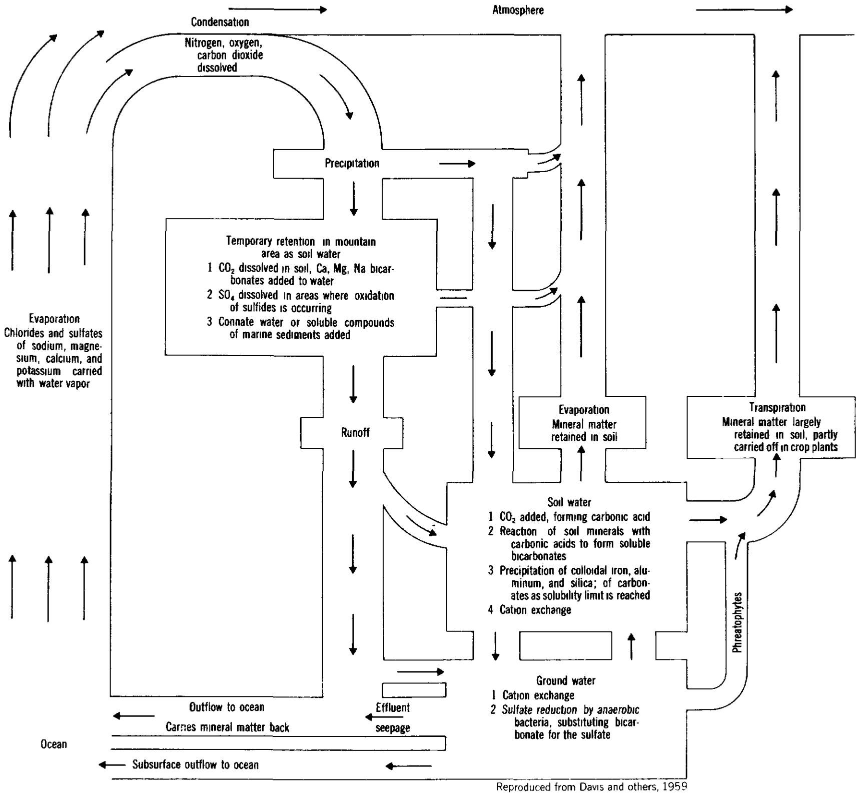


FIGURE 7.—Geochemical cycle of surface and ground waters.

This picture, of course, is greatly simplified and shows only the more important stages in the cycle. Moreover, most of the reactions may be reversed if the chemical or physical environment of the solution changes. This is especially true of the reactions involving carbon dioxide, carbonic acid, and the carbonates, because of the instability of the compounds formed, because of the ease with which carbon dioxide passes in and out of solution, and because of the complex part played by organisms in the carbon cycle. Likewise the reactions involving the sulfur compounds are notably reversible: in the presence of oxygen, sulfides are oxidized to sulfates; in the absence of oxygen, anaerobic bacteria reduce the sulfates to sulfides.

Results of all available chemical analyses as of March 1956 of waters from wells are given in table 8, and of water from springs and streams in table 9. These analyses include a few published records but are chiefly the results of sampling programs carried out in recent years by the California Department of Water Resources and the U.S. Bureau of Reclamation.

Tables 8 and 9 present chemical analyses expressed in ppm (parts per million) and epm (equivalents per million). A part per million is a unit weight of a constituent in a million unit weights of solution. An equivalent per million is an expression of the concentration of a constituent in terms of chemical equivalents or combining weights. Parts per million may be converted to equivalents per million by dividing the concentration of each constituent, in parts per million, by the equivalent weight (combining weight) of the constituent or ion. The equivalent weight is the atomic or molecular weight of an element or ion divided by the valence. Percentage reacting value of total cations or anions is calculated from the analytical statement in equivalents and is a ratio, expressed in percent, of each cation or anion to the sum of the cations or anions, respectively.

Representative analyses are presented in graphic form on a geochemical map (pl. 5) and geochemical graphs (figs. 8–10). The map shows the areal distribution of surface and ground waters with respect to chemical character and concentration. The geochemical graphs show the chemical character in terms of relative proportions of the cations (basic ions) and anions (acid ions). The anions are shown in the lower right triangle, the cations in the lower left. The single-point plots in the diamond field provide a means for distinguishing waters of different character. The diagram is one utilized and described by Piper (1945).

In this report the terms describing the general chemical character of a water are used in particular senses, as in the following examples: (1) "calcium bicarbonate" designates a water in which calcium amounts to 50 percent or more of the cations and bicarbonate to 50 percent or more of the anions, in epm; (2) "sodium calcium bicarbonate" designates a water in which sodium and calcium are first and second in order of abundance among the cations but neither amounts to 50 percent of all the cations; and (3) "sodium sulfate bicarbonate" designates a water in which sulfate and bicarbonate are first and second in order of abundance among the anions, as above. A water described as being of "intermediate cation composition" is one in which the three principal cations are present in approximately equal proportions. Likewise, the description "intermediate anion composition" indicates that the three principal anions are present in approximately equal proportions.

SURFACE WATERS

The streams tributary to the Avenal-McKittrick area are notable for their small and flashy discharge. Because of the difficulty of sampling these streams, only a few analyses, reported in table 9 and illustrated on plate 5 and figure 8, are available for study.

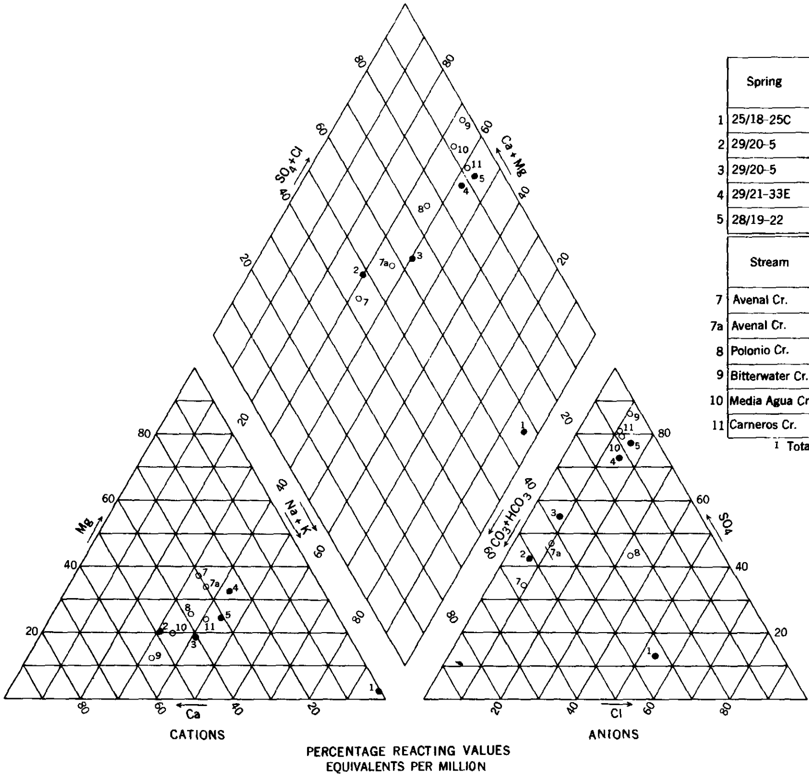
The surface waters of the area may be divided into two general groups on the basis of their chemical character: (1) The waters of Avenal and Polonio Creeks, as indicated by the available analyses, contain much less dissolved mineral matter and proportionally less sulfate but more magnesimum than (2) the waters of Bitterwater, Media Agua, and Carneros Creeks. All these streams were sampled during January 25 to 28, 1952, so it is assumed that comparable stages of flow existed and that there were no great differences in chemical quality related to the time and duration of the runoff. The samples range in dissolved solids from 530 ppm in the water of Avenal Creek to 3,200 ppm in the water of Bitterwater Creek.

The water of Avenal Creek, sampled in January 1952 at an estimated flow of 18 cfs (cubic feet per second) was a bicarbonate sulfate water of intermediate cation composition. However, a sample taken 2 years later, on January 26, 1954, at a flow of 0.2 cfs showed that the water was of the sulfate bicarbonate type and of lower mineral content than the sample of January 1952 (table 9). The water of Polonio Creek, like that of Avenal Creek, is relatively low in dissolved mineral matter; on January 25, 1952, it contained 540 ppm of dissolved solids. It was a calcium-sodium water of intermediate anion composition.

In contrast, the waters of Bitterwater, Media Agua, and Carneros Creeks are characterized by concentrations of dissolved solids in excess of 1,500 ppm and by the fact that sulfate constitutes about 80 percent or more of the anion total (fig. 8). Calcium is the predominant cation in the water of Bitterwater Creek, but the waters of Media Agua and Carneros Creeks are of calcium and sodium calcium composition, respectively. Although sulfate is the predominant anion in these waters, the concentration of bicarbonate nevertheless is about the same as in the waters of Avenal and Polonio Creeks. The chloride content, however, is substantially higher in these sulfate waters, ranging from 90 to 160 ppm, compared to 14 to 42 ppm in the samples from Avenal and Polonio Creeks.

The differences in chemical character and concentration of the surface waters of the Avenal-McKittrick area appear to be related chiefly to differences in lithology of the rocks of the respective drainage basins. The most distinctive differences are in the relative concentrations of the anions, but the waters of Avenal and Polonio Creeks show significant differences from those of other streams in relative concentration of magnesium as well.

Plate 1 and Kundert's geologic map of California (1955), show that Avenal and Polonio Creeks, the two streams in which sulfate is relatively unimportant, drain terranes formed predominantly by marine sediments of Cretaceous age and by sedimentary, igneous, and metamorphic rocks of the Franciscan formation of Jurassic and Cretaceous age. On the other hand, Bitterwater, Media Agua, and Carneros Creeks, the streams characterized by waters of high sulfate



	Spring	Date	Dissolved solids (ppm)	Flow (cfs)
1	25/18-25C	4-23-53	10,900	
2	29/20-5	8-7-54	362	
3	29/20-5	8-3-55	476	
4	29/21-33E	11-8-55	2831	
5	28/19-22	8-6-54	3060	

	Stream	Date	Dissolved solids (ppm)	Flow (cfs)
7	Avenal Cr.	1-28-52	[1] 530	18.0
7a	Avenal Cr.	1-26-54	306	
8	Polonio Cr.	1-25-52	540	.8
9	Bitterwater Cr.	1-25-52	3200	.2
10	Media Agua Cr.	1-25-52	1600	> .5
11	Carneros Cr.	1-25-52	1900	> .5

[1] Total solids by evaporation

FIGURE 8.—Geochemical graph of spring and stream waters in Avenal-McKittrick area.

content, drain terranes formed predominantly by marine and continental sedimentary rocks of Tertiary and Quaternary age.

The stream waters have little consistency in cation content, except that the waters of Avenal, Polonio, and Carneros Creeks contain relatively more magnesium than those of Bitterwater and Media Agua Creeks. (See fig. 8.)

The bicarbonate in the stream waters presumably is derived largely from the atmosphere either as carbon dioxide dissolved in rain or as a product of the decay of organic matter. However, the calcium carbonate cement of marine sandstones, which form a substantial part of the Mesozoic section, may contribute appreciable quantities of bicarbonate to the stream waters. The sulfate, so prominent in some of the waters, presumably was supplied initially by the oxidation of sulfides, especially pyrite (iron sulfide), present in organic marine deposits of Tertiary age. Undoubtedly, much of the sulfate is derived directly from gypsiferous continental deposits of late Tertiary and early Quaternary age, but the gypsum of these sediments probably was derived from waters whose source of sulfate was the older marine rocks.

The relatively high magnesium content of the waters of Avenal and Polonio Creeks can be explained by the presence of ultramafic intrusive rocks in the drainage basins of the two streams (Kundert, 1955). Ultramafic rocks, such as peridotite, saxonite, dunite, and pyroxenite or their altered equivalents of the serpentine group, all of which are composed largely of magnesium silicate minerals, are a source of readily weathered magnesium compounds; hence, the stream waters may be expected to show a correspondingly high magnesium content.

SPRING WATERS

Chemical analyses of the water of 4 springs in the Avenal-McKittrick area, reported in table 9 and shown on plate 5 and figure 8, have extreme variations both in the chemical character and in the concentration of the water. This is not surprising, however, as the waters are derived from rocks of different origin and age. The mineral content, expressed as the sum of determined constituents, ranges from 362 ppm in the water from the spring at 29/20–5 (Carneros Spring) to 10,900 ppm in the water from the spring at 25/18–25C. The chemical character likewise is erratic; the spring at 25/18–25C yields a sodium chloride water, the springs at 28/19–22 and 29/21–33E yield sulfate waters of intermediate cation composition, and the spring at 29/20–5 yields bicarbonate or sulfate water of calcium sodium composition.

The water from a sump at the spring at 25/18–25C is of the sodium chloride type and contains 10,900 ppm of dissolved solids. It issues near an outcrop of upper Miocene marine sediments, according to Kundert (1955), and seeps into a large fenced sump. There is no surface outlet or apparent escape from the sump; therefore, the high concentration may be due in part to evaporation of the water. The mud around the spring is black and smells strongly of hydrogen sulfide. Although this spring apparently is the same one described by Arnold and Johnson (1910, p. 44) as a tar spring issuing from the contact of the Vaqueros formation and alluvium, there was no evidence of tar or oil when the spring was sampled in April 1954. Because of the high mineral content of the water, the spring is unused at present.

The spring at 28/19–22, known locally as Mize Spring, yields a sodium calcium sulfate water containing 3,060 ppm of dissolved solids. The water issues from sedimentary rocks shown by Kundert as early Miocene (1955). It is used for stock and domestic purposes.

The spring at 29/20–5 (Carneros Spring) yields a calcium sodium sulfate bicarbonate or bicarbonate sulfate water containing less than 500 ppm dissolved solids. The water trickles from sandstone of Eocene age (idem). Arnold and Johnson (1910, p. 105) reported that the spring was used extensively by cattlemen and sheepherders and, as shown by the drawings and artifacts in the vicinity, was known to the Indians before the settlement of the area. At the present time the spring is used for watering stock.

The water from the spring at 29/21–33E is a sodium magnesium sulfate water containing 2,830 ppm of dissolved solids. The water issues from an outcrop of siliceous shale of middle Miocene age (Kundert, 1955). It is used for watering stock.

GROUND WATERS

With few exceptions the waters from wells in the Avenal-McKittrick area are consistent in chemical character but inconsistent in concentration of mineral matter. The typical wells yield sodium sulfate waters or sulfate waters of intermediate cation composition. Concentrations of dissolved solids range from 477 ppm in the water from well 22/19–19J1 in the northern part of the area east of Kettleman Hills to 7,040 ppm in the water from well 26/18–27F1 near the south flank of Antelope Valley. The range in hardness is reflected by that of the water in these same wells, 30 and 3,020 ppm, respectively. Boron content ranges from 0.3 ppm in the water of well 25/18–34R1, drilled in sandstone of Eocene age, to 11 ppm in well 26/18–11K1, a salt-water well less than 2 miles southeast near an outcrop of Eocene sediments. More critical for agriculture is the fact that of the 97 samples analyzed for boron only 12 had less than 1.0 ppm, 43 had 1.0 to 2.0 ppm, and 42 had more than 2.0 ppm.

KETTLEMAN CITY SUBAREA

Three wells in secs. 19 and 20, T. 22 S., R. 19 E., east of Kettleman Hills, yield high-sodium waters that differ greatly in anion composition (pl. 5). These waters range from the bicarbonate to the sulfate bicarbonate type and include a chloride water from well 22/19–20Q1 (fig. 9). The sodium exceeds 80 percent of the cation total in all the wells.

Owing to lack of information on the depths of wells in this subarea, it is difficult to evaluate the marked differences in water quality. Well 22/19–20Q1 not only yields a chloride water but also yields the warmest water of the group of wells, suggesting that it may be deeper than the other wells and, hence, may be producing water from a deep zone not tapped by the other wells.

KETTLEMAN PLAIN

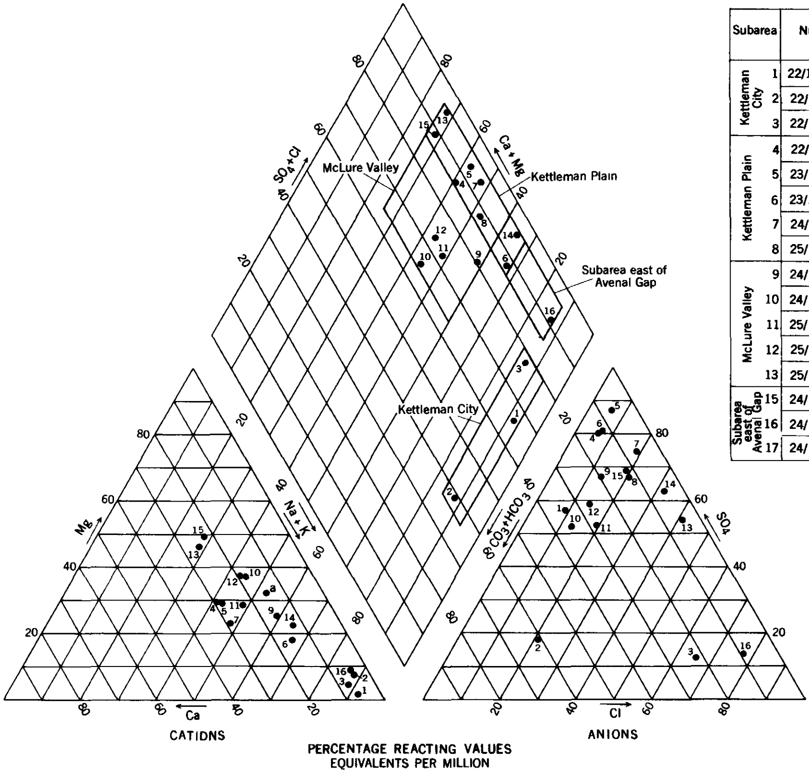
All ground-water analyses available for the Kettleman Plain subarea show sulfate waters, in which the concentration of dissolved solids ranges from 1,090 ppm in the water of well 23/18–30A1 to 2,270 ppm in the water of well 25/19–6D2. As shown on figure 9, sulfate exceeds 65 percent of the anion total in typical samples. Sodium, the predominant cation, ranges from 40 to 65 percent of the cations in typical waters. Among the other cations, magnesium generally is present in slightly greater quantities than calcium and is expressed as equivalents per million.

The high sulfate content of the ground waters probably reflects recharge from the hill areas to the east and west of Kettleman Plain, which are underlain chiefly by marine and continental deposits of Tertiary age and by continental deposits of early Quaternary age. The high percent sodium of the well waters are compared to that of typical stream waters of the Avenal-McKittrick area (fig. 8) is characteristic of most of the ground waters of the area. Presumably the high percent sodium is the result of cation exchange between the ground waters and the sediments in which they occur.

McLURE VALLEY

Wells in McLure Valley yield sulfate-type waters that have a range in concentration of dissolved solids from 849 ppm in the water from well 25/18–5J2, in the south-central part of the valley, to 4,900 ppm in the water of well 25/18–3N2, just west of Dagany Gap near an area where ground water formerly rose to discharge at the land surface. However, most of the waters contain less than 1,400 ppm.

As shown in figure 9, the typical waters contain sulfate in the proportion of more than 50 percent of their total anions, although the proportion of sulfate is lower than in the ground waters of



Subarea		Number	Date	Dissolved solids (ppm)	Depth or perforated interval (feet)
Kettleman City	1	22/19-19J1	1-6-54	477	241-487
	2	22/19-20P1	8-13-51	584	
	3	22/19-20Q1	8-12-51	1342	
Kettleman Plain	4	22/17-26E1	1-20-54	1720	417
	5	23/18-6D1	10-5-55	1504	303
	6	23/18-30A1	10-5-55	1089	200
	7	24/18-11	5-20-30	2018	119
	8	25/19-6D2	8-13-53	2270	
McLure Valley	9	24/17-11P1	10-11-55	1330	300
	10	24/18-30B1	3-21-50	882	150-300
	11	25/18-5J2	4-29-53	849	
	12	25/18-3E1	7-27-55	1160	303
	13	25/18-3N2	8-13-53	4900	
Subarea east of Avenal Gap	15	24/19-11G1	10-19-55	4971	
	16	24/19-12K1	5-12-52	2197	279
	17	24/19-12N1	5-12-52	3341	

FIGURE 9.—Geochemical graph of typical ground waters in Avenal-McKittrick area.

Kettleman Plain. In cation composition the waters range from sodium to sodium magnesium; magnesium exceeds calcium in all samples.

McLure Valley ground waters, with a relatively high proportion of sulfate, differ from the water of Avenal Creek (table 9; pl. 5; fig. 8), in which bicarbonate is the principal anion. This difference is difficult to explain as Avenal Creek is the principal stream discharging into McLure Valley and presumably is the principal source of recharge to the ground-water body. Aside from the possibility that the two analyses for Avenal Creek shown in table 9 are not representative of the average chemical quality of the water of the creek, the most likely explanation is that unsampled local tributary runoff may dilute the waters of Avenal Creek with water of sulfate content high enough to make the average blend a sulfate composition. Another possibility is that the alluvium contains soluble sulfate salts. The bicarbonate contribution of Avenal Creek definitely is shown by the composition of the ground waters of McLure Valley, which contain proportionally more bicarbonate and less sulfate than the ground waters of Kettleman Plain across Pyramid Hills to the east. As in the waters of Avenal Creek, magnesium is present in significant concentrations, although in most waters sodium is the predominant cation. The high-sodium content presumably is the result of cation exchange with the sediments or of solution of alkali salts.

SUBAREA EAST OF AVENAL GAP

Two of the three wells (pl. 5; fig. 9) immediately east of Avenal Gap yield sulfate waters of sodium or magnesium sodium composition. Well 24/19–12N1 yields a sodium chloride water containing 3,340 ppm of dissolved solids. The sulfate waters range in concentration of dissolved solids from 2,200 ppm in the water of well 24/19–12K1 to 4,970 ppm in the water of well 24/19–11G1. Among the other principal anions the chloride, in equivalents per million, exceeds the bicarbonate by 1½ to 6 times (table 8).

Although sodium is the predominant cation in most of the well waters, magnesium averages 30 percent of the cation total in the 6 waters analyzed; in the water of well 24/19–12K1 its content exceeds that of sodium, making up almost 50 percent of the cation total.

As indicated by the water-level contours on plate 3, subsurface inflow of water through Avenal Gap probably is the principal source of replenishment to ground water in this subarea, although surface flow may contribute recharge in times of heavy runoff. Hence, the quality of the water yielded by wells east of Avenal Gap is of interest. The generally higher mineral content of these ground waters compared to that of ground waters west of Avenal Gap in Kettleman Plain implies one of two possibilities: (1) that an increase in mineral content occurs as the ground waters move through the gap, presumably as a result of solution of mineral matter present in the deposits through which the water moves, or (2) that waters of inferior quality are supplied by minor accretions from the older rocks and deposits underlying Avenal Gap and Kettleman Hills. The relatively high proportion of magnesium among the cation radicals suggests further that the greater part of the water passing through Avenal Gap originated in the drainage basin of Avenal Creek rather than in the drainage tributary to Kettleman Plain.

The sodium chloride water reported from well 24/19–12N1 (depth not known) evidently comes from a different zone than that tapped by other wells in the vicinity. For the present, it is assumed to represent a deeper zone because highly concentrated chloride waters are tapped beneath fresh waters by water wells in Tulare Lake bed, about 10 miles to the north (Davis and others, 1959, p. 190).

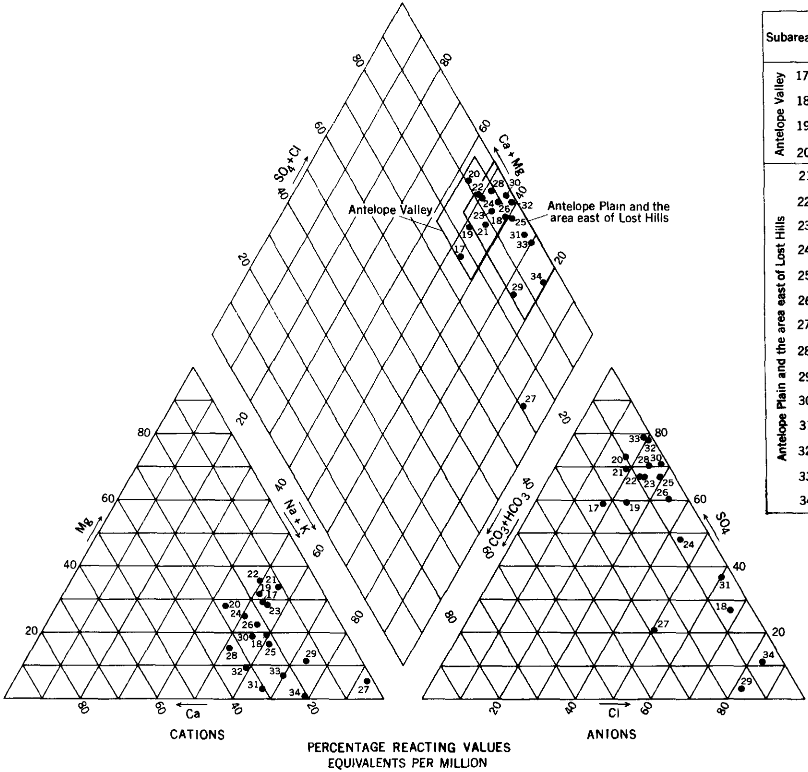
ANTELOPE VALLEY

Most of the wells in Antelope Valley yield sulfate waters that range in concentration from a little more than 1,000 ppm to more than 7,000 ppm (table 8). Except for the water from a few wells along the margins of the valley, the ground waters generally contain less than 2,000 ppm of dissolved solids. Well 26/17–11R1, in the northwestern part of the valley, yields water with the lowest mineral content, 1,250 ppm; well 26/18–27F1, near the south edge of the valley, yields water with the highest mineral content, 7,040 ppm. The mineral content of the latter well increased from 6,180 ppm in April 1953 to 7,040 ppm in August 1955. The reason for the increase is not known.

The typical ground waters are of the sulfate type, and sodium is the predominant cation (fig. 10). Among the other cations magnesium usually exceeds calcium, and among the anions chloride normally exceeds bicarbonate.

Along the margins of the valley several wells tap ground waters of high concentration. Well 26/18–27F1, mentioned above, in August 1955 yielded a sodium magnesium sulfate water containing 7,040 ppm of dissolved solids. The water of well 26/18–19B2, about 3 miles west of well 27F1 and also along the south edge of the valley, sampled in August 1954, was of sodium magnesium sulfate composition and contained 3,580 ppm of dissolved solids. Well 26/18–11K1, near the northern margin of the valley, when sampled at the discharge in January 1953, yielded a sodium chloride water containing 5,450 ppm of dissolved solids.

The relatively high proportion of sulfate in the ground waters of Antelope Valley evidently reflects the contribution of runoff from the sedimentary rocks of Tertiary age that flank the valley along its southern margin. The generally high percent sodium in the



Subarea		Number	Date	Dissolved solids (ppm)	Depth or perforated interval (feet)
Antelope Valley	17	26/17-11R1	8-4-54	1250	185
	18	26/18-11K1	1-30-53	5450	
	19	26/18-16J1	8-5-55	1470	
	20	26/18-27F1	4-21-53	6180	
Antelope Plain and the area east of Lost Hills	21	25/19-7M1	8-13-53	4170	383-1051
	22	25/19-20Q1	4-20-30	3454	501
	23	25/19-23B1	1-30-53	2480	130
	24	26/19-25M1	4-20-30	2354	363
	25	27/19-28H1	1-30-53	6500	920
	26	27/20-9C1	4-20-30	3863	149
	27	27/20-34G1	2-9-54	2848	460
	28	25/20-15Q1	8-3-54	2840	170
	29	25/20-35B1	5-25-54	2200	
	30	26/21-6F1	8-5-54	6950	
	31	26/21-26G1	8-4-54	4280	
	32	27/21-3A1	9-16-30	5041	300
	33	28/22-7Q1	3-13-45	4991	365
	34	29/23-18	11-30-1892	540	686

FIGURE 10.—Geochemical graph of typical ground waters in Avenal-McKittrick area.

ground waters presumably results from cation exchange between the ground waters and the containing sediments. Sulfate waters of high mineral content noted from wells 26/18–27F1 and 26/18–19B2 along the south edge of the valley may be representative of local slope runoff from the deposits of Tertiary age in that vicinity, whereas the sodium chloride water tapped by well 26/18–11K1 probably is of marine origin, either connate water contained in the deposits tapped by the wells or, possibly, water occurring in a fracture zone.

ANTELOPE PLAIN AND AREA EAST OF LOST HILLS

Antelope Plain is extensive and receives recharge from several drainage basins; accordingly, the ground waters have a considerable range in quality. The concentration of dissolved solids ranges from 2,480 ppm in well 25/19–23B1, at the north end of the plain, to 6,500 ppm in well 27/19–28H1, about 2 miles south of Bitterwater Creek along the southwest edge (table 8). However, most of the waters pumped from wells contain less than 4,500 ppm of dissolved solids.

As shown in figure 10, the typical ground waters of Antelope Plain are of sodium sulfate composition. Among the other cations magnesium generally exceeds calcium, and among the anions chloride generally exceeds bicarbonate.

A notable exception to the typical ground water of the area is the water yielded by well 27/20–34G1, near North Belridge (pl. 5). It is a sodium chloride water that contains 2,850 ppm of dissolved solids. Sodium makes up 93 percent of the cation total, and chloride, bicarbonate, and sulfate comprise 50, 29, and 21 percent, respectively, of the anions. The source of this anomalous water is not obvious, but the high proportions of sodium and chloride suggest a marine origin. Moreover, that the bicarbonate content is higher than the sulfate content suggests that sulfate reduction has occurred. In many respects this water is similar to oil-field brines described by Rogers (1919) from the Midway-Sunset oil field about 25 miles to the south. Well 27/20–34G1 is reported to be 460 feet deep and is less than 1 mile from the producing area of the North Belridge oil field. It seems likely, therefore, that this well taps reduced sediments similar in lithology to the oil-producing sediments of the North Belridge oil field.

Ground waters tapped by wells in the Lost Hills and the area to the east show a greater range in chemical character and concentration than those in other parts of the Avenal-McKittrick area (pl. 5). The range in mineral content as shown in table 8 is from 540 ppm in the water from well 29/23–18, at the railroad station at Lokern, to 6,950 ppm in the water from well 26/21–6F1, on the northeast flank of Lost Hills about 6 miles northwest of the town of Lost

Hills. However, most of the ground waters contain 2,000 to 5,000 ppm of dissolved solids. Although the normal waters are of sodium sulfate composition, chloride waters are found locally. The occurrence of sulfate chloride and chloride sulfate waters in some wells is indicative of mixed sources or possibly of vertical separation of water bodies which cannot be defined with the information available.

Two widely separated wells, 25/20–35B1, about 9 miles northwest of the town of Lost Hills, and 29/23–18 at Lokern, yield sodium chloride waters. The water from 25/20–35B1 contained 2,200 ppm of dissolved solids; sodium made up 73 percent of the cations and chloride 82 percent of the anions. In the water of well 29/23–18, which contained only 540 ppm of dissolved solids, sodium and potassium made up 79 percent of the cations and chloride 84 percent of the anions.

The sodium sulfate ground waters of this district appear to have the same origin as other sodium sulfate waters of the Avenal-McKittrick area; that is, they probably originated as sulfate waters derived from drainage areas in the Temblor Range underlain by Tertiary deposits, and the waters have become enriched in sodium by cation exchange reaction with the sediments of the valley. The chloride waters may be of marine origin, or they may be waters in which concentration by evaporation at the land surface had occurred before entrapment. Waters of proportionally high chloride content that originated as evaporation residues are known from several other areas in the San Joaquin Valley (Davis and others, 1959, p. 175). A marine source appears most likely for chloride waters near Lost Hills, as marine sediments are found at shallow depth on the Lost Hills anticline (Scouler, 1952, p. 164). In fact, the discovery well of the Lost Hills oil field, drilled in 1910 in sec. 30, T. 26 S., R. 21 E., as a water well, penetrated oil in marine deposits at a depth of 472 feet.

Waters in which bicarbonate makes up a substantial percentage of the anions, tapped by wells in the axial part of the San Joaquin Valley, probably indicate recharge from the east side of the valley. Both the streams and ground waters of the east side are characterized by proportionally high bicarbonate content.

QUALITY OF GROUND WATER AS A LIMITING FACTOR IN THE UTILIZATION OF THE GROUND-WATER BASINS

Solutions to problems of utilizing ground-water supplies and storage are beyond the scope of this report and beyond the scope of the basic data available in 1955. The following paragraphs outline some of the problems that must be considered in the planning for the efficient use of any imported water and the ground water in the Avenal-McKittrick area.

The chemical quality of the ground waters in the Avenal-McKittrick area may limit the future development and utilization of ground waters in the area. At present ground water is not available in suitable quality or quantity for irrigation throughout a large part of the area. Plans have been proposed by both the Federal Government (U.S. Bureau of Reclamation, 1955) and the State of California (California State Water Resources Board Bull. 3, pl. 6) to import water to the area. Under such proposed development the efficient use of the ground-water supply of the area is important to the success of the project.

If the several ground-water reservoirs in the area can be utilized effectively for the storage of imported water ,then it would be economically advantageous to use these reservoirs to balance fluctuations in the ground-water and surface-water supplies. On the other hand, if the utilization of the ground-water reservoirs for this purpose is not feasible, then imported water would have to be used to furnish most of the supply to the area. Imported irrigation water applied in excess of plant needs probably would cause a general rise of the water table, which in turn eventually would require local remedial drainage works. Because of the generally high mineral content of the ground waters, a careful and detailed evaluation of the quality of the ground waters would be essential to any detailed planning of water projects.

Systems for classifying waters in terms of their effects on soils and growing crops have been proposed by Schofield (1936), by the U.S. Salinity Laboratory (1954), by Wilcox (1948), by Thorne and Thorne (1951), by Doneen (1954), and by the California Water Pollution Control Board (1952). In using these methods for classifying ground waters of the Avenal-McKittrick area, it was determined that, according to most of the classifications, most of the waters were in the doubtful to unsuitable class.

Locally, as at Kettleman Plain, McLure Valley, and Antelope Valley, the ground water evidently is suitable for irrigation, as it has been the only supply to lands irrigated in these areas for 10 to 20 years. However, the lack of irrigation development in most of the area, despite the fact that the soils generally are suitable for cultivation, testifies to the unavailability of suitable ground-water supplies for irrigation. Sporadic efforts to obtain water suitable in quality for oil-well drilling generally have been unsuccessful. Intensive exploration of the undeveloped areas might reveal some bodies of ground water suitable for irrigation use, similar to water tapped by wells in the presently developed areas. However, the high mineral content of most of the ground waters pumped from the scattered stock and industrial wells in the areas not under irrigation (table 8) precludes their use for domestic and irrigation supplies.

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The critical problems concerning water quality are whether the ground waters, which in large areas are of marginal to inferior quality, can be utilized with their present mineral content, whether they can be improved to a level suitable for use, and whether the ground-water reservoirs can be utilized for storage of imported water without serious deterioration in the quality of the water stored. Even in areas where the native ground water is unsuitable for irrigation, it might prove feasible to blend imported surface water and native ground water to obtain a usable supply. In addition to blending these waters before application for irrigation, it might be feasible to apply irrigation water of low mineral content in excess quantities so that deep penetration might dilute an inferior native ground water to such concentration that the blend could be utilized.

In any consideration of the utilization of ground-water storage, it will be necessary to consider the probability that water spread for recharge or applied for irrigation will become more concentrated owing to leaching of salts from the soil. In order to maintain a proper salt balance, adequate provision for drainage will also be essential in any plan for the area.

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BASIC DATA

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*

Well locations shown on plate 1; for explanation see text.
Type of well and casing diameter: P, drilled by percussion method; R, drilled by rotary method; D, dug; G, gravel packed.
Type of pump and power: L, lift; T, deep-well turbine; S, deep-well submersible turbine; J, jet; C, centrifugal; a airlift; d, diesel engine; g, gasoline engine; ng, natural gas engine; w, wind; numbers indicate rated horsepower of electric motor.
Use: D, domestic; S, stock; U, unused; I, irrigation, Ind, industrial.
Discharge-drawdown and depth to water: a, pumping level; b, owner's report; c, driller's log; d, pump-station record; e, driller's report; f, measurement by California Department of Water Resources; g, F. M. Eaton (1935, p. 80, table 35).
Other data available: C, chemical analysis shown in table 8; L, driller's log; E, electric log.

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
22/17- 26E1	....	Wayne ranch...	....	755	417	P, 10	L, 3	D, S	....	....	....	....	....	....	....	C	No access.
28F1	576	Union Oil Co., Tar Canyon pump station.	....	787	....	P	....	Ind	....	....	....	....	....	....	....	....	Do.
18- 32N1	....	O. E. Evans....	1920	702	300	P, 8	L, g	S	....	....	....	....	....	....	....	....	Do.
19- 19J1	....	Standard Oil Co., 19R–W7.	1934	268	487	16–12	S	Ind	....	....	....	....	....	....	77	L, C	No access, perforated interval 241–487 ft.
20N1	....	O. Friend.......	....	263	....	P, 6	J, 5	D	....	....	....	....	....	....	....	....	No access.
20N2	8932	.....do.........	....	264	....	14	T, 50	I	....	....	Hole in pump base, west side.	1	3– 8–51	a250+	78	C	
20P1	8293	.....do.........	....	244	....	R, G, 12	T, 50	I	....	....	Top casing...	0	3– 8–51	a160	77	C	
20Q1	8727	.....do.........	....	214	....	R, G, 14	T, 60	I	....	....	.....do........	1	3– 8–51	a220.0	80	C	

20Q2	8572	do	....	221	....	R, G, 14	T, 50	I	....	....	do	2	3– 8–51	a140	....	C	
30A1	8265	do	1944	265	323	R, 8	J, 5	D	....	....	do	1	3– 8–51	141.1	....	....	
													4–10–57	165.5			
30B1	....	do	....	287	192	R, G, 10	....	U	....	....	do	1	3– 8–51	221.1	....	....	
													4–10–57	....	....	....	Plugged or dry at 197 ft.
30B2	....	do	....	287	....	12	....	U	....	....	Hole in casing, northeast side.	1	3– 8–51	172.7	....	....	
30B3	....	do	....	295	140	R, G, 10	....	U	....	....	Top casing	....	3– 8–51	Dry	....	....	Measured depth 140 ft, 1951.
23/17- 12Q1	....	....	....	680	218	P, 8	....	U	....	....	do	0	10– 4–55	Dry	....	....	Measured depth 218 ft, 1955.
14E1	....	....	....	830	....	P, 14	L, g	S	....	....	....	....	9–14–50	b220	....	....	No access.
18- 6B1	....	O. E. Evans	....	678	300	R, 6	L, g	U	....	....	....	....	Spring, 1954	b211	....	....	Do.
6D1	....	do	1920	671	303	P, 12	L, g	D, S	....	....	....	....	Sept., 1949	b213	....	C	Do.
8Q1	....	....	....	582	....	P, 8	L, w	U	....	....	....	....	Spring, 1954	b201	....	....	
													10– 4–55	Dry	....	....	Obstruction at 106 ft.
20N1	....	Morris	....	544	....	P, 8	L, g	U	....	....	....	....	....	....	....	....	No access.
21D1	....	Standard Oil Co.	1946	530	920	R, G, 26; 16, 12	....	U	c650	165	Top casing	0	Jan., 1946	c85	....	L	Perforated interval 192–618 ft.
													10– 4–55	89.5	....	....	
													5– 8–56	89.57	....	....	
22D1	....	....	....	580	250	P, 8	L, g	S	....	....	....	....	....	....	....	....	No access.
27M1	....	....	....	497	....	P, 8	L, g	S	....	....	Hole in casing, north side.	1	7–12–51	68.1	....	....	Not in use.
													10– 4–55	68.1	....	....	
													4–10–57		....	....	Obstruction at 71 ft.
29E1	....	Tidewater Associated Oil Co., Reef pump station 1.	1910	560	426	P, 10	L, a	Ind	d31	....	Top casing	0	7–22–10	d129	....	L	
									d38	....	....	....	11–28–25	....	....	....	
													6–24–27	d144	....	....	
									d14	....	....	....	6–28–28	d174	....	....	Measured depth 354 ft, 1928.
													4–12–29	d146	....	....	
													4–23–34	d148	....	....	

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
23/18-29E1									d38	...	...	...	7–28–37	...	...	...	
									d...	16	...	...	9– 5–49	d137	...	...	
													10– 5–54	d139.7	...	...	
													10– 5–55	139.3	...	...	
													5– 8–56	139.25	...	...	
													4–10–57	134.6	...	...	
29E2	...	Tidewater Associated Oil Co., Reef pump station 2.	1910	560	364	P, 10	T, 5	Ind	...	...	Top casing...	0	1910	d126	...	L, C	Airlift pump used before 1950.
									d34	...	...	...	11–25–25	d154	...	...	Measured depth 346 ft, 1925.
									d...	33	...	...	6–24–28	d142	...	...	
													4–12–29	d158	...	...	
													6– 8–29	d137	...	...	Measured depth 344 ft, 1929.
													9–13–32	d132	...	...	
									d42	...	...	...	4–23–34	d159	...	...	
											Hole in pump base, east side.	1	10– 5–55	139.2	...	...	
30A1	...	Mrs. R. L. Reed	...	560	200	P, 8	L, 1	D, S	...	...	...	...	...	...	75	C	No access.
30B1	...	...do...	...	595	...	P, 10	...	U	...	...	Top pump column.	2	7–12–51	147.5	...	...	Do.
													4–10–57	...	...	...	

													10– 5–55	162			
													5– 8–56	155.61			
32L1				580		P, 8		U			Top casing	1	7–12–51	Dry at 118 ft.			Obstruction at 40 ft, Oct. 5, 1955.
32N1				610		P, 7		U									Obstruction at 130 ft, Oct. 5, 1955.
19- 11D1		O. Friend		220	360	P, 8	L, w	S			Top casing	2	9–13–50	33.8		C	
													6–12–51	32.5			
													10–18–55	34.2			Natural gas forcing spurts of water out discharge pipe.
													5–21–56	35.18			
													4– 9–57	35.3			
11D2		do		223		P, 12	T, ng	S			do	0	6–12–51	35.8			Too salty for irrigation.
													10–18–55	42.7			
													5–21–56	38.59			
12J1				207		12		U			do	4	9–13–50	22.9			
													6– 8–51	24.2			
													10–18–55	30.2			Gas bubbling in water.
													5–21–56	29.84			
													4– 9–57	30.5			
13Q1				228		P, 8	L	U			do	1	10–18–55	41.4			
													5– 8–56	41.17			
													4– 9–57	43.2			
14R1				235		P, 10		U			do	1	7– 7–51	41.2			Measured depth 59 ft, 1955.
													10–18–55	42.2			
													5– 8–56	42.13			
													4– 9–57	41.8			
24F1				238		P, 12		U									Obstruction at 20 ft.
24N1				245		P, 8		U			Top casing	1	6– 7–51	52.2			Measured depth 57 ft, 1955.
													10–18–55	50.9			
													5– 8–56	60.98			

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
23/19- 24N1													4– 9–57	51.9	....	....	
24R1	......	....	......	243	......	P, 4	......	U	....	....	....	......	....	....	....	....	Obstruction at 43 ft, 1951.
26J1	......	....	......	255	......	P, 8	......	S	....	....	Top casing..	1	10–18–55	64.4	....	....	
													5– 8–56	64.31	....	....	
													4– 9–57	63.0	....	....	
26M1	......	A. Ball........	......	267	......	P, 6	L, w	S	....	....	.....do.......	0	6– 7–51	73.9	....	....	
													4– 9–57	72.8	....	....	
													10–18–55	75.6	....	....	
													5– 8–56	a78.05	....	....	
20- 19B1	......	....	......	229	......	P, 6	......	U	....	....	....	......	....	....	....	....	Measured depth 40 ft, 1951.
19J1	......	....	......	237	......	P, 8	......	U	....	....	Top casing..	0	10–18–55	42.5	....	....	Measured depth 43 ft, 1955.
30N1	......	....	......	254	......	P, 10	......	U	....	....	.....do.......	.5	6– 5–51	59.7	....	....	Measured depth 60 ft, 1955.
													10–18–55	Dry	....	....	
30Q1	......	....	......	247	......	P, 6	L, g	S	....	....	....	......	....	....	....	....	No access.
31Q1	......	....	......	253	......	P, 8	L, g	S	....	....	....	......	....	....	....	....	Obstruction at 52 ft, 1955.
34L1	......	....	......	214	......	4	......	U	....	....	Top casing..	1	6– 8–51	Dry	....	....	Measured depth 76 ft, 1951.

24/17-11P1		Avenal ranch		765	300	P, 10	L, g	S								C	No access.
13J1				725				U			Land surface	0	10–11–55	72			No casing, measured depth 130 ft, 1955.
													5–22–56	72.69			
													4– 8–57				Destroyed.
15A1		Avenal ranch		785	150	D, 36		U									Filled with junk.
22D1		do		950	100	P, 8	L, w	S			Top casing	1	10–11–55	70			Falling water.
22F1		do	1951	875	90	P, 14	L, w, g	S							73		No access.
23A1				740	200	P, 8		U			Top casing	1	7–17–51	165.6			
													10–11–55	190			
													5–23–56	192.56			Abandoned.
													4–10–57				
23F1				770		P, 8	L, g	D, S									No access.
23G1				750		D		U									Measured depth 53 ft, 1951.
24A1				730	1,100	P, 12	L, g	S			Top 4 by 6 in. beam, east side pump base.	3	7–17–51	179.7			
													10–11–55	205.8			
													5–23–56	206.26			
25B1	8483	Orchard ranch		700		16	T, 100	I			Top casing	1	5–31–51	169.9			
25D1	9383	Orchard ranch, 10.	1951	715	340	P, 12	T, 40	I	b334	17	do	2	10– 5–54	b207		L	Casing set at 218 ft, perforated interval 100–218 ft.
													10–10–55	111.8			
													5–23–56	213.9			
													4– 8–57	229.4			
25E1		Orchard ranch		720	200	P, 8		U			do	1	10–11–55	149.2			
													5–23–56	158.08			
25H1		Orchard ranch, 2.		690		16	T, 60	I					5–31–51				No access.
							T, 50	I					10–11–55				
25M1		Orchard ranch		720	150	P, 8	L, 1	D, S			Top 4 by 6 in. beam, north side pump base.	2	7–18–51	a105.2	73		
													10–11–55	102.9			

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
24/17-25M2		Orchard ranch		720	150	P, 14	S, 1	D, S	b12								No access.
25P1		do		710		P, 8		U			Top casing	3	7-18-51	113.4			
													10-11-55	126			
													5-23-56	130.38			
													4- 8-57	130.5			
26R1		do	1951	720	704	R, 12					do	1	7-18-51	114.0		E	Destroyed before 1955.
34R1				860		D					Top wood curbing.	0	7-18-51	19.0			Do.
35B1		Orchard ranch		755	192	P, 8	L, g	S	b15-20		Top 4 by 6 in. beam, south side pump base.	1	6-24-50	b91			
													7-17-51	90.3			
													10-11-55	97.3			
													5-23-56	96.25			
													4- 8-57	95.5			
35B2		do		755	192	P, 8	L, w	S	b15-20		Top 4 by 6 in. beam, west side pump base.	1	6-24-50	b91			
													7-17-51	93.9			
													10-11-55	109.8			
													5-23-56	108.61			

													4- 8-57	99.9	....	....	
18- 5D1	....	....	....	610	150	D, 48	....	U	....	....	Top wood platform.	0	7-12-51	Dry	....	....	
													10- 5-55	Dry	....	....	
11D1	....	H. M. Holloway Inc.	1950	470	....	R, 14	T, g	Ind	....	....	Top casing..	0	7-12-51	36.3	....	....	
													10- 5-55	36.5	....	....	
													5- 8-56	37.07	....	....	
													4- 9-57	36.8	....	....	
11G1	....	A. McPhaill....	....	438	....	P, 8	....	U	....	....	....do........	1	10- 5-55	24	....	....	Measured depth 26 ft, 1955.
11L1	....	....	....	450	....	P, 8	....	U	....	....	....do........	1	10- 5-55	34.6	....	....	Measured depth 62 ft, 1955.
													5- 8-56	34.9	....	....	
													4- 9-57	35.0	....	....	
13D1	....	A. McPhaill....	....	435	1,700	P, 12	L, w, g	S	....	....	....do........	0	7-12-51	25.7	....	....	Original depth about 1,700 ft; junk in hole about 800 ft; to be developed as an irrigation well if possible, 1955.
							T, g	....	....	....	....	....	10- 6-55	31.2	....	....	
													5- 8-56	30.9	....	....	
													4- 9-57	170.3	....	....	
13M1	....	....do....	....	432	....	P, 10	....	U	....	....	....	....	....	....	....	....	Plugged near land surface.
19P1	....	....	....	699	....	P, 8	....	U	....	....	....	....	....	....	....	....	Measured depth 35 ft, 1955.
19Q1	8843	P. Rowe........	....	698	300	P, 16	T, 75	I	....	....	Top casing..	1	10-10-55	225+	....	....	
19Q2	....	....do....	....	700	300	P, 16	....	U	....	....	....do........	1	10-10-55	241.9	....	....	
20N1	8278	....do....	....	676	300	P, 16	....	U	....	....	....	....	....	....	....	....	
20N2	....	....do....	....	676	....	P, 8	L, g	S	....	....	....	....	....	....	....	....	
20N3	8278	....do....	....	676	300	16	T, 40	I	....	....	....	....	....	....	....	....	
23J1	....	....	....	468	....	P, 10	....	U	....	....	....	....	....	....	....	....	Measured depth 106 ft, 1955.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
24/18- 24Q1	9127	J. B. Hill Co., 23.	....	457	....	G, 16	T, 50	I	....	.....	Top casing..	1	5—29—51	83.0	....	....	
													9—22—56	79.41	....	....	
													10— 6—55	86.3	....	....	
24R1	1189	J. B. Hill Co., Scott 3.	....	456	....	R, 16	T, 50	I	....	.....	.....do.........	0	5—29—51	a164.8	....	....	
													5—22—56	71.82	....	....	
25G1	8556	J. B. Hill Co., Scott 5.	....	471	....	P, 16	T, 30	I	....	.....	Top 8 by 8 in. pump support, west side.	1	7—19—51	a158	74	....	
													5—22—56	112.7	....	....	
25H1	927	J. B. Hill Co., Scott 1.	....	470	....	P, G, 14	....	U	....	.....	Top casing..	0	10— 6—55	96.5	....	....	Measured depth 110 ft, 1955.
25J1	1131	J. B. Hill Co., Scott 4.	....	470	....	16	T, 2	D	....	.....	.....do.........	1	5—29—51	a104.8	....	....	
													10— 6—55	97.2	....	....	Well 24-19-30M1 pumping.
25J2	1273	J. B. Hill Co., Scott 2.	....	471	....	16	T, 50	I	....	.....	.....do.........	2.5	5—29—51	a126.0	73	....	
29D1	8278	P. Rowe.........	....	676	....	P, 10	T, 15	I	....	.....	....	......	....	....	....	....	No access. Well not in use.
29D2	9136	.....do...........	....	675	300	16	T, 75	I	....	.....	Top casing..	.5	5—31—51	197.7	....	....	

29N1	8310	....	....	655	....	10	T, 3	D	....	....	....	.....	....	....	....	....	No access.
30B1	8669	Orchard ranch, 7.	1948	685	540	P, 16	T, 100	I	c1780	16	....	.....	10–12–48	c137.5	....	L, C	No access. Cased to 300 ft, perforated interval 150–300 ft.
							T, 100	I	....	....	....	.....	June, 1950	c173.6	....	....	
							T, 60	I	....	....	....	.....	10–10–55	....	....	....	
30C1	484	Orchard ranch, 5.	....	695	....	P, 16	....	U	....	....	Top casing ..	1	5–31–51	192.4	....	....	
													10–10–55	245	....	....	
													5–23–56	237.92	....	....	
30D1	8299	Orchard ranch, 3.	1946	699	453	P, 16	T, 100	I	1450	21	.....do.........	1	8–26–46	c103	76	L	
							T, 100	I	....	....	....	.....	5–31–51	184	....	....	
							T, 75	I	495	89	....	.....	10– 5–54	b249	....	....	
													5–23–56	222.78	....	....	
													4– 8–57	224.1	....	....	
30F1	8321	Orchard ranch, 8.	1941	680	628	R, 16–14	T, 100	I	c1575	....	....	.....	2–24–51	c163	....	L	Perforated interval 199–639 ft.
									b975	105	....	.....	....	....	....	....	
													10– 5–54	b218	....	....	
													5–23–56	177.75	....	....	
30P1	....	Orchard ranch, 4.	....	675	....	16	....	U	....	....	Top casing ..	1	5–31–51	142.9	....	C	
													10–10–55	167.8	....	....	
													5–23–56	167.19	....	....	
													4– 8–57	171.1	....	....	
30P2	....	Orchard ranch, 11.	1953	675	400	14	....	U	b500	....	.....do.........	1	10–15–53	b164	....	L	Perforated interval 200–400 ft; well never used.
													10–10–55	175.4	....	....	
													5–23–56	168.01	....	....	
32D1	8227	Orchard ranch, 1.	....	652	....	12	....	U	....	....	.....do.........	1	10–10–55	203.5	....	C	Well 32D2 pumping. Perforated interval 183–514 ft.
													5–22–56	202.25	....	....	

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
24/18- 32D2	8227	Orchard ranch, 9.	1951	652	525	R, 16–12	T, 75	I	....	....	Top casing..	1	5–31–51	161.2	74	L	
33K1	8510	J. B. Hill Co...	....	620	....	....	......	.....	....	....	....	.....	....	....	....	.....	Destroyed.
33M1	8661	J. B. Hill Co., 17.	....	630	....	16	T, 50	I	....	....	Top casing..	.5	5–31–51	a180+	....	.....	
													5–22–56	194.14	....	.....	
													4– 8–57	....	....	.....	Obstruction at 213 ± ft.
33M2	8755	J. B. Hill Co., 18.	....	630	....	16	T, 40	I	....	....	.....do........	0	5–31–51	a140+	73	C	
													Mar., 1956	f199.1	....	.....	
33N1	8753	J. B. Hill Co., 21.	....	625	295	14	T, 50	I	....	....	.....do........	2	5–30–51	a200+	74	C	
													10–29–51	e154	....	.....	
													5–22–56	186.36	....	.....	
													4– 8–57	200.0	....	.....	
33N2	8754	J. B. Hill Co., 22.	....	630	....	16	T, 50	I	....	....	.....do........	.5	5–30–51	154.3	...	.....	
33N3	8752	J. B. Hill Co., 20.	....	625	....	16–12	T, 25	I	....	....	.....do........	1	5–30–51	a163.0	....	.....	Casing collapsed 221 ft.
													2–23–55	e179	....	.....	
33P1	8751	J. B. Hill Co., 19.	....	620	....	16	T, 25	I	....	....	.....do........	1	5–30–51	a175.6	....	.....	
33Q1	8508	J. B. Hill Co., 14.	....	615	....	16	T, 40	I	....	....	.....do........	0	10– 7–55	200.6	....	.....	

33Q2	8507	J. B. Hill Co., 13.	...	615	...	16	T, 30	I	...	...	do	1	5-30-51	a170.4	74	C	
													5-22-56	179.39	...	...	
33Q3	8506	J. B. Hill Co., 16.	...	615	320	14	T, 50	I	...	...	do	.5	5-31-51	168.1	75	...	
													3- 5-55	e190	...	...	
33Q4	8509	J. B. Hill Co., 15.	...	610	...	16	...	U	...	...	do	0	5-30-51	164.8	...	...	
													5-22-56	184.8	...	...	
													10- 7-55	197.9	...	...	
36J1	9474	J. B. Hill Co., 36.	...	495	...	R, 18	T, 50	I	...	...	...	...	...	...	77	...	
36P1	9480	J. B. Hill Co., 35.	...	508	...	R, 16	T, 100	I	...	...	...	...	5-22-56	172.98	80	...	
19- 1D1	...	J. B. Hill Co.	...	282	...	P, 6	...	...	...	...	Top casing	1	6- 7-51	19.5	...	...	Destroyed before 1955.
1E1	...	do	...	286	...	P, 4	...	...	...	...	...	...	...	...	...	...	Do.
1M1	...	do	...	287	...	P, 10	...	...	...	...	Top casing	0	6- 7-51	Dry	...	...	Measured depth 66 ft, 1951. Destroyed before 1955.
1M2	...	do	...	287	...	P, 6	L, g	S	...	...	...	...	...	...	...	...	Destroyed before 1955.
2L1	9511	J. B. Hill Co., W. C. 6.	...	298	704	R, G, 16	...	U	...	...	Top casing	2	10-19-55	68.7	...	C	
													5- 8-56	68.8	...	...	
2Q1	9510	J. B. Hill Co., W. C. 5.	...	300	...	R, 16	T, d	I	...	...	do	1	10-19-55	98.8	...	C	
													5- 8-56	98.28	...	...	
10P1	...	...	...	330	...	P, 10	L, w	S	...	...	do	1.6	6- 8-51	25.0	...	...	
													8- 2-51	25.0	...	...	
													10-19-55	25.3	...	...	Measured depth 100 ft, 1955.
													5- 8-56	25.4	...	...	
													4- 9-57	25.4	...	...	
11C1	...	...	...	304	...	P, 10	L, w, g	S	...	...	do	0	6- 7-51	94.2	...	...	Obstruction at 90 ft, 1955.
11G1	...	J. B. Hill Co.	...	305	...	R, 16	L, g	S	...	...	do	1	10-19-55	94.4	...	C	

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point		Water level		Temperature (°F)	Other data	Remarks
											Description	Distance above or below (-) land surface (feet)	Date measured	Depth to water below land-surface datum (feet)			
24/19- 11Q1	...	J. B. Hill Co...	...	310	...	P, 10	...	U	...	...	Top casing..	1	6- 7-51	Dry	...	...	Measured depth 52 ft, 1955.
12E1	9507	J. B. Hill Co., W. C. 2.	...	292	...	R, 16	...	U	...	...	...do...	1	10-19-55	92.0	...	...	
													5- 8-56	91.0	...	...	
12G1	...	J. B. Hill Co...	...	274	...	P, 10	L, g	S	...	...	Top 4 in. pump colum.	8	6- 8-51	77.8	...	...	
													5- 8-56	76.8	...	...	
12K1	9509	J. B. Hill Co., W. C. 4.	...	279	...	R, G, 16	...	U	...	...	...	...	...	...	...	C	
12Q1	9508	J. B. Hill Co., W. C. 3.	...	280	...	R, G, 16	...	U	...	...	Top casing..	1	10-19-55	82.4	...	C	
													5- 8-56	81.78	...	...	
12N1	9506	J. B. Hill Co., W. C. 1.	...	287	...	D, 14	...	U	...	...	...do...	0	10-19-55	90.1	...	C	
													5- 8-56	89.33	...	...	
													4- 9-57	82.0	...	...	Unused owing to salt; pump removed.
13C1	...	J. B. Hill Co...	...	282	...	D, 4	...	...	...	...	...do...	1	6- 8-51	85.9	...	...	Destroyed before 1955.

15C1	...	...	...	330	...	P, 10	...	U	...	...	do	1.6	6– 8–51	25.1	...	...	Measured depth 31 ft, 1951.
													8– 2–51	25.5	...	...	
													10–19–55	Dry	...	...	Obstruction at 24 ft, 1955.
17P1	527	J. McGlashan..	...	387	...	P, 10	L, 1	D, S	...	...	do	10	10– 6–55	36	...	...	
													4– 9–57	...	...	...	No access.
18G1	...	...	...	407	...	P, 10	...	U	...	...	do	2	7–12–51	14.9	...	...	Measured depth 30 ft, 1955.
													10– 6–55	12.8	...	...	
												1.3	5– 8–56	12.9	...	...	
													4– 9–57	12.3	...	...	
23C1	...	...	...	307	...	P, 10	...	U	...	...	do	0	6– 8–51	89.4	...	...	Measured depth 94 ft, 1955.
													10–19–55	Dry	...	...	
27G1	...	...	...	395	...	P	L, w, g	S	...	...	do	0	6–12–51	121.9	...	...	No access 1955.
30M1	9484	J. B. Hill Co., 34.	...	470	...	R, 18	T, 125	I	...	...	do	1	5–22–56	119.69	77	...	
30 30N1	9499	J. B. Hill Co., 37.	...	483	...	R, 18	T, 100	I	...	...	do	2	10– 6–55	150.6	...	...	
													5–22–56	135.05	...	...	
20- 5D1	...	J. B. Hill Co...	...	247	...	P, 10	...	U	...	...	do	1	6– 8–51	52.7	...	...	Destroyed before 1955.
9K1	...	...	...	228	...	P, 10	...	U	...	...	do	0	6–18–51	32.9	...	...	Measured depth 102 ft, 1955.
													10–18–55	33.2	...	...	
													5–22–56	33.09	...	...	
													4– 9–57	32.2	...	...	Pump removed; open casing.
11P1	...	...	...	205	...	P, 4	...	U	...	...	do	.8	6–18–51	13.9	...	...	Measured depth 34 ft, 1955.
													10–18–55	13.8	...	...	
14C1	...	...	...	207	...	P, 4	...	U	...	...	do	0	6–18–51	15.6	...	...	
21N1	...	J. B. Hill Co...	...	233	...	P, 10	...	U	...	...	do	0	6–14–51	32.5	...	...	Measured depth 37 ft, 1951.
21N2	...	do	...	233	120	P, 6	J	S	...	...	...	...	...	...	...	...	No access.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
24/20-21P1	....	J. B. Hill Co.	....	232	....	P, 8	....	U	....	.....	....	.....	....	....	.....	....	Casing filled with rocks. Maximum depth reached 24 ft, 1951.
31K1	....	do	....	288	....	P, 10	L, g	U	....	.....	Top casing	0	6-14-51	83.9	.....	....	Measured depth 119 ft, 1951.
													10-20-55	83.8	.....	....	
													5-24-56	83.92	.....	....	
33G1	....	do	....	245	....	P, 4	....	U	....	.....	do	0	6-14-51	Dry	.....	....	Measured depth 45 ft, 1951. Destroyed before 1955.
33G2	....	do	....	244	....	P, 10	....	U	....	.....	do	1	6-14-51	48.0	.....	....	Measured depth 48.4 ft, 1951. Destroyed before 1955.
34E1	....	do	....	243	....	P, 8	....	U	....	.....	do	0	6-14-51	40.2	.....	....	Measured depth 24 ft, 1955.
34E2	....	do	....	243	120	P, 6	J, g	S	....	.....	do	2	10-20-55	39.3	.....	....	
													5-24-56	38.23	.....	....	
													4-9-57	38.8	.....	....	

21-19N1	....	....	....	208	....	P, 8	L, g	S	....	.....	.....do.........	.5	6–18–51	2.1	....	.....	Gas bubbling in water.
													10–21–55	....	....	.....	No access.
25/17- 1A1	....	Orchard ranch..	....	724	208	P, 8	L, g	S	....	.....	Top 4 by 6 in. beam, south side pump base.	1	7–17–51	137.3	....	.....	
													4– 8–57	178.3	....	.....	
									b15–20	.....	....	......	5–19–53	b150	....	.....	
1A2	....	.....do..........	....	724	240	P, 8	L, w	S	b15–20	.....	Top 4 by 6 in. beam, north side pump base.	1	May, 1950	b143	....	.....	
													7–17–51	139.8	....	.....	
													May, 1953	b150	....	.....	
													10–10–55	165.5	....	.....	
													5–23–56	165.01	....	.....	
1L1	....	Valley Pipeline Co., Cotton-wood station 3.	....	755	400	P, 12	L	D, Ind	....	.....	Top casing ..	1	7–18–51	111.5	....	.....	Cased to 300 ft.
									d5–12	40	....	......	Sept., 1954	d109	....	.....	
1L2	....	Valley Pipeline Co., Cotton-wood station 2.	....	755	150	P	L	D, Ind	....	.....	....	......	1950	d105	....	.....	
													7–19–54	d118	....	.....	
									d2.5–4	23	....	......	Sept., 1954	....	....	.....	
1P1	....	Valley Pipeline Co., Cotton-wood station 1.	....	765	....	P	....	......	....	.....	....	......	....	....	....	.....	Destroyed.
18- 1J1	8797	J. B. Hill Co., 26.	....	512	504	14–12	T, 40	I	....	.....	Top casing ..	1	5–29–51	a244	....	.....	Perforated interval 350–504 ft. Used as domestic well, 1955. No access, small submersible pump.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
25/18- 2N1	8283	J. B. Hill Co., 1.	....	560	....	P	T, 5	I	....	.....	Top casing..	0.5	5–30–51	19.4	68	C	
													Autumn, 1953.	f34.0	.....	.....	
													Spring, 1954.	f19.7	.....	.....	
													Spring, 1955.	f28.4	.....	.....	
													10– 7–55	23.3	.....	.....	
													Spring, 1956.	f27.7	.....	.....	
													5–22–56	25.56	.....	.....	
2N2	8283	J. B. Hill Co...	....	560	....	P, 14	....	U	....	.....	.....do..........	1	7–18–51	17.6	.....	.....	
													10– 7–55	22.1	.....	.....	
2R1	9461	J. B. Hill Co., 32.	....	536	....	R, 14	....	U	....	.....	.....do..........	0	Spring, 1955.	f30.0	.....	.....	
													10– 6–55	28.4	.....	.....	
													Mar., 1956	f21.7	.....	.....	
													5–22–56	25.05	.....	.....	
													4– 9–57	31.2	.....	.....	
3D1	8297	J. B. Hill Co., 12.	....	610	....	P, 14	T, 50	I	....	.....	.....do..........	0	5–30–51	a155.3	74	C	
													10– 7–55	170.0	.....	.....	

													5–22–56	172.15	.....	.....
3D2	8285	J. B. Hill Co., 9.	....	605	....	P, 14	T, 30	I	....	.....	....	.....	....	....	73	.....	No access.
3E1	8285	J. B. Hill Co., 11.	....	605	303	P, 14–12–10	T, 40	I	....	.....	Top casing..	0	5–30–51	a159.4	74	C	Casing set at 298 ft.
													10–26–51	e155	.....	.....	
													11–11–51	e148	.....	.....	
3E2	8285	J. B. Hill Co., 10.	....	605	....	P, 14	....	U	....	.....	.....do.........	0	10– 7–55	175.4	.....	.....	
3E3	8284	J. B. Hill Co...	....	600	....	....	....	.....	....	.....	....	.....	....	....	.....	.....	Destroyed.
3M1	8284	J. B. Hill Co., 6.	....	600	....	P, 14	....	U	....	.....	Top casing...	1	5–30–51	136.6	.....	.....	
													10– 7–55	168.7	.....	.....	
													5–22–56	154.89	.....	.....	
3M2	8287	J. B. Hill Co., 4.	....	599	....	P, 14	T, 30	I	....	.....	.....do.........	0	5–30–51	a140.4	76	C	
3M3	8284	J. B. Hill Co., 7.	....	595	352	P, 14–12	T, 20	I	....	.....	.....do.........	0	5–30–51	a203.1	73	C	14-in. casing set at 182 ft, 12-in. casing 182–352 ft.
													Spring, 1954.	f174.8	.....	.....	
													2–28–55	e158	.....	.....	
													Mar., 1956	f169.7	.....	.....	
3M4	8287	J. B. Hill Co., 2.	....	595	....	P, 14	....	U	....	.....	.....do.........	1	7–18–51	132.7	.....	.....	
													10– 7–55	154.5	.....	.....	
													5–22–56	146.3	.....	.....	
3M5	8287	J. B. Hill Co., 5.	....	595	....	P, 16	....	U	....	.....	.....do.........	0	5–30–51	122.8	.....	.....	
													10– 7–55	143.5	.....	.....	
3N1	8287	J. B. Hill Co., 4.	....	590	....	G, 16	....	U	....	.....	.....do.........	1	7–18–51	117.7	.....	.....	
													10– 7–55	138.0	.....	.....	
													5–22–56	130.69	.....	.....	
													4– 9–57	143.4	.....	.....	
3N2	8287	J. B. Hill Co., 3.	....	590	....	P, 14	L, 1	Ind	....	.....	.....do.........	3	7–18–51	114.9	77	C	
													Autumn, 1953.	f101.9	.....	.....	
													Spring, 1954.	f121.8	.....	.....	

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
25/18- 3N2													Spring, 1955.	f127.0	.....	.....	
													Mar., 1956	a, f138.0	.....	.....	
5J1	....	....	....	624	....	P, 8	L, g	S	....	.....	Top 4 by 6 in. beam, east side pump base.	2	7–17–51	82.4	.....	.....	
													10–10–55	114.2	.....	.....	
5J2	....	....	....	624	....	P, 8	L, w	S	....	.....	Top clamp on pump column.	2	7–17–51	81.9	71	C	
9P1	....	....	....	645	....	P, 8	....	U	....	.....	Top casing ...	2	7–17–51	78.5	.....	.....	Measured depth 146 ft, 1955.
													Autumn, 1953.	f78.2	.....	.....	
													10–10–55	95.9	.....	.....	
													5–23–56	98.11	.....	.....	
14D1	11973	....	....	650	....	P, 12	T, 3	Ind	....	.....	....	.....	4– 9–57	101.3	.....	.....	
15A1	....	....	....	600	....	P, 8	....	U	....	.....	Top casing ...	3	7–17–51	36.5	.....	.....	Measured depth 50 ft, 1955.
													10– 7–55	43.8	.....	.....	

15D1	....	....	....	600	....	P, 10	....	U	....	....	do	1	7–17–51	37.3	....	....	Measured depth 54 ft, 1955.
													10– 7–55	43.0	....	....	
													5–22–56	43.49	....	....	
													4– 9–57	44.0	....	....	
25E1	....	Hannah	....	510	140	5	....	U	....	....	do	1	10–12–55	122.2	....	....	
													5–24–56	122.05	....	....	
													4– 8–57	124.8	....	....	
34H1	....	....	....	565	....	P, 12	....	U	....	....	do	2	10–12–55	33.8	....	....	
34J1	....	....	....	550	....	P, 10	....	U	....	....	do	2	10–12–55	18.2	....	....	
34R1	....	Hannah	....	580	96	P, 12	L, g	D	....	....	do	1	6– 5–51	14.3	....	C	No access, 1955.
19- 6C1	9400	J. B. Hill Co., 30.	....	502	....	R, G, 16	T, 150	I	....	....	....	....	5–22–56	291.90	79	....	
6D1	8997	J. B. Hill Co., 24.	....	505	....	14	T, 75	I	....	....	Top casing	.5	5–29–51	a218.0	76	C	Discontinued as irrigation well. Now used as domestic well, 5 hp electric motor.
6D2	9186	J. B. Hill Co., 25.	....	506	....	R, G, 18	T, 125	I	....	....	do	1	5–29–51	a300+	73	C	
													Mar., 1956	a,f380+	....	....	
													5–22–56	327.35	....	....	
6L1	9512	J. B. Hill Co., 39.	....	508	....	R, 18	T, 150	I	....	....	do	0	10– 6–55	....	80	....	
													5–22–56	337.23	....	....	
6M1	9513	J. B. Hill Co., 38.	1950	511	1,118	R, 16–12	T, 100	I	....	....	....	....	5–10–56	327.14	....	L	16-in. casing set at 400 ft, 12-in. casing set at 1,400 ft. Perforated interval 400–1,400 ft.
6N1	9024	J. B. Hill Co., 27.	....	505	1,432	R, 16–	T, 40	I	....	....	Top casing	0	5–29–51	a277.1	78	C, L	Perforated interval 400–1,400 ft.
													Autumn, 1953.	f193.1	....	....	
													5–22–56	214.55	....	....	Falling water.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
25/19- 6P1	9660	J. B. Hill Co., 42.	....	504	....	R, 16	T, 100	I	....	.....	....	.....	....	....	81	....	
6P2	9530	J. B. Hill Co., 41.	....	505	....	R, 16	T, 100	I	....	.....	....	.....	5–22–56	154.35	....	....	Falling water.
7M1	9141	J. B. Hill Co., 28.	....	499	1,126	16–12	T, 75	I	....	.....	Top casing ..	1	5–29–51	a329.6	77	C, L	16-in. casing set at 383 ft, 12-in. casing set at 1,051 ft. Perforated interval 383–1,051 ft.
													Autumn, 1953.	f170.7	....	....	
7N1	9456	J. B. Hill Co., 31.	....	505	....	16	T, 20	I	....	.....	.....do.........	1	10–10–55	130.1	....	....	
													5–22–56	119.85	....	....	
7P1	8989	J. B. Hill Co., 29.	....	490	....	16	T, 75	I	....	.....	.....do.........	1	5–29–51	279.3	78	C	
													Autumn, 1953.	151.5	....	....	
													5–22–56	121.77	....	....	
11P1	....	....	....	404	....	P, 8	L, g	S	....	.....	....	.....	....	....	....	....	No access.

15G1	....	....	....	422	....	R, G, 12	....	U	....	....	Top casing..	4	1–30–53	104	....	....	
													10–14–55	104.7	....	....	
													5–24–56	104.79	....	....	
													4– 9–57	111.8	....	....	
18A1	9515	J. B. Hill Co., 40.	....	490	....	R, 16	T, 100	I	....	....	....	....	5–22–56	234.2	80	....	
20Q1	....	Tidewater Associated Oil Co., Temblor pump station 2.	1910	480	501	P, 10	L, a	Ind	d17	....	Top casing..	.5	May, 1910	d118	....	C, L	
													6–15–28	d127	....	....	Measured depth 450 ft, 1928.
													9–24–30	d118	....	....	Measured depth 436 ft, 1930.
													10– 5–31	d108	....	....	Measured depth 462 ft, 1931.
													9–10–41	d71.5	....	....	Measured depth 398 ft, 1941.
									d...	37	....	....	9–20–49	d117	....	....	Well in bad condition, casing caving.
													June, 1950	d132	....	....	
													6–19–51	131.4	....	....	Well not used since 1953.
20Q2	....	Tidewater Associated Oil Co., Temblor pump station 3.	1948	480	400	P, 10	T, 10	Ind	d44	....	Access pipe, north side pump base.	1.4	....	....	77	C, L	Well placed in operation March, 1948.
									d...	37	....	....	9–19–49	d116	....	....	
									d...	35	....	....	6– 3–50	d134	....	....	
									d...	37	....	....	4– 3–51	d124	....	....	
									d26	....	....	....	4–17–51	....	....	....	Operated 8 hr.
									d40	....	....	....	4–20–51	....	....	....	Operated 3 hr.
									d54	....	....	....	4–24–51	....	....	....	Do.
													6–19–51	a177.0	....	....	
													8–17–51	a,d204	....	....	
													7– 7–52	a,d189	....	....	

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
25/19-20Q2													5- 2-53	d124	.....	.....	
													1- 1-54	d114	.....	.....	
													1- 3-54	d118	.....	.....	
									d20	.....	.....	.....	1- 4-54	.....	.....	.....	
									d45	.....	.....	.....	1-26-54	a,d122	.....	.....	
									d35	.....	.....	.....	7- 2-54	a,d138	.....	.....	
									d22	.....	.....	.....	7-16-54	a,d230	.....	.....	
													7-23-54	d117	.....	.....	
									d44	.....	.....	.....	9- 1-54	.....	.....	.....	
									d22	.....	.....	.....	10- 6-54	a,d239	.....	.....	
									d40	.....	.....	.....	10-11-54	.....	.....	.....	
													10-21-55	123.6	.....	.....	
													5-24-56	126.31	.....	.....	
20Q3	.....	Tidewater Associated Oil Co., Temblor pump station 1.	1910	480	404	P, 10	.....	U	.....	.....	.....	.....	May, 1910	d118	.....	L	Well capped, 1947.
													6-15-28	d127	.....	.....	Measured depth 351 ft, 1928.
													10-19-28	d120	.....	....	Measured depth 335 ft, 1928.
																	Measured depth 360 ft, 1932.

21D1	...	...	...	495	...	P, 10	L, g	S	...	...	Top casing..	0	6–20–51	96.2	...	...	
													10–14–55	92.7	...	...	
													5–24–56	92.64	...	...	
													4– 8–57	92.7	...	...	
23B1	...	J. Errotaberre	...	405	130	P	L, g	D, S	...	...	...	...	...	...	...	C	
25B1	...	...	...	410	...	P, 8	...	U	...	...	Top casing..	0	6–14–51	94.6	...	...	Measured depth 117 ft, 1955.
													10–14–55	104	...	...	
													5–24–56	94.98	...	...	
													4– 8–57	95.2	...	...	
20- 3D1	...	...	...	261	...	P, 10	...	U	...	...	.....do.........	.5	6–14–51	57.7	...	...	Measured depth 63 ft, 1955.
													10–20–55	57.7	...	...	
4C1	...	J. B. Hill Co...	...	268	200	P, 12	L, g	S	...	...	.....do.........	0	6–14–51	62.7	...	...	Perforated interval 0–200 ft.
													10–20–55	63.2	...	...	
													5–24–56	62.67	...	...	
													4– 9–57	62.8	...	...	
15Q1	...	...	...	286	...	P, 10	J, g	S	...	...	.....do.........	4	4–23–53	81.8	...	C	Measured depth 170 ft, 1955.
								U	...	...	.....do.........	4	10–14–55	82.7	...	...	
													5–24–56	82.82	...	...	
													4– 8–57	80.5	...	...	
19G1	...	J. Barker......	...	381	...	P, 8	...	U	...	...	.....do.........	.5	6–13–51	101.7	...	...	Measured depth 95 ft, 1955.
													10–14–55	94.0	...	...	
27N1	...	...	...	356	...	P, 8	...	U	...	...	.....do.........	1	6–14–51	Dry	...	...	Measured depth 115 ft, 1951.
29Q1	...	...	...	386	220	P, 10	L, g	U	...	...	...	...	...	...	...	...	No access.
35B1	...	T. Bigoni......	...	290	...	P, 8	w, g	S	...	...	Top casing..	0	10–20–55	83.1	...	C	
													5–23–56	83.01	...	...	
													4– 8–57	82.7	...	...	

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
25/21-20F1	...	Shell Oil Co., Mid station.	...	220	1,254	10	...	U	...	...	...	...	...	...	...	L	No access, perforated interval 300–318, 432–450, 486–494, 325–330, 464–472, 570–580 ft. Casing set at 600 ft.
22H1	...	...	...	217	649	10	...	U	...	...	Top casing	0	7–26–51	39.9	...	...	Flowing 1919.
													10–21–55	66.8	...	...	
													5–24–56	62.17	...	...	
													4– 8–57	67.7	...	...	
26M1	...	B. Colquitt	...	218	180	R, 14	T, d	I	e800	...	do	0	11– 9–55	16.2	...	...	Cement seal 0–155 ft. Perforated interval 155–180 ft.
26N1	...	do	...	222	...	P, 12	...	U	...	...	do	0	5–30–51	17.1	...	...	Measured depth 22 ft, 1955.
30E1	...	...	...	245	...	P, 10	...	U	...	...	do	0	6–13–51	Dry	...	...	Measured depth 32 ft, 1955.
													10–20–55	Dry	...	...	
30L1	...	...	...	242	...	P, 10	...	U	...	...	do	2	6–13–51	32.5	...	...	Measured depth 50 ft, 1955.

													10–20–55	33.8			
30M1				245		P, 10–6		U			do	2	6–13–51	38.1			Measured depth 61 ft, 1955.
													10–20–55	38.5			
30Q1				236		P, 10		U			do	.5	6–13–51	29.7			Measured depth 80 ft, 1955.
													10–20–55	30.4			
32E1				232		P, 4	L, w	S								C	No access.
32R1				227		P, 12	L, g	S			Top casing	1	7–25–51	19.0			Measured depth 68 ft, 1955.
													10–21–55	20.3			
													5–24–56	20.02			
													4– 8–57	20.5			
34Q1				224		P, 8		U			do	1	10–21–55	15.8		C	Measured depth 63 ft, 1955.
													5–24–56	15.49			
													4– 8–57	16.0			
26/17-11F1		E. Still		880		P, 14	L, g	S			do	1	10–13–55	116.9			
11R1		do	1953	860	185	P, 12	T, -	D, S, I					1953	c65	73	L, C	Cased to 171 ft.
13L1	8519	do		910		P, 14	T, 10	I									
13L2	8519	do		910		P, 14	T, 10	I			Top casing	.5	6– 5–51	138.7	74	C	
							T, $7\frac{1}{2}$	I					10–13–55				
													4– 8–57	136.8			
18- 9E1		do		715	1,020	R, G, 14		U			Hole in casing north side.	0	Oct. 1950	c136		L	Cased to 410 ft. Perforated interval 214–410 ft.
													6–23–51	134.5			
													10–13–55	141.0			
													5–23–56	141.75			
													4– 9–57				Plugged; dry at 48 ft.
11K1		do		624		P, 8	L, w, g	S			Top casing	0	6–21–51	91.0		C	
													10–12–55	93.1			
													5–24–56	93.31			
													4– 9–57	93.4			
13E1				650	231	G, 14–10		U			do	1	6–22–51	112.6		L	Cased to 575 ft.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
26/18-13E1													10-12-55	117.5	....	....	
													5-24-56	118.11	....	....	
													4- 9-57	....	....	....	Believed destroyed.
14E1	8522	E. Still..........	1950	645	350	G, 14	T, 15	I	....	....	....	.....	....	....	....	L	No access.
								U	....	....	Top casing..	0	10-12-55	133.5	....	....	Not in use, pump and motor removed.
													5-23-56	134.57	....	....	
													4- 9-57	136.0	....	....	
14G1	8523	....	....	650	275	G, 14	T	I	....	....	.....do........	1	6-22-51	135.1	....	L	Perforated interval 125-275 ft.
								U	....	....	....	.....	10-12-55	144.0	....	....	Not in use, pump and motor removed.
													5-24-56	145.10	....	....	
14N1	8530	E. Still..........	1949	670	333	....	T, 40	I	....	....	Top casing..	0	6-22-51	148.7	....	L	Motor reduced from 40 hp to 25 hp. Perforated interval 135-300 ft.

							T, 25	I	....	....	.....do.........	0	10–12–55	187.6	....	.....	
													5–23–56	188.79	....	.....	
													4– 9–57	190.0	....	.....	
14R1	8532	....	....	670	....	G, 14	....	U	....	....	.....do.........	1	6–22–51	141.5	....	L	
							T, 10	I	....	....	.....do.........	1	10–12–55	168.5	72	C	
													5–22–56	163.86	....	.....	
													4– 9–57	162.1	....	.....	
14R2	8529	....	....	670	....	G, 14	T, 25	I	....	....	.....do.........	2	6–22–51	175.0	....	L	
													10–12–55	174.3	....	.....	
													5–24–56	161.27	....	.....	
15K1	9551	I. Hansen.......	....	655	....	G, 14	....	U	....	....	.....do.........	.5	6–23–51	129.6	....	.....	
													10–12–55	158.9	....	.....	
													5–23–56	159.51	....	.....	
15P1	11630	.....do...........	1951	670	....	P, 14	T, 10	I	....	....	....	.....	5–23–56	117.20	....	C, L	
													4– 9–57	76.2	....	.....	Motor removed.
15Q1	9550	.....do...........	....	660	....	14	T, 50	I	....	....	Top casing..	0	6–23–51	172.1	....	L	
16D1	....	E. Still..........	....	730	....	14	....	U	....	....	.....do.........	4	6–23–51	168.8	....	.....	
													10–13–55	203.0	....	.....	
16E1	8520	.....do...........	....	730	....	....	T, 20	I	....	....	Hole in pump base, south side.	1	6– 5–51	a239.9	....	.....	
													10–13–55	204.2	....	.....	
16H1	8521	I. Hansen.......	....	685	....	14	....	U	....	....	.....do.........	0	6–23–51	146.6	....	.....	
													10–13–55	153.8	....	.....	
													5–23–56	155.26	....	.....	
													4– 9–57	157.4	....	.....	
16J1	8526	.....do...........	....	680	....	G, 14	T, 30	I	....	....	Top casing..	0	6–23–51	a226.4	75	C	Horsepower reduced from 30 to 25 before 1955.
16M1	8525	E. Still.........	1949	725	300	14	T, 25	I	....	....	....	.....	....	....	....	C, L	
							T, 20	I	....	....	Access hole in casing.	1	10–13–55	192.8	....	.....	

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
26/18-16N1	8527	E. Still	......	725	290	14	S	I	....	....	....	.....	6–5–51	....	....	C,L	Submersible pump removed and a deep-well turbine pump and 25-hp electric motor installed before 1955.
18F1	....	....	......	845	....	12	....	U	....	....	....	.....	....	....	....	....	No access.
18F2	8517	P. Reinke	......	840	....	12	T, 15	I	....	....	....	.....	....	....	....	....	Do.
18F3	8518	....do....	1949	835	225	14	T, 15	I	....	....	Access hole in pump base, north side.	0	6–5–51	a160.6	74	C,L	
													10–13–55	128.1	....	....	
													5–23–56	123.02	....	....	
													4–8–57	122.7	....	....	
18F4	8518	....do....	......	835	....	12	T, 20	I	....	....	.....do.....	0	6–5–51	a145.3	....	....	
													10–13–55	126.2	....	....	
18G1	13672	....do....	......	830	....	14	....	U	....	....	Top casing..	1	6–5–51	....	....	....	Mud at 200 ft.
							T, $7\frac{1}{2}$	I	....	....	....	.....	10–13–55	171.9	....	....	

													5–23–56	173.31	....	.....	
													4– 8–57	176.3	....	.....	
19B1	9549	E. Newson.......	....	860	....	14	T, 10	I	....	....	Top casing...	1	6– 5–51	138.8	....	.....	
													10–13–55	146.1	....	.....	
													5–23–56	156.39	....	.....	
19B2	9348	.....do............	1944	875	....	14	T, 20	I	....	....	Access hole in pump base north side.	0	6– 5–51	149.2	....	C	
							T, 5	I	....	....	....	0	10–13–55	152.7	....	.....	
													5–23–56	152.24	....	.....	
													4– 8–57	154.0	....	.....	
21A1	8528	I. Hansen........	1949	680	285	14	T, 25	I	....	....	Top casing...	0	6–23–51	a208.2	76	C, L	
22B1	8981	.....do............	....	670	....	14	T, 50	I	....	....	.....do.........	0	6–23–51	a199.8	....	L	Horsepower reduced from 50 to 30 before 1955.
22C1	10017	.....do............	....	673	300	P, 14	T, 40	I	....	....	Access hole in pump base west side.	1	6–23–51	163.3	....	L, C	
22E1	....	.....do............	....	685	....	14	....	U	....	....	Top casing...	.5	6–23–51	170.5	....	.....	Well destroyed before 1955.
22H1	9548	....	....	680	....	14	T, -	I	....	....	.....do.........	.5	6–23–51	190.8	....	.....	
22F1	9545	....	....	680	....	14	T, 50	I	....	....	.....do.........	1	6–23–51	a208.4	....	.....	
							T, 30	I	....	....	.....do.........	1	10–12–55	230.8	....	.....	
22G1	9546	....	....	680	....	14	T, 40	I	....	....	.....do.........	1	6–23–51	a213.3	....	.....	
							T, 30	I	....	....	.....do.........	1	10–12–55	241	....	.....	
22P1	....	....	....	700	....	R	....	U	....	....	....	....	....	....	....	.....	No casing, well never used.
23A1	9556	E. Still.........	....	670	....	14	T, 15	I	....	....	Access hole in pump base south side.	0	6–22–51	159.7	74	C	
													10–12–55	183.1	....	.....	
23C1	9012	.....do............	....	670	286	G, 16	T, 25	I	....	....	....	....	....	....	....	C, L	Perforated interval 160–286 ft.
							L, 2	D	....	....	Top casing...	1	10–12–55	177.7	74	.....	
													5–23–56	176.59	....	.....	

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
26/18-23C2	10211	E. Still	1951	670	297	16	T, 25	I	...	...	...	...	...	...	...	L	No access. Perforated interval 160–297 ft.
23M1	8531	do	...	680	707	R, 14	T, 30	I	...	...	Top casing	0	6–23–51	193.2	...	L	
							T, 25	I	...	...	do	0	10–12–55	220	...	...	Cased to 400 ft.
													5–23–56	220.88	...	...	
													4– 9–57	208.3	...	...	Pump removed.
23M2	10253	...	...	700	1,200	R, G, 16	T, 50	I	...	...	do	0	10–12–55	246.1	77	C	Cased to 900 ft.
27C1	...	California Div. Highways.	...	720	...	10	...	U	...	...	do	0	6–21–51	Dry	...	...	Measured depth 83 ft, 1951.
27F1	...	...	...	730	...	P, 10	L, w, g	S	...	...	do	1	10–13–55	200.2	74	C	
													5–23–56	211.79	...	...	
													4– 9–57	217.6	...	...	
19- 7J1	...	...	...	620	...	R	...	U	...	...	...	...	...	...	...	...	No casing, well drilled to supply water for drilling oil well.
8D1	...	...	...	585	...	R, 16	...	U	...	...	...	...	...	...	...	...	Plate welded over casing, obstruction about 230 ft, 1951.

12L1	...	...	...	530	358	P, 14	L, g	S	...	...	Top casing..	0	6–21–51	208.4	...	C	
													10–14–55	201	...	...	
													5–24–56	201.09	...	...	
													4– 9–57	201.0	...	...	
15N1	...	...	...	655	...	P, 8	L, g	S	...	...	...	...	...	...	...	...	No access, reported to be an old oil well cemented at 358 ft.
19J1	...	Union Oil Co., Junction pump station 3.	...	715	501	P, 12–10	...	U	...	...	...	...	Sept., 1913	d310	...	L	12-in. casing set at 423 ft. 10-in. casing set at 501 ft.
19J2	...	Union Oil Co., Junction pump station 2.	1910	715	600	P, 8–6	...	U	...	...	...	...	...	...	...	L	Destroyed, 8-in. casing set at 407 ft, 6-in. casing set at 600 ft.
19J3	...	Union Oil Co., Junction pump station 1.	1909	715	393	P, 8	...	U	...	...	...	...	...	...	...	L	Destroyed, 8-in. casing set at 394 ft.
25M1	...	...	...	670	363	...	...	U	...	...	...	...	1930	g357	...	C	No casing, obstruction at 250 ft, 1951; obstruction at 94 ft, 1955.
26A1	...	De Artney Brothers.	...	660	1,170	R	...	...	...	...	...	...	...	...	...	...	Test hole, no casing, no water strata below 850–900 ft.
21- 4F1	...	...	...	228	...	P, 8	...	U	...	...	Top casing..	0	10–25–55	27.8	...	...	Measured depth 87 ft, 1955.
													5–24–56	27.64	...	...	
6F1	...	T. Bigoni...	...	268	...	P	L, w, g	S	...	...	...	...	...	...	...	C	
6F2	...	...do...	...	262	...	P, 10	...	U	...	...	Top casing..	.5	6–13–51	50.7	...	...	Measured depth 150 ft, 1955.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
26/21- 6F2													10–21–55	51.5	....	.....	
													5–24–56	51.49	....	.....	
6F3	....	T. Bigoni	....	262	....	P, 10	....	U	....	.....	Top casing ..	1	6–13–51	50.7	....	.....	Measured depth 194 ft, 1955.
													10–21–55	54.4	....	.....	
													5–24–56	51.38	....	.....	
													4– 9–57	51.1	....	.....	
10A1	....	....	....	228	....	P, 10	....	U	....	.....	.....do..........	2	7–25–51	16.8	....	.....	Measured depth 24 ft, 1955.
													10–24–55	18.6	....	.....	
10E1	....	....	....	241	....	P, 10	....	U	....	.....	.....do..........	3	10–24–55	32.5	....	.....	Measured depth 65 ft, 1955.
10P1	....	....	....	246	....	P, 10	....	U	....	.....	.....do..........	2	10–24–55	37.2	....	.....	Measured depth 101 ft, 1955.
10R1	....	....	....	239	....	P, 10	....	U	....	.....	.....do..........	1	10–24–55	33.0	....	.....	Depth greater than 300 ft, 1955.
													5–24–56	31.18	....	.....	
													4– 9–57	32.0	....	.....	
12F1	....	....	....	240	....	P	L, g	U	....	.....	....	.....	....	....	....	C	
12F2	....	....	....	240	....	P, 8	L,w,g	S	....	.....	Top casing ..	0	10–24–55	31.4	....	.....	
													5–24–56	30.51	....	.....	
													4– 9–57	32.0	....	.....	

14E1	......	J. Franz, west pump.	1949	244	300	R, 16	T,ng	I	....	....	.....do.........	0	5–30–51	a69.4	....	E	
								U	....	....	.....do.........	0	10–24–55	34.4	....	.....	
14F1	......	J. Franz........	......	238	....	P, 10	J, 1½	D	....	....	.....do.........	1	5–30–51	21.9	....	C	
								U	....	....	.....do.........	1	10–24–55	24	....	.....	
14H1	......	J. Franz, east pump.	1949	236	190	12	T,ng	I	....	....	Access hole in pump base, south side.	0	5–30–51	a39.4	72	.....	
14H2	......	J. Franz........	1953	237	300	P,G,14	T,ng	I	....	....	....	.....	....	....	72	C	
14J1	......	.....do..........	1953	237	300	P, 14	....	U	....	....	Top casing...	1	10–24–55	32.4	....	.....	
14M1	......	....	......	242	....	16	....	U	....	....	Top 16-in. casing in bottom 4-ft, square curbing.	-4	10–24–55	31	....	.....	
14M2	......	....	......	242	....	16	....	U	....	....	....	.....	....	....	...	.....	Obstruction at 25 ft, 1955.
18H1	......	....	......	315	....	12	....	U	....	....	Top casing...	0	5–31–51	111.0	....	.....	Measured depth 157 ft, 1955.
													10–25–55	131.5	....	.....	
20K1	......	T. Bigoni.......	......	331	....	....	....	U	....	....	....	.....	....	....	....	.....	No access.
22G1	......	....	......	263	....	P, 8	......	U	....	....	Top casing...	0	10–25–55	49.5	....	.....	Measured depth 77 ft, 1955.
22G2	......	....	......	263	....	P, 12	....	U	....	....	.....do.........	0	10–25–55	44.4	....	.....	Measured depth 189 ft, 1955.
25F1	......	Standard Oil Co., W-1 (RE-9).	1945	245	396	P, 14	T, d	S	....	....	Access hole in casing, north side.	0	7–26–51	32.9	....	L,C	Perforated interval 164–384 ft.
													3–20–53	30.2	....	.....	
													10–24–55	33.8	....	.....	
													4–9–57	34.4	....	.....	
26G1	......	....	......	247	....	P, 8	L, w	S	....	....	Top casing...	0	10–24–55	37.2	....	C	
26N1	......	....	......	266	....	P, 10	....	......	....	....	....	.....	....	....	....	.....	Destroyed before 1955.
28P1	......	T. Bigoni.......	1946	340	130	P, 8	L,w,g	S	....	....	Top casing...	0	10–25–55	131.8	....	C	
													4–9–57	127.8	....	.....	
34E1	......	....	......	320	....	P, 10	....	U	....	....	....	.....	....	....	....	.....	Cement plug about 16 ft, below land surface.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
26/21-34N1	......	....	......	330	....	P, 10	....	U	....	....	....	.....	....	....	...	....	Measured depth 73 ft, 1955.
34Q1	......	B. Hadlock	......	310	....	P, 12	....	U	....	....	....	.....	....	....	...	....	No access.
27/18-15R1	......	Twisselman ranch.	......	1,220	....	P, 10	L, w	S	....	....	Top casing ...	0	10–26–55	38.1	...	....	
15R2	......	.....do..........	......	1,220	....	P, 8	C, g	S	....	....	.....do.........	.5	10–26–55	37.8	...	....	
15R3	......	.....do..........	......	1,220	....	P, 14	L, g	S	....	....	.....do.........	0	10–26–55	39.3	...	....	
15R4	......	.....do..........	......	1,215	....	P, 6	....	U	....	....	.....do.........	1	10–26–55	37.6	...	....	Measured depth 40 ft, 1955.
15R5	......	.....do..........	......	1,215	....	P, 12	....	U	....	....	.....do.........	1	10–26–55	30	...	....	Measured depth 42 ft, 1955.
19-28A1	......	E. Still	1953	925	198	P, 14	L, w	S	....	....	....	.....	....	....	...	....	No access.
28H1	......	.....do..........	......	925	920	P, 10	L,w,g	S	....	....	Top casing ...	0	1–30–53	137.6	...	C	
28H2	......	.....do..........	......	925	....	P, 4	L, w	S	....	....	....	.....	....	....	...	C	Do.
20- 9C1	......	Twisselman ranch.	......	575	....	P, 8	....	U	....	....	Top casing ...	0	10–27–55	Dry	...	C	Measured depth 149 ft, 1955.
22M1	......	Tidewater Associated Oil Co.	......	650	855	R, 12–10–8	....	....	....	....	....	.....	....	....	...	L	Destroyed. 464 ft, 12-in. casing; 200 ft, 10-in. casing; 160 ft, 8-in. casing; cement plug

																	at 738 ft. Perforated interval at 464–664 ft.
34G1	....	Tidewater Associated Oil Co., Reward well.	....	725	460	6	L, 5	Ind	....	....	....	......	8–16–27	d375	.....	C	Measured depth 449 ft, 1928.
													10–18–28	d395	....	.....	Measured depth 450 ft, 1928.
													11– 7–29	d390	....	.....	Measured discharge between March, 1933 and August, 1933 was about 15 gpm.
													8–11–38	d394	.....	....	Measured depth 459 ft, 1938.
													8–11–49	d389	.....	.....	Measured depth 450 ft, 1949.
34P1	....	Tidewater Associated Oil Co., Carneras pump station 1.	......	750	986	12–10	....	U	....	....	....	......	10–17–22	c390	.....	L	12-in. casing set at 283 ft; 10-in. casing set at 740 ft; well backfilled with cement and rock to 725 ft. Casing capped with cement, 1955.
													4–11–27	d400	.....	....	Depth about 675 ft, 1927.
													6– 7–29	d395	.....	.....	
													3– 4–32	d395	.....	.....	Measured depth 602 ft, 1932.
													10– 4–32	d395	.....	.....	
													5–31–33	d396	.....	.....	
													5–30–34	d398	.....	.....	Depth about 587 ft, 1934.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
27/20-34P2	......	Tidewater Associated Oil Co., Carneras pump station 2.	......	750	688	12–10	....	U	....	....	....	......	10–19–22	c383	.....	L	12-in. casing set at 548 ft; 10-in. casing set at 688 ft; wooden plug set at 585 ft.
													5–29–27	d395	.....	....	Measured depth 596 ft, 1927.
									d22–26	....	....	......	2–12–28	....	.....	....	
									d20	....	....	......	4–10–29	....	.....	....	
													6– 6–29	d395	.....	....	
									d20	....	....	......	2– 9–32	....	.....	....	
									d12–18	....	....	......	5–26–33	....	.....	....	
													5–30–34	d399	.....	....	Depth about 588 ft, 1934.
21- 3A1	......	California Div. Highways, Lost Hills maintenance station.	......	300	300	10	....	U	....	....	....	......	....	....	.....	C	Casing perforated for three strata. Well ran dry after being pumped a few minutes. Well now used as a sewer-well for

																	bath and wash water.
15D1	......	....	......	375	....	12	......	U	....	....	Top casing..	1	10–27–55	Dry	....	....	Measured depth 130 ft, 1955.
22- 6C1	......	B. Anderson...	......	232	....	14	......	U	....	....	.....do........	0	7–23–51	11.7	....	....	
													10–27–55	14.5	....	....	
6G1	......	.....do..........	......	234	....	R, G, 14	T, d	I	....	....	Access hole in casing, south side.	0	7–23–51	a63.1	....	....	Destroyed before 1955.
6M1	......	H. Dickson.....	......	255	500	G, 14	T, d	I	....	....	Top casing..	0	2–10–53	33.9	....	....	
													10–24–55	38.7	....	....	
8N1	7476	Houchin Farms, 7–27.	......	235	....	G, 18	T, 75	I	....	....	....	.....	7–23–51	....	....	....	No access.
								U	....	....	Top casing..	1	11– 4–55	19.3	....	....	
17P1	8289	....	......	240	....	R, G, 18	T, 40	I	....	....	Access hole in casing, north side.	3	7–16–51	a54.4	67	....	
							T, 60	I	....	....	....	3	11– 4–55	a66.8	....	....	
29P1	7286	Houchin Farms, 2–28.	......	240	516	R, G 18–12	T	I	....	....	....	.....	7–16–51	....	....	....	No access.
								U	....	....	Top casing..	4	2–16–53	18.1	....	L	Perforated interval 492–624 ft.
								U	....	....	.....do........	.....	11– 4–55	42.1	....	....	
30G1	......	....	......	265	....	P, 12	T	U	....	....	Top pump base, south side.	0	10–31–55	96	....	....	Measured depth 101 ft, 1955.
30J1	......	....	......	256	....	P, 10	......	U	....	....	....	.....	10–31–55	....	....	....	Measured depth 10 ft, 1955.
32B1	7285	Houchin Farms, 1–28.	......	235	....	G, 18	T, 75	I	....	....	....	.....	7–23–51	....	66	....	No access.
								U	....	....	Top casing..	3	2–16–53	13	....	....	
								U	....	....	....	.....	11– 4–55	23.1	....	....	
32N1	......	....	......	253	....	P, 12	......	U	....	....	Top casing..	3	2–10–53	23.5	....	....	Measured depth 138 ft, 1955.
													10–27–55	28.5	....	....	
28/19- 3D1	......	....	......	1,100	....	P, 8	L	U	....	....	....	.....	....	....	....	....	No access.
21-13E1	......	Belridge Oil Co.	......	370	....	P, 8	......	U	....	....	Hole in pump column.	5	11– 7–55	160.2	....	....	
13E2	......	.....do..........	......	370	....	P, 8	......	U	....	....	....	.....	....	....	....	....	No access.
22- 6A1	......	....	......	258	....	P, 12	......	U	....	....	....	.....	....	....	....	....	Measured depth 20 ft, 1955.

Table 7.—*Description of wells in the Avenal-McKittrick area, Kings and Kern Counties, Calif.*—Continued

Well	Transformer	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well, casing diameter (inches)	Type of pump, power	Use	Discharge (gpm)	Drawdown (feet)	Measuring point: Description	Measuring point: Distance above or below (-) land surface (feet)	Water level: Date measured	Water level: Depth to water below land-surface datum (feet)	Temperature (°F)	Other data	Remarks
28/22- 6Q1				285		P, 12		U									Filled with dirt, 1955.
7Q1		Standard Oil Co.		289		14		U			Top casing	2	2–10–53	64.4		L, C	Measured depth 550 ft, 1955.
													10–27–55	76.2			
9N1		Houchin Farms		248		G, 16	T, d	I			do	2	2–25–53	12.6			
20M1				290		P, 10–8		U			do	0	11– 2–55				Obstruction at 70 ft, 1955; water level about 69 ft.
28R1				255		P, 12		U			do	1	11– 4–55	31.6			Depth greater than 300 ft, 1955.
30N1				380		P, 8		U					11– 2–55				Measured depth 12 ft, 1955.
35P1	4455	Bloemhoff		249		P, 10	J, 1½	D			Top casing	1	2–19–53	26.4			
								D			Top concrete pipe.	1.5	11– 4–55	49.2			
29/22- 1P1	7073	Torreta, Klassen, well 1.	1937	255	270	16	T, 60	I								L	No access.
4R1				307	186	P, 10		U			Top casing	0	11– 2–55	67.7			Measured depth 161 ft, 1955.

23- 7L1	4917	Delfern Farms 42.	1952	257	324	G, 18	T, 60	I	....	....	....	....	11–10–52	....	....	L	Depth to water in 1919 was 60 ft. No access. Perforated interval 102–318 ft.
											Access hole in casing north side.	1	11– 4–55	26.8	....	....	
7Q1	9848	Delfern Farms.	1951	257	300	G, 18	T, 75	I	....	....	Top casing ...	0	11–10–52	18.1	....	L	
17P1	3632	J. Chicca, Miller and Lux, 83.	....	260	280	G, 16	T, 30	I	....	....	.....do.........	2	2–17–53	18.3	....	L	
20H1	3708	....	1935	260	250	....	T, 30	I	....	....	Top pump base, west side.	1	2–25–53	19.8	....	L	
													11– 4–55	32.4	....	....	
27M1	4117	J. Smith........	1935	269	252	G, 14	T, 40	I	....	....	Top casing ...	3	2–25–53	16.7	....	L	
													11– 4–55	38.5	....	....	
27Q1	3789	Ghilarducci Bros.	1935	269	238	G, 14	T, 40	I	....	....	Hole in concrete pump base, north side.	2	2–25–53	16.9	....	L	
													11– 4–55	30.3	....	....	
34A1	3591	Mirasol ranch.	....	270	238	16	T, 15	I	....	....	Access hole in pump base, east side.	3	2–26–53	16.6	....	L	
													11– 4–55	29.4	....	....	
35F1	8360	.....do..........	....	270	....	R, G, 16	T, 30	I	....	....	Hole in casing, south side.	0	2–26–53	15.9	....	....	
35G1	4065	Erskin..........	....	270	182	12	T, 15	I	....	....	....	....	....	....	....	L	No access.
30/23- 1C1	3603	Davini Bros....	....	280	234	G, 16	....	U	....	....	Top casing	0	11–12–52	15.5	....	L	
													3–10–53	17.6	....	....	
													11– 4–55	33.7	....	....	
30/23- 1C2	7608	.....do..........	....	280	....	G, 16	T, 40	I	....	....	.....do.........	1	11–12–52	14.6	....	....	
24- 6B1	3640	T. Olson	....	280	....	G, 14	T, 15	I	....	....	.....do.........	0	11–12–52	18.8	....	....	
													3–10–53	19.7	....	....	
6M1	8912	Asbury	....	280	250	G, 16	T, 30	I	....	....	.....do.........	1	11– 4–55	34.8	....	....	
6N1	1999	.....do..........	....	300	250	14	....	U	....	....	.....do.........	1	11– 4–55	52.7	....	....	

Table 8.—*Chemical analyses of waters from wells in the*

Laboratories: USGS, Quality of Water Branch, U.S. Geological Survey; T, Twining California, Berkeley, Calif.; USDA, Division of Western Irrigation Agriculture, U. S. Bureau of Reclamation; H, Frank Hornkohl Chemical Laboratory, Bakersfield, Calif.; tories have been modified to agree with Geological Survey practice. Other constitu- silica, iron, and aluminum together; Fe, Al, iron and aluminum together; NH_4 , am- includes silica when expressed. For analyses by Division of Western Irrigation computed by assuming (Na+K) is wholly Na and (CO_3 +HCO_3) is wholly HCO_3 .

Well	Date sampled	Temperature (°F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
22-17-26E1....	Jan. 20, 1954	....	USGS	2,200	1,720	27	147 7.34	90 7.40
22-19-19J1	Jan. 6, 1954	78	USGS	730	477	33	9.7 .48	1.4 .12
20N2	Aug. 13, 1951	79	USGS	783	480	....	12 .60	8.0 .66
20P1	.....do.............	78	USGS	983	584	....	12 .60	9.0 .74
20Q1	Aug. 12, 1951	80	USGS	2,390	1,342	....	38 1.90	14 1.15
20Q2	Aug. 13, 1951	75	USGS	1,480	899	....	23 1.15	9 .74
23-18- 6D1	Oct. 5, 1955	....	USGS	2,140	1,504	....	145 7.24	88 7.20
29E2	Feb. 16, 1954	....	T	(1)	[2]1,634.0	48	72.6 3.62	66.7 5.49
30A1	Oct. 5, 1955	75	USGS	1,620	1,089	....	49 2.45	38 3.11
19-11D1	Jan. 6, 1954	75	USGS	8,230	4,600	37	26 1.30	51 4.19
24-17-11P1	Oct. 11, 1955	....	USGS	1,980	1,330	....	69 3.44	67 5.52
25NE¼	Mar. 21, 1950	....	UCB	1,920	1,255	....	82 4.1	69 5.7
18-11 (nr ctr)	May 20, 1930	....	USDA	2,960	2,018	....	183 9.16	91 7.47
19NE¼	Dec. 1905	....	USRS	....	[2]2,090	....	....	....
30B1	Mar. 21, 1950	....	UCB	1,400	882	....	56 2.8	68 5.6
30P1	.....do.............	....	UCB	1,490	937	....	64 3.2	46 3.8

See footnotes at end of table.

Laboratories, Fresno, Calif.; USRS, U. S. Reclamation Service; UCB, University of Department of Agriculture; NBS, National Bureau of Standards analyses for U. S. SO, Standard Oil Co. of California; SP, Southern Pacific Co. Analyses by other labora- ents expressed in parts per million, in Remarks column as follows: SiO_2, Fe, Al, monium; NO_2, nitrite; I, iodide; Br, bromide. The sum of determined constituents Agriculture, U. S. Department of Agriculture, the sum of determined constituents were The error introduced in this manner probably is small.

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as ($CaCO_3$) (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
232 10.09	3.7 0.09	0 0.00	86 1.41	994 20.69	58 1.64	0.3 0.02	123 1.98	0.43	40	737	7.6	
153 6.65	.8 .02	0 .00	188 3.08	162 3.37	23 .65	.2 .01	0.1 .00	1.5	91	30	8.2	
170 7.39	....	0 .00	304 4.98	94 1.96	45 1.27	....	....	1.0	85	63	8.0	
205 8.91	....	0 .00	382 6.26	95 1.98	74 2.09	....	....	1.5	87	67	8.0	
455 19.79	....	14 .47	286 4.69	139 2.89	540 15.23	....	....	1.4	87	152	8.4	
295 12.83	....	0 .00	442 7.24	222 4.62	130 3.67	....	....	1.8	87	94	8.1	
241 10.48	3.6 .09	0 .00	90 1.48	930 19.36	52 1.47	....	....	.48	42	722	7.7	
324.2 14.10	....	0	156 2.56	896 18.65	71 2.00	....	....	.4	61	459	7.9	Fe, Al, 8.0
259 11.27	2.0 .05	0 .00	121 1.98	636 13.24	45 1.27	....	....	1.5	67	278	7.7	
1,720 74.79	3.3 .08	0 .00	666 10.91	20 .42	2,410 67.97	.0 .00	.4 .01	8.3	93	274	8.2	
284 12.35	6.4 .16	0 .00	265 4.34	672 13.99	99 2.79	....	....	2.6	58	448	7.7	
251 10.9	....	281 4.6		543 11.3	170 4.8	....	....	2.08	52	490	.....	
342 14.87			125 2.05	1,120 23.40	215 6.05	....	....	1.28	47	832	.....	
......	....	0	241	....	183	....	....	......	......	....	.....	
154 6.7	....	317 5.2		375 7.8	71 2.0	....	....	1.72	44	420	.....	
191 8.3	....	238 3.9		408 8.5	103 2.9	....	....	1.80	54	350	.....	

Table 8.—*Chemical analyses of waters from wells in the Avenal-*

Well	Date sampled	Temperature (°F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
24-18-32D1	Mar. 21, 1950	....	UCB	1,520	944	....	70	68
							3.5	5.6
33M2	Sept. 15, 1954	73	USGS	1,560	1,080	40	63	76
							3.14	6.26
33N1	.....do............	74	USGS	1,480	1,010	33	63	64
							3.14	5.24
33Q2	July 27, 1955	74	USGS	1,600	1,140	42	73	82
							3.64	6.76
19- 2L1	May 12, 1952	....	T	....	[2]4,458.4	51.6	189.5	282.9
							9.46	23.26
2Q1	.....do............	....	T	....	[2]4,476.8	48.4	184.4	288.9
							9.20	23.76
11G1	Oct. 19, 1955	73	USGS	6,470	[2]4,971	....	201	215
							10.03	17.67
12K1	May 12, 1952	....	T	....	[2]2,196.8	40.8	153.2	200.3
							7.64	16.72
12Q1	.....do............	....	T	....	[2]2,976.0	50.4	101.2	168.2
							5.05	13.83
12N1	.....do............	....	T	....	[2]3,340.8	26.4	55.0	57.1
							2.74	4.70
25-18- 2N1	Aug. 13, 1953	68	USGS	4,280	3,410	34	151	234
							7.53	19.24
2N1	July 27, 1955	70	USGS	4,250	....	....		
							26.50	
3D1	Sept. 15, 1954	74	USGS	1,550	1,090	43	61	79
							3.04	6.47
3E1	July 27, 1955	73	USGS	1,640	1,160	41	72	84
							3.59	6.91
3M2	.....do............	76	USGS	1,980	1,410	51	131	90
							6.54	7.39
3M3	Aug. 13, 1953	72	USGS	1,970	1,400	40	92	114
							4.59	9.37
3M3	July 27, 1955	75	USGS	1,950	....	....		
							13.84	
3N2	Aug. 13, 1953	77	USGS	6,400	4,900	39	425	459
							21.21	37.75

See footnotes at end of table.

McKittrick area, Kings and Kern Counties, Calif.—Continued

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as $(CaCO_3)$ (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
154 6.7	....	244 4.0		427 8.9	103 2.9	....	....	1.52	42	455	.....	
174 7.57	4.0 0.10	6 0.20	231 3.79	481 10.01	88 2.48	0.4 0.02	32 0.02	1.5	44	470	8.4	
182 7.91	4.2 .11	9 .30	214 3.51	407 8.47	108 3.05	.4 .02	36 .58	1.2	48	419	8.3	
176 7.65	4.0 .10	0 .00	274 4.49	514 10.70	84 2.37	.2 .01	26 .42	1.6	42	520	8.0	
813.2 35.36	....	....	460 7.54	2,310 48.09	443 12.49	....	....	1.4	52	1,650	7.9	Fe, Al, 9.6
805.3 35.02	....	....	467 7.65	2,300 47.88	440 12.41	....	....	1.5	52	1,660	7.8	Fe, Al, 6.0
1,160 50.46	10 .26	0 .00	244 4.00	2,360 49.14	900 25.38	....	....	4.9	64	1,380	7.7	
210.6 9.16	....	....	244 4.00	1,100 22.90	227 6.40	....	....	1.0	27	1,220	7.9	Fe, Al, 9.2
639.2 27.79	....	....	293 4.80	1,360 28.31	479 13.51	....	....	.9	60	953	7.7	Fe, Al, 3.6
1,124.7 48.91	....	....	320 5.24	359 7.47	1,550 43.71	....	....	1.1	87	375	7.8	Fe, Al, 8.8
600 26.09	4.5 .12	0 .00	366 6.00	1,930 40.18	240 6.77	.7 .04	27 .44	8.2	49	1,340	7.9	
620 26.96	....	....	......	....	275 7.76	....	....	.....	.....	1,320	.....	
178 7.74	4.6 .12	0 .00	236 3.87	507 10.56	88 2.48	.1 .01	15 .24	1.5	45	475	8.2	
187 8.13	3.8 .10	0 .00	278 4.56	517 10.76	96 2.71	.1 .01	18 .29	1.7	43	525	8.0	
187 8.13	9.2 .24	0 .00	266 4.36	639 13.30	150 4.23	.2 .01	17 .27	1.6	36	696	7.6	
203 8.83	5.2 .13	0 .00	264 4.33	673 14.01	128 3.61	.3 .02	17 .27	1.3	39	698	7.5	
200 8.70	....	....	....	....	122 3.44	....	....	.....	.....	692	.....	
522 22.70	9.6 .25	0 .00	218 3.57	2,120 44.14	1,200 33.84	.4 .02	12 .19	2.3	28	2,950	7.7	

Table 8.—*Chemical analyses of waters from wells in the Avenal-*

Well	Date sampled	Temperature (F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
25-18- 5J2	Apr. 29, 1953	71	USGS	1,300	849	23	64 3.19	48 3.95
34R1	Aug. 4, 1954	86	USGS	876	565	21	98 4.89	7.2 .59
34R1	Nov. 19, 1955	72	USGS	946	544	....	95 4.74	9.5 .78
19- 6D1	May 4, 1953	76	USGS	2,770	2,030	41	87 4.34	123 10.12
6D1	Aug. 13, 1953	79	USGS	2,720	1,990	43	78 3.89	122 10.03
6D1	July 27, 1955	74	USGS	2,740	....	....	15.72	
6D2	Aug. 13, 1953	77	USGS	3,100	2,270	61	106 5.29	136 11.18
6D2	July 27, 1955	79	USGS	3,440	....	....	18.60	
6N1	Sept. 15, 1954	77	USGS	3,450	2,650	68	117 5.84	199 16.36
6N1	July 27, 1955	78	USGS	3,540	....	....	23.60	
7M1	Aug. 13, 1955	77	USGS	5,210	4,170	75	149 7.44	265 21.79
7M1	July 27, 1955	78	USGS	5,240	....	....	28.50	
7P1	Aug. 13, 1953	77	USGS	5,260	4,270	72	172 8.58	272 22.37
7P1	Aug. 4, 1954	79	USGS	5,190	4,230	76	162 8.08	264 21.72
7P1	July 27, 1955	80	USGS	5,250	....	....	28.50	
20Q1	Apr. 20, 1930	....	USDA	4,580	3,454	....	168 8.36	224 18.42
20Q2	Feb. 16, 1954	....	T	....	[2]4,367.2	49.6	219.0 10.93	321.1 26.41
20Q2	Aug. 4, 1954	77	USGS	4,940	3,960	60	180 8.98	304 25.02

See footnotes at end of table.

McKittrick area, Kings and Kern Counties, Calif.—Continued

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as ($CaCO_3$) (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
152 6.61	1.2 0.03	0 0.00	226 3.70	347 7.22	96 2.71	0.3 0.04	4.4 0.07	1.3	48	357	7.9	
79 3.44	2.9 .07	5 .17	129 2.11	164 3.41	102 2.88	.2 .01	22 .35	.30	38	274	8.4	NH_4, 0.4; NO_2, 0.01
84 3.65	2.0 .05	0 .00	117 1.92	198 4.12	97 2.74	....	....	.46	40	276	7.6	
390 16.96	4.5 .12	0 .00	242 3.9	1,040 21.65	205 5.78	.5 .03	12 .19	4.1	54	723	7.9	
395 17.18	4.4 .11	0 .00	244 4.00	1,020 21.24	195 5.50	.5 .03	12 .19	1.6	55	696	7.9	
370 16.09	....	....	....	......	215 6.06	....	....	......	......	786	.....	
418 18.18	12 .31	0 .00	254 4.16	1,140 23.73	260 7.33	.4 .02	12 .19	1.8	52	824	7.7	
482 20.96	....	....	....	......	330 9.31	....	....	......	......	930	.....	
430 18.70	16 .41	0 .00	206 3.38	1,400 29.15	295 8.32	.1 .01	25 .40	2.4	45	1,110	8.1	
451 19.61	....	....	....	......	305 8.60	....	....	......	......	1,180	.....	
800 34.79	10 .26	0 .00	464 7.60	2,190 45.59	435 12.27	.5 .03	10 .16	5.7	54	1,460	7.6	
829 36.05	....	....	....	......	445 12.55	....	....	......	......	1,420	.....	
810 35.22	12 .31	0 .00	474 7.77	2,270 47.26	410 11.56	.6 .03	4.4 .07	10	53	1,550	7.7	
840 36.53	16 .41	0 .00	416 6.82	2,260 47.05	395 11.14	.2 .01	5.7 .09	4.7	55	1,490	7.9	NH_4, 0; NO_2, 0; I, 0.2; Br, 1
829 36.05	....	....	....	......	450 12.69	....	....	......	......	1,420		
606 26.34		296 4.85		1,690 35.22	463 13.05	....	....	3.9	50	1,340	.....	
709.6 30.86	....	....	342 5.60	2,370 49.34	468 13.20	....	....	1.9	45	1,880	7.4	Fe, Al, 16
638 27.74	23 .59	0 .00	273 4.47	2,190 45.59	430 12.13	.0 .00	2.5 .04	.98	45	1,700	7.7	NH_4, 0.1; NO_2, 0; I, 0.3; Br, 1

Table 8.—*Chemical analyses of waters from wells in the Avenal-*

Well	Date sampled	Temperature (F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
25-19-23B1	Jan. 30, 1953	....	USGS	3,350	2,480	37	129 6.44	132 10.86
23B1	Aug. 3, 1954	88	USGS	3,360	2,470	37	138 6.89	131 10.79
20-15Q1	Apr. 23, 1953	....	USGS	3,720	2,830	35	286 14.27	87 7.15
15Q1	Aug. 3, 1954	82	USGS	3,620	2,840	37	297 14.82	80 6.58
15Q1	Aug. 4, 1955	....	USGS	3,890	3,010	46	303 15.12	91 7.48
35B1	May 25, 1954	70	USGS	4,420	2,200	....	136 6.79	61 5.02
21-32E1	Aug. 5, 1954	....	USGS	5,160	3,650	48	286 14.27	60 4.93
34Q1	May 25, 1954	70	USGS	4,780	3,157	....	177 8.83	50 4.11
34Q1	Aug. 4, 1954	84	USGS	4,900	3,240	32	293 14.62	9.5 78
26-17-11R1	.....do............	73	USGS	1,800	1,250	40	67 3.34	72 5.94
13L2	Oct. 13, 1955	71	USGS	1,740	1,188	51	67 3.34	77 6.30
18-11K1	Jan. 30, 1953	67	USGS	8,370	5,450	23	378 18.86	220 18.09
11K1	Aug. 5, 1954	77	USGS	15,700	10,400	40	814 40.62	473 38.88
14R1	.....do............	75	USGS	2,350	1,620	43	89 4.44	87 7.18
14R1	Aug. 5, 1955	72	USGS	2,370	1,610	44	79 3.94	93 7.66
15P1	.....do............	74	USGS	2,180	1,530	42	82 4.09	97 7.99
16J1	Apr. 22, 1953	75	USGS	2,160	1,490	42	85 4.24	94 7.73

See footnotes at end of table.

McKittrick area, Kings and Kern Counties, Calif.—Continued

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as ($CaCO_3$) (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
470	8.3	0	204	1,240	340	0.4	16	3.6	54	856	7.6	
20.44	0.21	0.00	3.34	25.82	9.59	0.02	0.26					
484	7.0	0	201	1,240	3.11	.2	20	2.5	54	884	8.2	NH_4, 0.1; NO_2, 0
21.05	.18	.00	3.29	25.82	8.77	.01	.32					
483	3.5	0	110	1,500	375	.5	0	3.4	49	1,070	7.6	
21.00	.09	.00	1.80	31.23	10.58	.03	.00					
512	9.0	0	120	1,460	378	.0	2.5	4.1	51	1,070	7.7	NH_4, 0.1; NO_2, 0; I, 0.4; Br, 2
22.26	.23	.00	1.97	30.40	10.66	.00	.04					
528	3.0	0	124	1,570	402	.4	1.4	5.1	50	1,130	7.9	I, 0.9; Br, 1
22.96	.08	.00	2.03	32.69	11.34	.02	.02					
750	5.0	0	316	59	1,040	....	....	.....	73	590	7.9	
32.61	.13	.00	5.18	1.23	29.33							
870	8.0	0	151	1,470	830	.4	1.8	5.3	66	960	7.5	NH_4, 0.4; NO_2, 0.01; I, 0.6: Br, 4
37.83	.20	.00	2.47	30.60	23.41	.02	.03					
870	5.2	0	234	1,100	840	....	....	.....	74	647	8.1	
37.83	.13	.00	3.83	22.90	23.69							
840	9.0	0	386	992	870	.5	1.8	.80	70	770	7.8	NH_4, 0; NO_2, 0; I, 0.7; Br, 4
36.53	.23	.00	6.33	20.65	24.54	.03	.03					
241	1.6	0	249	552	126	0.9	24	.95	53	464	8.0	NH_4, 0.7; NO_2, 0.02
10.48	.04	.00	4.08	11.49	3.55	.05	.39					
228	1.6	0	259	550	136	....	....	1.5	......	482	7.8	
9.92	.04	.00	4.25	11.45	3.84							
1,250	5.7	0	236	1,180	2,200	.5	70	11	59	1,850	7.4	
54.35	.15	.00	3.87	24.57	62.05	.03	1.13					
2,290	12	....	....	....	....	....	....	.....	......	....	....	
99.58	.31											
319	5.2	0	204	658	288	.5	29	1.0	54	581	7.8	
13.87	.13	.00	3.34	13.70	8.12	.03	.47					
327	2.0	0	199	654	276	.4	32	2.7	55	580	7.6	
14.22	.05	.00	3.26	13.62	7.78	.02	.52					
280	1.5	0	195	666	232	.6	26	2.0	50	604	7.7	
12.18	.04	.00	3.20	13.87	6.54	.03	.42					
261	2.0	0	208	700	185	.7	17	1.1	49	598	7.9	
11.35	.05	.00	3.41	14.57	5.22	.04	.27					

Table 8.—*Chemical analyses of waters from wells in the Avenal-*

Well	Date sampled	Temperature (F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
26-18-16J1	Aug. 5, 1955	74	USGS	2,100	1,470	42	80 3.99	91 7.45
16M1	Aug. 4, 1954	75	USGS	2,060	1,470	44	95 4.74	85 6.96
16M1	Aug. 5, 1955	72	USGS	2,020	1,400	44	74 3.69	81 6.67
16N1	Aug. 4, 1954	75	USGS	2,500	1,840	44	115 5.74	102 8.42
16N1	Aug. 5, 1955	74	USGS	2,510	1,820	46	105 5.24	104 8.58
18F3	Apr. 22, 1953	74	USGS	1,730	1,180	45	60 2.99	71 5.84
18F3	Aug. 4, 1954	75	USGS	1,770	1,270	44	78 3.89	64 5.27
18F3	Aug. 5, 1955	72	USGS	1,790	1,270	45	64 3.19	73 6.01
19B2	Aug. 4, 1954	77	USGS	4,400	3,580	44	159 7.93	268 22.07
19B2	Aug. 5, 1955	....	USGS	4,550	3,750	50	322 16.07	183 15.01
21A1	....do.............	74	USGS	2,720	2,000	44	114 5.69	127 10.41
22C1	Aug. 5, 1954	....	USGS	2,310	1,680	44	111 5.54	97 7.96
22C1	Aug. 5, 1955	72	USGS	2,320	1,680	45	93 4.64	107 8.84
23A1	Apr. 22, 1953	74	USGS	2,290	1,560	42	87 4.34	95 7.81
23C1	Aug. 5, 1954	75	USGS	2,300	1,590	40	88 4.39	98 8.09
23C1	Aug. 5, 1955	74	USGS	2,290	1,590	43	100 4.99	91 7.49
23M2	Aug. 5, 1954	77	USGS	2,490	1,800	42	102 5.09	121 9.95
23M2	Aug. 5, 1955	76	USGS	2,480	1,800	45	105 5.24	113 9.33

See footnotes at end of table.

McKittrick area, Kings and Kern Counties, Calif.—Continued

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as ($CaCO_3$) (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
272	1.5	0	214	657	198	0.6	22	1.7	51	572	7.7	
11.83	0.04	0.00	3.51	13.68	5.58	0.03	0.35					
273	3.6	0	201	687	172	.8	15	.36	50	585	7.7	NH_4, 0;
11.87	.09	.00	3.29	14.30	4.85	.04	.24					NO_2, 0.01
264	3.0	0	233	633	170	1.0	15	1.7	52	518	7.7	
11.48	.08	.00	3.82	13.18	4.79	.05	.24					
332	4.0	0	231	926	205	.7	.5	1.7	50	708	8.2	NH_4, 0.36;
14.44	.10	.00	3.79	19.28	5.78	.04	.01					NO_2, 0.02
336	3.0	0	232	897	200	.8	14	2.0	51	691	7.7	
14.61	.08	.00	3.80	18.67	5.64	.04	.23					
215	2.0	0	252	522	120	.9	16	1.1	51	442	7.0	
9.35	.05	.00	4.13	10.87	3.38	.05	.26					
231	3.6	0	246	576	132	.9	18	1.5	52	458	8.2	
10.04	.09	.00	4.03	11.99	3.72	.05	.29					
241	2.5	0	254	575	128	1.0	14	1.5	53	460	7.5	
10.48	.06	.00	4.16	11.97	3.61	.05	.23					
587	14	0	358	1,980	338	.0	6.6	3.1	46	1,500	8.0	NH_4, 0.2;
25.53	.36	.00	5.87	41.22	9.53	.0	.11					NO_2, 0.01
620	14	0	391	2,060	304	.6	1.8	4.1	46	1,500	7.9	
26.96	.36	.00	6.41	42.89	8.57	.03	.03					
352	3.2	0	218	1,010	220	.5	23	2.1	49	805	7.8	
15.31	.08	.00	3.57	21.03	6.20	.03	.37					
284	3.6	0	203	827	190	.5	20	1.6	48	675	7.8	NH_4, 0.54;
12.35	.09	.00	3.33	17.22	5.36	.03	.32					NO_2, 0.01
297	2.5	0	207	820	192	.6	21	1.7	49	674	7.8	
12.91	.06	.00	3.39	17.07	5.42	.03	.34					
286	2.8	0	210	675	240	.6	27	1.4	50	608	7.9	
12.44	.07	.00	3.44	14.05	6.77	.03	.44					
296	2.0	0	208	683	240	.3	41	1.9	51	624	7.8	NH_4, 0.7;
12.87	.05	.00	3.41	14.22	6.77	.02	.66					NO_2, 0.02
300	2.0	0	210	677	237	.4	33	2.3	51	624	7.9	
13.05	.05	.00	3.44	14.09	6.68	.02	.53					
311	2.4	0	211	885	204	.4	29	1.6	47	752	7.7	NH_4, 0.4;
13.52	.06	.00	3.46	18.42	5.75	.02	.47					NO_2, 0.01
319	3.0	0	220	874	208	.6	23	1.8	49	728	7.7	
13.87	.08	.00	3.61	18.20	5.87	.03	.37					

Table 8.—*Chemical analyses of waters from wells in the Avenal-*

Well	Date sampled	Temperature (F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
26-18-27F1	Apr. 21, 1953	74	USGS	7,200	6,180	26	534 26.65	325 26.73
27F1	Aug. 4, 1954	77	USGS	7,140	6,250	27	535 26.70	332 27.30
27F1	Aug. 5, 1955	....	USGS	7,960	7,040	29	577 28.79	386 31.71
19-12L1	Aug. 3, 1954	84	USGS	4,730	3,660	51	363 18.11	188 15.43
25M1	Apr. 20, 1930	....	USDA	3,630	2,354	....	199 9.93	114 9.35
21- 6F1	Aug. 5. 1954	77	USGS	8,410	6,950	31	552 27.54	239 19.65
6F1	Aug. 4, 1955	74	USGS	7,960	6,660	38	528 26.35	234 19.25
12F1	Feb. 2, 1953	....	USGS	2,750	1,860	41	81 4.04	40 3.29
14F1	June 28, 1948	....	NBS	3,600	[2]2,700	....	230 11.48	43 3.54
14H2	Aug. 4, 1954	72	USGS	4,060	2,650	27	254 12.67	19 1.55
14H2	Aug. 4, 1955	72	USGS	4,400	2,950	27	303 15.12	34 2.78
14H2	Oct. 24, 1955	72	USGS	4,420	2,965	....	302 15.07	36 2.93
25F1	....	....	H	....	....	....	3.20	
25F1	....	....	H	....	....	....	3.56	
25F1	....	....	H	....	....	....	3.84	

See footnotes at end of table.

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as ($CaCO_3$) (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
952 41.40	16 0.41	0 0.00	536 8.78	3,440 71.62	612 17.26	.8 0.04	5.2 0.08	5.4	43	2,670	7.5	
1,020 44.35	17 .43	0 .00	452 7.41	3,450 71.83	600 16.92	.2 .01	38 .61	6.9	45	2,700	7.7	NH_4, 0; NO_2, 0.01; I, 0.3; Br, 4
1,160 50.44	18 .46	0 .00	490 8.03	3,930 81.82	690 19.46	.6 .03	5.2 .08	8.1	45	3,020	7.5	I, 0.3; Br, 3
544 23.66	6.0 .15	0 .00	147 2.41	1,790 37.27	629 17.74	.0 .00	12 .19	2.7	41	1,680	8.0	NH_4, 0; NO_2, 0; I, 0.6; Br, 3
450 19.57		....	204 3.35	884 18.40	606 17.10	....	....	1.2	50	964	.....	
1,380 60.01	6.0 .15	0 .00	94 1.54	3,630 75.57	1,050 29.61	.4 .02	1.4 .02	9.7	56	2,360	7.4	NH_4, 0.4; NO_2, 0.05; I, 1; Br, 4
1,330 57.83	4.0 .10	0 .00	97 1.59	3,470 72.24	1,000 28.20	.4 .02	1.6 .03	10	56	2,280	7.4	I, 2; Br, 3
500 21.74	3.6 .09	0 .00	500 8.19	712 14.82	230 6.49	1.0 .05	.4 .01	2.9	75	366	8.0	
620 26.96	5.3 .14	0 .00	580 9.50	920 19.15	500 14.10	....	.9 .01	......	64	751	.....	
6.29 27.35	7.0 .18	0 .00	237 3.88	803 16.72	795 22.42	.4 .02	1.2 .02	1.5	66	711	7.8	NH_4, 0; NO_2, 1.0; I, 1; Br, 4
692 30.09	3.0 .08	0 .00	399 6.54	870 18.11	820 23.13	0.3 .02	2.3 .04	2.0	63	895	7.7	I, 1; Br, 2
702 30.54	3.0 .08	0 .00	396 6.49	900 18.74	825 23.26	....	....	1.9	63	900	7.6	
......	....	0 .00	357 5.85	1,240 25.9	386 10.9	....	....	......	92	160	7.4	Sample from 100 ft depth. Analyzed March 13, 1945
......	....	3 .1	296 4.85	1,430 29.8	629 17.75	....	....	......	93	178	7.3	Sample from 220 ft depth. Analyzed March 13, 1945
......	....	0 .00	415 6.8	2,130 44.3	791 22.3	....	....	......	95	192	7.3	Sample from 312 ft depth. Analyzed March 13, 1945

Table 8.—*Chemical analyses of waters from wells in the Avenal-*

Well	Date sampled	Temperature (F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
26-21-25F1	....	....	H	....	....	....	11.2	
26G1	Aug. 4, 1954	75	USGS	6,320	4,280	29	418 20.86	31 2.54
28P1	Aug. 9, 1954	81	USGS	4,970	3,730	45	366 18.26	91 7.50
27-19-28H1	Jan. 30, 1953	....	USGS	8,040	6,500	43	437 21.81	202 16.61
28H1	Aug. 3, 1955	78	USGS	7,570	6,130	43	416 20.76	184 15.14
28H2	Aug. 6, 1954	86	USGS	8,020	6,490	44	482 24.05	195 16.07
20- 9C1	Apr. 20, 1930	....	USDA	5,450	3,863	....	282 14.07	166 13.67
34G1	Feb. 9, 1954	....	T	....	[2]2,848.4	52.8	20.3 1.01	26.4 2.17
21- 3A1	Sept. 16, 1930	....	USDA	6,100	5,041	....	487 24.30	88 7.24
4K	....	....	SO	....	[2]3,781	31	280 13.97	109 8.96
22- 6NW¼	Oct. 18, 1944	....	UCB	890	537	....	22 1.1	13 1.1
28-22- 7Q1	....	....	H	....	3,198	....	277 13.8	59 4.82
7Q1	....	....	H	....	3,875	....	274 13.65	65 5.36

See footnotes at end of table.

McKittrick area, Kings and Kern Counties, Calif.—Continued

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as ($CaCO_3$) (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
......	....	3 0.1	387 6.35	2,220 46.3	972 27.4	....	....	.....	86	560	7.9	Sample from 375 ft depth. Analyzed March 13, 1945
1,040 45.22	16 0.41	0 .00	143 2.34	1,200 24.98	1,460 41.18	.2 0.01	8.9 0.14	5.5	65	1,170	7.9	NH_4, 0.4; NO_2, 0.01; I, 0.4; Br, 7
711 30.92	17 .43	0 .00	166 2.72	1,670 34.77	745 21.01	.0 .00	3.1 .05	3.2	54	1,290	7.6	NH_4, 0; NO_2, 0; I, 0.7; Br, 3
1,380 60.01	17 .43	0 .00	216 3.54	3,240 67.45	1,050 29.61	1.1 .06	9.3 .15	9.5	61	1,920	7.7	
1,360 59.14	12 .31	0 .00	206 3.38	3,020 62.87	980 27.64	1.4 .07	4.4 .07	9.1	62	1,800	7.5	
1,370 59.50	4.0 .10	0 .00	211 3.46	3,310 68.91	972 27.41	1.2 .06	2.0 .03	9.4	60	2,010	8.2	NH_4, 1.3; NO_2, 0; I, 3; Br, 4
779 33.87		....	186 3.05	1,780 36.96	766 21.60	....	....	3.31	55	1,390	....	
998.4 43.41	....	Trace	827 13.55	464 9.66	830 23.4	....	....	.4	93	161	8.3	Fe, Al, 9.2
1,025 44.55		....	85 1.40	2,850 59.33	542 15.30	....	....	5.23	59	1,580	....	
869		92 3.07	....	1,330 27.69	1,060 29.90	....	....	.....	....	1,150	....	Fe, Al, 9; CO_3, as reported probably in part HCO_3
177 7.7	....	....	445 7.3	48 1.0	57 1.6	....	....	.92	78	110	....	
692 30.1	....	2 .06	75 1.23	1,700 35.39	431 12.15	....	....	.....	62	930	6.9	Sample from 115 ft depth. Analyzed March 13, 1945
911 39.6	....	0 .00	100 1.64	2,110 43.93	463 13.05	....	....	.....	68	950	6.9	Sample from 150 depth. Analyzed March 13, 1945

Table 8.—*Chemical analyses of waters from wells in the Avenal-*

Well	Date sampled	Temperature (F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
28-22- 7Q1	...	...	H	...	4,077	...	276 13.75	59 4.87
7Q1	...	...	H	...	3,771	...	237 11.85	27 2.23
7Q1	...	...	H	...	4,890	...	347 17.15	64 5.25
7Q1	...	...	H	...	4,991	...	348 17.35	63 5.15
29-23-18	Nov. 30, 1892	...	SP	...	540	...	37	...

[1]No report.
[2]Total dissolved solids were determined by evaporation.

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as ($CaCO_3$) (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
957 41.6	....	2 0.08	99 1.63	2,220 46.22	445 12.56	....	....	.....	69	931	6.9	Sample from 230 ft depth. Analyzed March 13, 1945.
975 42.4	....	9 .3	87 1.43	2,040 42.47	444 12.52	....	....	.....	75	704	6.8	Sample from 310 ft depth. Analyzed March 13, 1945.
1,171 50.9	....	0 .00	114 1.87	2,740 57.04	514 14.5	....	....	.....	70	1,120	6.8	Sample from 352 ft depth. Analyzed March 13, 1945.
1,207 52.5	....	0 .00	114 1.87	2,800 58.3	517 14.57	....	....	......	70	1,120	6.8	Sample from 365 ft depth. Analyzed March 13, 1945.
181		0 .00	26 .43	49 1.02	261 7.36	....	....	......	79	....	.....	SiO_2, Fe, Al, 19; well 686 ft deep.

Table 9.—*Chemical analyses of waters from streams and springs*

Upper number indicates constituents in parts per million, lower number indicates ness as $CaCO_3$ are given in parts per million. Laboratories abbreviated as follows: ards analyses for U. S. Bureau of Reclamation. Other constituents expressed in ppm trate; I, iodide; Br, bromide.

Source and location	Date collected	Temperature (F)	Laboratory	Specific conductance (micromhos at 25°C)	Sum of dissolved solids (ppm)	Silica (SiO_2) (ppm)	Upper number,	
							Calcium (Ca)	Magnesium (Mg)
Streams								
Avenal Creek, 24-17-10, SW¼, north end McLure Valley.	1–28–52	55	NBS	700	[1]530	....	52 2.59	38 3.12
Avenal Creek, 24-17-14, NW¼, north end McLure Valley; 1.6 miles west of State Highway 41.	1–26–54	50	USGS	499	306	....	31 1.55	21 1.73
Polonio Creek, 25-17-30, S¼, cor., northwest end Antelope Valley.	1–25–52	....	NBS	590	[1]540	....	50 2.49	20 1.64
Bitterwater Creek, 27-18-13, NE¼.	1–25–52	59	NBS	3,100	[1]3,200	....	500 24.95	64 5.26
Media Agua Creek, 28-19-11, near bridge on McKittrick wagon road.	1–25–52	55	NBS	1,800	[1]1,600	....	210 10.48	52 4.28
Carneros Creek, 28-20-29, near S¼ cor.	1–25–52	55	NBS	2,200	[1]1,900	....	200 9.98	81 6.66
Springs								
Unnamed spring, 25-18-25C.	4-23-53	....	USGS	16,100	10,900	....	0.0 0.00	49 4.03
Mize Spring, 28-19-22	8– 6–54	73	USGS	3,830	3,060	14	301 15.02	140 11.54
Carneros Spring, 29-20-5.	8– 7–54	90	USGS	542	362	31	56 2.79	14 1.18
Do..................	8– 3–55	88	USGS	704	476	21	58 2.89	17 1.36
Unnamed spring, 29-21-33E.	11– 8–55	94	USGS	3,530	2,830	....	230 11.48	181 14.92

[1]Determined by evaporation.

constituents in equivalents per million. Dissolved solids, silica, boron, and hard-
USGS, Quality of Water Branch, U. S. Geological Survey; NBS, National Bureau of Stand-
are given as follows: SiO_2, silica; Fe, iron; Al, aluminum; NH_4, ammonium; NO_2, ni-

parts per million, ppm. Lower number, equivalents per million, epm								Boron (B) (ppm)	Percent sodium	Hardness as ($CaCO_3$) (ppm)	pH	Other constituents and remarks (ppm)
Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)					
Streams												
62 2.70	2 0.05	24 0.80	220 3.60	130 2.71	23 0.65	....	2.6 0.04	0.8	32	286	.....	Estimated discharge, 18 cfs.
40 1.74	5.1 .13	0 .00	132 2.16	114 2.37	14 .39	....	5.2 .08	.54	34	164	7.3	SiO_2,11; Fe, 0.52; Al, 0.02.
40 2.09	10 .26	0 .00	100 1.64	140 2.92	42 1.82	....	23 .37	.4	32	207	.....	Estimated discharge, 0.8 cfs.
320 13.92	7.8 .20	0 .00	79 1.29	1,800 37.47	160 4.51	....	6.5 .10	.9	31	1,510	.....	Estimated discharge, 0.2 cfs.
160 6.98	5.2 .13	0 .00	110 1.80	820 17.07	90 2.54	....	4.4 .07	.3	32	837	.....	Estimated discharge, 7½ cfs.
260 11.31	7.1 .18	0 .00	150 2.46	1,100 22.90	110 3.10	....	4.4 .07	.6	40	832	.....	Estimated discharge, 7½ cfs.
Springs												
4,220 183.50	40 1.02	683 22.76	2,370 38.84	1,130 23.53	3,560 100.40	....	14 0.23	14	97	202	9.2	
484 21.05	4.8 .12	0 .00	207 3.39	1,740 36.23	264 7.45	0.6 0.03	4.9 .08	5.5	44	1,330	7.7	NH_4, 0.4; NO_2,0.01.
39 1.70	1.9 .05	0 .00	179 2.93	117 2.44	14 .39	.2 .01	.4 .01	.17	30	199	8.0	NH_4, 0; NO_2, 0.
66 2.87	3.3 .08	0 .00	156 2.56	197 4.10	21 .59	.2 .01	9.0 .15	.00	40	213	7.8	
430 18.70	10 .26	0 .00	337 5.52	1,560 32.48	250 7.05	....	....	3.8	41	1,320	7.7	

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*

[Altitudes are approximate; interpolated from topographic maps. Datum is mean sea level]

	Thickness (feet)	Depth (feet)
23-18-21D1		
Standard Oil Co.; well on alluvial plain about 4 miles southeast of Avenal. Altitude 530 ft. Drilled by Roscoe Moss Co., 1946. Water level when drilled was about 85 ft below land surface]		
Soil	18	18
Sand and gravel	67	85
Clay, yellow	35	120
Gravel and clay, yellow	23	143
Clay, sandy, yellow	42	185
Clay, yellow	135	320
Clay, yellow, and cemented gravel streaks	23	343
Clay, sandy, yellow	22	365
Gravel and sand	23	388
Clay, yellow	22	410
Sand, gravel, and clay, yellow	23	433
Clay, sandy, yellow	46	479
Clay, yellow	81	560
Clay, yellow, sandy, and sand streaks	160	720
Clay, yellow, and gravel	35	755
Clay, yellow	75	830
Clay, yellow, and gravel	24	854
Clay, yellow	56	910
Shale, brown	10	920
23-18-29E2		
[Tidewater Associated Oil Co.; well 2 at Reef pump station on edge of alluvial plain about 8 miles southeast of Avenal. Altitude 560 ft. Water level when drilled was about 126 ft below land surface]		
Hardpan	52	52
Boulders, cemented	7	59
Clay, sandy	104	163
Water sand	2	165
Clay, sandy	16	181
Water sand	1	182
Clay	1	183
Boulders, cemented	17	200
Clay, hard	145	345
Boulders, cemented	1	346
Clay, hard	5	351
Boulders, cemented	13	364
24-17-25D1		
[Orchard ranch 10; well on alluvial plain about 0.8 mile north of Orchard ranch headquarters in McLure Valley. Altitude 715 ft. Drilled in 1951. Water level when drilled was about 175 ft below land surface]		
Top soil	12	12
Gravel	2	14
Clay	14	28
Gravel	6	34

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
24-17-25D1—Continued		
Clay	140	174
Clay, sand, and gravel	26	200
Clay	46	246
Clay, red	4	250
Sandstone, soft	30	280
Clay, sandy	8	288
Sandstone and boulders	27	315
Clay, yellow	3	318
Sandstone, soft, and boulders	20	338
Shale, yellow	2	340
24-18-30B1		
[Orchard ranch 7; well on alluvial plain about 1.5 miles northeast of Orchard ranch headquarters in McLure Valley. Altitude 685 ft. Deepened by L. E. Williams, 1950. Water level when drilled in 1948 was about 123 ft below land surface. Water level when deepened in 1950 was about 174 ft below land surface]		
Old well	300	300
Clay, sandy, white	15	315
Clay, hard	42	357
Gravel, cemented	6	363
Clay, gray	43	406
Clay, yellow	62	468
Sand shell, hard	3	471
Gravel, cemented	5	476
Sand, hard, and rust streaks	44	520
Gravel, cemented	3	523
Sediment, blue	5	528
Gravel, blue	8	536
Clay, blue, sticky	4	540
24-18-30D1		
[Orchard ranch 3; well on alluvial plain about 1 mile northeast of Orchard ranch headquarters in McLure Valley. Altitude 699 ft. Drilled by Lantis and Sorensen, 1956. Water level when drilled was about 103 ft below land surface]		
Surface soil	14	14
Rock and gravel	36	50
Gravel, cemented	14	64
Surface clay	16	80
Rock and gravel (good water strata)	40	120
Clay, sandy	8	128
Rock and gravel	24	152
Clay, sandy, and rock	16	168
Rock and gravel	24	192
Clay, sandy, and rock	8	200
Sand and gravel	20	220
Clay, sticky	150	370
Sand and gravel	8	378
Clay, sandy	16	394
Clay, sticky	8	402
Rock and gravel	8	410
Clay	4	414
Rock and gravel	6	420

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
24-18-30D1—Continued		
Clay	4	424
Gravel, cemented	4	428
Rock and gravel	22	450
Clay	3	453
24-18-30P2		
[Orchard ranch 11; well on alluvial plain about 1.2 miles east of Orchard ranch headquarters in McLure Valley. Altitude 675 ft. Drilled in 1953. Water level when drilled was about 165 ft below land surface]		
Top soil	10	10
Clay, yellow	40	50
Sand and gravel	5	55
Clay, yellow	100	155
Gravel and clay	15	170
Clay, yellow	10	180
Gravel and boulders	25	205
Clay, yellow	20	225
Clay and gravel	10	235
Clay, yellow, sticky	30	265
Gravel and boulders	20	285
Clay, yellow	17	302
Gravel and clay	14	316
Gravel	8	324
Clay, yellow	34	358
Gravel	13	371
Clay and gravel	3	374
Clay, yellow	4	378
Clay and gravel	10	388
Clay, yellow	12	400
25-19-20Q1		
[Tidewater Associated Oil Co.; well 2, at Temblor pump station on alluvial plain near the southwest edge of Kettleman Hills. Altitude 480 ft. Drilled in 1910. Water level when drilled was about 118 ft below land surface]		
Soil	20	20
Gravel, cemented	4	24
Clay	36	60
Gravel, cemented, dry	7	67
Clay, hard	27	94
Gravel, cemented, mixed with clay	24	118
Clay, hard	12	130
Clay, some water	24	154
Clay, hard	24	178
Clay, porous	11	189
Clay, hard	16	205
Clay, sandy, soft	5	210
Clay, hard	15	225
Clay, sandy, soft, and water	6	231
Clay, hard	41	272
Clay, porous	12	284
Clay, hard	25	309
Clay, porous	15	324
Clay, hard and soft, in small stratas	60	384

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
25-19-20Q1—Continued		
Fossil rock, cemented	3	387
Clay, hard	89	476
Shale	4	480
Clay, hard	8	488
Sandstone	4	492
Fossils, cemented	9	501

25-19-20Q2

[Tidewater Associated Oil Co.; well 3 at Temblor pump station on alluvial plain near southwest edge of Kettleman Hills. Altitude 480 ft. Drilled in 1948]

Not logged	98	98
Gravel	3	101
Not logged	19	120
Gravel	2	122
Not logged	43	165
Clay, yellow	67	232
Gravel	4	236
Clay	49	285
Shale and gravel	2	287
Clay	17	304
Shale and gravel	4	308
Clay	27	335
Clay, yellow	28	363
Gravel and sand	2	365
Clay	35	400

25-21-20F1

[Shell Oil Co.; well and Mid Station on alluvial plain about 9 miles north of Lost Hills. Altitude 220 ft. Water reported to be too highly mineralized for domestic or industrial use]

Sand, fine	35	35
Clay, sandy, blue	5	40
Sand, fine	17	57
Sand, yellow	28	85
Sand, loose	27	112
Sand, fine	5	117
Clay, sandy	5	122
Sand, fine	26	148
Shale, sandy, blue	47	195
Sand, gray, fine	5	200
Shale, blue	6	206
Sand, gray, coarse	27	233
Clay, blue	15	248
Sand, gray	8	256
Sand and shale, streaks	26	282
Sand, gray	13	295
Shale, sandy, blue	5	300
Sand, gray	18	318
Shale, blue	7	325
Sand, gray	5	330
Shale, blue	18	348
Sand, gray	5	353

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
25-21-20F1—Continued		
Sand and clay streaks	18	371
Sand, gray, fine	8	379
Sand and shale, blue	14	393
Shale, blue, with sand	21	414
Sand, gray, fine	10	424
Clay, gray	8	432
Water sand, gray	18	450
Sandy shale, blue	14	464
Sand, gray	8	472
Shale, blue	14	486
Sand, gray, fine	8	494
Shale, blue	14	508
Sand, gray, fine	8	516
Shale, blue, and streaks of sand	13	529
Sand, fine, and streaks of shale	18	547
Shale, blue, and streaks of sand	23	570
Sand, gray, hard	10	580
Shale, blue, and streaks of sand	10	590
Sand, gray, fine	5	595
Shale, blue	81	676
Sand, gray, fine	6	682
Shale, blue, and streaks of sand	8	690
Shale, blue	564	1,254

26-17-11R1

[E. Still; well on alluvial plain about 1.2 miles west of Keck's Corner in Antelope Valley. Altitude 860 ft. An old well redrilled by L. E. Williams, 1953. Water level when redrilled was about 65 ft below land surface]

Top soil	20	20
Clay, sandy, and gravel	36	56
Clay, gravel, and boulders	28	84
Clay and gravel	12	96
Gravel	4	100
Clay and gravel	10	110
Gravel	8	118
Clay, gravel, and boulders	47	165
Boulders	13	178
Clay and gravel	6	184
Shale, black	1	185

26-18-14E1

[E. Still; well on alluvial plain about 4.1 miles east of Keck's Corner. Altitude 645 ft. Drilled by L. E. Williams in 1950]

Top soil	27	27
Clay and silt	80	107
Gravel	2	109
Clay	7	116
Gravel	3	119
Clay	5	124
Gravel	7	131
Clay	7	138
Gravel	4	142

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
26-18-14E1—Continued		
Clay	17	159
Gravel	2	161
Clay, blue	36	197
Clay, yellow	51	248
Gravel	11	259
Shale, yellow and gray	91	350
26-18-14N1		
[E. Still; well on alluvial plain about 4.2 miles southeast of Keck's Corner. Altitude 670 ft. Drilled by L. E. Williams in 1949]		
Top soil	29	29
Clay, yellow, and chalk gravel streaks	106	135
Gravel (surface water)	5	140
Clay, yellow	20	160
Gravel	25	185
Clay	25	210
Gravel	32	242
Clay	51	293
Gravel	7	300
Sandstone	33	333
Shale, blue		
26-18-16M1		
[E. Still; well on alluvial plain about 2.2 miles southeast of Keck's Corner. Altitude 725 ft. Drilled by L. E. Williams in 1949. Water level when drilled was about 150 ft below land surface]		
Surface soil and clay	42	42
Gravel, dry	48	90
Clay, yellow	48	138
Boulders, dry	7	145
Clay, yellow	4	149
Gravel	17	166
Clay	2	168
Clay and gravel	22	190
Clay	20	210
Gravel	5	215
Clay	5	220
Gravel	6	226
Clay	10	236
Gravel	3	239
Clay	6	245
Gravel	4	249
Clay	4	253
Gravel	10	263
Clay, yellow	33	296
Shale, blue	4	300

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Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)

26-18-18F3

[P. Reinke; well on alluvial plain about 0.5 mile southeast of Keck's Corner. Altitude 835 ft. Drilled by L. E. Williams in 1949. Water level when drilled was about 127 ft below land surface]

	Thickness (feet)	Depth (feet)
Surface soil and silt	29	29
Boulders, dry	25	54
Clay, yellow	16	70
Gravel, dry	8	78
Clay	39	117
Gravel (water seepage)	2	119
Clay	6	125
Gravel	23	148
Clay	4	152
Gravel	3	155
Clay	5	160
Gravel	2	162
Clay	8	170
Gravel	5	175
Clay, yellow	40	215
Shale, gravel, brown	10	225
Shale, black, hard		

26-18-21A1

[I. Hansen; well on alluvial plain about 3 miles southeast of Keck's Corner. Altitude 680 ft. Drilled by L. E. Williams in 1949]

	Thickness (feet)	Depth (feet)
Top soil	26	26
Clay, dry, and gravel streaks	126	152
Gravel (surface water)	6	158
Clay	21	179
Gravel	4	183
Clay	16	199
Gravel	1	200
Clay	23	223
Gravel	2	225
Clay	15	240
Gravel	9	249
Clay	3	252
Gravel	2	254
Clay	7	261
Gravel	4	265
Clay	5	270
Gravel	13	283
Shale, blue	2	285

26-18-22B1

[I. Hansen; well on alluvial plain about 3.8 miles east of Keck's Corner in Antelope Valley. Altitude 670 ft. Drilled by L. E. Williams]

	Thickness (feet)	Depth (feet)
Not logged[1]	118	118
Gravel	4	122
Not logged[1]	8	130
Gravel	3	133
Not logged[1]	13	146

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
26-18-22B1—Continued		
Gravel	5	151
Not logged[1]	16	167
Gravel	3	170
Clay, yellow	48	218
Clay, blue	38	256
Shale, black	37	293

[1]Driller reported that sections not logged contained fine-grained, relatively impermeable materials.

26-18-23C1

[E. Still; well on alluvial plain about 4.6 miles east of Keck's Corner. Altitude 670 ft. Drilled by L. E. Williams]

	Thickness (feet)	Depth (feet)
Soil and clay	127	127
Gravel	6	133
Clay	27	160
Gravel	16	176
Clay	15	191
Gravel	6	197
Clay	13	210
Gravel	10	220
Clay	20	240
Gravel	15	255
Clay	8	263
Gravel	6	269
Clay, blue	17	286

26-18-23C2

[E. Still; well on alluvial plain about 4.4 miles east of Keck's Corner. Altitude 670 ft. Drilled by L. E. Williams in 1951. Water level when drilled was about 160 ft below land surface]

	Thickness (feet)	Depth (feet)
Top soil	29	29
Clay and chalk gravel streaks	81	110
Boulders, dry	7	117
Clay	4	121
Boulders, dry	10	131
Clay, yellow	28	159
Gravel	11	170
Clay	38	208
Gravel	7	215
Clay	5	220
Gravel	11	231
Clay	3	234
Gravel	4	238
Clay	2	240
Gravel	12	252
Clay	3	255
Gravel	3	258
Clay	2	260
Gravel	19	279
Clay	2	281
Gravel, cemented	13	294
Clay, blue	3	297

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)

26-18-23M1

[E. Still; well on alluvial plain about 4.5 miles east of Keck's Corner in Antelope Valley. Altitude 680 ft. Drilled by L. E. Williams to a depth of 707 ft in 1949 or 1950 and deepened in December 1955 by rotary method from 707 ft to 1,444 ft]

	Thickness (feet)	Depth (feet)
Alluvial fill, yellow	146	146
Gravel	8	154
Not logged[1]	16	170
Gravel	26	196
Not logged[1]	18	214
Gravel	8	222
Not logged[1]	17	239
Gravel	39	278
Not logged[1]	6	284
Gravel	22	306
Shale, cemented	12	318
Not logged[1]	28	346
Gravel	4	350
Sand, cemented	15	365
Sandstone, gray	41	406
Clay, yellow	34	440
Clay and gravel streaks	98	538
Sandstone, yellow	5	543
Clay and boulders, yellow	19	562
Gravel, sand, and boulders	42	604
Sandstone, hard	15	619
Boulders	11	630
Sand, coarse	13	643
Sand, white, coarse	64	707

[1]Driller reported that sections not logged contained fine-grained, relatively impermeable materials.

26-19-19J2

[Union Oil Co.; well 2 at Junction pump station about 5.8 miles northwest of Blackwells Corner. Altitude 715 ft. Drilled by Reilly and Kibele in 1910]

	Thickness (feet)	Depth (feet)
Clay, brown	50	50
Shale, blue	225	275
Shale, brown	80	355
Water sand	30	385
Shale, blue	22	407
Shale, sandy, light blue	33	440
Shale, blue	3	443
Water sand	5	448
Sand	32	480
Clay, yellow	36	516
Water sand	54	570
Shale, blue, and gravel	20	590
Sandstone, hard	10	600

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)

26-21-25F1

[Standard Oil Co.; well W-1 (RE-9) on alluvial plain near Buena Vista Slough about 2.3 miles northeast of Lost Hills. Altitude 245 ft. Drilled by Roscoe Moss Co., in 1945. Level when drilled was about 28 ft below land surface]

	Thickness (feet)	Depth (feet)
Clay, silty	10	10
Clay, brown, stiff	62	72
Clay, brown, and fine silty sand	22	94
Sand, gray, fine-grained	16	110
Sand, fine-grained, silty, muddy	54	164
Sand, blue, muddy	12	176
Clay, blue, sandy	52	228
Sand, medium-grained, gray	6	234
Clay, sandy, gray; with streaks of blue clay	30	264
Clay, blue	24	288
Sand, medium-grained, gray	4	292
Clay, blue	26	318
Clay, sandy, gray	10	328
Clay, blue, with streaks of sand	38	366
Sand, gray, muddy	8	374
Clay, blue, stiff	22	396

27-20-22M1

[Tidewater Associated Oil Co.; well on dissected upland plain about 1.3 miles northwest of North Belridge. Altitude 650 ft. Drilled by L. E. Williams]

	Thickness (feet)	Depth (feet)
Top fill	207	207
Clay, yellow	66	273
Synthetic silicate	30	303
Clay, blue	52	355
Clay, blue, and dry packed sand	7	362
Shells, hard	12	374
Sandy clay, blue	34	408
Shale and fossil shell rock	12	420
Fossil shells, gray, solid, hard	7	427
Shale, sandy	13	440
Fossil and lime shell, gray, very hard	36	476
Shale, blue, streaked with sandy shale	101	577
Shale, loose, and granite eggs mixture	3	580
Granite sand, coarse and round eggs; very tight	12	592
Shale, light-gray, and granite sand; very caving	11	603
Sand, blue, packed	5	608
Sandstone shell	3	611
Clay, blue, streaked with lime and sand	25	636
Shale, blue	14	650
Shale, blue	35	685
Shale, sandy, blue	27	712
Sandstone, gray, and shell	5	717
Shell, hard	3	720
Sand, coarse, and boulders	4	724
Granite	2	726
Sand, blue, fine	12	738
Shale, blue	13	751
Boulders	3	754
Sand, coarse	2	756
Shale, blue	4	760

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
27-20-22M1—Continued		
Sandstone	4	764
Shale, blue	12	776
Sand, coarse	2	778
Shale, blue	2	780
Sandstone	11	791
Shale, sandy, blue	60	851
Sand, cemented	3	854
Shale, sandy, blue	1	855
27-20-34P1		
[Tidewater Associated Oil Co.; well at Carneras pump station about 1.7 miles south of North Belridge. Altitude 750 ft]		
Soil, sandy	100	100
Clay, sandy, dry	77	177
Sand, yellow, dry	10	187
Clay, sandy, dry	24	211
Sand, white, dry	12	223
Clay, sandy	30	253
Sand, cemented	24	277
Sandstone	24	301
Sand, blue, cemented	26	327
Shale, blue, with shell rock	12	339
Sand, hard, cemented	61	400
Shale, sandy, brown	38	438
Rock, hard	2	440
Shale, sandy, brown	80	520
Water sand	10	530
Shale, sandy, brown	120	650
Water sand, clean, sharp, very coarse	75	725
Shale, blue	261	986
Salt water reported at 986 ft		
28-22-7Q1		
[Standard Oil Co.; well on alluvial plain about 5 miles northeast of South Belridge. Altitude 289 ft. Not a complete log. Measured depth of well in 1955 was 550 ft]		
Clay, sandy, yellow	2	2
Clay, silty, yellow	43	45
Clay, yellow, stiff	31	76
Clay, yellow, and fine silt	46	122
Clay, yellow, stiff	20	142
Clay, yellow, and sand and gravel too closely bedded to separate, sand predominating	14	156
Silt, light-yellow, and fine sand	19	175
Clay, sandy, light-yellow	17	192
Clay, blue	17	209
Sand, fine, clay, blue	15	224
Sand, gray with faulty yellow streaks, medium-to coarse-grained, silty	11	235
Clay, blue	19	254
Clays(?), black and brown	24	278
Clay, sandy, blue	27	305
Sand, gray, medium-grained, silty	9	314

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
28-22-7Q1—Continued		
Clay, sandy, gray	32	346
Sand, gray, with yellow streaks, silty, fine-grained	18	364

29-22-1P1

[Torreta, formerly Klassen 1 well; near Buena Vista Slough about 5.5 miles northwest of Buttonwillow. Altitude 255 ft. Drilled in 1937]

	Thickness (feet)	Depth (feet)
Soil	16	16
Clay, yellow	6	22
Sand	29	51
Clay, gray	3	54
Sand	38	92
Clay, blue	26	118
Sand	10	128
Clay, blue	4	132
Sand	6	138
Clay, blue	5	143
Clay, and sand streaks	5	148
Clay, sandy	5	153
Sand	7	160
Clay, blue	8	168
Sand	4	172
Clay, sandy	21	193
Sand	7	200
Clay, blue	5	205
Sand	11	216
Clay, sandy	7	223
Clay, and sand streaks	26	249
Sand	18	267
Clay, blue, tough	3	270

29-23-17P1

[J. Chicca, formerly Miller and Lux 83; well near Buena Vista Slough about 3.5 miles west of Buttonwillow. Altitude 260 ft. Drilled by D. W. Slocum in 1934 and deepened from 246 ft to 280 ft in 1935]

	Thickness (feet)	Depth (feet)
Soil	10	10
Sand	43	53
Clay, gray	5	58
Sand	1	59
Clay, yellow	23	82
Sand	16	98
Clay, yellow	15	113
Clay, sandy	20	133
Clay, blue	9	142
Clay, sandy	9	151
Sand	22	173
Clay, blue	5	178
Sand	53	231
Clay, yellow	15	246
Clay, blue	11	257
Sand	21	278
Clay, yellow	2	280

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)
29-23-20H1		
[Formerly Miller and Lux 94; well near Buena Vista Slough about 3 miles southwest of Buttonwillow. Altitude 260 ft. Drilled by D. W. Slocum in 1935]		
Soil	19	19
Sand, fine	8	27
Clay, blue	10	37
Sand	14	51
Clay, blue	6	57
Sand	5	62
Clay, blue	8	70
Sand	40	110
Clay, blue	6	116
Sand	8	124
Clay, blue	6	130
Sand	21	151
Clay, blue	15	166
Pack sand	13	179
Clay, gray	5	184
Sand	22	206
Clay, blue	4	210
Clay, yellow	13	223
Sand	5	228
Clay, gray	22	250
29-23-27M1		
[J. Smith, formerly Miller and Lux 106; well near Buena Vista Slough about 2.5 miles southwest of Buttonwillow. Altitude 269 ft. Drilled by D. W. Slocum in 1935]		
Soil	14	14
Sand	81	95
Clay, blue	3	98
Sand	4	102
Clay, blue	3	105
Sand	24	129
Clay, blue	4	133
Sand	45	178
Clay, yellow	6	184
Sand	22	206
Clay, blue	4	210
Sand	4	214
Clay, yellow	6	220
Sand	6	226
Clay, blue	7	233
Sand	3	236
Clay, yellow	3	239
Sand	4	243
Clay, blue	9	252

Table 10.—*Drillers' records of wells in the Avenal-McKittrick area, Kings and Kern Counties, California*—Continued

	Thickness (feet)	Depth (feet)

29-23-34A1

[Mirasol ranch, formerly Miller and Lux 78; well near Buena Vista Slough about 2.2 miles southwest of Buttonwillow. Altitude 270 ft. Drilled by D. W. Slocum in 1934]

	Thickness (feet)	Depth (feet)
Soil	6	6
Sand, dry	2	8
Clay, sandy	10	18
Sand, fine	2	20
Clay, blue	8	28
Sand	31	59
Clay, blue	3	62
Sand	19	81
Clay, blue	19	100
Sand	24	124
Clay, blue	3	127
Sand	38	165
Clay, blue	5	170
Clay, yellow	4	174
Sand, yellow	11	185
Clay, yellow	7	192
Sand, yellow	6	198
Clay, yellow	32	230
Clay, blue	8	238

30-23-1C1

[Davini Bros., formerly Miller and Lux 80; well near Buena Vista Slough about 3.2 miles south of Buttonwillow. Altitude 280 ft. Drilled by D. W. Slocum in 1934]

	Thickness (feet)	Depth (feet)
Soil	6	6
Sand	24	30
Clay, blue	2	32
Sand	35	67
Clay, blue	5	72
Sand	9	81
Pack sand	7	88
Sand	47	135
Clay, yellow	5	140
Sand	45	185
Clay, yellow	6	191
Sand	15	206
Clay, yellow	2	208
Sand	25	233
Clay, sandy	1	234

INDEX

U.S. GOVERNMENT PRINTING OFFICE: 1959 O - 503194