Geology and Ground Water in the Santa Rosa and Petaluma Valley Areas Sonoma County California

By G. T. CARDWELL

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GEOLOGY AND GROUND WATER IN THE SANTA ROSA AND PETALUMA VALLEY AREAS, SONOMA COUNTY, CALIFORNIA

By G. T. Cardwell

ABSTRACT

Santa Rosa and Petaluma Valleys are the westernmost of the several small valleys immediately north of San Francisco Bay, California. The two valleys occupy alined, structurally controlled depressions in the Coast Ranges of northern California. Together they extend from the northern margin of San Francisco Bay northwestward about 35 miles to the Russian River. The valleys are underlain by unconsolidated marine and continental sediments and volcanic rocks of Tertiary and Quaternary age. This material is water bearing in large part and makes up a relatively deep ground-water basin. Santa Rosa Valley, the northernmost and larger of the two valleys, contains about 90 square miles of the approximately 150 square miles of plains and essentially flat-lying lands in the area. Petaluma Valley contains about 45 square miles of alluvial plains, of which about 10 square miles is unreclaimed tidal marsh. The remaining area includes Bennett, Rincon, and Kenwood Valleys, small intermontaine valleys east of Santa Rosa, and a portion of the Russian River flood plain. Ground water is the principal source of water supply for the area, which is chiefly agricultural and has (1950) a population of about 85,000. The overall area of investigation comprises about 450 square miles.

The geologic formations in the area are grouped in three classes based on relative capacity to yield water: (1) consolidated rocks of Jurassic and Cretaceous age which yield essentially no water and include, in ascending order, the Franciscan group, the Knoxville formation, and the Novato conglomerate; (2) sedimentary and volcanic rocks of Tertiary age which are mainly secondary aquifers and include the Tolay volcanics of Morse and Bailey (1935), the estuarine and continental Petaluma formation, and the Sonoma volcanics, all of Pliocene age; and (3) deposits of late Tertiary and Quaternary age which are unconsolidated or poorly consolidated and include the marine Merced formation of Pliocene and Pleistocene(?) age and the continental Glen Ellen formation of Pliocene and Pleistocene age, the older alluvium and terrace deposits of Pleistocene age, and younger alluvium of Recent age. The formations of class 3 are the most important aquifers in the area.

Rocks in class 1 are chiefly sandstone, shale, and conglomerate in this area. Locally they yield enough water for domestic use, mainly from fractures or from beds in which limited primary porosity is preserved. The Tolay volcanics (class 2) are not tapped by wells. The Petaluma formation has a maximum thickness of about 4,000 feet and consists primarily of clay, sandstone, and minor conglomerate. It is tapped by wells mainly on the northeastern flank of upper Petaluma Valley, where it generally yields enough water for domestic needs, and locally as much as 300 gallons per minute (gpm) to individual wells. The Sonoma volcanics consist of interbedded lavas, tuff and tuff breccia, reworked tuff, and

volcanic sediments, and have a thickness of about 2,000 feet. The heterogeneity of these volcanic rocks makes for a wide range in permeability and in the depth of wells, but generally moderate yields can be obtained; irrigation wells commonly yield more than 500 gpm, and locally more than 1,000 gpm.

The Merced and Glen Ellen formations (class 3) have the greatest areal and vertical extent. The Merced crops out principally on the western sides of Santa Rosa and Petaluma Valleys. It consists mainly of fine-grained fossiliferous sand, sandstone, and sandy clay, tuffaceous in part, and has a maximum thickness of 2,000 feet or more. The permeability is fairly low, but wells tapping a thick section in the upper part of the formation have good yields, commonly 500–1,000 gpm if the wells are properly constructed; the lower part of the formation is indurated and has lower permeability. The Glen Ellen formation consists of lenticular bodies of poorly sorted gravel and sand and silty and clayey material, and coarse conglomerate and reworked tuff near the base. It is exposed in the northern part and on the eastern side of Santa Rosa Valley and in the Kenwood Valley–Glen Ellen area. Fair yields are obtained from wells in the upper part of the formation, commonly 300–750 gpm in the northern part of Santa Rosa Valley. Yields are generally low in other areas. The older alluvium and terrace deposits consist of gravel, sand, silt, and clay deposited as alluvial fans and valley alluvium. Terrace deposits locally yield water to wells in the Russian River area, and the older alluvium is an important aquifer in Petaluma Valley where the estimated maximum thickness is about 200 feet. Yields commonly range from about 20–200 gpm. The younger alluvium is the principal aquifer in the Russian River valley where extensive channel deposits of gravel and sand yield water freely to wells. Younger alluvium locally contributes to the yield of wells tapping older deposits in Santa Rosa Valley. In Petaluma Valley maximum yields reported from younger alluvium are about 150 gpm; in Novato Valley, about 50 gpm.

The principal ground-water body in the Santa Rosa Valley area is in the Glen Ellen and Merced formations, which interfinger beneath Santa Rosa Valley. East of Santa Rosa Valley separate water bodies occur in the Sonoma volcanics and locally in the Glen Ellen formation. The Merced formation and the younger and older alluvium comprise the principal water body in Petaluma Valley. Both water-table and confined conditions occur in the ground-water bodies, but the conditions can be distinguished only locally. Generally the separation within principal water bodies is small in Santa Rosa and Petaluma Valleys. Deeper wells commonly have lower heads than shallow wells during summer and autumn, but head differences generally level off in the spring. In the Glen Ellen formation east of Santa Rosa Valley, in the Sonoma volcanics, and in the Petaluma formation, confined conditions are common.

An estimated 10,000 wells (1950) pump ground water for domestic, public-supply, irrigation, and other uses in the Santa Rosa Valley and Petaluma Valley areas. About 200 irrigation wells were in use in 1952. The total pumpage in 1949 was about 15,000 acre-feet (about 13,000 in the Santa Rosa Valley area and 2,000 in Petaluma Valley), an increase of 65 percent over 1945, the earliest year for which pumpage was computed.

The source of ground water in the area is rainfall, which recharges the water bodies by infiltration and deep penetration in the soil zone and by lateral and downward percolation from the beds of shallow streams that cross permeable zones. In Santa Rosa Valley the direction of ground-water movement is generally toward the Laguna de Santa Rosa and Mark West Creek, where discharge takes place. The average gradient across Santa Rosa Valley is about 20 feet per mile. The depth to water in most of the relatively flat-lying portions of the Santa Rosa Valley area ranges from 5 to 20 feet in the spring; the average seasonal fluctuation ranges from 5 to 20 feet. Although locally seasonal fluctuations have increased slightly as a result of increased development, the recovery of water levels each spring generally reflects the rainfall regimen and does not indicate overdraft.

Ground water in the Santa Rosa Valley area is of good quality for most uses and generally is a moderately hard bicarbonate water. Water in two local areas has a high boron content.

The gross storage capacity of the upper 200 feet of deposits lying beneath the flat-lying part of the Santa Rosa Valley area (excluding the adjacent part of the Russian River flood plain) was computed to be about 1,000,000 acre-feet.

In Petaluma Valley, ground water moves toward Petaluma Creek and down valley to discharge into tidal sloughs. In the upper part of Petaluma Valley, the area of heaviest ground-water development, the gradient is 20–50 feet per mile. Water levels in wells in the alluvial-plain area of upper Petaluma Valley generally are 10–25 feet below the land surface in the spring; water levels in the tidal portion are near the land surface. Seasonal fluctuations range from less than 1 foot to about 20 feet. Local overdevelopment is indicated in the vicinity of Petaluma, where water levels are near sea level and withdrawals are concentrated.

Ground water in the principal ground-water body in upper Petaluma Valley is of good quality, generally a calcium magnesium bicarbonate water containing 250–500 ppm of dissolved solids. Local encroachment by brackish water from tidal sloughs occurs in the lower part of Petaluma Valley as far north as Petaluma. Connate water, of poor quality, occurs locally in the Petaluma formation.

The gross storage capacity of upper Petaluma Valley is estimated to be about 200,000 acre-feet between the land surface and a depth of 200 feet. The usability of the storage would be affected by the amount of ground-water recharge that could move in from the upland area underlain by the Merced formation and the gradient that could be maintained at the south end of upper Petaluma Valley without inducing brackish tidal water to move into the fresh-water body.

Although the period of record for water-level observations in the Santa Rosa and Petaluma Valleys is relatively short, it appears that the ground-water resources of the area are in a relatively early stage of development as compared with potential development.

INTRODUCTION

LOCATION OF THE AREA

The Santa Rosa and Petaluma Valley areas are in Sonoma County, Calif., immediately north of San Francisco Bay (fig. 1). They are the westernmost of the so-called North Bay valleys, the valleys draining to the bay from the north. The areas lie between 38°05′ and 38°35′ north latitude and between 122°25′ and 122°55′ west longitude. Santa Rosa, near the center and the largest city, is about 21 miles east of the Pacific Ocean and 26 miles northwest of San Pablo Bay, which forms the northern portion of San Francisco Bay.

The area covered by this report is delimited on the north by the Russian River, on the south by San Francisco Bay, on the east by the Mayacmas and Sonoma Mountains, and on the west by the Mendocino Range. It includes about 450 square miles and has a

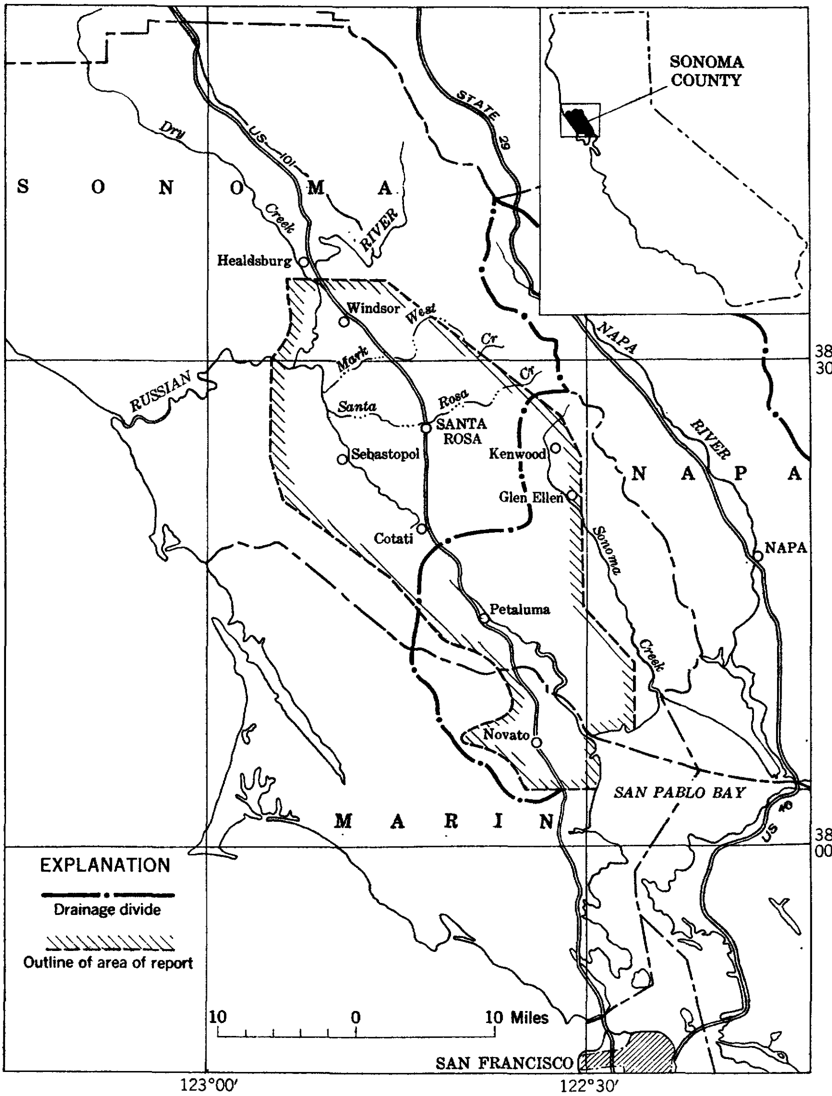

FIGURE 1.—Index map showing the location and extent of the Santa Rosa and Petaluma Valley areas Sonoma County, Calif., described in this report.

north–south length of 36 miles and an average east–west width of 12 miles.

The Santa Rosa Valley area, as defined for this report, includes Santa Rosa Valley and the smaller Bennett, Rincon, and Kenwood Valleys which lie east of it. The area includes also a small contiguous part of the Russian River valley which adjoins the northwestern part of Santa Rosa Valley. The Petaluma Valley area includes Petaluma

Valley and the smaller contiguous Novato Valley on the south. These areas are covered by the following topographic quadrangle maps of the U. S. Geological Survey: Calistoga (1945), Healdsburg (1940), Mare Island (1916), Petaluma (1914), Santa Rosa (1944), and Sebastopol (1942). In addition, topographic maps of the U. S. Army, Corps of Engineers, are available for the Mare Island (1942), Petaluma (1942), and Point Reyes (1940) quadrangles. All maps are published at a scale of 1:62,500 and have a contour interval of 25 feet, except the Calistoga quadrangle of the Geological Survey and the Petaluma and Point Reyes quadrangles of the Corps of Engineers, which have a contour interval of 50 feet.

PURPOSE AND SCOPE OF THE INVESTIGATION

The investigation whose results are given in this report was begun in September 1949 in cooperation with the California Division of Water Resources (now California Department of Water Resources) as a part of the program of reappraisal of the water resources of the State by that agency. The work has been limited largely to the determination of the geologic conditions, particularly the subsurface geologic conditions of the occurrence of ground water. An estimate of the gross storage capacity of the several ground-water basins has been made, and factors bearing on usability of the storage have been considered.

The collection of basic hydrologic and geologic data constituted a large part of the investigation and was essentially completed in the spring of 1951. Most of the data are found in tables in the back of the report and represent information for about 1,100 wells. Logs for about 1,050 of the wells were available: 800 for wells that were located in the field, 250 for wells whose locations were approximately established. Periodic measurements of water level were made in about 70 wells, and chemical analyses were made of water from 200 wells, 80 analyses being relatively complete.

The geologic map of the area was compiled chiefly from the mapping of others. However, the geology was field checked, revised, supplemented, and correlated throughout the area. Several months of field work was devoted to geologic mapping, which was completed in the summer of 1952. An intensive study was made of the water-bearing formations and deposits.

Similar work was carried on concurrently by the Geological Survey in cooperation with the California Division of Water Resources in contiguous valley areas to the east [Sonoma and Napa Valleys (Kunkel and Upson, 1957, written communication)], and to the north in alluvial valleys along the Russian River and other valleys in Mendocino County.

ACKNOWLEDGMENTS

The cooperation of many people of Sonoma County materially aided the investigation. Industries, local ranchers, and other people of the area aided the study by furnishing data on their wells and by allowing access to their properties for collection of geologic and hydrologic data. Special thanks are due officials of the Water Department of the City of Santa Rosa, the Sonoma County farm advisor and his staff, the Pacific Gas and Electric Co., the California Water Service Co., and local well drillers who freely furnished well data or other useful information. The writer acknowledges the advice and criticism of colleagues of the Geological Survey, especially the critical review of the text by G. F. Worts, Jr., and A. R. Leonard. J. E. Upson gave assistance in and valuable suggestions concerning the geologic mapping. W. J. Hiltgen, D. H. Kuhlman, and Fred Kunkel assisted in the collection of data.

PREVIOUS WORK RELATED TO WATER RESOURCES

Previous investigations related to water resources of the area have been limited chiefly to the collection of data having a bearing on specific problems. In 1940–41 the United States Bureau of Reclamation [1] studied a poorly drained area in the northern part of Santa Rosa Valley to determine the feasibility of using wells for drainage. In 1950, the Whipple Engineering Co. made a survey for the Sonoma County Board of Supervisors concerning the adequacy of ground water to meet needs for future development. Weaver (1949, p. 200–202) included in his geologic report a section on water resources which discussed briefly some of the general features of ground-water occurrence in the area.

WELL-NUMBERING SYSTEM

In California the Geological Survey uses a well-numbering system based upon the location of the well in the rectangular system used for the subdivision of public land. Many of the valleys were acquired privately through land grants made by the Spanish or Mexican governments and have never been so subdivided. For these areas the system is extended by projecting or superimposing an arbitrary land grid.

The well-location number has two basic parts: For example, in the number 7/8–29R2, the part preceding the hyphen indicates the township and range (T. 7 N., R. 8 W.) and the remainder indicates the section (29) and the position within the section. The letter indi-

[1] Gamer, R. L., Geological and ground-water reconnaissance of Santa Rosa Plains—Russian River studies—general investigations, California: unpublished rept. in files of the Geology Branch, U. S. Bur. Reclamation, 1942.

cates the 40-acre subdivision as shown in the diagram, and the last number indicates the serial number within the 40-acre tract. Thus, well 7/8–29R2 is the second well canvassed by the Geological Survey in the SE¼SE¼ sec. 29. Letters indicating cardinal directions follow

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

the first two parts of a number if an area spans two or more quadrants of a base line and meridian. Because all the Santa Rosa and Petaluma Valley areas are north and west of the Mount Diablo base line and meridian, the letters indicating cardinal direction are omitted from the well number.

Incomplete numbers, such as 6/9–1B or 5/7–20, indicate locations of wells, springs, or sampling points which are approximate to the extent indicated by the symbol. These locations are not shown on the base map. This system is used also to indicate the location of some rock outcrops or other points or areas that are mentioned in the text.

GEOGRAPHY

PHYSICAL FEATURES

TOPOGRAPHY

The Santa Rosa and Petaluma Valleys occupy a northwest-trending structural depression in the southern part of the Coast Ranges of northern California. This depression divides the Mendocino Range on the west from the Mayacmas and Sonoma Mountains on the east. The Mendocino Range in this area is made up mostly of low, rounded hills that increase in altitude from about 200 feet adjacent to Santa Rosa Valley to 600–1,200 feet at the crest, 8–10 miles west of Sebastopol. West of the southern end of Petaluma Valley are the Marin Mountains, in which Burdell Mountain, immediately adjacent to the valley, rises to an altitude of 1,560 feet. The Sonoma Mountains rise steeply on the eastern side of Santa Rosa and Petaluma Valleys to altitudes of 1,000–2,000 feet; their maximum altitude is 2,465 feet. They descend to the south and dip beneath San Pablo Bay. Northward, the Mayacmas Mountains rise less steeply, and ridges bordering the valley range in altitude between 500 and 1,000 feet.

Santa Rosa Valley, which contains about 90 square miles of plains, is the largest physiographic unit of the area. On the northwest it adjoins the Russian River plain, to which it is connected by a narrow gap in the hills about 3 miles southeast of Healdsburg (8/9–3). From this gap it extends about 20 miles south-southeastward where it is terminated by a series of low hills just north of Penngrove. These hills have been breached by south-flowing drainage, and the topographic divide is in Santa Rosa Valley about 2 miles northwest of Penngrove. Normal to the axis, the valley width ranges from 4 to 7 miles. Although the Santa Rosa Valley is a plain in comparison with the adjoining upland and mountain areas, much of it is not very level and it is marked by several internal topographic features. Along the western side a swampy area, Laguna de Santa Rosa, forms the lowest part of the valley trough. Along the eastern side lies a flat, gently sloping alluvial plain, 1–2 miles wide, which merges with the alluvial plains of Mark West and Santa Rosa Creeks and, to the south, with the Cotati plain. The northwestern two-thirds of the valley has an uneven surface produced by erosion of weakly consolidated continental deposits. The southern part of this area is characterized by low mounds and poorly drained depressions which are typical of Pleistocene deposits in northern California. Local relief increases northward, so that north of Santa Rosa Creek the surface is rolling or hilly. Most of the valley is between altitudes of 50 and 150 feet.

Petaluma Valley contains about 45 square miles of alluvial plain. It is 16 miles long and 2–3 miles wide over most of that length and has a maximum width of 3½ miles at Petaluma. Most of the upper part of Petaluma Valley, about 20 square miles, is between sea level and an altitude of 50 feet. Most of the lower part of Petaluma Valley is at or as much as 3 feet below sea level, although much of it has been reclaimed by a system of levees and drainage ditches so that only about 10 square miles is presently occupied by tidal swamps and the drowned portions of Petaluma Creek.

Novato Valley adjoins Petaluma Valley near San Pablo Bay, and the two are separated by a ridge of consolidated rocks through which a low divide has been cut just north of the town of Novato. Novato Valley contains about 12 square miles of alluvial plain, of which about two-thirds is tidal marsh and lies at or slightly below sea level. The remainder, about 4 square miles, lies between sea level and an altitude of 200 feet, but most of it is less than 100 feet in altitude.

That part of the Russian River valley extending from about 1 mile south of Healdsburg to Wilson Grove is included in the area of this report. It comprises about 6½ square miles of flood plain and is 5 miles long and 1–1½ miles wide. Altitudes range between 50 and 100 feet.

Bennett Valley is an alluvium-filled structurally controlled valley that parallels Santa Rosa Valley to the east and joins it just east of the city of Santa Rosa. The lower part of Bennett Valley is underlain by a continuous body of alluvium, having a surface area of about 2½ square miles; it is 3 miles long and 1½ miles wide at the mouth. The valley floor ranges in altitude from 200 to 300 feet.

Rincon Valley is north of Bennett Valley, from which it is separated by a breached ridge of volcanic rock. The eastern part of Rincon Valley occupies part of a structural depression extending from Sonoma Valley northwestward to and beyond Mark West Creek. The valley floor comprises about 2½ square miles.

The Kenwood-Glen Ellen area, which is in the Kenwood-Sonoma structural trough, includes Kenwood Valley and the country north and northwest of Glen Ellen lying adjacent to and between Sonoma and Calabazas Creeks. The floor of Kenwood Valley covers about 5 square miles; it has a length of 6½ miles and a maximum width of 1½ miles. Most of the valley floor is at altitudes of 400–500 feet.

In all, the area covered by the report comprises two principal and five subsidiary valleys containing about 150 square miles of alluvial land. Geologic and hydrologic continuity exists between several of the valleys, as shown by the geologic map and water-level contours (pls. 1 and 2).

DRAINAGE

The drainage divide between Santa Rosa and Petaluma Creeks, about a mile southeast of Cotati in Santa Rosa Valley, and a similar one between Santa Rosa and Sonoma Creeks, about 2 miles northwest of Kenwood, separate the area into parts of two of the seven major hydrographic divisions of the State (California State Water Resources Board, 1951, pl. 2). The northern portion drains into the Pacific Ocean through the Russian River and belongs to area 1, north coastal area; the southern portion drains into San Pablo Bay and is part of area 2, the San Francisco Bay area.

The Russian River, one of the major streams of the north coastal area, flows southward along the northwestern edge of Santa Rosa Valley, then turns westward toward the Pacific Ocean just west of Wilson Grove.

Santa Rosa and Mark West Creeks rise in the Mayacmas Mountains northeast of Santa Rosa and are the principal streams draining Santa Rosa Valley. Most of the runoff originates in the mountains on the east side of the valley and flows westward through Santa Rosa and Mark West Creeks to collect in the Laguna de Santa Rosa, from which it moves northward and discharges into the Russian River

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through a narrow outlet. The Laguna de Santa Rosa, or the Laguna, as it is known locally, is a swampy, intermittent drainage course at the western edge of the floor of Santa Rosa Valley that extends from about 4 miles southeast of Sebastopol (in 6/8–17) to about half a mile east of Trenton (in 7/9–3F). Along the Laguna are several permanent lakes or "lagoons," the largest of which are in 7/9–10 and in 7/9–26 and 7/9–35 (pl. 1). However, the extent of the lakes ranges considerably, particularly during winter and spring when the water surface of the Laguna generally expands owing to storm runoff. The lake level in 7/9–14 commonly rises 8–12 feet above the dry-season level, and, at times, the Laguna area is one continuous body of water as much as 10 miles in length and ranging in width from a few hundred feet to as much as 1½ miles locally.

Mark West Creek has a perennial flow from its headwaters to Laguna de Santa Rosa. A gaging station was operated by the Geological Survey from April 1940 through September 1941 at the bridge on U. S. Highway 101, about 4 miles southeast of Windsor. The observed extremes in discharge were 6,500 cubic feet per second (cfs) on April 4, 1941, and 0.3 cfs during the period September 18–23, 1941. Runoff during the 1941 water year (October 1, 1940, through September 30, 1941) was 80,680 acre-feet (Parker and others, 1942, p. 379).

Santa Rosa Creek is perennial upstream from the city of Santa Rosa. Records from a gaging station on Santa Rosa Creek, 30 feet downstream from the A Street bridge in Santa Rosa, operated by the Geological Survey from December 1939 through September 1941, show a maximum discharge of 8,600 cfs on April 4, 1941, and a minimum of 0.1 cfs during several days of September, October, and November 1941. Total runoff for the water year 1941 was 94,440 acre-feet. The drainage area above the gage embraces 53 square miles (Parker and others, 1942, p. 378).

The figures given for runoff of the two creeks are not, however, representative of normal conditions in the drainage basin; precipitation during the water year 1941 was 70–80 percent greater than normal, as based on Weather Bureau records for stations within the area.

Surface outflow from Laguna de Santa Rosa usually is not perennial. The Geological Survey operates a gaging station on the Laguna at the Guerneville Road bridge (7/9–15) from which records of water-surface altitude or gage height and contents in acre-feet are available. Contents of the Laguna have ranged from less than 500 acre-feet (gage height, less than 52.3 feet) during several months of each year, to the maximum of 61,408 acre-feet (gage height, 72.1 feet) on February 28, 1940 (Paulsen and others, 1952, p. 413). Several creeks heading in the Sonoma Mountains, notably Crane, Copeland, and Lichau Creeks, cross the Cotati plain; Crane and Copeland Creeks drain into Laguna de Santa Rosa and Lichau Creek is tributary to Petaluma Creek. All are perennial for varying distances upstream from the edge of the valley floor, but Crane and Copeland Creeks have through flow to the Laguna only during the rainy season. Copeland Creek, according to unconfirmed local reports, formerly was tributary to Petaluma Creek, but during the early stages of land development was channeled to Laguna de Santa Rosa to improve local drainage conditions.

Petaluma Creek is the principal stream draining Petaluma Valley. It is tidal from its mouth to the city of Petaluma, the greater part of its length. Flow in the reach above tidewater is seasonal, generally beginning in the period from October to December and continuing until the following June. A gaging station has been operated by the Geological Survey 2 miles northwest of Petaluma, 70 feet downstream from the Corona Road bridge, from October 1948 to date. For the 1950 water year the total discharge was 8,400 acre-feet; the mean daily discharge rate was 11.6 cfs. The drainage area above the gage comprises 29.6 square miles (Paulsen and others, 1952, p. 407). The tributaries to Petaluma Creek are small, the principal ones being Lichau Creek (and its tributary, Willow Brook), Lynch Creek, and Adobe Creek (pl. 1). San Antonio Creek drains a large area on the west side of the lower Petaluma Valley and discharges into the tidal portion of Petaluma Creek.

Novato Creek, which drains Novato Valley, discharges into San Pablo Bay. In October 1948 the Geological Survey established a gaging station 1 mile west of U. S. Highway 101, 500 feet downstream from the county road bridge. The mean daily discharge during the 1950 water year was 7.91 cfs, and total runoff amounted to 5,730 acre-feet. The drainage area above the station comprises 16.9 square miles (Paulsen and others, 1952, p. 406).

Rincon and Bennett Valleys are drained, respectively, by Brush and Matanzas Creeks, tributaries of Santa Rosa Creek. Brush Creek is a small intermittent stream, and Matanzas Creek has a perennial low flow that extends onto the alluvial plain of lower Bennett Valley before sinking into the alluvium.

The northwestern part of Kenwood Valley is drained by a small unnamed tributary of Santa Rosa Creek. The southeastern part is drained by Sonoma Creek, which together with its principal tributary, Calabazas Creek, also drains the Glen Ellen area, and flows southeastward to Sonoma Valley. Sonoma Creek is perennial except for short stretches of channel underlain by permeable deposits, which go dry in the summer. No records of streamflow are available except for an isolated measurement made by the Geological Survey at the Warm Springs Road bridge, 2.0 miles northwest of Glen Ellen, on July 27, 1950, when the flow was 1.0 cfs, excluding several diversions upstream.

CLIMATE

GENERAL FEATURES

The climate of the region is of the Mediterranean type. The temperature is controlled largely by the proximity of the Pacific Ocean and San Pablo Bay, and seasonal and daily variations are moderate. In the northern and eastern parts of the area, seasonal and diurnal fluctuations of temperature increase directly with the altitude and the amount of enclosure provided by the adjacent uplands. In high enclosed valleys the moderating influence of the water bodies has little effect.

The growing season is long, the usual number of frost-free days per year ranging from about 280 in the south to about 240 in the north. The average annual temperature is about 57 degrees and the monthly average ranges from about 47 degrees in January to 66 degrees in July; temperatures below freezing are rare. Fog and high humidity are common in the mornings, especially during the summer, and the fog is dense during about 20 days of each year. During July the average relative humidity is about 80–90 percent in the early morning, and 60–65 percent at noon. Hours of daily sunshine average 9–10 in the summer. The prevailing wind is from the south for the area as a whole, although it varies, somewhat, within the area, being mainly from the west at Petaluma.

PRECIPITATION

Precipitation is the utlimate source of recharge to the ground-water reservoir. Essentially all the precipitation in the area is rainfall, although limited amounts of snow fall on the higher ridges and peaks in the Mayacmas Mountains during winter storms when the temperatures are subnormal. Most rainfall occurs between the months of October and May, the greatest amount falling during the period December through March. (See table 1 for monthly rainfall at a representative station.) Rainfall from April 1 to September 30 generally amounts to less than 5 inches, or only 10–15 percent of the yearly total.

The general distribution of rainfall over the area is shown by table 2, which gives yearly rainfall for five representative stations. Monthly and daily rainfall for all those stations except Lakeville are available in the publications or files of the U. S. Weather Bureau, San Francisco.

Data for eight additional stations in or near the area for which precipitation records are available are listed in table 3. More complete data are omitted because the records are relatively short and

TABLE 1.—*Monthly and yearly precipitation, in inches, at Santa Rosa,*[1] *Sonoma County, Calif.*

[From publications of the U. S. Weather Bureau. T=trace]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1887-88										0.00	0.00	0.62	
1888-89	0.00	3.48	5.37	1.77	0.35	7.92	1.09	2.93	0.25	0	0	0	23.16
1889-90	8.78	4.39	15.94	12.84	4.74	6.15	1.82	1.40	0	0	0	.20	56.26
1890-91	0	0	3.93	1.25	10.49	1.22	2.39	1.23	0	.75	0	.20	21.46
1891-92	.20	1.50	8.64	3.43	5.07	4.14	2.65	3.78	0	0	0	0	29.41
1892-93	1.44	3.37	6.55	4.13	5.56	6.59	2.07	.80	0	0	0	.25	30.76
1893-94	.52	4.82	2.61	9.61	3.78	1.31	1.08	1.84	1.30	0	0	1.50	28.37
1894-95	2.55	.89	13.41	18.42	3.35	2.94	1.35	1.39	0	.33	0	.37	45.00
1895-96	.00	1.83	2.95	10.57	.69	3.53	4.70	1.45	0	0	0	.46	26.18
1896-97	1.50	5.09	6.42	2.27	6.25	5.50	1.03	.57	.83	0	0	.10	29.56
1897-98	1.88	2.18	6.82	1.81	5.32	.66	.38	3.32	.17	0	0	.62	23.16
1898-99	1.07	1.16	1.20	8.77	.00	8.57	.67	2.09	0	0	.15	0	23.68
1899-00	5.94	5.44	4.78	4.98	.77	3.72	2.83	.60	.16	0	0	0	29.22
1900-01	4.41	5.60	3.35	6.05	5.77	.90	3.31	1.12	0	0	0	1.17	31.68
1901-02	1.16	4.22	2.25	1.79	14.40	4.54	2.61	1.79	0	T	T	0	32.76
1902-03	3.70	5.00	4.43	6.38	2.58	6.49	.60	T	.03	0	T	T	29.21
1903-04	.64	9.65	3.59	1.77	12.23	12.93	2.99	.24	.07	T	T	4.39	48.50
1904-05	4.60	2.74	4.50	5.53	4.26	5.59	1.45	2.93	0	0	0	T	31.60
1905-06	T	1.97	1.81	10.95	5.24	7.95	.72	3.31	1.23	0	0	.16	33.34
1906-07	.00	1.88	6.79	7.57	5.17	11.21	.34	.32	1.00	0	0	.46	34.74
1907-08	.87	.13	6.30	5.61	4.88	1.45	.30	.85	.08	.02	0	T	20.49
1908-09	1.37	2.12	4.00	18.45	8.74	3.98	0	T	.07	0	T	1.29	40.02
1909-10	1.73	4.53	7.61	4.94	3.75	4.17	.85	.08	.05	0	0	.01	27.72
1910-11	.68	1.76	1.68	14.20	2.75	4.96	3.04	.44	.02	T	0	T	29.53
1911-12	.58	.72	2.41	3.39	1.09	4.69	1.54	2.88	1.14	0	0	2.99	21.43
1912-13	1.47	5.11	1.78	6.11	.58	2.73	1.91	1.28	.05	.07	0	0	21.09
1913-14	0	7.50	11.15	14.00	5.60	1.49	1.66	.95	.41	0	0	.07	42.83
1914-15	1.91	1.30	7.23	9.08	13.52	3.98	.65	4.82	0	0	0	0	42.49
1915-16	.20	1.71	8.34	15.20	3.53	1.89	0	.65	.06	.61	.32	.32	32.83
1916-17	1.17	2.68	5.92	2.37	5.15	1.22	2.52	.14	.02	0	0	.33	21.52
1917-18	0	1.49	2.25	1.43	7.06	4.73	.86	.03	T	0	.03	2.52	20.40
1918-19	1.04	3.96	2.55	5.59	8.52	2.30	.50	.20	0	0	0	.58	25.24
1919-20	.25	.30	4.35	.40	1.35	3.06	2.46	0	.50	.06	0	.10	12.83
1920-21	3.00	7.78	8.65	9.60	1.83	2.74	.75	1.19	T	0	0	.15	35.69
1921-22	.63	2.03	8.78	1.10	6.81	3.66	.25	.52	.06	T	0	0	23.84
1922-23	2.79	4.92	10.84	2.27	1.14	.05	5.24	.22	.44	0	.22	1.78	29.91
1923-24	.50	.48	1.25	4.50	5.58	.83	.43	.33	.01	.01	.01	.01	13.94
1924-25	4.34	2.35	7.33	1.88	14.42	3.93	1.77	5.11	.01	.07	.01	1.17	42.39
1925-26	.19	3.53	1.53	8.84	6.88	.25	9.58	.40	T	.02	.03	.02	31.27
1926-27	1.37	12.64	2.91	6.82	10.93	3.68	3.47	.43	.40	.01	.01	.01	42.68
1927-28	1.98	7.48	3.71	3.10	3.52	6.96	1.97	.18	0	0	0	T	28.90
1928-29	.34	4.28	5.02	1.48	2.10	2.10	1.30	.13	2.48	0	0	0	19.23

[1] Altitude, 167 feet.

TABLE 1.—*Monthly and yearly precipitation, in inches, at Santa Rosa,*[1] *Sonoma County, Calif.*—Continued

[From publications of the U. S. Weather Bureau. T=trace]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1929–30	.04	0	12.47	5.40	3.91	2.53	1.53	.62	0	0	0	.44	26.94
1930–31	.87	1.40	.62	6.52	1.87	2.94	.49	.90	.67	0	0	0	16.28
1931–32	1.40	2.27	11.29	3.45	1.49	1.21	1.43	1.65	0	T	0	0	24.19
1932–33	.08	1.69	4.06	6.40	1.51	4.64	.12	2.23	T	.02	0	.17	20.92
1933–34	2.02	0	8.14	1.75	4.69	1.13	.73	1.39	1.00	0	T	.03	20.88
1934–35	2.28	5.19	3.45	7.36	3.50	6.31	6.87	0	0	0	.12	.23	35.31
1935–36	1.02	1.47	3.09	7.77	11.81	1.58	1.86	.61	.80	T	.03	0	30.04
1936–37	.22	.02	2.90	4.92	8.59	6.31	1.87	.19	1.28	.05	0	T	26.35
1937–38	1.06	7.47	5.40	4.77	9.66	8.03	2.45	.06	0	.02	0	.38	39.30
1938–39	2.18	2.22	2.14	3.36	1.61	2.41	.14	.12	T	0	0	.08	14.26
1939–40	.52	.46	2.88	10.87	12.31	7.14	1.84	1.96	.07	0	0	.50	38.55
1940–41	1.82	2.59	13.56	11.02	8.22	5.59	6.71	1.84	.30	0	T	.13	51.78
1941–42	1.53	2.98	9.12	6.50	8.65	3.78	5.58	1.67	T	.02	0	.15	39.98
1942–43	1.23	5.75	5.80	9.28	2.73	4.85	2.67	.05	T	.03	0	0	32.39
1943–44	.68	1.16	2.38	5.07	7.66	2.25	2.15	1.58	.28	0	0	.02	23.23
1944–45	2.45	5.90	4.22	3.13	4.92	5.82	.33	1.39	T	T	0	T	28.16
1945–46	2.91	4.23	10.37	2.32	2.98	2.20	.10	.47	0	.20	0	.06	25.84
1946–47	.28	4.08	3.66	.76	3.82	4.94	.65	.40	1.63	0	0	T	20.22
1947–48	5.28	1.55	1.22	4.18	1.51	5.57	7.61	1.03	.25	.06	T	.13	28.39
1948–49	.85	1.87	4.67	1.39	3.32	6.83	.08	.74	0	.05	.04	.02	19.86
1949–50	.02	2.12	2.79	10.12	5.15	3.29	1.31	.56	.06	0	0	0	25.42
1950–51	3.46	7.19	9.38	5.14	2.84	1.25	1.27	1.48	T	0	.01	.04	32.06
1951–52	2.68	6.26	8.01	10.19	2.88	4.62	.84	.57	1.38	.04	0	.05	37.52
1952–53	.08	2.73	14.72	6.74	.08	3.17	3.91	.57	.97	0	.17	0	33.14
1953–54	1.31	4.64	.96	7.80	3.19	5.74	3.23	.37	.26	T	1.35	T	28.85
66 year average	1.53	3.32	5.58	6.16	5.07	4.10	1.98	1.13	.30	.04	.04	.36	29.61
66-year median													29.22

[1] Altitude, 167 feet.

represent only small parts of the area investigated. However, records for these stations indicate more clearly than table 2 the range in the amount of rainfall over the area. Typically the range in rainfall within the Coast Ranges of northern California is large.

The data in tables 2 and 3 show that the rainfall is greater on bordering mountains than on the valley floors, increasing eastward and westward from the valley areas and also increasing northward within the Santa Rosa-Petaluma valley trough. No rainfall records are available for Rincon, Bennett, and Kenwood Valleys, east of Santa Rosa, but the annual average is probably somewhat greater than at Santa Rosa, and may be on the order of 35 inches. The increase of rainfall northward is probably due, at least in part, to the general rise in altitude of the Coast Ranges from the bay northward. Much of the higher watershed receives considerably more rainfall than the lower, areas, and runoff also is greater.

TABLE 2.—*Annual rainfall, in inches, at five stations in the Santa Rosa and Petaluma Valley areas, California*

[Data from publications of the U. S. Weather Bureau, except for Lakeville]

Water year [1]	Healdsburg (altitude, 110 feet)	Graton (altitude, 190 feet)	Santa Rosa (altitude, 167 feet)	Petaluma (altitude, 10 feet)	Lakville, Sleepy Hollow Dairy [2] (altitude, 75 feet)
1874				26.20	
1874–75				18.18	
1875–76				25.59	
1876–77				13.85	
1877–78	68.27			39.40	
1878–79	41.60			21.39	
1879–80	45.11			25.00	
1880–81	45.94			24.85	
1881–82	30.85			17.09	
1882–83	39.27			18.64	
1883–84	30.89			24.49	
1884–85	15.35			14.92	
1885–86	54.05			28.94	
1886–87	29.82			17.08	
1887–88	35.48			18.66	
1888–89	36.28		23.16	23.19	
1889–90	72.65		56.26	46.08	
1890–91	32.09		21.46	18.44	
1891–92	38.49		29.41	19.43	
1892–93	55.00		30.76	27.03	
1893–94	36.63		28.37	23.64	
1894–95	61.53		45.00	29.82	
1895–96	45.06		26.18		
1896–97	38.91	39.87	29.56		
1897–98	23.97	25.65	23.16		
1898–99	29.59	22.62	23.68		
1900	41.75	40.83	29.22		
1900–01	40.63	42.21	31.68		
1901–02	51.31	46.60	32.76		
1902–03	39.17	42.42	29.21		
1903–04	67.70	67.86	48.50		
1904–05	48.50	43.89	31.60		
1905–06	52.21	49.50	33.34		
1906–07	54.39	47.49	34.74		
1907–08	28.90	29.06	20.49		
1908–09	62.34	59.88	40.02		
1909–10	28.93	35.29	27.72		
1910–11	32.86	36.73	29.53		
1911–12	28.30	27.43	21.43		
1912–13	26.72	29.40	21.09		
1913–14	60.42	61.88	42.83	41.20	

See footnotes at end of table.

TABLE 2.—*Annual rainfall, in inches, at five stations in the Santa Rosa and Petaluma Valley areas, California*—Continued

[Data from publications of the U. S. Weather Bureau, except for Lakeville]

Water year [1]	Healdsburg (altitude, 110 feet)	Graton (altitude, 190 feet)	Santa Rosa (altitude, 167 feet)	Petaluma (altitude, 10 feet)	Lakville, Sleepy Hollow Dairy [2] (altitude, 75 feet)
1914–15	56.78	54.78	42.49	36.51	----------
1915–16	46.20	44.93	32.83	30.29	----------
1916–17	25.82	31.00	21.52	17.19	----------
1917–18	25.19	28.32	20.40	15.08	----------
1918–19	32.11	35.07	25.24	21.05	----------
1919–20	18.82	23.31	12.83	11.58	----------
1920–21	55.54	51.23	35.69	28.00	----------
1921–22	28.92	28.35	23.84	18.69	----------
1922–23	32.04	38.72	29.91	24.75	----------
1923–24	15.37	18.04	13.94	10.76	----------
1925	50.27	55.21	42.39	36.29	----------
1925–26	34.87	34.30	31.27	26.26	----------
1926–27	51.30	53.73	42.68	----------	----------
1927–28	36.15	36.12	28.90	21.52	----------
1928–29	24.33	27.01	19.23	16.28	----------
1929–30	38.81	36.51	26.94	18.47	15.55
1930–31	23.67	22.73	16.28	14.92	12.75
1931–32	30.36	29.15	24.19	22.60	20.46
1932–33	26.67	25.92	20.92	17.17	13.06
1933–34	31.19	28.62	20.88	18.02	15.77
1934–35	45.56	43.60	35.31	27.68	21.74
1935–36	37.44	43.33	30.04	24.95	19.39
1936–37	33.93	38.21	26.35	24.70	20.17
1937–38	56.09	58.18	39.30	33.98	32.86
1938–39	19.27	21.83	14.26	13.21	11.32
1939–40	57.05	52.57	38.55	30.98	26.68
1940–41	72.19	70.56	51.78	45.69	38.06
1941–42	54.87	51.92	39.98	32.50	32.62
1942–43	38.47	41.12	32.39	24.93	22.72
1943–44	31.83	34.01	23.23	21.00	19.68
1944–45	34.59	38.94	28.16	22.85	19.67
1945–46	37.54	37.12	25.84	25.23	22.76
1946–47	25.82	26.00	20.22	16.61	16.01
1947–48	36.11	35.22	28.39	19.03	14.16
1948–49	28.04	31.19	19.86	17.62	17.00
1950	30.10	35.20	25.42	20.60	16.97
1950–51	40.08	46.47	32.06	26.43	24.10
1951–52	52.82	57.65	37.52	30.31	27.75
Average	[3] 40.37	[4] 39.55	[5] 29.56	[6] 23.78	[7] 20.92
23-year average, 1930–52	38.37	39.39	28.60	23.89	20.92

[1] A water year begins on October 1 of any designated year and ends on September 30 of the succeeding year.
[2] Private record supplied by M. S. Herzog of the S. K. Herzog Co.
[3] 74-year average.
[4] 56-year average.
[5] 64-year average.
[6] 60-year average.
[7] 23-year average.

TABLE 3.—*Data for additional precipitation stations in and near the Santa Rosa and Petaluma Valley areas, California*

Station	Distance (miles) and direction from Santa Rosa	Altitude (feet)	1952 annual [1] rainfall (inches)	Length of record, as of 1952 (years)
Cazadero	21 WNW	1,040	94.74	13
Guerneville	16 WNW	115	64.44	13
Hamilton Field	29 SSE	−2	32.98	19
Healdsburg, 2 miles east	13 NNW	76	47.15	7
Novato, 8 miles northwest	18 S	350	----------	8
Occidental	13 WSW	1,000	70.56	13
Petaluma, 1 mile north	14 SSW	27	----------	9
Sebastopol, Taber farm	7 WSW	175	----------	16

[1] Weather Bureau averages for climatic year July 1–6 June 30.

CULTURE

Most of the population in the Santa Rosa and Petaluma Valley areas is rural. The following figures, taken largely from the 1950 census, show the distribution in 1950 and the percentage increase of population during the period 1940–50 in Sonoma County and the Santa Rosa-Petaluma area.

TABLE 4.—*Distribution in 1950 and percent increase in population, 1940–50, in Sonoma County and the Santa Rosa and Petaluma Valley areas*

Type of population	Sonoma County	Percent increase 1940–50	Santa Rosa and Petaluma Valley areas
Urban	34,076	47.2	30,818
Rural	[1] 69,329	51.0	[2,3] 54,000
Total	103,405	49.7	[3] 85,000

[1] 67 percent of total population.
[2] 64 percent of total population.
[3] Estimated.

The principal urban areas of Sonoma County are Santa Rosa (1950 population, 17,902) and Petaluma (1950 population, 10,315) in Santa Rosa and Petaluma Valleys, respectively. The population of Santa Rosa is about one-half of the urban population of the county, and, together with that of Petaluma, constitutes four-fifths of the total urban population of the county. Sebastopol, the only other incorporated city within the area, had a population of 2,601 in 1950.

As suggested by the distribution of population (table 4), the economy of the area is predominantly agricultural. Among agricultural products poultry and poultry products have led for a long time in total market value; they were followed in 1950 by dairy products, fruits and nuts, field crops, livestock, seed crops, and vegetable crops, in that order. Eggs are the leading commodity produced, followed by milk and dressed poultry. Apples and prunes are the leading fruits produced. Wine grapes are important, but are restricted chiefly to the hilly areas and to the northern part of the county. Hops are grown on the flood plains of Mark West and Santa Rosa Creeks and the Russian River. Leading annual crops are hay and oats. In 1941 dairy products ranked below fruit and nuts and livestock in value of production. By 1950 the value of dairy products had tripled, whereas the value of other products had increased only 150–200 percent of 1941 values. This increase was largely a result of the accelerated development of sprinkler-irrigated pastures, leading to increased production and higher-grade products. Potatoes were once a principal crop, and about 2,600 acres were grown in 1854. However, they have gradually been replaced by other crops.

Until the early 1950's, local industry was limited almost entirely to the processing of agricultural products, which included the packing and canning of orchard products, wine production, processing of poultry products, milk processing, and milling of livestock and poultry feeds. Newer important industries are the manufacture and remanufacture of lumber products, primary and fabricating metal work, and the manufacture of textiles, apparel, and machinery. The trend in industry and in population growth indicates an expansion that is closely related to the development of the water resources of the area.

HISTORY OF WATER USE

The development of ground water in the area began shortly before 1850, when settlement of the area began. Water for domestic and livestock supply was obtained largely from springs or shallow dug wells. Later wells were bored by hand tools or drilled by crude horse- or steam-powered rigs. The oldest bored or drilled wells canvassed during this investigation were constructed in about 1875. Most of the wells put down from 1900 to 1945 were drilled by cable-tool (percussion) methods. Since 1945 an increasing number of wells, especially irrigation wells, have been drilled by the rotary method.

Many dug wells remained in use until fairly recently. A well canvass made by the Bureau of Reclamation in the Santa Rosa area in 1940–41 revealed a large number of dug wells in use, and a few used dug wells were found by the Geological Survey during the 1949–51 canvass. These dug wells are not necessarily an indication of a shallow water table, as many of them were more than 30 feet deep. In the area west of Sebastopol a few dug wells as deep as 90 feet were still in use. Some springs are still being used in the area, several for irrigation.

In 1951 about 10,000 wells were in use, of which approximately 95 percent were used primarily for domestic purposes, indicating the large amount of ground water needed to support the large rural population. Because of the intensive irrigation of gardens, lawns, and small pastures, and the large amounts of water consumed by animals, in addition to that reserved for domestic use, the use of water on a per-capita basis is greater in rural and suburban portions of the Santa Rosa and Petaluma Valley areas than in the urban portions and probably is much greater than the national average per-capita use, rural or urban.

In addition to being pumped for rural domestic use, ground water is also pumped for public-supply, irrigation, stock, dairy, orchard (spraying), industrial, and commercial uses. The chief industrial users are canneries, ice plants, breweries, wineries (for cooling), packing plants, and plants having air conditioning. Commercial use is restricted largely to swimming pools and bottling.

Municipal water-supply systems serve Santa Rosa, Sebastopol, Cotati, and Petaluma. All are publicly owned except that for Petaluma, which is owned and operated by the California Water Service Co. Several privately owned or community-owned systems are operated in the more densely settled suburban and rural areas, but probably each has less than 100 connections. Water is supplied to Sebastopol and Cotati exclusively by wells, and to Santa Rosa and Petaluma partly by wells and partly by surface-water diversion. Santa Rosa diverts water from Santa Rosa Creek into a surface reservoir to augment the supply from 6 wells in the mouth of Bennett Valley and from 2 at the south end of Rincon Valley. The Petaluma water system uses a surface reservoir in the Sonoma Mountains, northwest of the city, and stream diversions as the principal supply; supplemented by pumpage from wells. In years of deficient rainfall and runoff, wells become the principal source of supply. During the 1951 calendar year the city of Petaluma obtained 48 percent of its supply from ground water. In recent years considerable expansion of the water-supply systems for Petaluma and Santa Rosa has been necessary to keep pace with the population increases of 28 and 42 percent, respectively, during the period 1940–50.

Irrigation.—Irrigation of land has developed largely since 1900. So far as is known, water was first obtained for irrigation from sumps or small reservoirs produced by damming small creeks or from low-flow diversions of the larger creeks. Gravity flood-irrigation was used at first; later low-lift pumps powered by internal-combustion engines were used in some instances. The 13th census (1910) listed 631 acres under irrigation on 38 farms in Sonoma County. Of this amount, 434 acres was irrigated from streams, 40 acres from springs, and 157 acres from 11 wells. Adams (1913) reported that 60 acres of 90,000 acres of "valley agricultural land" in Santa Rosa and Petaluma Valleys was under irrigation, 15 additional acres being irrigated in Kenwood Valley. Judging from these figures, it appears that only 4 or 5 irrigation wells were in use in the Santa Rosa and Petaluma Valleys by 1913. The remainder of the 11 irrigation wells reported in 1910 were probably located on the Russian River flood plain. There was some expansion of irrigation from wells during the 1930's, but the major development occurred from 1945 to 1950.

During the canvass of wells conducted by the Geological Survey in this investigation, 210 irrigation wells were located. Table 5 shows the areal distribution and the increase in number of irrigation wells in the area from 1940 through 1952.

TABLE 5.—*Areal distribution of irrigation wells and development of irrigation by periods* [1]

Area	Wells in use, 1940	New wells in use, 1941-50	New wells in use, 1951	New wells in use, 1952 [2]	Total
Santa Rosa Valley	28	73	19	2	122
Petaluma Valley	2	10	2	0	14
Bennett Valley	1	14	0	0	15
Rincon Valley	3	5	0	0	8
Kenwood-Glen Ellen area	1	[3] 15	3	------------	19
Russian River plain (in area of report)	9	10	0	0	19
Green Valley	0	8	3	0	11
Bloomfield area	0	2	0	0	2
Total	44	137	27	2	210

[1] Only wells canvassed by Geological Survey are included.
[2] Incomplete.
[3] Includes two wells in eastern part of Glen Ellen area not shown on map.

It is believed that the well canvass included all irrigation wells that were in use before and during 1951, except for a few small-capacity wells. Eight irrigations wells, in addition to the two canvassed, are known to have been put in use during 1952, and there were probably others. About 230 irrigation wells are estimated to have been put in use at the end of 1952. The period of greatest development, to date, was 1947 through 1950, when 113 irrigation wells were drilled, an average of more than 28 wells per year.

The 1939 Census of Agriculture reported 4,195 acres under irrigation by both surface water and ground water in Sonoma County. A similar census in 1949 reported 9,285 acres irrigated on 348 farms, 3,995 acres on 210 farms being irrigated by sprinklers. Most of the increased acreage was probably in the Santa Rosa and Petaluma Valley areas. Figure 2 shows the irrigation pumpage for the years 1945–49 compared to the gross pumpage for the same period. It indicates that most of the increase in gross pumpage is attributable to the increase in irrigation.

The wells in use in the area in 1951 provided water for the irrigation of about 5,200 acres; most of this water was distributed by sprinkling systems. The approximate number of acres irrigated were as follows: For permanent pasture and hay, 3,800; hops, 900; alfalfa, 160; English walnuts, 100; garden truck, 90; seed, 65; prunes, 55; lawn (golf course), 25; nursery plants, 20; and orchard and pasture (combined), 20. In some years of low rainfall small acreages on which other crops are grown, such as corn and potatoes, are irrigated. Permanent pasture has the highest water requirement of the irrigated crops. Because it is perennial, it is irrigated from the cessation of the spring rains until rainfall begins in the fall, generally a period of 5–6 months. Hops are irrigated once or twice in the early summer. The acreages on which they are grown are the only ones in this area

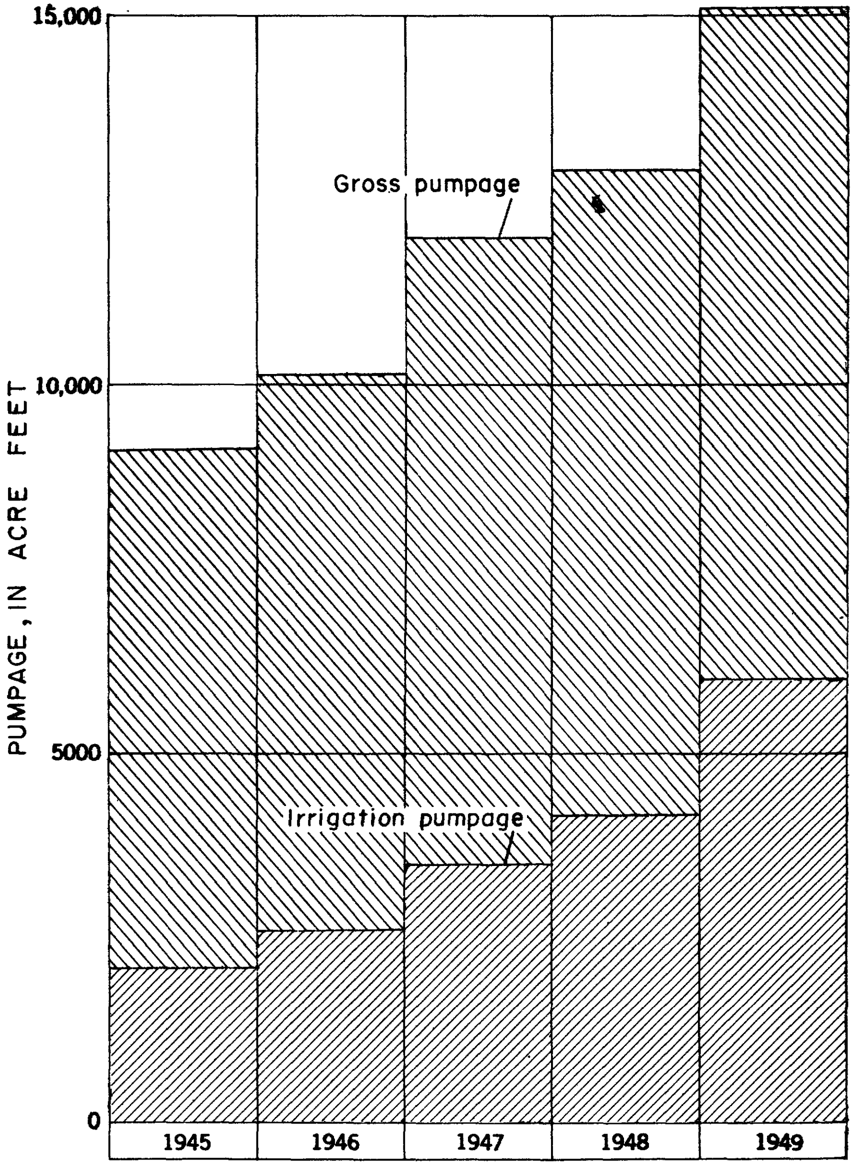

FIGURE 2.—Increase in irrigation and gross pumpage, 1945–49, Santa Rosa and Petaluma Valley areas, California.

which are flooded in general practice, although some sprinkler irrigation is used. Alfalfa is irrigated in the same manner as permanent pasture. Walnuts are usually irrigated after seasons of deficient rainfall or early cessation of spring rains. Prunes are irrigated once or twice during the spring and again in the fall if rains are late,

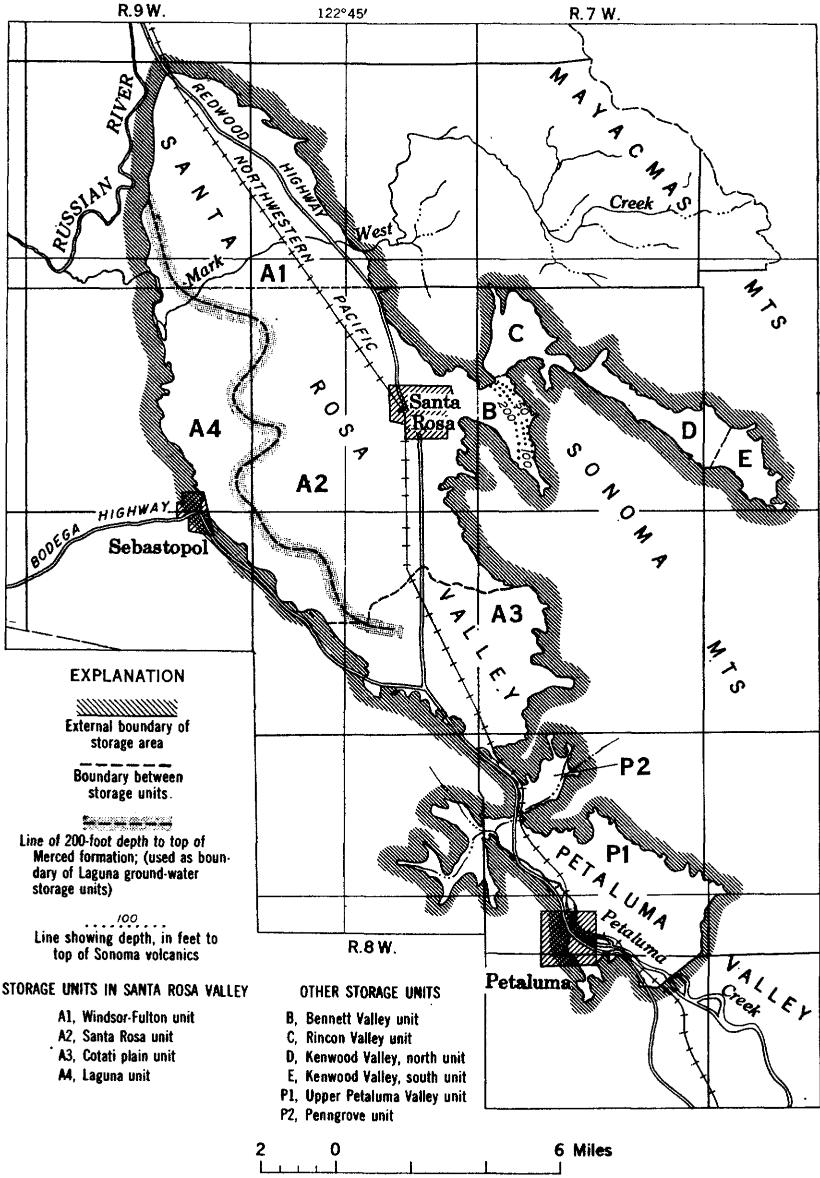

FIGURE 3.—Map showing ground-water storage units and pumpage areas, Santa Rosa and Petaluma Valley areas, Sonoma County, Calif.

although some growers favor only the fall irrigation. Water requirements for seed culture depend upon the crop and season. Most seed crops are not irrigated at all. Nurseries and golf courses have a high water requirement. Irrigation of orchard acreages on which cover crops have been planted for the dual purposes of preventing weed growth and soil erosion and providing forage for grazing in the summer is a new practice being tried in the Sebastopol area.

A small amount of surface water is used for irrigation along Mark West and Santa Rosa Creeks and near Laguna de Santa Rosa.

Since 1951 storage reservoirs have been built on small creeks in increasing numbers, many in cooperation with the Soil Conservation Service, to store winter runoff for irrigation or stock use and to prevent soil erosion.

In 1952 about 90–95 percent of the water used in the Santa Rosa and Petaluma Valley areas was ground water. Total water pumped from wells in 1949 amounted to about 15,000 acre-feet. The storage units and their areas and subdivisions are shown on figure 3.

GEOLOGY

PREVIOUS WORK

The chief contributors to the knowledge of the geology of the Santa Rosa and Petaluma Valley areas are Osmont (1905), Dickerson (1922), Morse and Bailey (1935), Weaver (1949), Gealey (1950), Travis (1952), and F. A. Johnson.[2] Osmont drew geologic sections across the Coast Ranges and subdivided the Sonoma volcanics. Dickerson mapped the Santa Rosa and Petaluma quadrangles and discussed the Petaluma and Merced formations, naming the former. Johnson made a comprehensive study ot the Merced formation. Morse and Bailey described the Petaluma formation and adjacent rocks and mapped an area northwest of Petaluma in detail. Weaver compiled the results of studies made by himself and others over the period 1903–35, including the geologic mapping of nine 15-minute quadrangles of which parts of three—Santa Rosa, Petaluma, and Mare Island—are included in the area of this report. Travis and Gealey mapped the Sebastopol and Healdsburg quadrangles, respectively. The work of all was used to some extent in this report, and the mapping of Weaver, Gealey, and Travis was used with some modification in preparing the geologic map (pl. 1).

DESCRIPTION AND GENERAL WATER-BEARING CHARACTER OF THE ROCKS

GENERAL FEATURES

The valley areas are underlain by the alluvial deposits of gravel, sand, silt, and clay ranging in age from Pliocene to Recent. In Santa Rosa Valley the alluvium is interbedded with marine sediments.

[2] Johnson, F. A., Geology of the Merced, Pliocene, formation north of San Francisco Bay, Calif.: unpublished dissert. for Ph. D., Calif. Univ., 1934.

Underlying the valley fill are volcanic, continental, estuarine, and marine rocks ranging in age from Jurassic to Pliocene. Most of the area investigated is underlain by rocks that are water bearing to some extent, although the deposits beneath the valleys form the principal ground-water reservoirs.

For the purposes of this report the rock units in the Santa Rosa and Petaluma Valley areas are divided into three classes based largely upon their relative capacity to hold and to yield water. The consolidated rocks of Jurassic and Cretaceous age, which yield some water from joints and other fractures, and locally from poorly cemented beds, are the poorest water-yielding rocks. They include, in upward succession, the Franciscan group of Jurassic(?) and Cretaceous(?) age, the Knoxville formation of Late Jurassic age, and the Novato conglomerate of Cretaceous(?) age. On the geologic map (pl. 1) these rocks are shown as one unit (KJ). The sedimentary and volcanic rocks of Tertiary age include units which, though water bearing in part and important locally, do not form an appreciable portion of the ground-water reservoir. In upward succession the units are the Tolay volcanics of Morse and Bailey (1935), the Petaluma formation, and the Sonoma volcanics, all of Pliocene age. The Tertiary and Quarternary deposits that are unconsolidated or poorly consolidated yield appreciable quantities of water to wells, and, therefore, have received the most critical study in this investigation. Included, in ascending order, are the Merced and Glen Ellen formations of Pliocene and Pleistocene age; the older alluvium, of Pleistocene age; and the younger alluvium, of Recent age.

The various stratigraphic units that were distinguished in this study, their general character, and their water-bearing properties are summarized in table 6, and their areal distribution is shown on plate 1. Stratigraphic relations, generalized lithology, and structure are shown on the cross sections (pls. 3, 4, 5, and figs. 4 and 5).

A peg model of Santa Rosa Valley was constructed to aid in the study of the subsurface geology. Logs of about 530 wells were reproduced on quarter-inch dowels or pegs placed on a base map of the area (scale 1:20,000) which was affixed to a table. A color scheme was used to make each peg represent the generalized lithology penetrated by an individual well as reported by the driller's log. The vertical scale of the model is 1 inch equals 50 feet, and the horizontal scale is 1:20,000, so that the vertical exaggeration is 33⅓ times.

So that most deep wells could be shown, sea-level datum was established 20 inches (or 1,000 feet) above the table. On each peg a 2-inch length was left above the top of the log (land surface) to allow space for numbering; thus the surface connecting the tops of the pegs represents the normal topography exaggerated 33⅓ times.

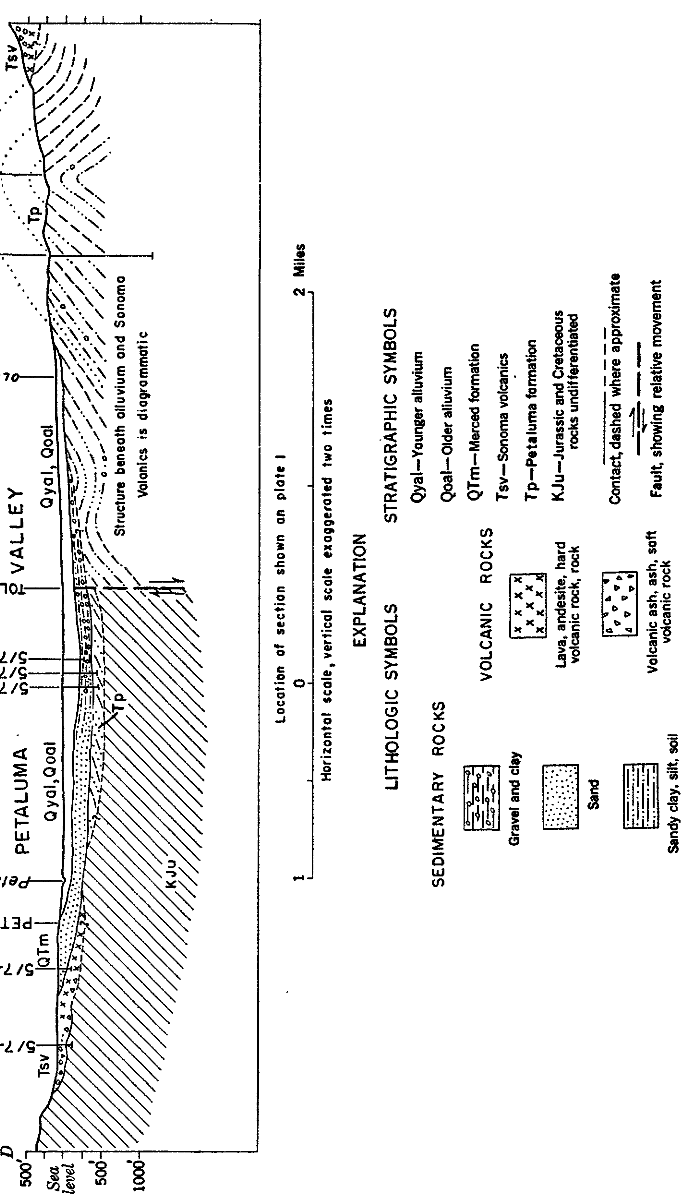

FIGURE 4.—Geologic section across Petaluma Valley, near Petaluma, Calif.

TABLE 6.—*Stratigraphic units distinguished in the Santa Rosa and Petaluma Valley areas, Sonoma County, Calif.*

Geologic age	Formations and symbol on plate one	Previously mapped units included	Thickness (feet)	General character	Water-bearing properties
Recent.	Younger alluvium (Qyal).	Alluvium and younger alluvium of others.	0–200±	Stream-channel and flood-plain deposits, predominantly silt and clay, but containing small, discontinuous gravel lenses, except beneath the Russian River plain where thick bodies of gravel and sand are encountered in wells.	Permeability generally low (except in Russian River valley); greater thickness of deposits above saturated zone; locally contributes small amounts of water to wells tapping older formations.
	Local unconformity.				
Pleistocene.	Terrace deposits (Qt) and older alluvium (Qoal).	Parts of younger alluvium and Montezuma formation of Weaver (1949).	0–200±	Poorly sorted fluvial deposits of gravel, sand, silt, and clay; unconsolidated except for local surface induration. Caps stream-cut terraces (Qt) and forms elevated alluvial deposits at valley margins; underlies parts of alluvial plains.	Terrace deposits generally above saturated zone. Older alluvium yields small to moderate amounts of water to wells from gravel and sand; water of good quality although generally hard.
	Angular unconformity.				
Pleistocene and Pliocene(?).	Glen Ellen formation (Qtge).	Includes Glen Ellen formation of Weaver (1949), continental Merced of Johnson (1934), upper part of Sonoma group of Gealey (1950), and older alluvium of Travis. (1952)	0–3,000	Poorly sorted lenticular deposits of silty clay, clayey gravel, sand, and gravel. Lower part tuffaceous and contains much coarse conglomerate. Reworked tuff beds at base. Considerably deformed at valley margins. Interbedded with Merced formation beneath Santa Rosa Valley.	Yields are adequate for domestic wells over most of extent. Locally yields are fair to good for irrigation wells. Permeability moderately low in Santa Rosa Valley; very low on valley sides and in Kenwood-Glen Ellen areas. Quality of water good except for local high boron content.
Pleistocene(?) and late Pliocene.	Merced formation (QTm).	Includes part of Sonoma group of Gealey (1950).	0–2,000±	Medium- to fine-grained fossiliferous marine sand, sandstone, and silty clay, with minor interbedded gravel and pebbly beds; generally fairly well sorted; tuffaceous in part; interbedded with Sonoma volcanics and Glen Ellen formation.	Upper part of formation yields water freely to wells and is tapped by most irrigation or other deep wells on west side of Santa Rosa and Petaluma Valleys. Lower part of formation more compact and somewhat cemented, but yields adequate domestic supplies to wells west of Santa Rosa Valley. With Glen Ellen formation forms principal aquifer in Santa Rosa Valley. Quality of water generally good.

Late and middle Pliocene.	Sonoma volcanics (TSv).	Lower part of Sonoma group of Gealey (1950).	0–2,000(?)	Interbedded lava flows, tuff, tuff breccia, and agglomerate; sand, gravel, and conglomerate of volcanic origin, and reworked tuff.	More permeable rocks of unit yield moderate amounts of water to wells. Locally, excellent yields obtained from tuffs. Denser volcanics may yield quantities sufficient for domestic supplies from fractures or flow-contact zones. Quality of water generally excellent.
	Angular unconformity.				
Middle or early Pliocene.	Petaluma formation (Tp).	Orinda formation of Johnson (1934).	0–4,000	Continental and brackish-water clay, shale, sand, and sandstone, and some conglomerate and nodular limestone; generally fine grained and somewhat compacted or cemented.	Yields moderate quantities of water to wells where appreciable thickness of sands penetrated. Quality of water poor in places because of high sodium, chloride, and sulfate.
Early Pliocene or middle.	Tolay volcanics of Morse and Bailey (1935) (not exposed).		4,000+	Volcanic rocks not exposed in area of plate 2 but presence known from oil tests.	Not known to be penetrated by water wells.
	Angular unconformity.				
Cretaceous(?) and Jurassic.	Jurassic and Cretaceous rocks undifferentiated (KJ).	Franciscan formation Franciscan-Knoxville group of Taliaferro (1943b), Knoxville formation, Novato conglomerate.	7,000+	Consolidated sandstone, shale, chert, and conglomerate, and metamorphic and igneous rocks.	Impermeable and generally not water bearing; locally small supplies obtained from fractures or poorly cemented sandstone and conglomerate. Quality of water ranges widely; dissolved solids may be high.

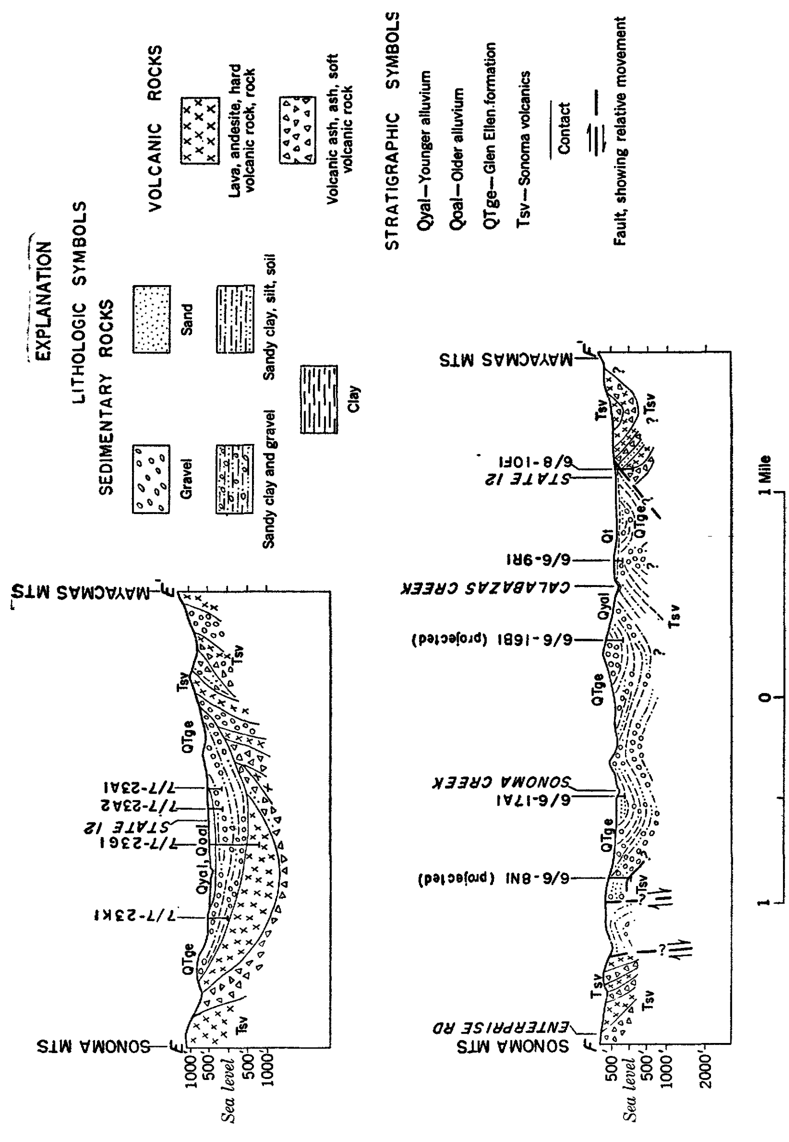

FIGURE 5.—Geologic section across Kenwood Valley (*E-E'*) and the Glen Ellen area, California (along lines *E-E'* and *F-F'*, respectively, of plate 1).

The model shows the change from marine (Merced) sand to continental (Glen Ellen) deposition from west to east and in places indicates the interfingering relations of the two formations. It was useful in laying out geologic cross sections and in considering local problems. Because of the lack of marker beds that could be correlated definitely from well to well, the details of subsurface structure could not be worked out on the peg model.

CONSOLIDATED ROCKS OF JURASSIC AND CRETACEOUS(?) AGE

FRANCISCAN GROUP

General features.—The basement complex of the area is formed by the Franciscan group of rocks of Late (?) Jurassic and Cretacous age. The name was given by Lawson (1895, p. 347) to a series of sandstones, cherts, and limestones exposed on the San Francisco peninsula. They are described in detail by Lawson (1914, p. 4–7) in the San Francisco folio and by Taliaferro (1943b, p. 109–219). More recently these rocks have been described within the area of this investigation by Weaver (1949, p. 19–28), Gealey (1950), and Travis (1952). These rocks have been treated in the literature as both a formation and a group. Because of the proximity of the area covered by this report to areas where the rocks have been subdivided, the group term is used here.

The Franciscan group consists of a series of sedimentary, metamorphic, and igneous rocks having a maximum thickness of possibly 40,000 feet or more. Weaver (1949, p. 20) reports 10,000 feet of sandstone of the Franciscan exposed west of Petaluma Valley; Travis (1952, p. 11) reports 7,000 feet of unrepeated beds of the Franciscan and Knoxville exposed; and Gealey (1950, p. 13) gives an indicated exposed thickness of 16,000 feet of the Franciscan in the Healdsburg quadrangle. In the area of the present report the sedimentary rocks are most abundant and are composed predominantly of massive arkosic sandstone, but include some shale, foraminiferal limestone, radolarian chert, and conglomerate. Although most of the rocks are fine grained, a cobble conglomerage was noted along San Antonio Creek, several hundred yards west of U. S. Highway 101 in 4/7–14.

The base of the Franciscan group is not exposed in the area. However, to the west on the Point Reyes peninsula, the group is in fault contact with crystalline rocks of Paleozoic(?) age. Overlying the Franciscan in places is the Knoxville formation of Late Jurassic age. The base of the Knoxville is not exposed, but Gealey (1950, p. 19) in mapping the Healdsburg quadrangle considered the contact as "probably gradational." Between Petaluma and Novato Valleys, Weaver, (1949, p. 46) found the Franciscan in contact with conglomerate which he calls Cretaceous(?), but he does not describe the nature of the contact. Unconformably overlying the Franciscan at various places are the Petaluma and Merced formations, the Sonoma volcanics, and alluvium.

No distinctive fossils have been found in rocks at the type section, and the age assigned to the Franciscan group has remained somewhat unsettled, generally being given as Late Jurassic(?). Taliaferro (1943b) considered the age as middle Upper Jurassic, on the basis of fossils and field relationship to the Knoxville formation of Late Jurassic age. Recently published reports however, suggests that the Franciscan is in part of Cretaceous age (Schlocker, Bonilla, and Imlay, 1954; Church, 1952; Cushman and Todd, 1948). It seems probable that the age of the Franciscan differs from place to place and that it includes rocks of both Jurassic and Cretaceous ages.

The Franciscan group underlies essentially the entire area, and surface exposures in and near the area are widespread. It crops out intermittently to the west in places where the overlying Merced formation has been eroded away, and is exposed west of the Russian River. Immediately northeast of the area it forms the core of the Mayacmas Mountains. South of Petaluma, the Franciscan bounds the western side of the valley and crops out along the crest of the ridge on the eastern side. East of Petaluma it is uplifted by the Tolay fault.

The rocks of the Franciscan group consist largely of clastic and chemical sediments of marine origin and are intercalated with pillow basalts and more basic igneous rocks. Some metamorphic rocks are associated with the group, namely, serpentine, glaucophane and related schists, greenstone, and silica-carbonate rock. In the upper part the rocks are considerably finer grained in general than those composing the lower part, shales and lenses of radiolarian chert predominating. The lower part is comprised primarily of massive arkosic sandstone and mudstone.

Drillers have little difficulty in recognizing the Franciscan group, especially when the hard sandstones or metamorphic rocks are encountered. They commonly log the Franciscan as "serpentine," and sometimes as "shale," though the latter term, or both, may sometimes indicate the Knoxville formation.

The Franciscan group is intensely folded and faulted, and in many places there are zones of shearing and crushing. No attempt was made to map the complex structure in the Franciscan group.

Water-bearing properties.—Rocks of the Franciscan group are so well consolidated that they are considered to be essentially not water bearing. Locally, however, small supplies of water sufficient for domestic or stock use have been developed where coarse-grained, poorly cemented zones or fracture systems have been penetrated. The log of well 5/7–33Q1,[3] which penetrates the Franciscan group, shows 5 feet of water-bearing cemented "gravel." (See table 27.) Generally, drilling is stopped when the Franciscan is recognized at depth, unless there are indications that fractured zones are present or unless a premium is placed on obtaining even an extremely small yield.

KNOXVILLE FORMATION

The Knoxville formation as referred to here is the Knoxville stage of the Franciscan-Knoxville group of Taliaferro (1943a). The formation was named by White (1885) for exposures at Knoxville, Napa County. As defined by White, the formation includes about 20,000 feet of marine clastics, largely sandstone and shale, in the lower part of the Shasta series. He assigned it to the Lower Cretaceous epoch. As redefined by Taliaferro, the Knoxville is restricted to the Upper Jurassic and includes a maximum thickness of about 12,000 feet of dominantly fine-grained clastics, largely shale, interbedded with thin strata of siltstone and containing small lenses of sandstone and limestone. Thin flows of pillow basalt and beds of impure chert are found in the lower part of the formation. Recently published evidence indicates that the Knoxville is probably of Jurassic(?) and Cretaceous age (p. 30).

In the area of this report the Knoxville appears to grade upward from the underlying Franciscan group without evidence of a marked contact. For this reason Taliaferro has used the term Franciscan-Knoxville group. Taliaferro differentiated the two formations in the field by the predominantly fine-grained character of the Knoxville rocks as compared to the coarser Franciscan. The Knoxville is overlain unconformably by the Sonoma volcanics, Merced and Glen Ellen formations, and alluvium.

The distribution of the Knoxville formation is not indicated on plate 1 but probably is limited to the northern part of the mapped area of the Franciscan and Knoxville. The water-bearing character of the Knoxville is similar to that of the Franciscan.

NOVATO CONGLOMERATE

The name Novato conglomerate was given by Weaver (1949, p. 46) to beds exposed over an area of about 3½ square miles on the west side of Petaluma Creek just upstream from the mouth. Good exposures occur along State Highway 37 near Black Point, about 3 miles east of Novato. There the Novato is composed of poorly consolidated well-rounded cemented pebbles and cobbles which in places grade into grit or coarse sandstone.

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[3] For a description of the well-numbering system, see pp. 6–7.

The Novato is surrounded by alluvium except on the west side in 3/6–5 and 8 where it is reported by Weaver (1949) to rest on the Franciscan group and to be in fault contact with the Sonoma volcanics. Weaver tentatively assigned the Novato conglomerate to the Cretaceous system because of its resemblance to conglomerate in the Chico formation farther east. Similar conglomerate, considered to be of Cretaceous age by Gealey (1950), occurs just north of the area on the west side of Alexander Valley.

The Novato conglomerate is fairly well consolidated but locally is poorly cemented and friable. It is cut by numerous joints and veinlets that contain secondary deposits, probably of calcium carbonate, which would tend to reduce the movement of ground water. Nothing is known of wells that may penetrate the Novato conglomerate, but locally small yields might be obtained from it.

SEDIMENTARY AND VOLCANIC ROCKS OF TERTIARY AGE

TOLAY VOLCANICS OF MORSE AND BAILEY (1935)

Morse and Bailey (1935, p. 1441) gave the name Tolay volcanics to a thick series of lava flows, breccia, tuff, and agglomerate encountered in a core hole drilled in the Petaluma oil district (in 5/6–30). They report that 4,162 feet of these rocks were logged without penetrating the entire thickness. They also reported an outcrop of the Tolay volcanics in a small area west of Tolay Creek near Lakeville School. Weaver (1949), who apparently questioned their mapping, mapped these exposed beds as part of the Sonoma volcanics and his mapping is followed in this report. He indicated (1944, p. 588) that the Tolay was not exposed at the surface but occurred at depths of 2,223–5,964 feet in a well on Adobe Creek. These rocks do not influence the occurrence of ground water in the area and they are mentioned only to show the position they occupy in the stratigraphic sequence.

Morse and Bailey considered the Tolay volcanics to be of early Pliocene age. However, inasmuch as the uppermost strata of the Tolay are interbedded with the lowermost beds of the overlying Petaluma formation, now believed to be of middle or late Pliocene age, the Tolay volcanics are probably of middle Pliocene age.

PETALUMA FORMATION

The Petaluma formation is composed of strongly folded continental and brackish-water clay, shale, sand, and sandstone, and contains some conglomerate and nodular limestone. The formation is unconformably overlain by the Sonoma volcanics, Merced formation, and alluvium. Morse and Bailey (1935, p. 1441) reported the Petaluma to be conformably underlain by the Tolay volcanics at one place. The Petaluma may be in depositional contact with the Franciscan group, but only fault contacts have been mapped. In general, the Petaluma formation is a distinct lithologic unit, although some of the thicker sands appear to be similar to those of the overlying Merced formation.

Age and areal distribution.—Dickerson (1922, p. 540–543) named the formation from exposures northeast of Petaluma, assigned it to the upper Miocene on the basis of brackish- and fresh-water mollusks, and considered it to be a phase of the marine San Pablo formation. Previously, Osmont (1905, p. 57) had assigned these beds to the Pliocene on the basis of a horse tooth from the uppermost beds, immediately below the Sonoma volcanics. These same beds were considered by Dickerson to belong in the Sonoma volcanics. Morse and Bailey (1935) supported Osmont's correlation and found two additional horse teeth which Stock (oral communication in Morse and Bailey, 1935) regarded as indicative of a Pliocene age. Stirton (1939, p. 393) concluded, further, that the tooth of a horse identified as *Neohipparion gidleyi* Merriam from the Petaluma formation could be no older than late middle or early late Pliocene. Johnson [4] and Morse and Bailey (1935, p. 1447–1449) correlated the Petaluma with the Orinda formation, which is exposed across San Pablo Bay to the southeast. Most workers have noted a marked lithologic similarity between the Petaluma and the Orinda, but Stirton (1952, p. 2013) believes that this does not necessarily reflect an identical age but is to be expected, because they occupy the same structural trough. The flora of the Petaluma formation is considered by Axelrod (1944, p. 186–187) to be not older than middle Pliocene.

Exposures of the Petaluma formation are largely confined to a belt 1–2 miles wide along the southwestern flank of the Sonoma Mountains, extending from north of Penngrove to near the mouth of Tolay Creek. In that belt the formation is closely folded into a series of narrow anticlines and synclines and is cut by numerous faults. Small exposures occur about 3 miles west and about 3½ miles northeast of Cotati. Weaver (1949) mapped about 5 square miles of the Petaluma formation near the head of Bennett Valley, and his mapping is followed on plate 1. That area was not studied in detail for this report, but data from well logs and brief surface reconnaissance suggests that the Glen Ellen formation crops out and overlies the Sonoma volcanics in the eastern part, and that a structural discontinuity exists between that area and the exposures of the Petaluma in the western part.

Thickness and origin.—In the Petaluma Valley the thickness of exposed beds of the Petaluma formation probably exceeds 3,000 feet. Morse and Bailey (1935, p. 1444) estimated a total thickness of more

[4] Johnson, F. A., 1934. (See footnote, p 23.)

than 4,000 feet, which they subdivided into two units: their upper Petaluma formation, of fluviatile or lacustrine origin, consists of poorly stratified gray-green clay containing thick lenses of poorly sorted sand and gravel and is as much as 4,000 feet thick. The lower Petaluma, which is 500–600 feet thick, contains beds of estuarine origin consisting of dark laminated clay shale and thin sand interbedded locally with thin beds of limestone. The contact between the two units is gradational. Morse and Bailey report that the basal part of the Petaluma contains a transition zone of alternating beds of volcanic rock and shale which grade downward into the Tolay volcanics.

Lithology and subsurface distribution.—Dickerson noted (1922, p. 540) that the Petaluma formation is characterized by a great abundance of clay, and this observation seems to be supported by evidence from exposures and well logs. A stratigraphic section measured by Weaver (1949, p. 86–87), consisting of 1,059 feet of beds in the lower part of the so-called upper Petaluma unit near Lakeville, contained about 70 percent clay, shale, and clayey or shaly beds; 25 percent sandstone; and 5 percent pebbly conglomerate. In the exposures visited during this investigation only a few gravel or conglomerate beds were observed. Those beds were compact, poorly consolidated, and composed largely of debris from the Franciscan group. The following section was measured in a road cut on Old Adobe road 0.4 mile southeast of Waugh School:

Section of upper part of Petaluma formation exposed in well 5/7–16G

	Feet
Sandstone, medium-grained, yellow to gray	10
Clay, yellow to white; contains large nodules and ledges of limestone	25
Sandstone, thinly crossbedded, friable, yellow to blue; contains thin pods of argillaceous limestone	35
Clay, silty; grades downward from clay at top to sandstone at base of exposed section; contains large nodules and ledges of limestone	24
	94

Johnson[5] describes the clays of the Petaluma as "discoidal," and that type of fracture appears to be a characteristic of the massive clay shales in the formation. The Petaluma formation, as exposed in a small branch of Gossage Creek which cuts across the Washoe anticline about 2½ miles west of Cotati, consists of dark-gray discoidal clay shale and lighter fissile shale. Those beds are overlain by yellowish-brown silty sandstone and pebble conglomerate, having lower dips than the steeply dipping shales and differing in strike by 30–60 degrees, which strongly suggests an unconformity. On this

[5] Johnson, F. A., 1934. (See footnote, p. 23.)

basis, these overlying beds have been assigned to the Merced formation, although other workers have previously included them in the Petaluma.

Where exposed, the sand and sandstone beds of the Petaluma formation are generally light brown. The thin sands are commonly well stratified; the thicker bodies are generally lenticular in shape and massive, although faint crossbedding can be discerned in places. Generally, the sorting is poor.

The subsurface distribution of the Petaluma formation in the area studied has been inferred largely from well logs (pl. 5 and fig. 7). The formation dips beneath the northeastern side of upper Petaluma Valley and is reached in wells near the center of the valley at depths of 300–400 feet. On the western side and in the northwestern part of the valley, the Petaluma is overlapped by the Merced formation at depth. The Petaluma formation also occurs beneath the Cotati plain, although probably at considerable depth (pl. 5). In the vicinity of Penngrove, the Petaluma formation is possibly reached in the deeper wells. To the west it is folded upward by the Washoe anticline, and to the east and north it lies at relatively shallow depths beneath the Merced formation and alluvium. Because the Merced formation in the vicinity of Penngrove contains a continental facies, the contact with the Petaluma is difficult to distinguish in drillers' logs. Some anomalous water levels observed in this area may be the result of wells entering the Petaluma formation and reaching water of different head than that contained in the Merced formation. If the head differential is a valid criterion, it suggests that the Petaluma formation occurs locally at depths of less than 200 feet.

Water-bearing properties.—The Petaluma formation is an important aquifer, or water-bearing formation, only in the northern part of Petaluma Valley where it supplies many wells at the northeastern edge of the valley and contributes to the yield of some of the deeper wells near the center of the valley. The water occurs mostly in lenses or beds of sand or poorly consolidated sandstone separated by clay beds. Yields vary according to the thickness and extent of the sands penetrated and are generally low, although quantities sufficient for domestic use can generally be developed. Wells 5/7–15K1, 5/7–25A1, and 5/7–25C1 are typical of those tapping the Petaluma formation (table 27).

SONOMA VOLCANICS

General character and age.—The Sonoma volcanics were named from numerous exposures in the Sonoma Mountains and consists of a series of lava flows, agglomerates, tuffs, and intercalated sediments of volcanic debris. They were first described by Osmont (1905), who, regarding them as a group, subdivided them in ascending order into the Mark West andesite, Sonoma tuff, and St. Helena rhyolite. Dickerson (1922) also referred to the volcanic series as the Sonoma group, although he followed Weaver's then unpublished work in terming Osmont's subdivisions members. Morse and Bailey (1935), who first published the name Sonoma volcanics, considered the rocks as one formation, as did Weaver (1949). Detailed studies and descriptions of the formation have been made by Weaver (1949) and in Sonoma and Napa Valleys by Kunkel and Upson (written communication, 1957).

The Sonoma volcanics accumulated over an area about 30 miles in east-west extent and about 40 miles in north-south extent. The sources apparently were numerous vents and fissures that intermittently erupted material of variable chemical and lithologic composition during a long period, so that an extremely complex assemblage of flows, dikes, plugs, mudflows, breccias, pumice beds, and intercalated bodies of stratified material, essentially volcanic in composition but sedimentary in deposition, was formed. These rocks have been folded, faulted, and eroded so that they now form a series of elongate ridges separated by narrow alluvial valleys.

In places, especially in areas where the rocks include thin flows, stratified tuff, or rhyolite, regional structure is discernible in the Sonoma volcanics. However, intense faulting is common in the formation (pl. 6), as indicated by narrow, closely spaced folds, steeply dipping beds, overturned beds, and small structures. Thus observed attitudes are often misleading and determinations of regional structure difficult to make. The volcanic sequence generally differs considerably between adjacent areas because of the effects of diastrophism and of the inherent heterogeneity of the formation.

The Sonoma volcanics unconformably overlie the Petaluma formation and underlie the Merced formation; on the basis of its stratigraphic position, the formation is believed to be post-middle Pliocene in age and probably is late Pliocene. Additional evidence supporting this age assignment is provided by plant fossils found in diatomaceous deposits in the upper part of the Sonoma volcanics and identified by Axelrod (1944, 1950).

That deposition of the Merced formation began slightly before or near the beginning of Sonoma time is indicated by occurrences of basalt overlying sandstone of the Merced and the prominent tuff bed intercalated with sandstone near the base of the Merced. Thus, the lower part of the Merced is contemporaneous with part of the Sonoma volcanics. Possibly the Sonoma volcanism began first but did not extend into the area of Merced deposition until after the first sandstones were laid down.

Distribution and thickness.—Exposures of the Sonoma volcanics are mainly restricted to the eastern part of the area of this report, where they have been intensely folded and faulted to form the Sonoma and Mayacmas Mountains. On the southwestern flanks of the Sonoma Mountains the volcanics are in depositional contact with the underlying Petaluma formation. Isolated exposures west of the Santa Rosa and Petaluma Valley troughs are limited to two general areas. In the vicinity of and south of the city of Petaluma, the Sonoma volcanics, for the most part, directly overlie the Franciscan group, although individual flows may be intercalated with sandstone of the Merced formation. Other exposures lie along a structure paralleling and about 1 mile west of a line drawn between Penngrove and Cotati. The southernmost of these exposures is south of Penngrove and consists of andesite and tuff breccia overlying sandstone of the Merced. About 1 mile northwest, basalt, andesite, and tuff are intercalated with the Merced and may overlie the Petaluma formation in places. Several miles farther northwest, andesite and basalt are intercalated with the Merced formation, although not in contact with the Petaluma formation where the base was seen. Northeast of Kenwood Valley the Sonoma volcanics rest unconformably on the Franciscan group.

The Sonoma volcanics are overlain by the Glen Ellen formation, although in places some interbedding of the two units occurs. Where exposures are poor or discontinuous, intravolcanic sands, gravels, clays, and redeposited tuffs are difficult to distinguish from similar beds in the Glen Ellen formation. Usually the interbedding occurs in the tuffaceous phase of the upper part of the Sonoma volcanics, but on the west side of Kenwood Valley basalt may be intercalated with or intrude beds assigned to the Glen Ellen formation. Where not overlain by the Glen Ellen formation, the Sonoma volcanics dip beneath alluvium at the valley margins.

The thickness of the Sonoma volcanics is not uniform. On the northeastern side of Kenwood Valley a persistent zone of tuffs and tuff breccias totals about 1,000–1,200 feet in thickness. The St. Helena rhyolite member is absent there, but beneath the tuffs is a thick series of basalt flows, so the total thickness may exceed 2,000 feet. Weaver (1949) measured a section east of Napa Valley that contained 1,290 feet of volcanic rock, excluding the overlying St. Helena rhyolite member and some basal volcanic beds.

Lithology and water-bearing character.—The andesitic and basaltic flows form the most outstanding surface feature of the Sonoma volcanics because of their hard, resistant qualities. They are largely impervious and act as confining beds which restrict the movement of ground water. Locally, however, small amounts of water are obtained from fractures or scoriaceous zones and possibly larger amounts from clinkery or rubbly flow-contact zones. Some of the flow rocks exhibit well developed platy jointing or sheeting which apparently developed parallel to flow surfaces and which may, in places, supply fair yields to wells.

Pumice tuff, tuff breccia (pl. 6), and redeposited stratified tuff form a large part of the formation, are of chief importance in the occurrence of ground water in the Sonoma volcanics, and generally occur interspersed with andesite and basalt flows. The water-yielding capacity of this type of material apparently is not uniform, being dependent on the size of the interstitial openings and on the amount of interconnection as well as the degree of weathering. From drillers' logs and well samples it is inferred that the best yields are usually obtained from beds of coarse reworked tuff or volcanic ash. All wells in the Sonoma volcanics from which good yields are reported penetrate considerable thicknesses of tuff or tuffaceous material, generally called volcanic ash or ash by drillers.

Well 7/7–29D1 (see table 22) in Bennett Valley yields sufficient water to irrigate 70 acres of pasture and alfalfa. The well penetrated 130 feet of "gray ash," which the driller reported "appears to have had stream action," and which forms the chief aquifer. Also in Bennett Valley, well 7/7–32G1 has a natural artesian flow of 150 gpm from volcanic ash and basaltic tuff interbedded with basalt flows; and well 6/7–3Q1 is reported to yield 1,200–1,500 gpm, with a drawdown of about 50 feet, from gravel and white ash. The deeper wells in the city of Santa Rosa, situated in the mouth of Bennett Valley, probably obtain much of their water from Sonoma volcanics of this type. The subsurface character of the Sonoma volcanics in the mouth of Bennett Valley and the manner in which they interfinger with the Merced formation and continental deposits is shown by geologic section B–B′ (pl. 6).

Other types of volcanic rock, such as agglomerate, scoria, rhyolite, perlite, welded tuff, and obsidian, as well as diatomite, are commonly encountered in wells and are largely not water bearing. Extensive beds of scoria, commonly called "sponge rock," may contribute moderate amounts of water to wells, and some agglomerate beds may supply small amounts.

TERTIARY AND QUATERNARY DEPOSITS

MERCED FORMATION

General character.—The Merced formation is a marine deposit, locally fossiliferous, consisting chiefly of massive beds of fine sand and sandstone and thin interbeds of clay and silty clay, lenses of gravel, and pebble stringers. The lower part is tuffaceous and contains one extensive stratum of pumiceous tuff. On the basis of fossils collected from strata in this area, Dickerson (1922, p. 543–550) correlated the strata with the Merced at the type locality, named by Lawson (1893, p. 142–149) from exposures near Lake Merced, on the San Francisco peninsula.

The most comprehensive study of the Merced to date was made by Johnson [6], who considered the sources of material and conditions of deposition. He concluded that the Merced was deposited in a semicircular subsiding embayment which corresponded in extent roughly to the present-day distribution of outcrops of the Merced. The main source of the material, Johnson concluded, was to the north, and from it a large south-flowing trunk stream carried detritus from the Franciscan group to the basin, where it was spread out by long-shore currents. Johnson believed that a "lagoonal barrier"—an offshore bar seems to be implied—largely prevented admixture of continental deposits from the east until it was eroded away after subsidence ended. Such a barrier was inferred to have been present somewhere near the present axis of Santa Rosa Valley. However, the field work and study of well logs suggests that a simple interfingering of marine with continental deposits occurred near the margin of the basin of deposition, rather than the effective separation of marine and continental deposits as suggested by Johnson. If such a barrier existed it must have disappeared long before the end of Merced time, judging from the thickness of the interbedded section.

Stratigraphy.—Surface mapping by the Geological Survey on both the eastern (see p. 75) and western sides of Santa Rosa Valley and examination of logs of wells on the Santa Rosa plain show that marine strata of the Merced are interbedded with both the Sonoma volcanics and younger continental beds, which here are placed in the Glen Ellen formation (pls. 3 and 4). These continental beds were called "freshwater Merced" by Johnson [6] and were placed by Gealey (1950) in the upper part of his Sonoma group.

Beneath much of the area over which it occurs the Merced formation rests unconformably upon an irregular erosion surface cut on rocks of the Franciscan and Knoxville. In the western part of the area the Merced is in fault contact with the Franciscan and Knovxille in many places. At the south end of Santa Rosa Valley and in the north part of Petaluma Valley, the Merced formation overlies the Petaluma formation with marked angular unconformity. West of Petaluma Valley the Merced locally overlies basalt of the Sonoma volcanics; in at least one place, however, it underlies basalt.

At the northern edge of the area over which it occurs the Merced is overlain in places by terrace deposits of the Russian River. Where

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[6] (See footnote, p. 23.)

it dips beneath the valley areas it is overlain by younger or older alluvium, except in the northern part of the Santa Rosa Valley where it is overlapped by deposits assigned to the upper part of the Glen Ellen formation.

The Merced is a distinct stratigraphic unit, except in areas where it is believed to be interbedded with the Glen Ellen formation and Sonoma volcanics. Parts of the Petaluma formation are somewhat similar, but, in general, the Petaluma is darker and contains a much higher percentage of clay than the Merced. The Petaluma is usually more compact and thinly bedded. Because the Merced formation contains some material from the Sonoma volcanics, and the Petaluma is generally considered to consist chiefly of debris from the Franciscan, the absence of volcanic material has sometimes been taken to indicate Petaluma. However, the Petaluma does contain some material derived from the Tolay volcanics, at least in the basal part, and locally the Merced appears to consist solely of Franciscan debris; thus this criterion is of little use.

Interbedding of the lower part of the Merced with the Sonoma volcanics is exhibited on the western side of Petaluma Valley in the vicinity of Petaluma and near Burdell Mountain (Weaver, 1949; Dickerson, 1922). In the Washoe anticline on the southwestern flank of Santa Rosa Valley, basalt of the Sonoma volcanics is underlain and overlain by strata assigned to the Merced formation. There the underlying beds include lenses of gravel and clay as well as beds of sandstone. On the eastern side of the valley, immediately north and south of the notch cut through the Sonoma Mountains by Santa Rosa Creek, beds probably belonging to the Merced formation are interbedded with strata lithologically similar to the Glen Ellen formation, and with the Sonoma volcanics. Well logs in this area definitely show interbedding of volcanics with sand and sandy clay containing "clam shells" which probably represent the Merced formation. The nonvolcanic deposits on the eastern side of the valley were all mapped as Glen Ellen because the separation of the Merced and Glen Ellen formations there is too intricate to show at the mapping scale. Johnson found evidence of interfingering of marine and continental deposits near Penngrove. Although the deposits there were mapped by the present writer as the Merced formation, some wells penetrate beds not typically marine.

Age and correlative formations.—The age determination of the Merced formation north of San Francisco Bay was first made from marine mollusks by Gabb (1869, p. 25), who identified them as Pliocene. Grant and Gale (1931, p. 61) considered the Merced fauna as middle Pliocene, and C. W. Merriam in a written communication

NEARLY VERTICAL BEDS OF BASALTIC TUFF OF THE SONOMA VOLCANICS.

FOSSILIFEROUS SANDSTONE OF THE MERCED FORMATION.

to Johnson[7] considered the Merced fauna to be "not older than middle Pliocene."

Stirton (1939, 1952) redetermined the age of the underlying Petaluma formation as late middle or early late Pliocene. If this determination is correct, the Merced formation, which rests with marked unconformity on the Petaluma, is not older than late Pliocene. The faunal assemblage of the Merced, as reviewed by Durham and Stirton (Stirton, 1952, p. 2014), is indicative of late Pliocene age. In general, Merced time is believed to span the time interval occupied by the Sonoma volcanics of Pliocene age and the Glen Ellen formation of Pliocene (?) and Pleistocene age. Evidence bearing on the relative ages of basal Merced and Sonoma is uncertain, but Glen Ellen deposition probably continued, overlapping Merced sediments, after the Merced sea retreated.

At the type locality on the San Francisco peninsula the Merced formation has been subdivided into two members: a lower member, considered to be of middle or late Pliocene age, and an upper member, considered to be of Pleistocene age (Schlocker, Julius, oral communication, 1951).

A factor bearing on the age determination of the Merced formation is the stratigraphic horizon exposed at the localities where the marine fossils have been collected and identified. At each of the localities the beds sampled appear to be within a few hundred feet of the base of the formation. Accordingly, because no fossils have been identified from beds near the top, the upper part of the Merced formation in this area, as on the San Francisco peninsula, may be considerably younger than the fossiliferous lower part. Fossils, collected from a new locality about 7 miles west-northwest of Santa Rosa on the Denner ranch, in an artificial channel dug as a distributary to Mark West Creek (7/9–10A), were identified by L. G. Hertlein of the California Academy of Sciences, who supplied the following faunal list and discussion (written communication, Oct. 7, 1954):

Pelecypoda	Gastropoda
Arca trilineata Conrad	*Calicantharus fortis* Carpenter
Cardium cf. *C. meekianum* Gabb	cf. *C. angulatus* Arnold
Macoma nasuta Conrad	*Nassarius moranianus* Martin
Protothaca staleyi Gabb	*Polinices lewisii* Gould
Siliqua cf. *S. patula* Dixon	*Thais emarginata ostrina* Gould

This list contains nine species (five pelecypods and four gastropods) of which five are extinct and are not known to occur later than Upper Pliocene. The five extinct species and two others, Recent ones, occur in typical lower Merced beds along Seven Mile Beach near San Francisco. This portion of the Merced is generally considered to be of Middle or Upper Pliocene age.

[7] (See footnote, p. 23) p. 99, 104.

This locality may be considerably higher stratigraphically than other fossil localities of the formation but because of possible structural complications its stratigraphic position is uncertain.

Distribution and thickness.—The Merced formation is exposed extensively in both the Santa Rosa and Petaluma Valley areas, mainly along the western side of the Santa Rosa-Petaluma Valley trough from Wilson Grove, on the Russian River, southward to Petaluma. The width of the outcrop ranges from about 1 mile to about 6 miles (west of Sebastopol). The Merced crops out westward as far as the coast in isolated bodies separated by large areas of the Franciscan and Knoxville. One small outcrop of the Merced occurs north of the Russian River at Rio Dell. On the geologic map the Merced is not shown on the eastern side of Santa Rosa Valley, although fossiliferous beds were observed there. The formation extends eastward across the axis of the valley just north of Penngrove, and an isolated exposure south of Penngrove is separated from the main body by a tongue of alluvium. Exposures of the Merced are absent in the interval between the above-mentioned exposure and the lower part of Petaluma Valley, where it again crops out from the vicinity of Lakeville southward to the point where the Sonoma Mountains merge with the alluvial plain. The northwestern part of this latter exposure was called "upper Petaluma" by Morse and Bailey (1935); but Weaver (1949), whose mapping is followed here, mapped the area as the Merced formation. Woods [8] mapped the southward extension of these beds as the Merced formation and collected fossils which indicate a fairly late Pliocene age.

The subsurface distribution of the Merced formation has been determined from the study of well logs. In Santa Rosa Valley shallow wells immediately east and north of Laguna de Santa Rosa penetrate the formation, and deeper wells, 500–1,000 feet deep, encounter it at distances as great as 2 miles from the edge of the outcrop. (The area in which the Merced formation is encountered at depths of 200 feet or less is shown on figure 3.) There the subsurface evidence indicates that the beds were gently downwarped and overlapped from the east by gravel and clay beds of the Glen Ellen formation. In Petaluma Valley the Merced is encountered at shallow depths in the extreme northern part and beneath the southwestern side of the alluvial plain as far south as Petaluma and at increasing depths toward the center of the valley. Because of the lack of good well logs, the relation of the Merced formation to the underlying Petaluma formation beneath the valley eastward from the southwestern part of upper Petaluma Valley is unclear. The thickness and

[8] Woods, H. D., 1952, Geology of the Sears Point landslide, Sonoma County, Calif.: unpublished report submitted to fulfill requirements for graduate course, Univ. Southern Calif., 1952.

distribution of the Merced probably are affected by the Tolay fault, whose position beneath Petaluma Valley is not precisely known. In addition, as the area is near the postulated shoreline of the Merced sea, facies changes also may complicate correlation. Such complication is indicated by logs of wells 5/7–28A3 and 5/7–28H1 (table 27), which show continental-type strata in an interval which probably represents the Merced formation. On the northwest side of the valley, between Lakeville and State Highway 37, the Merced is penetrated by wells for a considerable distance westward from the edge of the alluvial plain.

The Merced has been estimated to be less than 300 feet and as much as 1,500 feet thick. Weaver (1949, p. 92) reports the Merced as "usually less than 300 feet thick," and Johnson[9] from cross sections, inferred an original maximum thickness of 1,300 feet and concluded "that the original maximum thickness was probably not more than 1,500 feet." On the basis of the persistent dip of the formation from the easternmost band of exposures of the Franciscan west of Sebastopol, the present writer estimates the thickness to be as much as 2,000 feet.

Another indication of maximum formation thickness is obtained from the log of oil-test well 7/9–24J1, drilled in 1948, 2.6 miles northeast of Sebastopol in Santa Rosa Valley (table 22). This well appears to penetrate marine deposits of the Merced from a depth of 195 feet to the bottom of the well at 2,075 feet, except for an interval of continental deposits between 615 and 826 feet. These continental deposits probably have a marine equivalent, so that the thickness of the Merced penetrated was 1,880 feet. Thus, a total thickness of 2,000 feet is probably a reasonable estimate for the Merced formation.

Lithology from surface exposures.—The Merced formation is typically a fine- to very fine-grained soft sandstone, locally clayey or silty, but contains beds of medium- to coarse-grained standstone and local pebble trains. Travis (1952, p. 19) reports: "Mechanical analyses of five samples showed that 75 to 94 percent of the sand is composed of grains between 0.2 and 0.05 millimeter in diameter. Most of the remaining material is finer grained." The color is commonly yellow, gray, or reddish brown but may be nearly white. Beds are generally massive, although at places they exhibit faint crossbedding. The sandstones are fairly well sorted and grains generally are fairly well rounded. Clay or claystone and siltstone generally occur in thin beds interbedded with fine sandstone. Conglomeratic sandstone occurs near the base, where the pebbles are largely derived from the Franciscan group and near the top, where pebble stringers contain rocks typical of both the Franciscan and the Sonoma volcanics.

[9] P. 118. (See footnote, p. 23.)

The character of the upper part of the formation is illustrated by the beds exposed in the road cut on the north side of Guerneville Road immediately west of the bridge over Laguna de Santa Rosa (7/9–15). There yellow-to-red fine-grained soft sandstone is interbedded with coarse-grained sandstone and thin clay layers and contains scattered pebble stringers and occasional nodules of pumice. The clay appears to be composed largely of weathered volcanic ash. Many of the beds exposed along the eastern edge of the outcrop area are tuffaceous. In some exposures in the vicinity of Cotati and Penngrove, the Merced contains a considerable amount of gravel derived from the Sonoma volcanics.

At the western edge of the area a prominent and persistent stratum of pumiceous tuff 10–20 feet thick is intercalated with the Merced formation about 200 feet above the base. This tuff crops out almost continuously for a distance of about 9 miles and terminates west of Sebastopol. A similar and probably equivalent bed, just north of Trenton, was placed by Gealey (1950) in his Sonoma group, although Travis (1952) considered it a member of the Merced formation. North of Mark West Creek the massive tuff thickens considerably and locally is well jointed. Travis (1952) estimated the thickness there to be 50 feet. While deepening well 8/9–34E1 the driller penetrated 44 feet of the tuff below the bottom of the existing well but did not reach the base of the stratum. The yield of the well was not increased, indicating a very low permeability for the tuff. Therefore, it may act as an aquiclude—that is, may retard the vertical movement of ground water and thus cause confined conditions where it is continuous for appreciable distances.

About 2 miles west of Cotati (in 6/8–33A) a branch of Washoe Creek parallels the local structure, exposing a pebble-gravel bed 15 feet thick overlain by silty clay grading to silty sand and yellow tuffaceous sandstone. The beds are near the base of the formation. Half a mile west, beds of the Merced of similar lithology overlie the Petaluma formation and are overlain by basalt of the Sonoma volcanics.

In some parts of the area the sand is loosely packed and uncemented, so that good exposures do not occur. At other places the beds are poorly cemented with iron oxide or argillaceous cement. Locally, thin fossiliferous beds are well cemented with calcareous cement leached from mollusk shells.

As would be expected in a formation having a northerly source of materials, the percentage of clay in the Merced appears to increase toward the south. Thick layers of clay encountered by wells in the central part of Santa Rosa Valley probably are lagoonal deposits laid down during Merced time.

Fossiliferous strata occur widely in exposed strata of the Merced but, as previously mentioned, most of the explored fossil localities are near the base of the formation. Good outcrops of fossiliferous strata occur near Freestone. In a narrow, curved band flanking the city of Sebastopol on the west, beds containing clamshells are reported to crop out and are penetrated at shallow depths by wells. At Wilson Grove and southward for about 1½ miles, shell beds crop out near the eastern edge of the exposed Merced. Other known outcrops are on the eastern side of Laguna de Santa Rosa near the mouth of Mark West Creek (pl. 7) and in a creek bed on the Schidecker ranch in 7/9–9K.

Subsurface lithology.—The subsurface character and lithology of the Merced formation where penetrated by wells are essentially the same as they are at the surface. The most noticeable difference is the lesser degree of coherence of sands at depth in the upper part of the formation. This difference is probably due to surface induration. The looseness and fineness of the sand hinder the construction and development of wells in the Merced formation, especially in the vicinity of and southeast of Sebastopol where thick layers of fine to very fine uniform sand are encountered. A short distance west of Sebastopol, deep wells encounter a fairly well indurated blue sandstone which apparently is basal Merced and which probably has remained below the zone of oxidation since its deposition. Several miles west of the eastern edge of the exposed Merced the indurated sandstone is covered only by soil or a thin weathered zone, and commonly wells are completed using only a few feet of surface casing. The sandstone is conglomeratic in places, and generally boulders or clamshells are encountered near the contact with the Franciscan and Knoxville rocks. (See table 22, logs of wells 6/9–22A1, 7/9–5N1, and 7/9–29J2.)

Beds containing fossil shells are found throughout the Merced, and at places they are almost a coquina (pl. 7). They are generally less than 10 feet thick, and commonly only 1–2 feet thick, and may occur as loose sand or sand and gravel or as cemented zones that may contain small interconnected solution cavities. (See table 22, logs of wells 6/9–2C1 and 7/9–21G1.)

Wells drilled near outliers of the Franciscan, which formed islands in the Merced sea, commonly enter beds of gravel and clay that were derived from these masses of the Franciscan by marine erosion.

The lithology of the strata penetrated in well 8/9–33J1 may represent this type of deposition, although it might represent a continental facies of the Merced—that is, a tongue of the Glen Ellen formation. The "decomposed rock" in the interval from 150 to 190 feet may correlate with the intercalated tuff bed of the Merced exposed about

400 feet east of the well, if the bed is undulating as suggested by the outcrop pattern. Tuff breccia is sometimes logged by drillers as decayed rock; however, fine-grained tuff is commonly logged as limestone (probably confused with marl).

Much of the material in the Merced formation logged by drillers as clay or sandy clay probably could be classified more strictly as silt or even very fine sand. However, well logs suggest that the formation becomes finer grained eastward beneath Santa Rosa Valley, where it is interbedded with continental deposits of the Glen Ellen formation. This interbedded relationship, the nonrestrictive use of the term "clay" by drillers, and the common occurrence of clay in the Glen Ellen formation make the subsurface differentiation of the Merced and Glen Ellen formations very tenuous.

Geologic cross sections *A–A′* and *B–B′* (pls. 3 and 4) illustrate diagrammatically the interbedded relationship of the Merced and Glen Ellen formations as interpreted from well logs. Section *B–B′* also indicates interbedding of the Merced and the Sonoma volcanics. Logs used to construct these cross sections and other logs showing the relationship reported above are given in table 22.

In Petaluma Valley the Merced deposits are somewhat finer grained than in correlative beds farther north, and both the exposed and subsurface units of the formation are considerably thinner than in the Santa Rosa Valley area. (See fig. 4.)

South of Lakeville, beds of marl are included in the sand and sandy clay of the Merced formation, and tuffaceous strata occur from Lakeville southward to Sears Point and possibly elsewhere.

Water-bearing properties.—Because of its extent, high porosity, and moderate transmissibility, the Merced formation is probably the most important water-bearing formation in the area. A high percentage of the material below the water table yields water, and the formation is comparatively homogeneous so that wells drilled below the water table almost anywhere in the formation yield water. Because of the looseness and fair degree of sorting, the porosity is high; but because of the fineness of the sands and the small amount of coarse material contained, the transmissibility is only moderate and large drawdowns are necessary to produce sizable yields.

The most common cause of well failure is the entry of very fine sand ("quick sand" in drillers' terms) into the casing through perforations or through the open bottom of the casing. Local well-construction and -development practices have not yet progressed sufficiently to enable obtaining the best yields. Until recently most domestic wells were drilled by cable-tool methods, the blank casing being landed in indurated sandstone strata or, rarely, a gravel, so as to avoid pumping of sand. Because of the low transmissibility of the semicemented zones and because of the small intake area exposed at the bottom of the casing, most of the overlying saturated water-bearing material either is not tapped or, if no aquicludes are penetrated, is rendered relatively ineffective because of the large "entrance" or frictional losses. Recently, rotary-drilled gravel-wall wells were introduced, but generally the gravel selected is much too coarse and only one or two of the coarsest intervals penetrated are perforated. Nearly all large industrial, irrigation, and public-supply wells are now constructed in this manner, and better yields are obtained, but well longevity and relatively high yields will be realized only when the proper perforation and gravel-pack sizes are used.

On the basis of the observations of various drillers, it is believed that some of the most prolific water-bearing zones in the Merced formation are in fossiliferous strata. Some of these strata consist of shells and sand cemented together but contain small interconnected cavities probably resulting from solution of the shells. Other strata, described as "clamshells" or "loose clamshells," apparently are essentially a coquina or gravel composed of shells. Probably many of the fossiliferous deposits represent beach or near-shore deposition, so that the material associated with them may include some clean coarse sand and gravel of high permeability. "Gravel and clamshells" or "shells and gravel" are reported in logs of wells 7/9–14K1, 8/9–27K1, 8/9–34R1, and 8/9–34R2, and "shells, sand, and grit" in 6/9–2C1.

The yields of properly constructed wells in the Merced formation average 100–1,500 gpm. The drawdowns average 10–100 feet, and specific capacities range from 2–30 gpm per foot of drawdown. In order to obtain yields of this magnitude, the wells are commonly drilled to depths of 200–600 feet.

GLEN ELLEN FORMATION

Definition and general character.—The Glen Ellen formation was named by Weaver (1949, p. 98) for exposures of continental deposits near Glen Ellen at the northern end of Sonoma Valley. As defined by Weaver (1949, p. 98–99), the Glen Ellen formation consists of stratified gravel and sand alternating with thick layers and lenses of conglomerate composed of andesite cobbles averaging 3–6 inches in diameter. Weaver states that the formation rests on the folded Sonoma volcanics and that the deposits near Glen Ellen are at least 300 feet thick. He mapped the Glen Ellen formation only at the northern edge of the Santa Rosa 15-minute quadrangle from Glen Ellen to the northern part of Rincon Valley. As referred to in this report, the Glen Ellen formation consists of the thick sequence of deformed continental deposits that discontinuously overlie and locally interfinger with the Sonoma volcanics and that interfinger with the Merced formation. The formation includes the Glen Ellen formation of Weaver, the upper part of the Sonoma group of Gealey (1950), and the Older Quaternary alluvium of Travis (1952).

The Glen Ellen formation characteristically consists of lenticular tongues and beds of poorly sorted gravel, sand, silt, and clay which vary widely in extent and thickness and grade in short distances, both laterally and vertically, into one another. The formation was deposited principally as piedmont and valley alluvial fans. Some of the deposits adjacent to and beneath Santa Rosa Valley were laid down in shallow bays or lagoons and grade into marine deposits. The Glen Ellen formation crops out discontinuously from a locality about 4 miles south of Glen Ellen to the vicinity of Cloverdale, about 45 miles northwest, but only about 25 miles of this reach is shown on plate 1.

Stratigraphy.—On the eastern side of Santa Rosa Valley the Glen Ellen formation is underlain by the Sonoma volcanics except for limited areas where it rests on and intertongues with the Merced formation. Locally the Glen Ellen is interbedded or is conformable with the volcanic rocks. Johnson [10], in discussing the "freshwater Merced deposits" north of Santa Rosa, states, "The relation of the freshwater Merced to the Sonoma volcanics is seen to be a depositional one involving no discordance in dip and strike." However, mapping shows that in many places a discordance in dip and strike does exist. Thus, it is believed that for the most part the Glen Ellen rests unconformably on the Sonoma volcanics.

Beneath Santa Rosa Valley the Glen Ellen formation overlies and is interbedded with the marine Merced formation. Locally the Glen Ellen is underlain by rocks of the Franciscan group. Beneath the alluvial plan of Sonoma Valley, which lies southeast of Glen Ellen in the same structural trough as the Kenwood Valley-Glen Ellen area, the Glen Ellen formation probably interfingers with or grades into the Huichica formation. The two formations are considered to be about of equivalent age. The Glen Ellen is unconformably overlain at valley margins by younger alluvium and locally by older alluvium and terrace deposits.

Some of the intravolcanic continental sediments intercalated with the Sonoma volcanics are similar to and locally may have been mapped with the Glen Ellen formation because the deposits are not easily distinguished in the field. The chief distinction between these intercalated beds of the Sonoma and the younger deposits of the Glen Ellen is the considerable dispersion and reworking of the lighter volcanic material through the Glen Ellen, with the result that the

[10] P. 101. (See footnote, p. 23.)

A. LENTICULAR BEDS OF LOOSE, POORLY SORTED GRAVEL OF THE GLEN ELLEN FORMATION.

B. CONGLOMERATE AND COMPACT, SANDY CLAY OF THE GLEN ELLEN FORMATION.

constituents of the Glen Ellen are more highly weathered than are the parent materials in the Sonoma volcanics.

Age and correlative formations.—Weaver assigned the Glen Ellen formation to the Pleistocene epoch because it overlies the Sonoma volcanics of late Pliocene age. Although no diagnostic fossils have been found in the type area, the Glen Ellen is believed to embrace parts of two epochs; deposition possibly began in very late Pliocene time but probably occurred largely in early Pleistocene time. Some difference may exist between the ages of the basal deposits of the Glen Ellen from place to place because volcanic activity may not have ceased everywhere at the same time. As referred to in this report, the Glen Ellen is considered to be of Pliocene(?) and Pleistocene age because (1) the basal beds interfinger locally with rocks of the Sonoma volcanics, (2) the Glen Ellen interfingers with marine strata of the Merced formation of Pliocene and Pleistocene(?) age through a thick sequence beneath Santa Rosa Valley (pl. 4), and (3) the Glen Ellen in the area of this report seems to be correlative with several formations of Pliocene and Pleistocene age in nearby areas. Correlative formations are the Merced and Huichica formations in Santa Rosa and Sonoma Valleys, respectively, possibly the San Antonio formation of Trask and Ralston (1951, p. 1082–1089) in the San Francisco Bay area, and the Tehama formation on the western side of the Sacramento Valley.

Distribution and thickness.—The deposits of the Glen Ellen formation accumulated in two principal structural troughs, the Windsor and Kenwood-Sonoma synclines, which were later steepened and the latter folded into a series of smaller anticlines and synclines (fig. 5). The deposits are exposed in the northern part of Santa Rosa Valley and on the northeastern flank of the valley where the inferred thickness is about 3,000 feet (pl. 4). Gealey (1950, p. 23) reports a maximum exposed thickness of 3,000 feet of clastics for the upper part of his Sonoma group, which part is equivalent to the Glen Ellen formation. He states, "It is estimated that a diminution by one-half occurs across the Windsor Syncline [synclinal axis of Santa Rosa Valley]." This diminution suggests that the Glen Ellen is not more than 1,500 feet thick on the west side of the valley.

Subsurface evidence indicates that the Glen Ellen is present beneath alluvium as far south as Penngrove (pl. 5), and some deposits may extend west of Santa Rosa Valley. On the south side of Mark West Creek, about half a mile west of Trenton, some gravel beds exposed in road cuts were mapped by Travis (1952) as older alluvium. However, the deposits have an attitude similar to those of the Merced and probably represent deposits laid down as an extensive tongue of the Glen Ellen formation, possibly as channel deposits of a large stream which built a delta into the Merced embayment. They are shown on the geologic map (pl. 2) as Glen Ellen. These deposits may be the conglomerate referred to by Johnson[11] and placed by him in the Merced formation.

In the Kenwood-Glen Ellen syncline, exposures of the Glen Ellen are continuous—except for short gaps at both ends of Kenwood Valley—from a point about 5 miles north of Santa Rosa southeastward to a point about 4 miles south of Glen Ellen (about 1 mile east of the area of pl. 1). These deposits are considerably more deformed than those in Santa Rosa Valley, and the maximum thickness is considerably less.

The Glen Ellen formation is believed not to be exposed in Petaluma Valley; however, some of the material mapped as older alluvium possibly may include remnants of the Glen Ellen.

Lithology.—Observations made in mapping the Glen Ellen formation indicate that it is extremely heterogeneous. Along the strike it is not unusual to pass from coarse boulder conglomerate directly into a massive siltstone in which the largest grains may be scattered granules.

The contact with the underlying Sonoma volcanics commonly occurs in a tuffaceous zone. The lower part of the zone is usually pumiceous tuff and is assigned to the Sonoma volcanics. The zone varies in thickness from place to place and is intermittently missing, indicating an unconformity. Upward, the tuff merges with a tuffaceous sandstone, which merges gradually with silt. This interval generally has a thickness of 25–100 feet and is overlain by interbedded boulder conglomerate and conglomeratic and tuffaceous silt.

Good exposures of the Glen Ellen formation, especially of layers of conglomerate and more resistant sandstone and siltstone, are fairly common, but continuous exposures for appreciable distances are rare. Described below is a relatively thin section exposed in the type area:

Section of Glen Ellen formation exposed about 0.5 mile northwest of Glen Ellen in 6/6–16F

	Feet
Silt and tuffaceous silt and occasional lenses of coarse crossbedded sandstone and pebble stringers 5–6 feet long	20
Conglomerate, medium sand to cobbles	8
Silt and clay, brown and yellowish-brown; contains sand and pebble lenses 2–3 feet thick	10
Concealed	5
Sandstone, fine- to medium-grained, thinly crossbedded, light-olive-brown	10
Siltstone and sandy clay, pebbly, tan to yellowish-brown, and occasional gravel stringers	15
Total	68

[11] P. 106. (See footnote, p. 23.)

In the Glen Ellen area and along the margin of Kenwood Valley, the Glen Ellen formation contains thick lenses of fairly compact silty or sandy clay in addition to sand and conglomerate (pl. 8*B*). The material is nearly everywhere poorly sorted, except for some of the sand, and in many places is poorly cemented. Good exposures occur northwest of Glen Ellen in the creeks tributary to Sonoma Creek, along Warm Springs Road, and along Henno Road immediately north of Glen Ellen. In Kenwood Valley outcrops are generally poor and discontinuous.

Along the road to the Santa Rosa Golf and Country Club (in 7/7–10N), coarse conglomerate of the Glen Ellen formation is exposed, and along the east slope of Rincon Valley the strata exposed are principally gravel beds which have a nearly vertical dip near their contact with the Sonoma volcanics. The steeply dipping beds cause artesian conditions in wells in the vicinity of 7/7–8A, 8H, and 9D.

In the hills immediately north and south of Santa Rosa, steeply dipping continental beds of the Glen Ellen crop out and are associated with marine sandstone, probably of the Merced formation. In nearby wells, shells are commonly encountered in marine sands interbedded with the continental Glen Ellen formation. Because the Merced is exposed over a small area, the sandstone, although mapped in the field, is included on the geologic map with the Glen Ellen formation. The Merced and Glen Ellen are associated with the upper part of the Sonoma volcanics, but the relations and degree of interbedding are largely obscured and complicated by faulting and steep, closely spaced folds.

Farther north on the eastern side of Santa Rosa Valley, where slopes are gentle, beds are well exposed at only a few places, and those exposures are generally of small vertical and areal extent. Coarse conglomerates are less common there than in the Glen Ellen area. The section described below, which probably occurs near the base of the formation, is believed to be typical of the Glen Ellen in that area.

Section of Glen Ellen formation exposed in 8/8–21P

	Feet
Tuffaceous sandstone, medium-grained, buff-colored, and fine-grained reworked tuff	4–5
Concealed by slope mantle	25
Sandstone, very fine to silty, compact; only slightly friable	15
Gravel, poorly sorted, weakly cemented; composed chiefly of volcanic rock, both vesicular and nonvesicular	2
Sandstone, coarse-grained and tuffaceous at top, grading to fine-grained at bottom of exposed section (glassy tuff in Sonoma volcanics exposed less than 100 feet lower, stratigraphically)	10
Total	56–57

On the eastern side of Chalk Hill Road in 8/8–17D, about 175 feet of loose, poorly sorted lenticular gravel interbedded with light-buff compact silt and gritty sand is exposed (pl. 8*A*); these materials may be representative of those encountered in well 8/8–20Q1 (table 22). The gravel is composed of debris from the Sonoma volcanics, including some obsidian, and much of it is of cobble size.

On the western side of Santa Rosa Valley, north of Mark West Creek, strata of the Glen Ellen, where exposed, are finer textured than the deposits to the east and are more nearly horizontal. In many places they are difficult to distinguish from the older terrace deposits along the Russian River. North of Wilson Grove for several miles the gravels are interbedded with sandstone. This relation probably reflects oscillations of the shoreline of the Merced sea. A typical section in the area is described below.

Exposure of the Glen Ellen formation, about half a mile northeast of Wilson Grove in 8/9–22P

	Feet
Sandstone, fine to very fine grained, tuffaceous, compact but poorly cemented, yellow. Grades downward into unsorted granular to pebbly sandstone having a clay matrix, then into a fairly well sorted sandy siltstone. Bottom obscured by soil	10
Clay silty, yellow; stained by iron-oxide	12
Claystone, somewhat sandy, hard, yellow; stained by iron-oxide	3
Obscured (although covered by slump and soil mantle, there are indications of the presence of silty and clayey gravel)	70
Clay, sandy, hard; stained by iron-oxide	6
Sandstone, medium to coarse, angular, friable; stained by iron-oxide. Massive and fairly well sorted, becoming pebbly at bottom	4
Gravel in thin lenses interbedded with thin layers of gritty sandstone	4
Clay, silty	4
Total	113

Only a few small exposures of the Glen Ellen formation occur in the slightly to moderately dissected area of the valley trough, and most consist of poorly sorted gravel. In the bed of Mark West Creek the predominant material cropping out is siltstone which in places appears to be tuffaceous.

Water-bearing properties.—Beneath the Santa Rosa Valley the lithology and water-yielding characteristics of the Glen Ellen formation vary considerably. In general wells not more than 100 feet deep will provide enough water for domestic use, and wells 250–600 feet deep will provide enough for irrigation.

Drillers' logs indicate that most wells penetrate lenticular bodies of unconsolidated, poorly sorted silty clay, clayey gravel, sand, and gravel. Computations made from drillers' logs to determine the storage capacity of Santa Rosa Valley indicate that in the Windsor-Fulton storage unit (fig. 3), which is underlain primarily by the Glen Ellen formation, an average of about 40 percent of the material penetrated in a zone 200 feet thick is clay. Of the remaining material, about 20 percent is gravel and sand whose water-bearing qualities are relatively good, and (40 percent is poorly assorted material containing much silt and clay, whose water-bearing qualities range from poor to fair. The gravels are composed mostly of debris from the Sonoma volcanics but include minor amounts of chert of the Franciscan group. The subsurface lithology of the Glen Ellen formation is shown by logs in table 22 of the appendix and diagramatically on cross sections *A–A′* and *B–B′* (pls. 3 and 4).

The range in materials and in yield is illustrated by wells 8/8–17L1 and 8/8–20Q1 (table 22) which are only 1½ miles apart. In well 17L1 a considerable amount of coarse material was penetrated between the surface and a depth of 278 feet, but it was so poorly sorted and contained so much clay that the yield of the well was only 10 gpm and the drawdown more than 100 feet. In contrast, well 20Q1, which is 312 feet deep, penetrated mostly poorly sorted gravel and yielded 300 gpm; the drawdown was 10 feet. Thus the specific capacity of well 20Q1 is about 300 times that of well 17L1. This range probably is close to the extreme for the formation.

Most of the wells on the eastern side of Santa Rosa Valley and north of Mark West Creek obtain all or most of their water from the Glen Ellen formation; no extensive tongues of the Merced are tapped by wells except at depth near the mouth of Mark West Creek. However, many wells in the eastern half of Santa Rosa Valley from Santa Rosa north to Mark West Creek encounter what appear to be fairly extensive lenticular bodies of blue clay or silty clay. Many wells penetrate more than 50 feet of the clay and some as much as 300–400 feet. The clay bodies do not form a well-defined zone in wells and apparently are discontinuous. Thus, they probably represent flood-plain or interfan deposits rather than lagoonal clays.

Most wells drilled in the Glen Ellen formation in Santa Rosa Valley tap only the upper part of the formation, which generally yields water more freely than the lower part, which is a relatively poor aquifer. This difference in yield is due in part to the large amount of weathered tuff disseminated in the lower part of the Glen Ellen formation. The reworked tuff is more weathered, finer grained, and more compact than the tuff of the Sonoma volcanics and therefore is less permeable.

In Rincon and Kenwood Valleys and in the Glen Ellen area only low to moderate yields are obtained from the Glen Ellen formation, probably because of the extreme heterogeneity of the deposits and the relatively large amount of tuffaceous material. However, it is the chief aquifer in the valley areas, except for the southern part of Kenwood Valley where fairly thick deposits of Recent alluvium are underlain by Sonoma volcanics, and in the vicinity of Glen Ellen where most large-capacity wells tap the Sonoma volcanics.

PLEISTOCENE AND RECENT DEPOSITS

OLDER ALLUVIUM AND TERRACE DEPOSITS

General character, extent, and thickness.—The older alluvium and terrace deposits are shown on the geologic map (pl. 1) by the same pattern. The older alluvium, where exposed, consists principally of alluvial-fan deposits but is probably contemporary with and includes some terrace deposits and old valley fill. In Petaluma Valley some of the older alluvium shown on the map may belong to the Glen Ellen formation. The older alluvium is generally slightly to moderately dissected; thus its initial surface has been altered or eroded away. No effort was made to map terraces other than the alluvial-fill terraces; where the bedrock is exposed, cut terraces are not shown.

The older alluvium and terrace deposits are probably of late Pleistocene age and locally overlie older deposits unconformably. The most extensive exposures of older alluvium are on the northeastern side of upper Petaluma Valley where the deposits overlie the Petaluma formation and consist principally of alternating clay or silt and gravel and some cemented gravel and sand. They were mapped by Weaver (1949), who assigned them to his Montezuma formation. The terrace deposits and older alluvium are mapped separately in Kenwood Valley, and extensive terraces are shown on the sides of the Russian River valley (pl. 1).

The older alluvium is well exposed in only a few places, but where examined it appears to consist of unconsolidated and poorly sorted sand or sand and gravel and interbedded silt and silty clay. Some coarse conglomerate exposed in the Glen Ellen area along the old railroad cut north of Calabazas Creek is cemented locally with argillaceous material. The maximum exposed thickness of the unit is less than 100 feet but the subsurface thickness in Petaluma Valley is estimated to be as much as 200 feet. The terrace deposits, especially along the western side of the Russian River valley, where they occur at several levels, are fairly well exposed. They consist of buff to light-brown poorly sorted crossbedded gravel and sand and have a maximum observed thickness of several hundred feet.

Because the older alluvium is similar to the uppermost deposits of the Glen Ellen formation, the two units are difficult to distinguish in drillers' logs. In exposures the older alluvium is generally distinguished from underlying deposits of the Glen Ellen or Petaluma formation by its flatness. However, according to Higgins (1952, p.

223–226), the terrace deposits and older alluvium locally may be slightly warped.

Water-bearing properties.—The older alluvium is of principal importance as an aquifer in the upper part of Petaluma Valley, where it supplies water to wells of intermediate depth. Yields generally range between 20 and 200 gpm and specific capacities range from less than 1 to about 5 gpm per foot of drawdown. Terrace deposits, where saturated, supply water to domestic wells along the margins of the Russian River valley and contribute to the yields of irrigation wells in areas where they underlie younger alluvium. However, the terrace deposits are commonly somewhat weathered, so that yields generally are comparatively low.

YOUNGER ALLUVIUM (RECENT)

The younger alluvium forms the alluvial-fan deposits at the margins of valleys and is spread out in a relatively thin veneer in the valley troughs. In the Santa Rosa and Petaluma Valley areas, it blankets the older deposits. The deposits were formed by aggradation along the courses of the streams traversing the area and by sheet wash and other colluvial processes in interstream areas. The deposits are thin at the margins of valleys and generally thicken toward the center and along streams, where they underlie flood plains and channels. The material underlying the Russian River flood plain, the Laguna de Santa Rosa, the flood plain near the mouth of Mark West Creek, and Petaluma Valley was deposited by streams which once were graded to a lower sea level; since that time, as sea level rose, they have backfilled their valleys. These deposits are the thickest deposits of younger alluvium in the area.

The deposits of younger alluvium are clearly Recent in age because they represent the cycle of alluviation now in progress, they are unconformable on the Pleistocene deposits, and their surfaces are only slightly weathered.

The deposits overlie with angular unconformity the Glen Ellen and Merced formations, the Franciscan group, and the Sonoma volcanics. The younger alluvium unconformably overlies the older alluvium, except locally where deposition may have been continuous.

Distribution, thickness, and lithology.—Plate 1 shows the areal extent of the younger alluvium in the area. In Santa Rosa Valley along the lower part of Laguna de Santa Rosa and near the mouth of Mark West Creek the deposits attain appreciable thickness. They are not exposed or tapped bywells along the Laguna, but near the mouth of Mark West Creek wells penetrate as much as 150 feet of clay and sandy clay, sand, and gravel, which, though seemingly poorly sorted, supply fair yields to wells. Upstream along Mark West Creek the alluvium consists mainly of poorly sorted silt and silty clay and thin crossbedded layers of sand and fine gravel.

At the mouth of Bennett Valley and at the head of the Santa Rosa Creek fan, deposits of the younger alluvium may attain a thickness of 30 feet or more in places. The thickness is uncertain because the base cannot be readily identified in drillers' logs. The deposits consist of coarse gravel, sand and gravel, clay, and sandy clay which may contribute appreciably to yields of wells. (See logs for wells 7/7–18L1, 18N1, and 18R2.)

In Petaluma Valley the younger alluvium is thickest near the bay where the maximum is possibly as much as 300 feet, but no confirming data are available. The material is chiefly fine grained, consisting of silt, sandy clay, some sand, and scattered beds of thin gravel. The materials comprising some strata may be fairly well sorted, but the permeability is low because of the overall fineness of the deposits. In the northern part of Petaluma Valley the younger alluvial deposits probably are relatively thin except possibly on the southwestern side in the vicinity of Petaluma, where it is difficult to distinguish the younger from the older alluvium.

In Novato Valley the younger alluvium rests on the Franciscan group and on older alluvium. In the vicinity of Novato the thickness of the younger and older alluvium, combined, exceeds 50 feet locally, and in places the younger alluvium alone may attain that thickness. The deposits consist of interbedded clay or sandy clay and gravel that have low to moderate permeability.

The deposits underlying the Russian River flood plain consist principally of poorly sorted channel deposits of sand and gravel interbedded with flood-plain deposits of silt and clay. Because of the difficulty in distinguishing in drillers' logs between the younger alluvium, terrace deposits, and the Glen Ellen formation, the thickness of the younger alluvium is not definitely known but may have a maximum of about 150 feet. A study of the well-log and well-yield data indicates that the younger alluvium is underlain by the Glen Ellen formation or older alluvial deposits of similar character at depths ranging from a few feet to 50 feet or more on the eastern side of the Russian River south of Healdsburg, and that the younger alluvium is probably thickest, about 100 feet, on the western side near the present course of the river.

Water-bearing properties.—The younger alluvium is important as a water-yielding formation in Novato Valley, in parts of Petaluma Valley, and in the Russian River valley. In Novato Valley yields are generally less than 25 gpm, and only locally as great as 50 gpm. In the northern part of Petaluma Valley the permeability, and yield to wells, of the younger alluvium are low. In the southern part of Petaluma Valley the highest yields from younger alluvium are 100–150 gpm. However, in the Russian River valley the younger alluvium contains a relatively high percentage of gravel and sand and good yields are obtained from wells 30–100 feet deep. Yields are commonly above 500 gpm and specific capacities generally 20–100 gpm per foot of drawdown or more.

GEOLOGIC STRUCTURE

The Santa Rosa and Petaluma Valley areas are in the northwest-trending structural province of the Coast Ranges of northern California. The regional structure consists primarily of northwest-trending folds and a few major faults, the most prominent of which is the San Andreas fault, a right-lateral fault, about 16 miles west of the area. The regional downwarp occupied by Santa Rosa and Petaluma Valleys extends from San Pablo Bay northwestward for about 50 miles. Folds and faults have deformed or displaced all formations except the younger alluvium of Recent age.

FOLDS

Folds in the rock strata are the most important geologic structures bearing on the occurrence of ground water in the Santa Rosa and Petaluma Valleys areas. In general, the major synclines or downfolds tend to localize the accumulation of and preserve the sediments that form the ground-water reservoirs. Largest of these is the major syncline that forms Santa Rosa Valley, named by Gealey (1950, p. 31) the Windsor syncline. At the north end of Santa Rosa Valley is a relatively broad asymmetrical downwarp characterized on the west side by low dips and on the east side by steeper dips and some displacement by faulting. Southward, in the vicinity of Mark West Creek, the east side becomes more complicated and is intricately folded and faulted (pl. 6). The present structure evolved during the Pleistocene epoch; before that time the area was occupied by a depression, probably monoclinal, which formed during middle or late Pliocene time and in which the marine Merced and continental Glen Ellen formations accumulated. This depression was uplifted and modified by erosion before the most recent orogeny. Where aquicludes, or confining beds, are folded in the syncline, artesian conditions are common locally. However, because of the low dips and lenticularity of the deposits in the axial part of the Windsor syncline, marked artesian conditions are not common there; they are prominent locally in the steeper eastern limb and in the gently dipping western limb where more extensive confining beds occur.

The Washoe anticline (Weaver, 1949) is a relatively minor fold on the western limb of the Windsor syncline in the southwestern part of Santa Rosa Valley. It extends from the margin of Petaluma Valley, south of Penngrove, northwestward to Gossage Creek, a distance of

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about 6 miles. It is not a simple structure; rather, the limbs are undulatory, and between Washoe and Gossage Creeks the anticline branches into several parallel folds. It locally limits the extent of the ground-water basin in Santa Rosa Valley. An anticlinal structure along the northeastern side of Petaluma Valley, which probably involves only the Petaluma and older formations, in part determines the southern extent of Santa Rosa Valley.

Petaluma Valley lies southward in the same general synclinal trough as Santa Rosa Valley, and it also has undergone some faulting. During the latter part of the early Pliocene, the syncline occupied a larger area than the present ground-water basin and received deposition of the Petaluma formation. It was modified by deformation during the middle Pliocene, after which the Merced formation was laid down. During the latter part of the Pliocene and probably continuing into the Pleistocene, the extent of the basin was localized, and sediments forming the upper part of the ground-water reservoir subsequently were deposited.

The Kenwood-Sonoma syncline determined the distribution of the Glen Ellen formation in the eastern part of the area. After the deposition of the Glen Ellen the extent of the basin was modified by folding, which produced narrow, closely spaced folds in the Glen Ellen area (fig. 5) and in the southwestern corner of the Calistoga quadrangle, north of Santa Rosa.

FAULTS

The northwest-trending faults at the margins of the valleys, especially in the Santa Rosa Valley area, have displaced the formations and therefore in part control the thickness of water-bearing deposits in the basins and the general form of the valleys. Steeply dipping beds exposed in some places along valley margins probably represent drag folds along faults. Wells such as 7/8–14A1, drilled into impermeable or poorly permeable near-vertical beds, generally have low yields. Even those wells drilled in more permeable vertical beds may have large drawdowns, because the vertical bedding may limit stringently the horizontal extent of the local aquifer, and its recharge.

On the basis of mapping in adjacent upland areas, several faults are inferred to pass beneath the valley areas. The largest of these is the Tolay fault (Weaver, 1949), which has been mapped from the mouth of Tolay Creek at San Pablo Bay northwestward to the vicinity of Hessel (pl. 2). The Tolay fault is not known to cut strata younger than the Merced formation and therefore probably has little subsurface effect on the hydrology of Petaluma Valley. However, it controls the thickness of water-bearing deposits, at least in the central part of Petaluma Valley, by bringing up impermeable strata of the

Franciscan group. (See fig. 4.) Logs of oil and gas test wells in 5/6–30A reveal more than 2,000 feet of the Petaluma formation, even though the site is near the crest of an anticline. The log of well 5/7–26R1 near the center of the valley reveals bedrock of the Franciscan group at a depth of 800 feet and indicates that the Petaluma formation has thinned to about 300 feet. The shallow depth to bedrock suggests that the position of the Tolay fault buried at depth beneath the valley is northeast of the well, as the upthrown side of the fault is the southwestern side.

Some of the faults mapped at the margins of Santa Rosa Valley probably cut the Merced and Glen Ellen formations beneath the valley, but no barrier effects that can be directly attributed to faults have been recognized. However, in 8/9–22 a fault is inferred from chemical data to affect the water quality. (See section on Quality of Water in Santa Rosa Valley area.)

Minor structures consist chiefly of drag folds and small faults and are common in the Sonoma volcanics and locally in the Glen Ellen and Merced formations, especially in areas affected by large-scale faulting. These locally restrict the occurrence, movement, and quality of ground water.

GEOLOGIC HISTORY

MESOZOIC ERA

The known geologic history of the area began during the latter part of the Jurassic period of the Mesozoic era, when the dominantly clastic marine sediments of the Franciscan group and Knoxville formation accumulated in a broad, slowly sinking geosyncline. During and after deposition, these sediments were intruded by basic and ultrabasic igneous rocks. The end of the Jurassic period was marked by uplift and local warping, but the general shape of the geosyncline was not destroyed and deposition of clastics continued into the Cretaceous period. At the end of the Cretaceous period sedimentation was interrupted by uplift accompanied by folding and faulting. Most of the Cretaceous rocks probably were removed by erosion during Late Cretaceous or early Tertiary time when sedimentation was taking place eastward; the only remaining Cretaceous deposit is the Novato conglomerate.

CENOZOIC ERA

PRE-PLIOCENE EVENTS

Pre-Pliocene Tertiary rocks are not exposed in the area studied, and such rocks, if deposited there, must have been largely removed by erosion before mid-Pliocene time. However, during the middle part of the Miocene epoch the marine Monterey shale was deposited over a wide area and is postulated by Morse and Bailey (1935, p. 1439) to underlie a part of the area and to be the source of oil in the Petaluma district. Throughout the Cenozoic era the area oscillated above and below sea level, and the crustal instability was marked by folding, faulting, and volcanic activity. During middle Miocene time, building of the Coast Ranges began with compressive deformation, producing ridges which rose above sea level.

PLIOCENE AND PLEISTOCENE EPOCHS

The earliest Tertiary event of which there is evidence within the area is the volcanism of pre-Petaluma (probably middle Pliocene) time, during which the Tolay volcanics of Morse and Bailey (1935) were deposited over an area of undetermined extent. Late in the middle Pliocene or early in the late Pliocene, the Petaluma formation was deposited in shallow embayments and stream basins graded to them, mostly over a surface of low relief on the Franciscan group but in part on the Tolay volcanics. Deposition was apparently followed by a period of orogeny, or deformation, during which these beds were strongly folded; subsequently they were beveled by erosion. Movement along the Tolay fault raised the southwestern block several thousand feet, and most of the Petaluma formation was removed from it by erosion.

The Sonoma volcanics were deposited on this erosion surface, which was subject to some crustal disturbance and local submergence. To the west a shallow sea was formed and sands of the Merced formation accumulated, interfingering with the lava flows and ash falls which extended into the sea from the centers of volcanic activity to the east. Near the close of the period of Sonoma volcanism, deposition of the continental Glen Ellen formation, which was largely derived from the volcanic material, was accelerated, probably owing to uplift, and the deposits extended into the Merced sea as lagoonal and deltaic deposits that interfingered with the Merced formation. The volcanic activity was most extensive in the eastern part of the area and apparently continued over a considerable period of time, during which were intermittent periods of quiescence in which sediments derived from the volcanic rocks were deposited. There are indications that as the volcanism ceased gradually, sporadic outbursts occurred at isolated centers, so that the age and structural relationships of the continental Glen Ellen formation, which in general overlies but in part probably interfingers with the volcanics, vary from place to place. After the volcanism ended, deposition and local interfingering of the Glen Ellen and Merced formations continued.

Late in Pliocene time and continuing into the Pleistocene, the Sonoma volcanics and Glen Ellen and Merced formations were uplifted, folded, and faulted. The coastal depositional basin apparently remained until about middle Pleistocene time, although, as indicated by the interfingered marine and continental beds, the shoreline alternately advanced and retreated. The Kenwood-Sonoma syncline also was formed at this time, as indicated by the strong deformation of the Glen Ellen formation.

Following the close of the period of major structural deformation, probably in late middle Pleistocene time, the region was uplifted and subjected to erosion, minor warping, and stream entrenchment; terrace deposits and the older alluvium were laid down. West-flowing consequent drainage to the sea was developed from the area of the Sonoma Mountains, on the eastern side of Santa Rosa and Petaluma Valleys, across the present valley sites on a terrane formed by the Merced formation.

In late Pleistocene time the present general form of Santa Rosa Valley was produced by downwarping, probably accompanied by elevation of adjacent upland areas, at least on the northeastern side of the valley, along marginal faults. The lack of appreciable amounts of older alluvium in Santa Rosa Valley indicates that warping may have proceeded slowly. Possibly the warping was brought about by the slow readjustment of the area resulting from earlier volcanic activity to the east. This deformation may be equivalent to the so-called mid-Pleistocene diastrophism of central and southern California, but a late Pleistocene age is indicated on the basis of the limited weathering and dissection of terraces which date the warping (Higgins, 1952, p. 225).

Studies of terraces along the Russian River by Higgins (1952) indicate that the Russian River was entrenched in about its present position before the period of latest structural deformation and was able to maintain its antecedent course across the downwarped area. However, the upper part of the drainage system which formerly was mainly consequent across the Merced formation westward to the ocean was deflected into the Santa Rosa-Petaluma Valley structural trough, and older alluvium probably was deposited locally. Local arching in the vicinity of Penngrove probably established a divide between Santa Rosa and Petaluma Valleys. Near the end of the Pleistocene, when sea level was several hundred feet lower than at present, the streams cut trenches graded to that level. As sea level rose the streams backfilled the trenches. The backfilled materials form the younger alluvium and probably were deposited mainly during the Recent epoch. At the present time, deposition is continuing along the lower course of the Russian River and in the downstream part of Petaluma Valley.

Anomalous lower course of Mark West Creek.—The lower part of Mark West Creek follows a seemingly anomalous course in the vicinity of Laguna de Santa Rosa. The former course, across a relatively wide flood plain in the S½ of 8/9–34 and 35, has been abandoned in favor of the present course, a rather circuitous route to the Laguna between low outliers of the Glen Ellen formation. From the Laguna the creek flows through a narrow channel cut in bedrock of the Franciscan group east of Trenton, then in an alluvial channel, which it apparently has occupied continuously during Recent time, to its junction with Windsor Creek. There are several possible explanations for the anomalous course, but the following is deemed the most plausible from what is presently known.

A comparison of stream courses suggests that the alluviation of trenches cut when sea level was lower has taken place more rapidly along the lower part of Mark West Creek than in the Laguna de Santa Rosa, thus impeding through drainage from the Laguna and maintaining swampy conditions there. When the flood plain of Mark West Creek at the northern end of the Laguna had been aggraded to near its present level, the creek, when at floodstage, spilled over its flood plain into the Laguna. The creek probably became entrenched in the course of a short tributary to the lower Laguna, so the process, in part, may have been stream piracy. When the level of the Laguna rose sufficiently to allow through flow to the Russian River, the outlet fortuitously occupied an old bedrock saddle cut by a tributary of the old drainage system that was graded to a lower sea level. The evidence suggests that the diversion of the creek into the Laguna and the reestablished flow through the bedrock channel have occurred during late Recent time. During flood periods the main current flows over the flood plain so that deposition on the flood-plain surface is continuing.

Some writers have attributed the marshy conditions along the Laguna, at least in part, to local subsidence; however, the more rapid aggradation along the lower part of Mark West Creek, as suggested above, seems a more likely cause and is at least a contributing one.

GROUND WATER

The two principal ground-water basins in the area are in Santa Rosa Valley and in Petaluma Valley. Because the hydraulic interconnection between the two is relatively poor, ground water in each has been discussed separately.

GENERAL HYDROLOGIC PRINCIPLES

The occurrence of ground water in the area of this report, as elsewhere, is controlled by climate and geologic conditions. Precipitation is the ultimate source of essentially all ground water of economic importance. Rainfall enters the ground-water reservoir by direct infiltration and by downward or lateral percolation from streams that are above the water table.

Practically all ground water is in motion, moving from points of higher altitude in the intake or recharge areas to points of lower altitude in the discharge areas. Rates of movement usually range from a few feet per year to several feet per day. Discharge from any given area by natural means occurs by evapotranspiration (combination of evaporation from soil and transpiration by plants), effluent seepage into streams, and underflow through water-bearing materials where physical conditions permit.

Any formation or stratum yielding water in sufficient quantity to be important as a source of supply is an *aquifer*, or "water-bearing formation" (Meinzer, 1923a, p. 52). An aquifer may hold water in storage, or, more commonly, "transient storage," the amount available being dependent on the specific yield and the dimensions of the aquifer. Unconsolidated deposits—gravel, sand, and clay—are commonly more porous than sandstone and other consolidated rocks which may be compacted or have cementing material filling many of the interstitial spaces. However, many rocks in the latter group are sufficiently permeable to function as important ground-water reservoirs. If pore spaces are relatively large and interconnected, as in sand and gravel, water is transmitted freely and the deposit is said to be permeable. If the spaces are small or poorly connected, as in clay or cemented sandstone, the rock is of low permeability and water is transmitted very slowly, and the rock may be called an *aquiclude*. Thus, *permeability* is the capacity of a rock to transmit water under pressure, and the *coefficient of permeability* may be defined as the rate of flow of water, in gallons a day at a temperature of 60° F, through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent, or through each mile of the water-bearing bed under investigation (measured at right angles to the direction of flow) for each foot of thickness of the bed and for each foot per mile of hydraulic gradient. If the determination is made under prevailing conditions in the field, the principal difference being that it is made at the prevailing temperature of the water rather than at 60° F, the constant is called the *field coefficient of permeability*. The product of the field coefficient of permeability and the thickness of the saturated portion of the aquifer, in feet, is the *coefficient of transmissibility* (Wenzel, 1942, p. 7).

The *specific yield* of a deposit may be defined as the ratio of the volume of water the deposit will yield by gravity to the saturated volume of the deposit (Meinzer, 1923b, p. 28). This ratio is commonly much less than the porosity because of *specific retention*, the volume of water held in pore spaces against gravity by molecular attraction and capillary force, compared to the total volume of the deposit.

If the water in an aquifer is not confined by an overlying impermeable stratum and has a "free" surface at atmospheric pressure, water-table conditions prevail. Water is obtained from an aquifer of this type by dewatering the deposits in the vicinity of the well, and water-level fluctuations reflect actual changes in ground-water storage. The *water table* is generally defined as the level at which unconfined ground water will stand in an opening of supercapillary size (such as a well) in an aquifer. If an aquifer is overlain by an impermeable stratum, the water in it is called *confined water*, and the water-level fluctuations reflect changes in pressure of the confined water. If water in a well penetrating the aquifer rises above the top of the confining stratum under hydrostatic pressure, the water is said to occur under artesian conditions (Meinzer and others, 1942, p. 451). When such water is yielded by the aquifer, dewatering of the deposits adjacent to the well does not occur, and the aquifer acts as a conduit to transmit water from areas of recharge to the well. Some water is supplied by its own expansion and the compression of the aquifer due to the lowering of hydrostatic pressure.

The amount of water yielded from storage under either water-table or artesian conditions is expressed by the coefficient of storage. The *coefficient of storage* is defined as the volume of water released from oı taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. For water-table conditions the coefficient of storage is essentially equal to the specific yield of the material unwatered during the pumping. The coefficient of storage for a confined aquifer is much smaller than that for a water-table aquifer formed of the same material, drained by gravity. Generally, in deeper ground-water basins containing valley-fill deposits, such as in the area of this report, both water-table and confined conditions occur, and the water levels in wells reflect composite conditions. Locally in the Santa Rosa and Petaluma Valley areas water occurs under water-table, artesian, and subnormal pressure-head conditions. Under *subnormal pressure-head* conditions the static level in wells is lower than the water table (Meinzer, 1923b, p. 38).

The yield of a well is dependent on the following factors: (1) Depth, diameter, and type and efficiency of construction of the well; (2) depth to water and saturated thickness of permeable materials penetrated (aquifers); (3) permeability of the aquifers; (4) amount and type of well development; and (5) capacity of the pump.

The geologic and hydrologic conditions that affect the amount of water in and movement of water through the aquifers tapped by the well determine how uniformly the yield will be sustained. The first four of these factors affect the specific capacity, a term generally used to indicate the productivity of a well. The *specific capacity* is defined as the amount of water, in gallons per minute (gpm), yielded for each foot of drawdown of water level in the well. Because of differences in well depths and the manner in which wells are completed, specific capacities are not an exact measure of the relative permeability of the water-bearing materials tapped by individual wells. To obtain a rough measure of the permeability of the material yielding water to a well, a comparative index, termed yield factor, is sometimes used. The term was originally introduced by Poland, Sinnott, and others [12] and was expressed "as an approximate relative measure for the permeability of the water-bearing material tapped by a well." It was defined as the specific capacity divided by the thickness, in feet, of the water-bearing material yielding water to the well. The quotient obtained was multiplied by 100 to avoid decimal values. In the initial use of the term in the Long Beach-Santa Ana area in California, the specific capacity was divided by the thickness of water-yielding material open to the perforations. As used in this report, the *yield factor* is defined as the specific capacity divided by the thickness of saturated material penetrated by the well, multiplied by 100. The modification of the original usage was necessary because some of the wells are gravel-wall wells to which most of the gravel-wall section of the hole contributes water, not just the section opposite the perforations in the casing, and because perforation data are lacking for many other wells in the Santa Rosa and Petaluma Valley areas. Furthermore, to the extent that there is vertical continuity of the permeable materials, the entire thickness of the aquifer contributes water to any well that is perforated in a part of its thickness. The derivation of the yield factor in dimensional units is given below: [13]

$$\text{Yield factor} = \frac{\text{Specific capacity}\left[\dfrac{\text{discharge (gpm)}}{\text{drawdown (feet)}}\right]}{\text{Saturated thickness}} \times 100$$

$$= \text{gpm/ft/ft/} \times 100$$

Although the differences in well depth are accounted for in deriving the yield factor, differences in well efficiency resulting from differences in construction are not. Thus, for the best results, wells similarly constructed and perforated should be selected for comparison.

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[12] Poland, J. F., Sinnott, Allen, and others, Withdrawals of ground water from the Long Beach-Santa Ana area, California: unpublished rept. in files of U. S. Geol. Survey, 1945, p. 57.

[13] In this area the saturated thickness used was depth of well minus average depth to water below the land surface during spring, the assumption being made that the vertical continuity of the permeable materials was poor enough that the part of the aquifer, if any, below the bottom of the well contributed little water to the well. Where data on depth to water in the well were lacking, the local average depth to water was used.

Transmissibility may be roughly estimated by the Thiem formula (Wenzel, 1942, p. 81) using the drawdown in the pumped well, the estimated effective well diameter (generally 10–12 inches), and an assumed radius for the cone of influence—a value of 300 feet for water-table conditions and 3,000 feet for confined conditions can be used to represent average operating conditions. An estimate of the field coefficient of permeability can then be obtained by dividing the transmissibility by the thickness of the aquifer, if it is completely penetrated by the well. If the well only penetrates part of the aquifer, permeability estimates greater than actual values will be obtained. However, in many cases, entrance losses due to poor well development or incomplete screening, even of fully penetrating wells, will tend to produce the effect opposite to, and thus compensate for, partial penetration, so that the rough values obtained are comparable to actual values. This method of obtaining an estimate of permeability is essentially the same as that used to obtain the yield factor; therefore, rough quantitative estimates for permeability may be obtained by multiplying the yield factor by a number which from experience in other areas has been found to be about 15 for water-table conditions and 20 for confined conditions. In several valley-fill areas in California where semiconfined conditions exist, as in this area, multiplying the yield factor by 17 has given permeability estimates that compare reasonably well with values obtained in pumping tests. When the full saturated thickness penetrated is used in deriving the yield factor, however, and the factor is multiplied by 17, the rough value of permeability so obtained is an average for all the saturated materials penetrated, including clay and silt as well as sand and gravel. The average permeability of the water-yielding beds tapped would be higher than that of the full saturated section, in inverse proportion to the percentage of water-yielding beds as compared to the full saturated section. Thus, if the average permeability of the saturated deposits tapped by a well as estimated by multiplying the yield factor times 17 is 1,000, and if only one-quarter, or 25 percent, of the saturated deposits tapped are water-yielding beds (sand, gravel, or other permeable materials), the average permeability of the water-yielding beds so estimated would be 4 times as great, or 4,000. It is important to keep this fact in mind in the following discussion, which derives estimated permeabilities for the full saturated section tapped by wells.

SANTA ROSA VALLEY AREA

The Santa Rosa Valley area includes Santa Rosa Valley and its minor tributaries, that portion of the Russian River flood plain bordering it on the northwest, and Bennett Valley, Rincon Valley, Kenwood Valley, and the Glen Ellen area on the east. The principal ground-water basin in the area is Santa Rose Valley. Hydrologic interconnection exists between Santa Rosa Valley and the Russian River flood plain, between Santa Rosa Valley and Bennett Valley and Rincon Valley, between Rincon and Kenwood Valleys, and between Kenwood Valley and the Glen Ellen area.

The principal water-bearing deposits underlying Santa Rosa Valley are the Glen Ellen and Merced formations; beneath the Russian River flood plain, the younger alluvium; and beneath the small valleys east of Santa Rosa Valley, the younger and the older alluvium, the Glen Ellen formation, and the Sonoma volcanics. The areal distribution of these formations is shown on the geologic map (pl. 1), and the subsurface extent, lithology, and thickness are shown on cross sections (pls. 3–5, and fig. 5).

PRINCIPAL WATER-BEARING FORMATIONS

YOUNGER ALLUVIUM

Except for small areas in the lower portions of the principal valleys and in the Russian River valley, the younger alluvium generally consists of only a thin veneer of poorly sorted, mostly fine-grained material resting on the older deposits. Much of it is not perennially saturated and is probably of low permeability. In the downstream parts of Rincon and Bennett Valleys, and near the mouth of Mark West Creek, the younger alluvium may yield some water to wells. Many wells penetrate the younger alluvium, but generally they are not perforated opposite these deposits.

Pump-test data for a few wells on the Russian River flood plain provide the only information relating to the yield of the younger alluvium, other than a few verbal reports of yields in Petaluma Valley. A test of well 8/9–9H1, which penetrated "loose yellow sand and gravel" between depths of 2 and 38 feet, indicated a yield of 250 gpm and a drawdown of 3 feet below a static depth to water of 13 feet at the beginning of the test; the yield increased to 350 gpm at the end of the test, and no additional drawdown was reported. This test indicates a specific capacity of about 115 gpm per foot of drawdown and a yield factor of about 460. By use of the method outlined onpage 65, the permeability of the sand and gravel bed is estimated to be on the order of 7,000–8,000 gallons a day per square foot. Well 8/9–15M1 has a specific capacity of about 70 gpm per foot of drawdown, and specific capacities for wells tapping the younger alluvium which were not influenced by recharge from the Russian River have been reported to be as high as 450 gpm per foot of drawdown.

Ground water in the younger alluvium generally is unconfined or only slightly confined. Locally in the southern end of Kenwood Valley poorly permeable beds near the surface cause slight confinement.

Well 7/6-32F1, which penetrates "tule mud" between the surface and a depth of 21 feet, generally has a head slightly above the land surface during the spring (pl. 10); however, this phenomenon may result from confinement in the Glen Ellen formation, which the well penetrates beneath the younger alluvium.

Ground water moves from points of recharge down gradient, and much of the recharge to the younger alluvium percolates downward to recharge the underlying more heavily pumped formations. In general, the quality of the water in the younger alluvium is good for most uses; however, for domestic use it may be slightly hard and may contain objectionable quantities of iron.

OLDER ALLUVIUM AND TERRACE DEPOSITS

The terrace deposits have a limited extent and are mostly above the average position of the water table when it is at its seasonal low, except along the western side of the Russian River where they attain greater thickness and yield water to some wells. However, because these are small, isolated aquifers, they yield large quantities of water only where they extend beneath the younger alluvium. Water in these deposits probably is unconfined and locally is in hydraulic contact with that in the younger alluvium. Well yields are moderate to poor. The quality of the water is good except for a high iron content.

In the Santa Rosa Valley area, the older alluvium probably yields water to wells in Kenwood Valley and in local areas where it underlies the younger alluvium. Where exposed as isolated, thin, elevated deposits, it probably yields little water. Because of the inferred limited subsurface occurrence and difficulties in distinguishing the older alluvium from the overlying younger alluvium and underlying Glenn Ellen formation, well yields cannot be used as a general index of the permeability, but the lithology indicates that the permeability is relatively low. Water in the older alluvium may be confined locally. The water is inferred to be of good quality, but locally it probably is slightly hard and contains iron in sufficient quantities to be objectionable for domestic use.

GLEN ELLEN FORMATION

The Glenn Ellen formation underlies the greater part of Santa Rosa Valley and together with the Merced formation forms the principal ground-water reservoir in the area. The Glen Ellen supplies water to numerous wells, including many irrigation wells. Some wells produce more than 500 gpm, but for most wells the specific capacities are less than 10 gpm per foot of drawdown. For wells deriving all their water from the Glen Ellen formation, the highest specific capacity reported was 30 gpm per foot of drawdown for 8/8-20Q1. The yield factor for this well is 10, suggesting a permeability of roughly 170 gallons per day per square foot for the formation locally. The yield factor for well 8/9–23L1 was 6, suggesting a permeability of about 100. The deposits of the Glen Ellen formation tapped by wells in Santa Rosa Valley probably are in the upper part of the formation, and, except near the outcrop along the northeastern side of the valley, are finer grained than the lower part but less consolidated and generally more permeable.

In Kenwood and Rincon Valleys and on the eastern side of lower Bennett Valley, most wells tap considerably deformed and heterogeneous beds near the base of the Glen Ellen formation that yield only small to moderate quantities of water to wells. In Kenwood Valley and in the Glen Ellen area, the yields are extremely low and commonly a thick section must be penetrated to obtain an adequate supply even for domestic use. From a very few wells sufficient water is obtained for limited irrigation, but the pumping lifts commonly exceed the economic limit. The low permeability in these areas may be due to the high percentage of weathered tuff contained in the deposits.

Water in the Glen Ellen formation is confined locally in areas of folding and faulting along the margins of some valleys, and also in other parts of the valleys where extensive lenses of impermeable material are present. Flowing wells and other wells having heads considerably above the water table are located on the southeastern side of Rincon Valley; in limited marginal and upland areas, north (mostly in 7/8–13D and 7/8–12N) and south of the city of Santa Rosa; and in synclinal areas northwest of Glen Ellen. However, beneath most of Santa Rosa Valley, water in the Glen Ellen formation occurs under water-table conditions.

MERCED FORMATION

The Merced formation forms the low hills on the western side of Santa Rosa Valley and underlies them to depths exceeding 1,000 feet. The formation dips beneath the valley and is penetrated by many wells on the western side of the valley. Figure 3 shows the line west of which wells obtain water from the Merced formation at depths of less than 200 feet. The depth to the top of the Merced varies, depending on the distance from the line of outcrop and the local relation of interbedding with the Glen Ellen formation. On figure 3, the two eastward bulges on the 200-foot contour suggest areas where prominent tongues of the Merced extend eastward at relatively shallow depths.

In general, the Merced formation is only poorly to moderately permeable; however, much of the material penetrated by wells generally is water yielding. Locally, some clean sand beds in the Merced, which are believed to be old beach deposits, are highly permeable. The specific capacities of wells for which records of pump tests are available range from 2 to 29 gpm per foot of drawdown. The highest values obtained were for wells near the contact with the Glen Ellen in the western part of Santa Rosa Valley, where the upper part of the Merced is tapped, and the lowest were for wells near the western edge of the outcrop, where the indurated basal deposits are tapped. The average specific capacity of wells tapping the lower part of the Merced is about 1 gpm or less per foot of drawdown, whereas in the upper part the average is more nearly 5–6 gpm. The yield factors for these wells range from 1 to 15, suggesting a range in permeability from 15 to 250 and an average of roughly 100 gallons per day per square foot for the Merced formation.

Ground water in the Merced formation is not confined except locally where differences in vertical permeability create pressure heads which are slightly above the water table in some wells. Many wells west of Graton in the downstream parts of the valleys of Atascadero and Green Valley Creeks flow or have heads slightly above the water table. Of these, some are deep and some are relatively shallow. In April 1951, water in wells 7/9–28P1 and 28P2, 585 and 100 feet deep, respectively, flowed over the top of the casings, which extended about 2 feet above the land surface. The flow of the deeper well was about 30 gpm and the temperature of the water was 69° F; of the shallow well, 5 gpm and 60° F. These data suggest the presence of one or more confining strata. Well 6/8–17K3, 132 feet deep, and several wells in 6/9–12 flow during the spring. Beneath Santa Rosa Valley, ground water in the Merced and Glen Ellen formations is essentially a single water body, and no significant hydraulic disparity exists between the two formations. The quality of water from the Merced formation is generally satisfactory.

SONOMA VOLCANICS

Although the Sonoma volcanics underlying the Santa Rosa Valley do not form a significant part of the ground-water basin, they are an important source of water in the tributary valleys, especially Bennett Valley, the southeastern part of Kenwood Valley, and the eastern part of the Glen Ellen area.

In the upper part of Bennett Valley good yields are generally obtained at depths of less than 500 feet from volcanic ash interbedded with basaltic flows underlying alluvium of the Glen Ellen formation. The water is generally confined and locally is under appreciable head. For example, on April 18, 1950, well 7/7–32G1 had an artesian flow of about 150 gpm; and the water levels in wells 7/7–29L1 and L2 were about at the land surface on the same date. The artesian water is separated from the unconfined water in the overlying alluvial deposits by relatively impermeable lava beds.

In places along the margins of the northwestern part of Kenwood Valley, wells tap the volcanic rocks—tuff breccia, andesite, basalt, and rhyolitic tuffs and flows—but generally the yield is small. On the northwestern and southeastern flanks of Kenwood Valley, rhyolitic beds crop out and dip beneath the valley. The low yields of wells in that area and in rhyolitic terrane west of Kenwood, compared with the relatively good yields of wells in basaltic terrane east of Glen Ellen and in Bennett Valley, suggests that the basic volcanic rocks are more permeable than the acidic ones.

At the western edge of Rincon Valley and in most of the area between Rincon and Santa Rosa Valleys, adequate supplies for domestic use can be obtained from wells drilled in the volcanic rocks. Well depths and yields have a considerable range, owing to the heterogeneity of the rocks, the position of the water table, and the local topography. The water beneath those areas may be confined locally, but no abnormally high heads have been noted.

In the southeastern part of Kenwood Valley the largest yields are obtained from wells tapping the volcanics. Well 7/7–29M1, 400 feet deep, is reported to yield 500–600 gpm; well 7/6–32H1, 406 feet deep, is reported to have a natural flow of about 200 gpm and to yield 1,000 gpm when pumped. Both wells penetrate several hundred feet of volcanic rocks. The yield of the latter well increased about tenfold after it was drilled into the volcanic rocks. Thus, ground water is locally confined by lava beds, and the water has considerable head in some wells. However, near the center of the valley, water levels in wells tapping the volcanic rocks are similar to those in wells penetrating only the alluvium, suggesting that locally ground water in the two units is in hydraulic continuity. Ground water moving up into the alluvium from the Sonoma volcanics may contribute to the waterlogging in the "wet" area southeast of Kenwood.

In the Glen Ellen area, most of the better yielding wells tap the Sonoma volcanics and probably obtain water from tuffs or waterlaid volcanic ash and fractured flow rocks. Similarly, on the southeastern side of Santa Rosa Valley, numerous domestic wells obtain water from rocks of the Sonoma volcanics, perhaps chiefly from tuff breccias and intercalated volcanic sediments and fractured flows. Here the relation of water in the volcanic rocks to that in the principal water body beneath Santa Rosa Valley is not clearly understood, but locally water in the volcanic rocks appears to merge with the principal water body.

In Bennett Valley the deep wells, 900–1,200 feet deep, in the main well field of the city of Santa Rosa (7/8–24A) obtain much of their water from the volcanic rocks. These wells yielded 500–2,000 gpm during tests; the shallow wells in the same field which tap only alluvium and the Glen Ellen formation yield less than 500 gpm. Many wells farther east penetrate the volcanic rocks at relatively shallow depths and are partly supplied from them. Lines on figure 13 show the approximate depth to the top of volcanic strata in this area. Many wells drilled into the volcanic rocks at the eastern edge of lower Bennett Valley obtain only meager yields. Water levels measured in that area in the spring of 1951 indicate that some of the water in the volcanic rocks is under a lower head than that in the alluvium. Water in volcanic strata beneath alluvium in the lower part of Bennett Valley is somewhat confined, but, in most wells tapping either one or both, a common head is usually found.

On the western side of Santa Rosa Valley, the Sonoma volcanics are not an important source of water, and beneath the central valley floor no water wells are known to tap the volcanic rocks. The quality of water in the Sonoma volcanics is generally satisfactory, although the dissolved-solid content is somewhat high.

PETALUMA FORMATION

The Petaluma formation is not an important source of ground water in the Santa Rosa Valley area. It may be penetrated by a few deep wells at the southern end of the Cotati plain, but the beds tentatively identified as the Petaluma formation are chiefly tough clays. Well 6/8–33E1, 215 feet deep, apparently taps the Petaluma formation where it is uplifted along the Tolay fault, but it produces only about 5 gpm. A few other wells in this area may obtain small amounts of water from the Petaluma formation. Deep wells in the low hills that separate the Cotati plain from the small valley southesst of Penngrove penetrate the Petaluma formation; however, most obtain little water from it.

PRINCIPAL WATER BODY

EXTENT, NATURE, AND DEPTH TO WATER

The principal water body in the Santa Rosa Valley area is contained in the unconsolidated deposits, consisting of the younger and older alluvium and the Glen Ellen and Merced formations, which occupy the large structural downwarp of which the floor of Santa Rosa Valley is the modified surface expression. The water body extends laterally beneath the hills on the west side of the valley, which are underlain by deposits of the Merced formation, and beneath the bordering hills on the east, which are underlain by the Glen Ellen formation and some volcanic rocks that are not separated from the principal body by stratigraphic or structural barriers. In all, it underlies an area of about 150 square miles. This water body is hydraulically connected with many of the smaller water bodies in the minor tributary valleys. However, the water is continuous with only the unconfined water in Bennett and Rincon Valleys, which in turn is connected with the ground water upstream in Kenwood Valley. In Bennett, Rincon, and Kenwood Valleys the principal water body is in the younger and the older alluvium, in the Glen Ellen formation, and locally in the Sonoma volcanics.

The principal water body does not occur under true water-table conditions, but, on the other hand, the incomplete confinement that does exist rarely produces large differences in head. Head differences, as reflected by water levels in wells, normally are small and are caused by differences in vertical permeability in the lenticular deposits tapped. True water-table conditions occur in shallow wells where permeable deposits extend to and above the water level. Wells tapping several permeable zones usually have a water level that represents a composite or average pressure head which may be higher or lower than the water table, depending upon the head in the aquifers. In the northern part of Santa Rosa Valley, extensive, thick lenticular deposits of clayey material (drillers usually log it as "clay") impede the vertical movement of water sufficiently to produce large differences in head during the pumping season in adjacent wells tapping beds above and below the "clay." Wells tapping deeper beds generally have lower water levels than nearby shallow wells. The behavior of water levels in two pairs of adjacent shallow and deep wells is shown on figure 7. In the vicinity of the Cotati auxiliary landing field (6/8–23), artesian conditions occur locally in wells tapping the Merced formation, possibly as a result of poorly permeable continental-type deposits overlying permeable, dipping sands of the Merced. The separation within the principal water body is not sufficiently widespread to warrant a separation into zones; furthermore, in places where there is separation the vertical boundary ranges widely.

The depth to water in the principal water body ranges within comparatively narrow limits, depending chiefly on the terrain, as the water table generally assumes a shape that corresponds in generalized form to that of the land surface; water levels in the upland area are higher than those on the valley floor but are farther below the land surface. During spring of 1951, water levels in wells in the flat valley areas generally were only 5–20 feet below the land surface, and in the lowest parts of the valleys they were locally less than 5 feet below. Along the sides of the valley, where the land surface slopes upward, water levels normally increase in depth, except where the water is confined.

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FLUCTUATIONS OF WATER LEVELS

In the Santa Rosa Valley area about 60 wells were measured periodically during the period 1949–52 to determine the general character and magnitude of the water-level fluctuations. Periodic measurements were begun in about 30 wells in the fall of 1949. Initially the measurements were weekly, being changed first to a monthly, then to a semiannual, and finally to an annual basis. About 50 wells were measured in 1950 and about 60 in 1951. Measurements were continued in most wells until the autumn of 1952, when the well-measuring program was reduced so as to embrace only 25 wells, which were measured semiannually. This schedule was continued through April 1954. Since April 1954, the only measurement made was in the spring of 1955. The periodic measurements are given in table 19. In addition a study was made of the fluctuations themselves, automatic water-level recorders being operated in three wells (fig. 6) during the time that field work was in progress. Hydrographs were plotted for most observation wells.

Water-level fluctuations fall mainly into three general categories—short-term, seasonal, and long-term. In general these fluctuations show different hydrologic features. Short-term fluctuations include daily changes in water level due to pumping; effects of variations in natural discharge, earth and ocean tides, changes in barometric pressure, and wind; and instantaneous fluctuations caused by earthquakes and by movement of heavy loads, such as railroad trains, in the vicinity of the well. Short-term water-level fluctuations, in

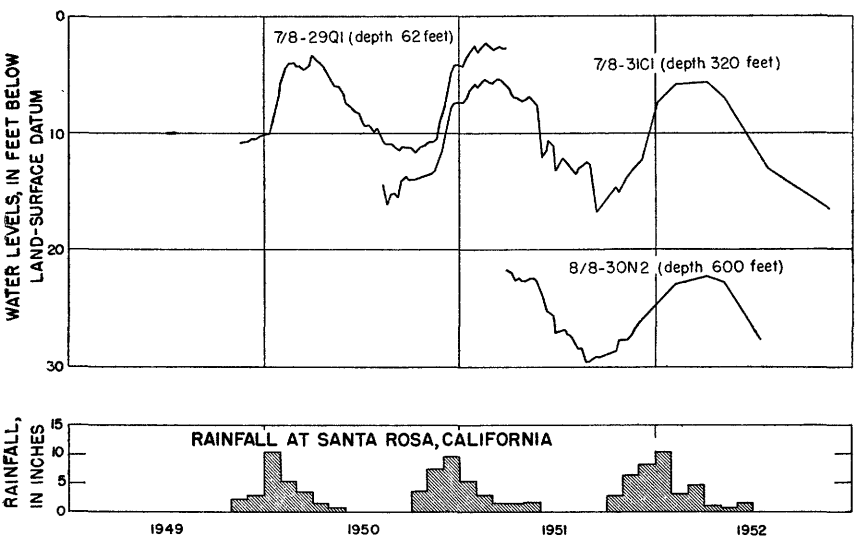

FIGURE 6.—Hydrographs showing fluctuations of water levels in three wells in the Santa Rosa Valley, and graph showing monthly rainfall at Santa Rosa, Calif., 1949–52.

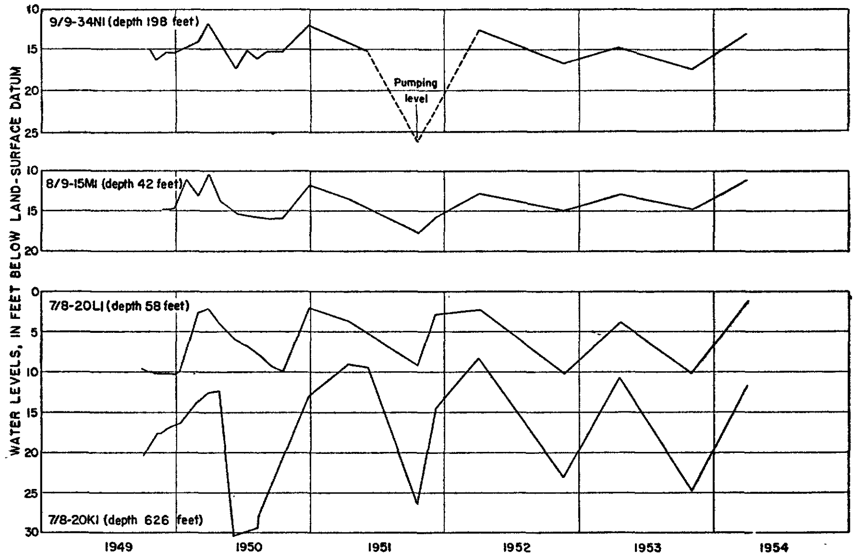

FIGURE 7.—Hydrographs showing fluctuations of water levels in paired shallow and deep wells in the Santa Rosa Valley area, California, 1949–54.

general, reveal characteristics of the aquifer, whereas the seasonal and long-term fluctuations commonly serve as an index to the amount of water in storage and may indicate whether there is an overdraft or a surplus.

Seasonal fluctuations.—Depending upon the distribution and amount of rainfall and the magnitude and duration of the pumping, water levels in Santa Rosa Valley are usually highest in the spring, during or shortly after the rainy season, and are lowest in the autumn, at the end of the pumping or irrigation season. The water levels in deep wells may change more slowly than those in shallow wells because the deep aquifers receive recharge more slowly than do the shallow ones. The hydrographs on figure 7 show that the rise of the water level in well 7/8–20K1, 626 feet deep, lagged behind that in well 7/8–20L1, 58 feet deep, about 1 month in the winter of 1950 and about 3 months in the winter of 1951. However, the hydrographs of shallow well 8/9–15M1 and deep well 9/9–34N1 show that the water levels rose at about the same rate. Figure 6 shows hydrographs of the three wells in which automatic water-level recorders were operated. Shallow well 7/8–29Q1 has a graph similar to that of deep well 7/8–31C1. However, the large amplitude of the fluctuation and the rapid response to pumping of the level in the deep well, as shown on the weekly recorder chart, indicates that the water is confined to some extent; whereas the slow response in the shallow well indicates essentially water-table conditions.

In Santa Rosa Valley water levels normally are 5–20 feet below the land surface in the spring. Before pumping is begun in the spring, high water levels in deep wells generally approximate those in nearby shallow wells. In the autumn the disparity in levels between shallow and deep wells depends chiefly on the amount of draft from the ground-water body during the pumping season. The disparity in levels decreases in proportion to the rate of recovery of pressure head in the deep aquifers after pumping stops. The autumn water levels in deep wells range from 15 to 35 feet below the land surface; in shallow wells, from 10 to 20 feet. Thus, during 1950 and 1951 the average seasonal decline of water levels in shallow wells was less than 10 feet; in deep wells, less than 15 feet. However, as the development of ground water increases, the seasonal fluctuation of water levels also increases.

In the hilly area in the vicinity of Sebastopol the depth to water varies widely with the undulating topography—in a few places the levels are above the land surface; in others they may be as much as 100 feet below the land surface. However, in the spring, most levels are between 10 and 50 feet below the land surface. The seasonal fluctuation of water level is generally 5–10 feet, seldom more, and locally is less than 5 feet. The water level in well 7/9–35D2 (fig. 8)

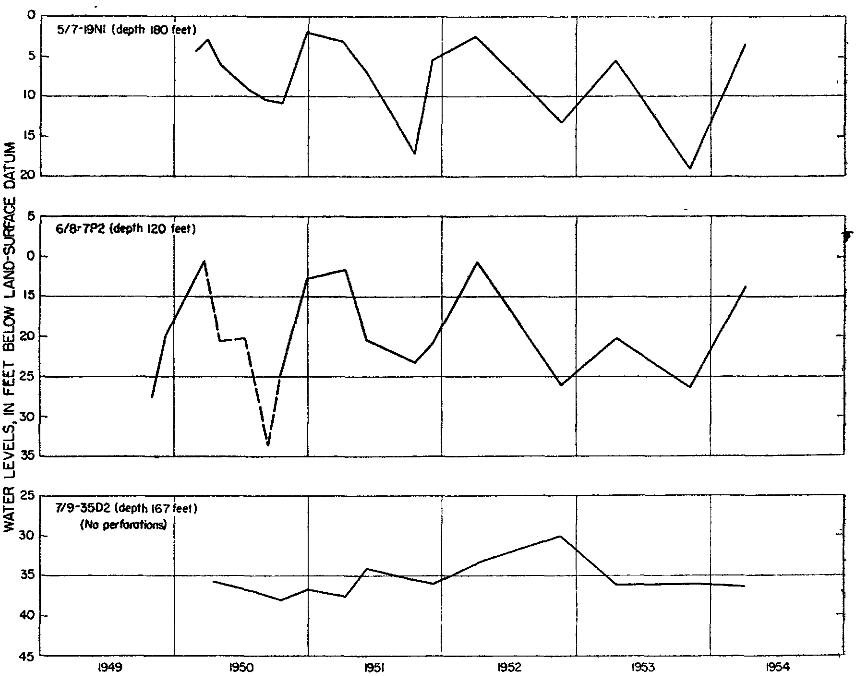

FIGURE 8.—Hydrographs showing fluctuations of water levels in three wells tapping the Merced formation in Santa Rosa and Petaluma Valleys, Calif., 1949–54.

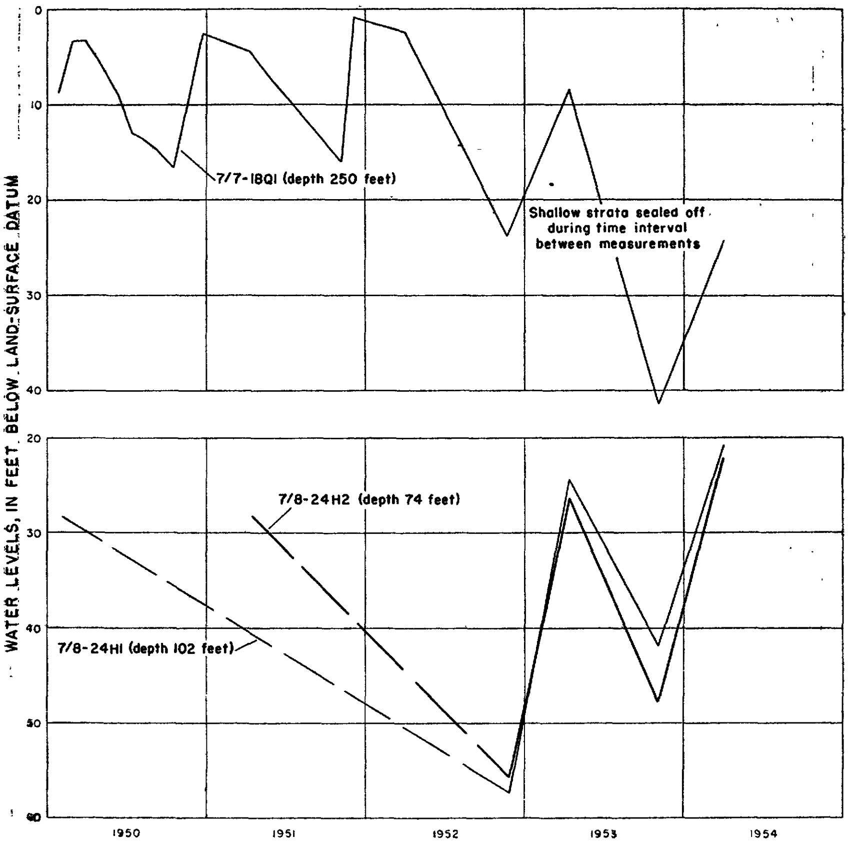

FIGURE 9.—Hydrographs for three wells in the mouth of Bennett Valley, Calif.

stood higher in October 1952 than in April 1951, and the hydrograph shows an overall upward trend for the period 1950–52. The rise probably reflects the increased rainfall during the period, and slow response to recharge from a distant source.

Wells in the mouth of Bennett Valley show a relatively wide range of water-level fluctuations, probably owing to large withdrawals from the Santa Rosa city wells in 7/8–24A. The ranges in water levels in wells 7/8–24H1 and H2 were 17.46 and 21.35 feet, respectively, in the 1953 pumping season. However, the rise in levels from November 1952 to April 1953 were 32.90 and 29.34 feet, respectively. Spring peak water levels do not indicate a net decline, but they do indicate an increase in the seasonal fluctuation (fig.9).

The abnormal 1953 seasonal decline of water level in well 7/7–18Q1 (fig. 9), which amounted to more than 30 feet, compared with a normal fluctuation of 15–20 feet, apparently reflects a local difference in head between shallow and deep water. Shallow strata in the well,

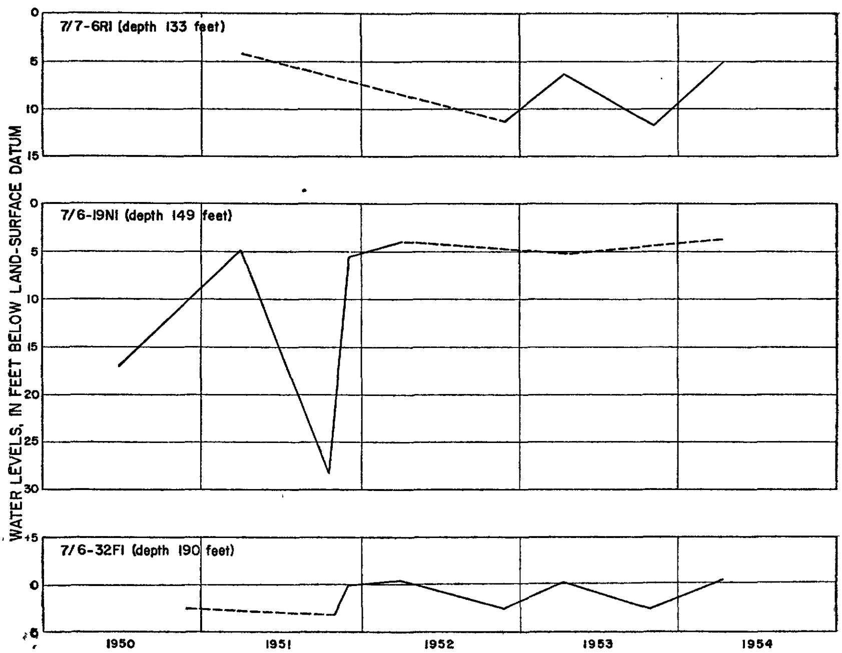

FIGURE 10.—Hydrographs for three wells tapping the principal water bodies in Rincon and Kenwood Valleys, Calif.

250 feet deep, were sealed off during the late spring or summer of 1953, and subsequent measurements indicate that the hydrostatic head in the deep zone, which is heavily pumped locally, is lower than in the shallow zone. In the spring of 1954 the level was about 20 feet below the normal spring level.

Water levels are relatively high in Rincon Valley and in the southern part of Kenwood Valley (fig. 10). In the northern part of Kenwood Valley and near the margins of Rincon Valley the local seasonal fluctuation may be relatively large because of the relatively low permeability of the Glen Ellen formation in those areas.

Long-term fluctuations.—Other than records of a few water-level measurements made by the U. S. Bureau of Reclamation [14] in the autumn of 1941 and the spring of 1942 and scattered measurements by drillers, data on the long-term fluctuations of water levels in the Santa Rosa Valley area are limited to the relatively short period 1949–54. Of the wells measured by the Bureau of Reclamation 24 were subsequently measured by the Geological Survey. Of those wells, 20 were measured at about the same times of the year by the

[14] Gamer, R. L., Geological and ground-water reconnaissance of Santa Rosa plains—Russian River studies-general investigations, California: unpublished rept. in files of Geologic branch, U. S. Bur. Reclamation 1942.

two agencies. (See table 17.) A comparison of the autumn levels in 1941 and 1949–52 reveals that levels in 10 wells declined by amounts ranging from 1 to 13 feet, averaging 4.6 feet, and that levels in 3 wells rose by amounts ranging from 1 to 16 feet, averaging 12.7 feet. Selective averages showed an average decline in 8 wells of 2.7 feet and an average rise in 2 wells of 2.6 feet. Comparison of spring levels reveals that levels in 7 wells declined over the period 1942 to 1950–52 by amounts ranging from 0.1 foot to 9.2 feet, averaging 3.4 feet, and that levels in 3 wells rose by amounts of 0.5 foot to 1.7 feet, averaging 1.1 feet. The selective average for 6 wells in which water levels declined is 2.6 feet.

However, rainfall for the water years 1940, 1941, and 1942 was far above average, amounting to 38.55, 51.78, and 39.98 inches, respectively. By comparison, rainfall during the water years 1949, 1950, and 1951 amounted to 19.86, 25.42, and 32.06 inches, respectively. Therefore the water-level changes, as suggested by the above comparisons, are significant only in that they show that the recharge was greater during the water year 1942 than during the water year 1952, owing to the greater rainfall.

The hydrographs for the period of record show no significant or widespread water-level trends other than those attributable to the amount of yearly rainfall. Except for some wells in areas where ground-water draft has increased, the range in seasonal fluctuation has been small, and the rise of water levels during the spring has, in general, been proportional to the amount of rainfall. Thus, water levels in most wells were slightly higher in 1951 than in 1949, and in many wells the highest levels of record were reached in 1952. There was a small decline in water levels during the spring from 1952 to 1953, which is correlative with the lower rainfall and, hence, less recharge, in 1953.

Even in areas of concentrated pumping no net decline in water levels during the spring has been observed. During the spring, water levels in wells 7/8–24H1, 24H2, and 7/7–18Q1 (fig. 10) showed a net rise in the period 1950–52, reflecting the above-normal rainfall. The same trend is indicated by the hydrographs for wells in other areas where ground-water withdrawals are relatively large. Thus, the fluctuations for the period 1949–53 show that the principal ground-water body has been essentially fully recharged in the spring of each year, which in turn indicates that there is no overdraft in Santa Rosa Valley.

OTHER WATER BODIES

Most of the ground water in the Sonoma volcanics occurs as isolated bodies contained in permeable beds separated by relatively impermeable lava strata. The folding and faulting have produced compartments in which the isolated water bodies are found. They are separate and distinct from the principal water body and therefore respond independently to the effects of recharge and pumping. No attempt has been made to study these small water bodies in detail. It is known that some occur under confined conditions and others may occur under water-table conditions. It is known also that, locally, water in the volcanic rocks is in hydraulic continuity with the principal water body.

The water-bearing properties of the younger alluvium and channel deposits in the Russian River valley are entirely different from those containing the principal water body in Santa Rosa Valley, and therefore the water in the younger alluvium and channel deposits is arbitrarily classed as another water body. This water body will be described more fully in a report on the geology and ground-water conditions in the Russian River valley now in preparation by the Geological Survey.

SOURCE AND RECHARGE

The source of most ground water in the Santa Rosa Valley area is rainfall and seepage from streams that infiltrates the soil zone and permeable zones beneath the stream beds and percolates downward to the ground-water body. Because the water levels are close to the land surface, there is little opportunity for recharge by seepage from streams. If water levels were drawn down substantially, recharge from streams probably would increase greatly. In general, surface conditions permit recharge of the ground-water body by rainfall in much of the Santa Rosa Valley area, but the rate of recharge is likely to be low at most times and places.

The amount of recharge in relation to rainfall depends on topography, surface geology, and vegetation as well as on the distribution of rainfall, storm intensity, and winds. In the valley areas the topography is favorable, as most of the land is fairly flat and water that accumulates on the surface runs off slowly. In the upland areas the reverse is true. The surface geologic conditions are not everywhere favorable for recharge. The areas mapped as younger alluvium are generally most favorable for recharge because the younger alluvium is capped by permeable soils; however, the soils generally are fairly fine grained, except for those occurring on channel deposits in the Russian River valley, and recharge is slow. Soils in areas underlain by older alluvium or by the Glen Ellen formation commonly have well-developed profiles and include clay or hardpan, which impedes downward movement of water. However, in some places rainfall percolates to the water body through those formations fairly readily, judging from the sharp rise in water levels that have been observed in some wells. For example, the level in well 7/8–29Q1, during or immediately after storms, responds rapidly to recharge from rainfall.

The sandy soils developed on the Merced formation (Goldridge soil series) accept recharge comparatively readily. On January 13, 1941, the U. S. Soil Conservation Service gaged the runoff of a small drainage basin, consisting of 83 acres, on a terrain formed by the Merced formation on the Taber farm near Sebastopol[15]. The highest rate of runoff measured was 0.95 cfs per acre, associated with a rainfall rate of 1.30 inches per hour for a period of 30 minutes. The rate of rainfall was produced by a storm of about 5-year frequency. The amount of rain falling on the test area in the 30 minutes corresponded to a rate of 1.31 cfs per acre. This amount, minus the runoff rate of 0.95 cfs per acre, indicated an infiltration rate of 0.36 cfs per acre, or 0.35 inch per hour in terms of rainfall. During the preceding 2 days, 1.60 inches of rain had fallen on the test area and during the 15 days preceding them, 4.50 inches had fallen. These amounts suggest that the soil moisture must have been essentially replenished, so that the indicated infiltration rate is presumably near the maximum rate at which the test area will accept recharge. Although the rate may be relatively low, especially as compared to rates that likely would occur in some areas of alluvial materials of Recent age, it would allow for considerable recharge in the large area underlain by the Merced formation, most of which normally receives 40 inches or more of rainfall annually.

Recharge through infiltration of rainfall in areas underlain by the Sonoma volcanics is somewhat inhibited by the steep slopes, which cause rapid runoff, but those areas underlain by tuffs or tuffaceous deposits, volcanic sand and gravel, and fractured flow rocks are sufficiently permeable to be recharged. However, weathering tends to reduce the permeability, especially of the tuffaceous rocks.

Vegetation affects infiltration of rainfall chiefly by holding and protecting the soil and by slowing the movement of runoff water in upland areas and on alluvial fans; thus it increases the opportunity for infiltration. Where vegetation does not occur, the water tends to run off more swiftly and erode the soil. However, so far as its effect on recharge is concerned, vegetation not only intercepts some rainfall but also consumes a major part of that which infiltrates the soil, thereby reducing the amount that reaches the ground water body.

Distribution of rainfall and storm intensity are important factors in recharge, especially where soils permit only slow infiltration. If the rate of rainfall greatly exceeds the infiltration rate, as commonly occurs during winter storms in the Santa Rosa Valley area, the ratio of recharge to rainfall is small, and the greatest part runs off. Long

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15 U. S. Dept. of Agriculture, Report of survey, Russian River watershed, California, for runoff and water flow retardation and soil erosion prevention for flood control purposes: unpublished rept. in files of Soils Conservation Service, U. S. Dept. Agriculture, 1950, app. 2, p. 21-22.

periods between storms permit some depletion of the soil moisture through evapotranspiration and downward movement of soil moisture. The rate of depletion is accelerated if windy conditions prevail. Thus, rain falling on the soils when their moisture content is low must first satisfy the soil-moisture deficiency before it can infiltrate deeply and, hence, recharge the ground-water body.

In the Santa Rosa Valley area there is ordinarily an appreciable time lag between the advent of the rainy season and the beginning of recharge to the water body. Before the wet season begins, water levels may rise slightly as a result of decreased evapotranspiration due to lower autumn or early winter temperatures or recovery from pumping for irrigation or to both, but in the water-level records for shallow wells these responses can generally be distinguished from the effects of recharge.

The shape of the water-level contours (pl. 2) suggests that a large part of the recharge is from local precipitation, especially in interstream areas along the valley sides. Thus, the westward bulges in contours north and south of Santa Rosa Creek—in the northwest part of 7/8 and in the south part of 7/8 and north part of 6/8—indicate ground-water movement from the interstream areas toward tributary streams, such as Santa Rosa Creek, and toward the Laguna de Santa Rosa.

No data are available concerning seepage losses and gains by streams in the area, but the water-level contour map (pl. 2) shows that the streams traversing Santa Rosa Valley are mainly effluent—that is, ground water is discharged into them—during the spring. Except near the Laguna de Santa Rosa, Mark West and Santa Rosa Creeks are incised 15–20 feet below their flood plains, so that their channels intersect the water table. Hence, except for areas of local heavy pumping near them, little recharge from the streams occurs. Low gradients away from the streams may be established late in the pumping season, when stream flow is low. In the middle reach of Mark West Creek, deposits having low permeability crop out or are inferred to be overlain by a thin veneer of channel deposits, so that downward percolation from the stream bed may be retarded there. However, water percolating laterally may reach old channels which cut the poorly permeable beds and thus facilitate recharge. The possibility that the recharge potential of the streams may be large is emphasized. However, this potential cannot be realized until such time as the adjacent ground-water levels are drawn down substantially below the historic levels.

Minor additions to the ground-water body may be made by upward leakage of water of higher head confined in the Sonoma volcanics or from connate, or deeply circulating, ground water rising along faults. Addition from a deep source locally in northern Santa Rosa

Valley is indicated by chemical analyses of water from well 8/9–23L1. (See section on quality of water.)

Finally, in areas where ground water is pumped for irrigation, some of the water applied to crops reaches the ground-water body in the same manner that rainfall does. This "irrigation return" could be classed as recharge. However, it is not a primary source of recharge, amounting only to the difference between the amount pumped and the amount consumed by crops. This difference varies in different areas, depending on the local irrigation practices and soil types; it is significant only where the land is generally overirrigated.

Over a period of time the net recharge tends to equal the discharge. Runoff indicates that potential recharge generally exceeds the amount that can infiltrate the soil and be transmitted to the ground-water body. Therefore, the recharge is limited, in part, by the amount and distribution of precipitation, the transmissibility of the soil and surficial deposits, and the availability of storage space within the aquifer.

MOVEMENT

Plate 2 shows contours connecting points of equal altitude on the water surface in the principal ground-water bodies in the Santa Rosa and Petaluma Valley areas. The contours are based chiefly on depth-to-water measurements made in April 1951, although a few measurements were made a short time before and after April 1951 to get better control locally. Water levels in about 450 wells were measured. This was done during the spring because at that time of the year the disparity between water levels in deep and shallow wells is at a minimum. Accordingly, the levels in both deep and shallow wells were used to draw the contours. Where anomalous water levels could not be satisfactorily explained or do not appear to reflect general conditions within the water body, they were not used to control the contours and are shown on the map as figures representing the altitude of the water surface in the wells.

Because ground water moves down gradient from points of higher altitude to points of lower altitude, or from points of high potential to points of low potential, the contours indicate direction of movement and areas of ground-water recharge and discharge. In the Santa Rosa Valley area the altitude of the water surface is highest at the eastern margin of the valley, in the eastern tributary valleys, and along the ground-water divide between Santa Rosa Valley and the valleys of Atascadero and Green Valley Creeks. Altitudes are lowest at the western side of the valley along the Laguna de Santa Rosa and along the lower parts of Mark West and Windsor Creeks. A ground-water divide lies beneath the Cotati plain, north of which water moves toward the Russian River and south of which water moves into Petaluma Valley. The water-level contours show also the configuration of the water surface and reflect to some degree the overlying topography; in some areas they show, by changes in the hydraulic gradient, the effect of changes in the permeability and cross-sectional area of the deposits through which the water is moving.

In Santa Rosa Valley the direction of movement from the east, west, and south is generally toward the Laguna de Santa Rosa and locally toward the streams that are tributary to it. The hydraulic gradient in Santa Rosa Valley is mostly between 10 and 40 feet per mile. In the upland area underlain by the Merced formation, gradients are as much as 120 feet per mile or more, reflecting the low transmissibility of the deposits as well as the steeper topography. The widely spaced contours in the Cotati plain mainly reflect the flatness of the terrain and, to some extent, the large cross-sectional area and the increased transmissibility of the deposits. The general steepening of the gradient eastward reflects a decrease in permeability or cross-sectional area of the deposits, or both. Control is lacking in the area of low hills separating Santa Rosa Valley from the alluvial plain of the Russian River, but, on the basis of the meager data available, the only ground-water divide in that area appears to be immediately north of Mark West Creek; from this divide, water moves through the Glen Ellen and Merced formations, then into the alluvial deposits along the Russian River.

At the western edge of the Cotati plain (6/8–16, 17) the 60-foot contour is closed, indicating a depression in the surface of the water body. The proximity of several irrigation wells suggests that this may be a small residual "pumping hole" produced by withdrawing ground water at a rate exceeding recharge.

NATURAL DISCHARGE

Natural discharge from the ground-water reservoir occurs by seepage into streams and springs, evapotranspiration, and underflow. Before ground water is developed, the total natural discharge is a rough measure of the yield of a basin in that it represents the water which could theoretically be obtained for use. Generally it is not feasible to salvage all the natural discharge; on the other hand, if the ground-water reservoir is readily rechargeable, artificial discharge (pumping) may induce more annual recharge than would occur normally and thus would increase the yield beyond the rate of natural discharge.

Except for pumpage, no quantitative estimates were made for the ground-water discharge in the Santa Rosa Valley area. The water-level contour map (pl. 2) shows that there must be considerable discharge into Santa Rosa, Mark West, and other creeks; spring water levels in wells near the streams generally stand several feet higher than the stream beds, except locally where residual pumping depressions exist. Discharge into streams occurs also in the valleys tributary to Santa Rosa Valley, as well as in the Russian River valley, and may constitute the largest single type of natural discharge.

Much ground water is discharged from the Merced formation on the western side of Santa Rosa Valley through springs and seeps. Most of these are gravity springs, occurring on the steeper slopes or in gullies where the water table intersects the land surface; but some are contact springs, occuring along the outcrop of the contact between a permeable and an impermeable or poorly permeable bed. Springs, of the contact type, are a common means of ground-water discharge from the Sonoma volcanics also. Some contact springs occur in the Glen Ellen formation, and many occur in the Franciscan group, constituting an important method of discharge and a local source of water. Some spring discharge sustains low flow in stream beds. However, many springs and seeps are marked by growths of vegetation which consume most of the discharge and release it to the atmosphere by evapotranspiration. Much water is lost from the Merced formation in this manner.

Evapotranspiration occurs on a large scale along the Laguna de Santa Rosa at the western side of Santa Rosa Valley in a swampy area that varies in size with seasonal rainfall conditions but averages about 1,000 acres during the summer (McBride, 1945). This area is subject to natural losses by evaporation from the water surface and by transpiration from reeds, tules, willows, and other water-loving plants which flourish around the margins of the Laguna. On the basis of studies made by Lee (1931, p. 247–304) of the tidal marshes of Suisun and San Pablo Bays, it is estimated that between 4,000 and 6,000 acre-feet of water is discharged annually from this area alone, mostly during the summer months when evapotranspiration rates are highest and when the watertable is at about the same level surface as that of the Laguna. Most of this evapotranspiration is believed to be supplied by ground-water inflow.

Other areas that lose considerable ground water by evapotranspiration are along the margins of streams where phreatophytes—plants whose roots extend to the water table or to the capillary fringe—grow in profusion, and in the lower parts of basins where the water table in spring is at or near the surface. Near the Laguna, the channels of Santa Rosa and Mark West Creeks support large growths of willows, poplars, live oaks, and various bushes that discharge ground water. At the southern end and along the southwestern side of Kenwood Valley the water table is at or near the surface in spring, and losses by evapotranspiration occur. It is reported that the

Cotati plain, before it was artificially drained for cultivation, was a swampy area during the spring and early summer. A large area in the lower part of Green Valley is poorly drained and loses much water by evapotranspiration.

The amount of underflow, or discharge of ground water from the area by movement through the aquifers, was not studied. The water-level contours indicate that ground water was discharging from Santa Rosa Valley to the Russian River valley through the low hills underlain by the Glen Ellen formation. Farther south ground water in the Merced formation discharges westward into the valleys of Atascadero and Green Valley Creeks. Better control of contours and data on the average transmissibility and the extent of the aquifer would be necessary for estimating the underflow from the area.

PUMPAGE FROM WELLS

An attempt was made to estimate as closely as possible the amount of ground water pumped in the Santa Rosa Valley area. As a basis for computation, the uses to which the water is put were categorized as follows: (1) Public-supply, which includes the water-supply systems of cities, towns, and communities for which some record of water consumption or pumpage is available; (2) used by industries having their own supply wells, including dairies; (3) irrigation; and (4) domestic, stock, and other uses, which include use by the large rural and suburban population for purposes other than irrigation.

Because several methods were used to obtain and to check the pumpage estimates (see table 7), the estimates are believed to be the best available for the several areas. The irrigation pumpage was largely computed on the basis of yearly totals of kilowatt-hours of electrical energy consumed by pumping plants and plant-efficiency tests that were kindly furnished by the Pacific Gas and Electric Co. The data for most wells cover the 5 years beginning in March 1945 and ending in March 1950, and they were tabulated by areas which in most cases coincide with the physiographic and ground-water storage divisions of the Santa Rosa Valley area as defined in this report (fig. 3). Because most irrigation occurs during the months April or May through October, the bulk of the pumpage computed is for the calendar years 1945 through 1949. All figures excepting totals were rounded to two significant figures. Depending on their probable accuracy, some figures were rounded to the nearest 100 acre-feet.

Pumpage for domestic, stock, and other uses was estimated for the entire Santa Rosa Valley area on the basis of the number of wells in use in the area during 1950. It is estimated that there were about 10,000 wells in the Santa Rosa and Petaluma Valley areas, about 85 percent, or 8,500, in the Santa Rosa Valley area and the remainder in the Petaluma Valley area. Half an acre-foot of water per well was estimated to be a reasonable average amount used annually for domestic, stock, and miscellaneous purposes. This factor was applied to the number of wells in use each year (scaled down from the 1950 estimate in proportion to population difference), diminished by the number of wells included in the public-supply, industrial, and irrigation categories. The figures obtained in this manner correspond to an average per-capita consumption of about 75 gallons per day (gpd) for the estimated rural population. Inasmuch as urban consumption generally averages between 100 and 150 gpd per person, the estimate for this category is probably very conservative because it includes pumpage from many wells that though not classed as irrigation wells, irrigate gardens and small pastures covering (less than 5 acres).

TABLE 7.—*Ground-water pumpage, in acre-feet, in the Santa Rosa Valley area, 1945–49*

Area and pumpage category	1945	1946	1947	1948	1949
Santa Rosa Valley:					
Public supply	2,200	2,400	2,900	2,800	2,800
Industrial	200	200	200	200	200
Irrigation	800	1,000	1,300	1,400	2,300
Total [1]	3,200	3,600	4,400	4,400	5,300
Sebastopol area:					
Public supply	280	300	320	340	340
Industrial	300	300	300	300	300
Irrigation	0	20	80	110	170
Total [1]	580	620	700	750	810
Other areas (irrigation only):					
Rincon Valley	60	70	90	130	150
Bennett Valley	40	90	180	360	740
Kenwood Valley, north part	80	80	80	100	160
Kenwood Valley, south part, and Glen Ellen area	110	150	120	180	260
Russian River plain [2]	900	1,100	1,600	1,700	2,000
Santa Rosa Valley area:					
Public supply	2,500	2,700	3,200	3,100	3,100
Industrial	500	500	500	500	500
Irrigation	2,000	2,500	3,400	4,000	5,800
Domestic, stock, and other	2,800	3,000	3,300	3,600	3,900
Grand total	7,800	8,700	10,400	11,200	13,300

[1] Pumpage from domestic, stock, and other wells not estimated for individual areas.
[2] Includes the Russian River flood plain from Rio Dell to Dry Creek on the west side and to Fitch Mountain on the east side.

Santa Rosa Valley.—In Santa Rosa Valley most of the public-supply pumping is done by the city of Santa Rosa. Water pumped from the principal well field is metered, but water from two other wells is not metered and is pumped into a surface reservoir, Lake Ralphine. The amount of unmetered water, estimated on the basis of pump discharges and hours of pumping reported by the city water department, usually amounts to 15–25 percent of the total amount of ground water pumped by the city. Water consumed by the Sonoma County Hospital was estimated on the basis of the average daily consumption of 250,000 gpd reported for 1949 by the engineering department. Consumption for years other than 1949 was estimated on the basis of the estimated population for the county. Water pumped by the Cotati Public Utility District was estimated on the basis of figures supplied by Robert A. Clothier, director. A small privately owned public-supply system is operated in the village of Windsor, but because no figures were available, estimates were based on the rural use.

All the industrial pumpage estimated, other than that for dairy use, was for industries in Santa Rosa that have their own wells. The estimate was based partly on data supplied by certain companies and partly on estimates. Possible errors in the estimates are small compared with the overall pumpage, because the total pumpage by industrial wells amounted to only 50 acre-feet. Dairy pumpage was estimated to average 5 acre-feet per year per dairy.

Irrigation pumpage was computed by dividing yearly totals of kilowatt-hours consumed by pumping plants engaged in each of two general types of irrigation—sprinkler and flood—by factors representing the average number of kilowatt-hours (kwhr) required by pumping plants in each group to pump an acre-foot of water. Pump-efficiency tests were available for 6 wells that pumped water for sprinkler irrigation. The average number of kilowatt-hours consumed by three wells was taken as 400 kwhr per acre-foot of water pumped. The average number of kilowatt-hours consumed by 5 wells that pumped water for flood irrigation was taken as 340 kwhr per acre-foot of water pumped. Pumpage by wells for which figures on kilowatt-hour consumption were not available was estimated on the basis of acreages irrigated and the average "duty of water" [16] for the particular crop irrigated. For most years the pumpage estimated in this manner amounted to less than 20 percent of the total irrigation pumpage. In addition, the total irrigation pumpage for each area was estimated on the basis of acreages and duty of water as a check on the figures derived from kilowatt-hour consumption. The average duty of water for various crops was computed on the basis of information supplied by many owners of irrigation wells in the Santa Rosa Valley area (table 8).

TABLE 8.—*Duty of water factors for the Santa Rosa Valley area*

Acreage irrigated	Feet of water applied per acre (acre-feet)
Alfalfa, pasture, cemeteries, golf courses, parks	2.5
Nurseries	2.0
Truck, potatoes, berries	1.0
Hops	.8
Walnuts	.6
Orchards, prunes, seed culture	.5

[16] The amount of water, expressed in feet (acre-feet per acre), applied to a crop during the growing or irrigation season.

The yearly totals obtained for irrigation pumpage for Santa Rosa Valley, based on the above factors and total acreages for irrigated crops in Santa Rosa Valley, were found to be higher than those computed on the basis of kilowatt-hours of electricity consumed. The differences ranged from 10 percent in 1946 to 57 percent in 1948 and averaged 28 percent. Thus the figures obtained by the two methods seem to be in reasonably close agreement. The computation of pumpage on the basis of acreages irrigated and duty of water data is considered to be the less accurate of the two methods for the following reasons: the size of the acreages was partly reported and partly estimated; no allowances were made for changes from year to year in water duties as a result of variations in precipitation; and data generally were not available for estimating the portion of the season that a well was used during its first year of operation.

Sebastopol area.—The Sebastopol pumpage unit spans the groundwater divide between Santa Rosa Valley and the valleys of Atascadero and Green Valley Creeks. Although the bulk of the pumping is in the Green Valley Creek area, the basins are contiguous, and increased withdrawals in Santa Rosa Valley probably would shift the groundwater divide westward. In tabulating the electric-power consumption on which the pumpage figures are largely based, it was deemed advisable to make the units as large as possible. Because pumping lifts throughout the Sebastopol unit are relatively high, owing to deeper static water levels in the hills adjacent to Santa Rosa Valley, and to low specific capacities resulting in large drawdowns in the western part of the unit, pumpage in the area was lumped rather than divided between two units as might otherwise have seemed logical.

Pumpage for the town of Sebastopol was reported by the city water department to be about 336 acre-feet for 1949 and was extrapolated for years before 1949 on the basis of the estimated change in population. The pumpage by the Fircrest Water District was based on the number of families served and was estimated to be about 10 acre-feet (1949).

Industrial pumpage in the vicinity of Sebastopol was principally for fruit-processing plants and dairies. Data supplied by one large plant indicate that it pumped about 40 acre-feet a year, and the average annual pumpage of each of nine plants known to operate in the area was estimated to be about 20 acre-feet. Thus, the total was about 200 acre-feet a year.

Because data on electric-power consumption were available for only about half the irrigation pumpage in the Sebastopol area, and because no data on plant-efficiency tests were available, the irrigation pumpage was computed on the basis of reported and estimated sizes of acre-

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ages irrigated, using the duty of water computed for Santa Rosa Valley. Most of the irrigation is in Green Valley.

Other areas.—In the Bennett, Kenwood, Rincon, and Russian River valleys and the Glen Ellen area, the pumpage for irrigation, except in the northern part of Kenwood Valley, was computed from electrical-energy totals on the basis of computed or estimated power factors (kilowatt-hours per acre-foot). Pumpage from wells for which records of power consumption were not available was estimated on the basis of the sizes of acreages irrigated and the duty of water, and in most areas amounted to less than 25 percent of the total pumpage. The computed pumpage was checked using irrigated acres and water duties and generally compared closely.

In Rincon Valley the power factors for two wells pumping most of the water in the area were computed from pumping levels, using assumed plant efficiencies of 50 percent, and estimated operating pressures, which produced power factors of 400 and 500 kwhr per acre-foot. For other wells, a factor of 400 kwhr per acre-foot was used. In Bennett Valley, plant-efficiency tests were available for three wells; for others, pumping levels were used as a basis for estimating factors, which ranged from 125 to 500 kwhr per acre-foot. In the northern part of Kenwood Valley, north area (*D*), data on plant-efficiency tests were not available, and there was some doubt that the electrical-energy totals represented power used solely for lifting water from wells; therefore, the irrigation pumpage was estimated on the basis of the size of the irrigated acreage and the duty of water. For the southern part of Kenwood Valley and for the Glen Ellen area, a factor of 400 kwhr per acre-foot was used. Estimates of the sizes of the acreages irrigated in the latter areas during 1945–47 apparently were unreliable; pumpage figures obtained by the two methods of computation for those years varied widely, but for 1948 and 1949 the figures agreed very closely.

On the Russian Russian River flood plain, pumping lifts are relatively low. No efficiency tests were available for the area for which pumpage was computed, but a factor of 150 kwhr per acre-foot was assumed on the basis of test data available for similar areas upstream. During the 5-year period, between 20 and 40 percent of the withdrawals for irrigation were from the eastern side of that part of river valley, included in the area of this report.

QUALITY OF WATER

As used in this report, "calcium bicarbonate," designates a water in which calcium amounts to 50 percent or more of the bases (cations), and bicarbonate, to 50 percent or more of the acids (anions), in chemical equivalents. "Calcium magnesium bicarbonate" designates a water in which both calcium and magnesium exceed sodium, yet neither amounts to 50 percent of the bases. If magnesium exceeds calcium the water is designated "magnesium calcium bicarbonate." If the concentrations of the principal bases are nearly equal, the water is designated by all three, listed in order of relative abundance. "Bicarbonate chloride" and "bicarbonate sulfate" designate waters in which those two radicals predominate among the acids, in order of relative abundance, but neither amounts to 50 percent, in chemical equivalents, of the acids in the water.

Chemical analyses of water samples collected from wells in the Santa Rosa Valley area indicate that the quality of the ground water is generally satisfactory for most uses. (See tables 20 and 21 of appendix for analyses.) The dissolved solids commonly range from 250 to 350 ppm, and the waters are of the calcium and/or magnesium or sodium bicarbonate types. The hardness generally ranges between 60 and 160 ppm (between moderately hard and hard), but in a few wells it exceeds 400 ppm. The average hardness is about 120 ppm.

GENERAL REQUIREMENTS AND SUITABILITY

It is beyond the scope of this report to present detailed data concerning water-quality requirements, and only the general criteria used to determine the suitability of water for domestic, industrial, and agricultural use have been considered. Specific water-quality criteria have been given in publications of the California State Water Pollution Control Board (1952, 1954).

Domestic use.—The chemical character of water to be used for domestic purposes is generally judged according to the standards of quality for drinking water set by the U. S. Public Health Service (1946), as listed below.

Constituent	*Maximum concentration (ppm)*
Chloride (Cl)	250
Sulfate (SO_4)	250
Magnesium (Mg)	125
Iron and manganese (Fe+Mn)	0.3
Fluoride (F)	1.5
Lead (Pb)	.1
Selenium (Se)	.05
Chromium, hexavalent (Cr)	.05
Arsenic (As)	.05
Zinc (Zn)	15
Phenolic compounds (in terms of phenol)	.001

In addition, the total solids should not exceed 500 ppm for a water of good chemical quality. However, if such water is not available, a dissolved solids content of as much as 1,000 ppm may be permitted.

Waters in the Santa Rosa Valley area meet these standards, except locally where iron and manganese may exceed slightly the permissible concentration. Also, locally, the hardness may be sufficiently high to be objectionable unless the water is treated.

It is widely believed that nitrate should not exceed 10 ppm as nitrogen or 44 ppm as NO_3 in waters used for feeding infants, as higher concentrations may cause infant cyanosis (methemoglobinemia) (Maxcy, 1950). A high concentration of nitrate commonly indicates pollution from decaying organic matter, such as septic-tank leachings or other organic wastes. However, it may result also from other sources, such as nitrogenous fertilizers leached from the soil zone by return irrigation waters or by deep penetration of rainfall. A relatively high concentration of nitrate may be present in water circulating through deposits laid down in a swampy environment. Except for the water in well 6/8–25Q1, which contained 30 ppm of nitrate, the concentrations of nitrate were low in the water samples analyzed.

Water samples analyzed for fluoride contained from 0.2 to 0.8 ppm, or less than the permissible limit of 1.5 ppm.

Industrial use.—Ground water in the Santa Rosa Valley area is suitable for most common industrial uses. For many of the more critical uses, however, most of the water would require some treatment. Generally, the depth of a well and the manner in which it has been completed must be considered if soft water of low iron-manganese content is to be obtained for use at breweries, laundries, and soft-drink bottling plants and in boilers. Generally, the depth of perforations must be chosen carefully to obtain the best water for these purposes. The average temperature of water from wells less than 100 feet deep in the Santa Rosa Valley area is about 63° F, making the water fairly suitable for cooling purposes. Because the temperature of earth materials generally increases about 1° F for each 50–100 feet below the land surface, the temperature of water from deep wells is usually higher than that from shallow wells. Thus, the shallow wells usually provide slightly better water for cooling purposes.

Agricultural use.—The suitability of water for irrigation purposes is dependent on (1) the concentration of dissolved solids, (2) the percentage of sodium, (3) the concentration of boron, and (4), in some instances, the concentration of bicarbonate in relation to the concentrations of calcium and magnesium. In the Santa Rosa Valley area items (2) and (3) are of most concern. The percentage of sodium, or percent sodium as it is commonly designated, is the ratio of the milligram equivalents per liter of sodium to the sum of the milligram equivalents per liter of the principal cations (Ca+Mg+Na+K), multiplied by 100. Ordinarily, waters having more than 50 percent sodium are likely to have a detrimental effect on soil texture, the magnitude of the effect depending on the soil and the drainage conditions. A water having a high percent sodium may be safely used on a well-drained soil, whereas it would damage a heavy or poorly permeable soil. In water from some wells tapping the Glen Ellen formation the percent sodium is high enough to make the water unsuitable, especially on soils of low permeability.

Also, locally, water in the Glen Ellen formation contains a relatively high concentration of boron, making it unsuitable for irrigation use. Small amounts of boron are necessary for the proper growth of most plants, but above a critical concentration, which is generally considered to be 0.4–0.5 ppm, boron has deleterious effects on certain boron-sensitive plants, such as citrus, walnuts, and camellias. In concentrations higher than 3 or 4 ppm it is detrimental to most plants. As with sodium, soil drainage may determine the limit of tolerance.

Dissolved solids, especially chloride, largely determine the suitability of water for use by livestock. All the waters that were analyzed are suitable for this purpose.

CHEMICAL CHARACTER

Analyses of typical waters from wells tapping the principal water-bearing formations in the Santa Rosa Valley area were plotted on a trilinear water-analysis diagram (fig. 11) for study and to show the types of water from the various formations. The analyses were also plotted as bar diagrams (fig. 12) to indicate more clearly the relative concentrations of principal cations and anions. Table 9 presents a summary of the chemical quality of water in the principal water-bearing formations.

TABLE 9.—*Summary of chemical character of water from the principal water-bearing formations in the Santa Rosa Valley area*

[Based on analyses in tables 20 and 21 and other analyses in files of U. S. Geological Survey.]

	Glen Ellen formation	Merced formation	Sonoma volcanics
Dissolved solids ppm	Range, 106–427; average, about 280	Range, 205–350	Range, 93–404; generally about 275.
Hardness ($CaCO_3$) ppm	Range, 15–390; normally 80–140.	Range, 35–220; commonly 50–60.	Range, 100–145.
Chloride ppm	Range, 7–69; normally about 30.	Range, 9–85; normally about 30.	Normally about 30.
Percent sodium	Generally 40–70	Generally less than 50	Commonly 40–45.
Boron ppm	As much as 22; normally not more than 2.5; (local contamination in northern Santa Rosa Valley and Glen Ellen area).	As much as 0.54	As much as 0.64.
Iron and manganese ppm	Commonly less than 0.3; locally, slightly more than 0.3.	May contain objectionable quantities, especially in lower part of formation; commonly less than 0.2 in upper part.	Generally less than 0.2.
pH	Generally about 7.5	Range, 7.1–9.1	Range, 7–8.5.

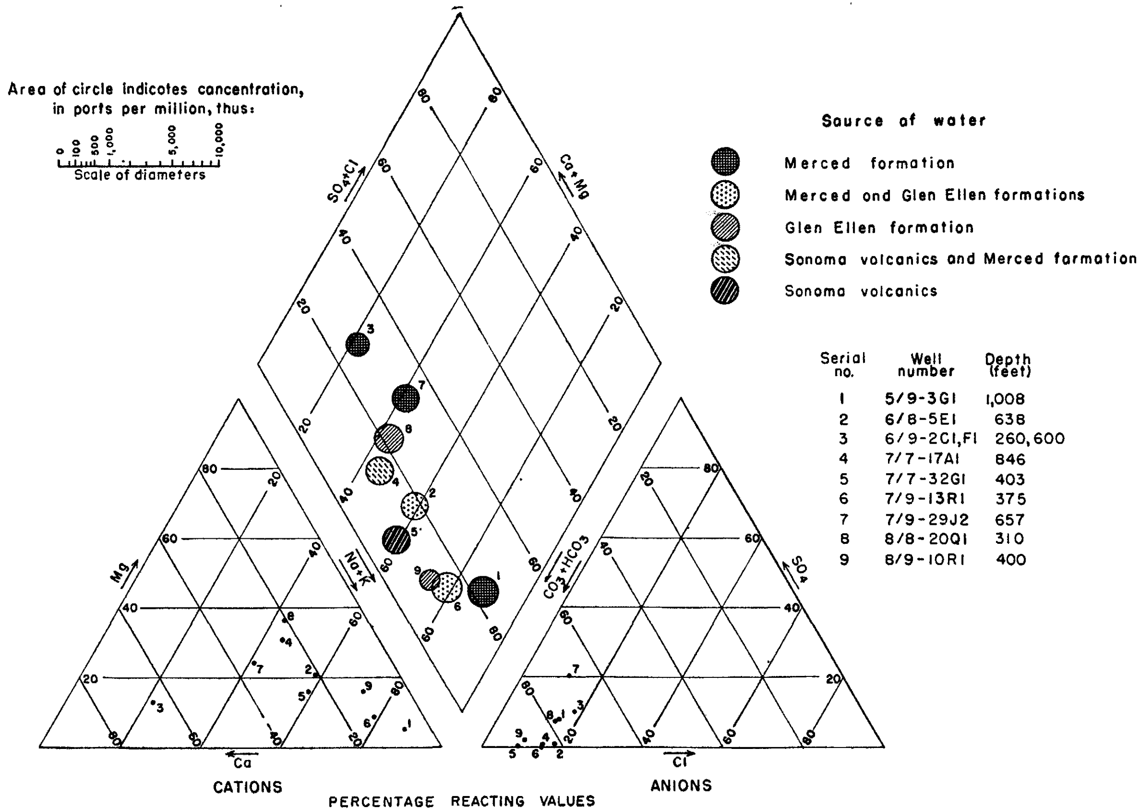

FIGURE 11.—Diagram showing the chemical character of ground waters in the Petaluma Valley area, California.

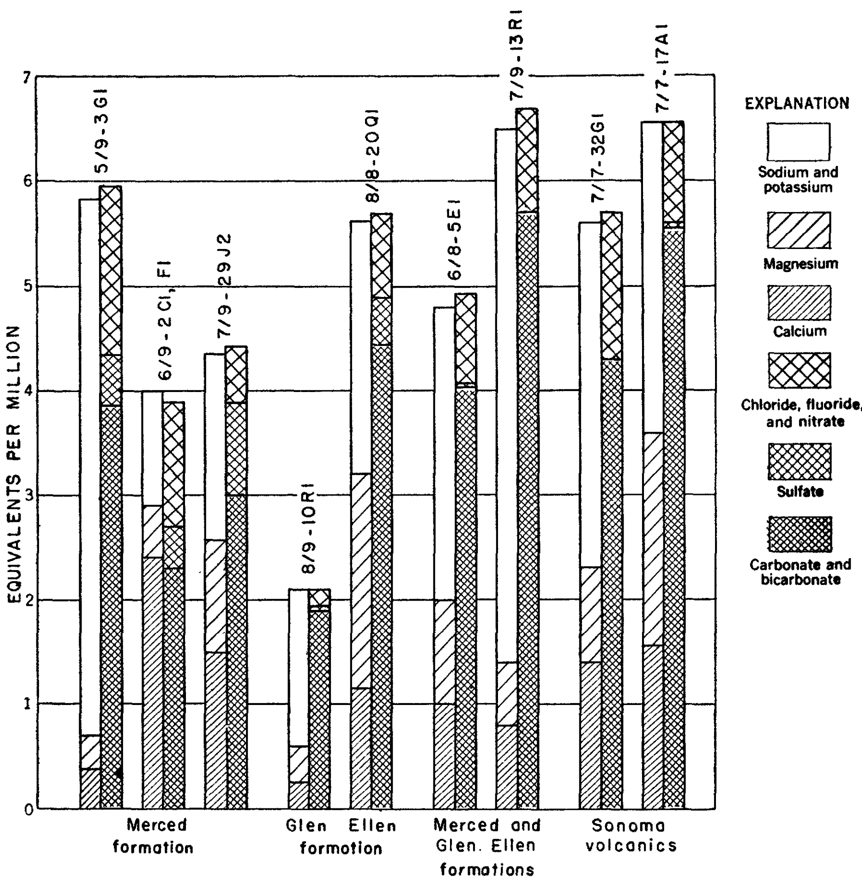

FIGURE 12.—Graphical representation of chemical analyses of water from wells tapping the principal water-bearing formations in the Santa Rosa Valley area, California.

Glen Ellen formation.—The water from wells in the Glen Ellen formation has a greater range in character than that in other formations. Some of the best and some of the poorest water in the area is obtained from the Glen Ellen. From the analyses available, the dissolved-solids content ranges from 106 ppm in well 8/9–14P1, 264 feet deep, to 427 ppm in well 7/8–15G1, 65 feet deep. By comparison, the water from well 8/9–36K1, 1,325 feet deep, contained only 407 ppm of dissolved solids. However, this well taps water not only in the Glen Ellen formation but probably in the Merced formation also. Normally, softer water is obtained from wells tapping deep water-bearing zones in the Glen Ellen and in the Merced foımation than from wells tapping shallow zones. This softening may be due principally to the process of base exchange, whereby the calcium and magnesium ions in the water are replaced by sodium ions as ground water moves through fine-grained deposits containing large amounts of replaceable sodium.

In the northern part of Santa Rosa Valley, well 8/9–10H1 and a few neighboring wells penetrating the Glen Ellen formation are reported to yield water that develops an oil scum, even though most of the pumps are lubricated with water. The wells are on the west limb of the Windsor syncline (pl. 1), but logs of wells do not suggest the presence of petroliferous beds. The "oil" scum could consist of precipitated iron oxide. Several miles south, "coal" has been reported. Locally, wells in the Glen Ellen formation tap water high in boron. (See section on local ground water containing boron.)

Merced formation.—Generally, less than 350 ppm of dissolved solids occur in ground water in the Merced formation, and the overall quality of the water is satisfactory. However, locally, waters having high concentrations of iron or manganese, or both, may be objectionable for many domestic uses, especially laundering, unless treated; such waters also are likely to be corrosive and to damage well casings and pump columns. These conditions are especially prevalent in the western part of the area in which the Merced formation crops out, where wells tap thick sections of "blue" (unoxidized) sandstone. Apparently base exchange does not occur in the Merced to as large a degree as in the Glen Ellen formation, although analysis 1 of well 5/9–3G1 (fig. 11) indicates a relatively high sodium content. Waters that have been plotted near the lower apex of the central diamond on figure 11, represent water that is believed to have undergone base exchange.

Sonoma volcanics.—The samples analyzed indicate that ground water in the Sonoma volcanics is of all-around satisfactory quality, and the range in character from place to place appears to be small. Because of a higher geothermal gradient in the volcanic rocks, ground-water temperature is slightly higher in deep wells tapping the volcanics than in wells of comparable depth in other formations. On April 18, 1950, the temperature of water from wells 7/7–29L2, 365 feet deep, and 7/7–32G1, 403 feet deep, both of which are supplied principally by the Sonoma volcanics, was 72° F and 74° F, respectively, which is about 6–8 degrees warmer than that in wells of comparable depth in the Merced and Glen Ellen formations.

GROUND WATER CONTAINING BORON

Analyses of ground water indicate two local areas in the Santa Rosa Valley where the boron content of the water is high. One area, apparently small, in the northern part of Santa Rosa Valley was disclosed by analyses of water samples taken during July 1950 from irrigation well 8/9–23L1, which had been put into limited use during the previous season. The well was drilled to a depth of 429 feet, where it bottomed in blue clay (Glen Ellen formation), and was completed at a depth of 410 feet as a gravel-packed well. During the early part of the summer of 1950, pasture grasses irrigated by the water from the well yellowed and eventually died. Attention was directed to the irrigation water as the possible cause, owing to the rapid change in the health of a walnut tree situated near and watered by the pump discharge. An analysis of leaves from the tree by the Division of Plant Nutrition of the University of California, showed a boron concentration of about 40 ppm. Analyses of two water samples taken from the well on July 12 and July 26, 1950, showed a boron concentration of 22 ppm at a pumping rate of 750 gpm. On September 8, 1950, after a wooden plug had been set at a depth of 227 feet, the yield was reported to be less than 200 gpm and the boron concentration was 0.44 ppm. Even though the well is gravel packed, the plug was effective as a barrier in sealing off the deep water of high boron content.

Water samples from seven other wells, comprising all the nearby irrigation wells and most of those within a radius of 1.5 miles, were collected during the period July 20–26, 1950, by the owner of the well 8/9–23L1 and a representative of the County Farm Advisor's Office to determine the extent of the area yielding water of high boron content. The results of the analysis of the water showed that all samples contained less than 2.5 ppm and most less than 1.0 ppm of boron, about the same as that normally present in water in the area. However, none of the wells were as deep as 8/9–23L1. Water from irrigation well 8/9–23G1, 0.3 mile distant, then 224 feet deep, contained 0.60 ppm of boron. An analysis of water taken from the same well on December 22, 1952, after deepening to 430 feet, showed a boron content of only 0.40 ppm.

Three of the most likely sources of the excessive boron in the water from well 8/9–23L1 are connate water from older marine formations, juvenile or deeply circulating ground water rising along a fault, or a pocket of water of high-boron content in the Glen Ellen. The low chloride content of the water appears to rule out connate water as a source. The fault hypothesis seems likely, especially because numerous faults are known to cut the Franciscan group across the Russian River. One of these faults extends from that area to the vicinity of the well, and, as indicated by the topography and outcrop pattern (pl. 1), may cut the Glenn Ellen formation. The possibility of an extensive pocket of water of high-boron content in the Glen Ellen formation appears unlikely, and the quantity of boron in the sample analyzed suggests that the source rock must have released considerable boron to have sustained such a high concentration in the water while the well was pumped. However, a relatively large amount could be derived from a fault zone extending upward into the deposits tapped by the well.

In the Glen Ellen area, waters having a boron content between 2.5 and 7.7 ppm were obtained from wells 6/6–16B2, 16H1, and 16J2 and from well 6/6–5L1 and spring 6/6–5L3 (table 20). The three wells in 6/6–16 appear to be very close to or slightly down dip from an inferred fault (pl. 1), which is the probable source of small amounts of rising juvenile water or deeply circulating meteoric water, or both, which discharge into the deposits and thereby cause the high concentration of boron. Warm water is obtained from well 6/6–5L1 and spring 6/6–5L3, which also suggests a deep source. All the wells begin in the Glen Ellen formation, but some may tap the Sonoma volcanics at depth.

Most of the ground-water samples from the Santa Rosa Valley area that were analyzed for boron contained only small concentrations. The data suggest that in the deeper parts of the water body the concentration increases slightly with depth. In analyses of water from the Sonoma volcanics no such change is noted, and the boron concentrations are lower than might be expected from rocks having a volcanic source.

RELATION OF SPECIFIC CONDUCTANCE TO SUM OF IONIZED CONSTITUENTS

The specific conductance (electrical conductance in micromhos at 25°C) of a water gives an approximation of the dissolved mineral content, although it gives no indication of the relative quantities of dissolved constituents. The relation of specific conductance to "sum of ionized constituents" [17] (calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, nitrate, and fluoride) in ground water in the Santa Rosa Valley area was determined by plotting these quantities from 44 analyses of ground waters (fig. 13). The average relation between these quantities is given by the equation for the line on figure 13 which is

$$S=0.56\ (K\times 10^6)$$

where S is the sum of ionized constituents in parts per million, and $K\times 10^6$ is the specific conductance in micromhos at 25°C.

Thus, for the 9 incomplete analyses in table 20 and the 88 partial analyses in table 21, the approximate sum of the principal ionized constitutents may be estimated by using the curve on figure 13 or by multiplying the specific conductance by 0.56. For the complete analyses available in table 20, the maximum error introduced by this method is 14 percent, but for most of the analyses it would be less

[17] This sum differs slightly from *sum of determined constituents*, in that it does not include silica, which is considered not to be ionized, or boron, iron, and other minor constituents found in the analysis.

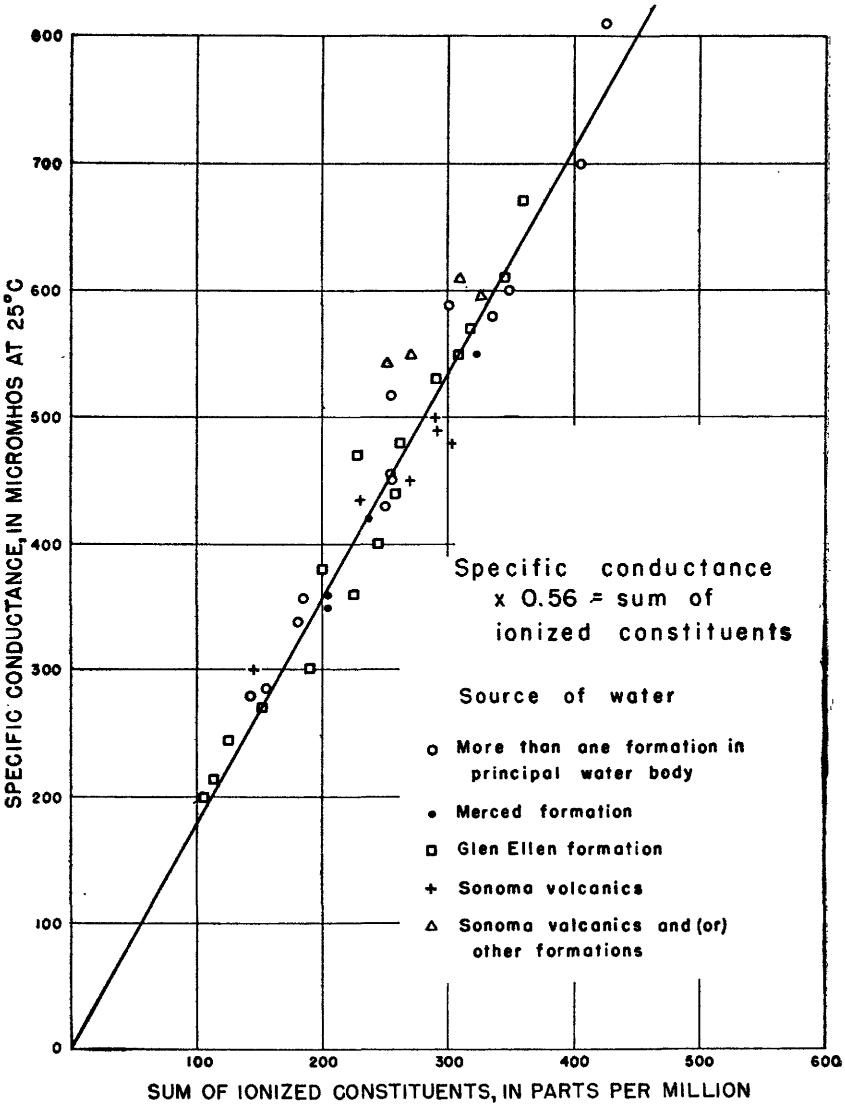

FIGURE 13.—Relation of specific conductance to sum of the ionized constituents in ground waters in the Santa Rosa Valley area, California.

than 7 percent. It should be pointed out, however, that the ratio for contaminated water, especially water contaminated by saline water, may differ considerably from that for normal ground water. A slightly higher factor is obtained for uncontaminated water from the Sonoma volcanics than for water from other formations, suggesting that the quantity of dissolved solids for a given conductivity is higher for the uncontaminated water from the Sonoma volcanics. However, not enough analyses are available to fix a curve for water from the Sonoma volcanics.

STORAGE CAPACITY

Ground-water storage capacity was computed for Santa Rosa, Bennett, Rincon, and Kenwood Valleys, using the same general methods used to estimate the ground-water storage capacity of the Sacramento Valley (Poland and others, 1951). The estimates are of gross, or total, ground-water storage capacity, not the usable storage capacity.[18] The gross storage estimates serve as an approximate measure of the water that is potentially available for use or as a basis for estimating usable storage capacity.

In general, for the Santa Rosa Valley area, the overall zone of cyclic storage was considered to extend from a level 10 feet below the land surface, which approximates the average position of the water table, to a depth of 200 feet below the land surface. For most of the area this 190-foot zone was subdivided into three depth zones, 10–50 feet, 50–100 feet, and 100–200 feet below the land surface. These zones correspond to those used by the Geological Survey for computing storage capacity in other northern California valleys which contain thick sections of water-bearing alluvial deposits.

Under the present state of development, cyclic dewatering of deposits forming the ground-water reservoir in the Santa Rosa Valley area takes place within the 10- to 50-foot zone. The 50- to 100-foot zone probably could be dewatered under present economic conditions. The 100- to 200-foot zone may represent the maximum storage space that could be utilized under future conditions of full development. It is beyond the scope of this report to consider the overall feasibility of utilizing the storage, especially in the 50- to 200-foot range, but pertinent factors bearing on usability are set down in the latter part of this section.

Except where noted in discussions of individual storage units (fig. 3), the units were treated as having vertical sides. Because in most places the deposits forming the sides of the valleys are water yielding and, to some extent, are hydraulically connected with the water bodies beneath the valleys, the lateral limits of the storage units are somewhat arbitrary. Some were selected for convenience, but most coincide with natural features.

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[18] Poland and others (1951, p. 621) define usable storage capacity as "That reservoir capacity that can be shown to be economically capable of being dewatered during periods of deficient surface supply and capable of being resaturated, either naturally or artifically, during periods of excess surface supply. Obviously it must contain usable water, which may be defined as that having a satisfactory quality for irrigation and occurring in sufficient quantity in the underground reservoir to be available without uneconomic yield or drawdown."

Storage units were restricted to the generally flat-lying valley areas, because the basins beneath them contain most of the storage space of the area, and in addition they could be dewatered and recharged most readily and most economically. The only area of appreciable ground-water storage that is not considered here is the upland area west of Santa Rosa Valley underlain by the Merced formation. This area was omitted because of insufficient data on water levels, depth to bedrock, porosity and permeability of the deposits, and the effect of faults on occurrence and movement of ground water.

The factors directly determining ground-water storage capacity are the volume of the material that is or can be saturated and the specific yield of the material. Volumes were obtained by planimetering the surface area of storage units, and multiplying this area by the thickness of zones. The specific yield was estimated by assigning an arbitrary specific-yield value to each category of material reported on the drillers' logs and averaging the material in the several categories, as explained on pages 103–104. The specific-yield values assigned were those used by Poland and others (1951, p. 624–25) for the Sacramento Valley.

SANTA ROSA VALLEY

The Santa Rosa Valley was divided into four ground-water storage units on the basis of geology, differences in specific yield, recharge characteristics, and grouping of wells. These units (fig. 3) are the Windsor-Fulton unit (*A*1), Santa Rosa unit (*A*2), Cotati plain unit (*A*3), and the Laguna unit (*A*4).

The Windsor-Fulton unit (*A*1) is underlain principally by soils of low permeability. However, on the eastern side a large area has a veneer of younger alluvium and on the western side local stream channels and flood plains incise older deposits, thus affording opportunity for recharge. In addition, isolated terrace remnants and local gravel beds, which have been exhumed by erosion, provide areas of recharge.

The Santa Rosa unit (*A*2), as shown on figure 3, roughly corresponds in extent to the alluvial fan of Santa Rosa Creek. Along the creek and its tributaries the unit has relatively permeable soils, formed on younger alluvium, but the western part of the unit has soils that probably are of low permeability; locally, however, they have been cut through by erosion.

The Cotati plain unit (*A*3) is named for the Cotati plain, with which it is essentially coextensive. All the soils are formed on younger alluvium, so that artificial recharge possibly could be accomplished fairly readily.

The eastern boundary of the Laguna unit (*A*4) is determined by the line along which the depth to the top of the Merced formation is 200 feet, which was drawn on the basis of well-log information. The western boundary is formed by the geologic contact between the Merced formation and the younger alluvium. The average specific yield, 9.7 percent, is highest for all units in the Santa Rosa Valley, because of the large percentage of sand in the deposits. The deposits forming the bed of the Laguna de Santa Rosa are fine grained and would tend to inhibit recharge to unit *A*4.

In about 30,000 acres, or about 40 percent, of the ground-water storage units in the Santa Rosa Valley, the soils have a relatively low permeability.

Most of the area of Santa Rosa Valley is relatively flat lying, and in spring the water levels are fairly high, probably averaging 10 feet or less below the land surface in the southern two-thirds of the valley. Therefore, in that part of the valley storage was computed for deposits below a depth of 10 feet, so that the upper zone provides 40 feet of storage. In the northern part of Santa Rosa Valley, storage was computed for an interval of 190 feet beneath the high water table of spring, which in some parts is considerably more than 10 feet below the land surface. In most of that area it would be impracticable to raise the water table above its natural high position of spring by artificial recharge and thus increase the effective storage capacity of this part of the area.

BENNETT, RINCON, AND KENWOOD VALLEYS

Bennett Valley unit.—Because the Sonoma volcanics in the Bennett Valley unit (B) contain water which in part is separated from the principal water body, the top of the volcanic rocks, where less than 200 feet below the land surface, was taken as the bottom of the ground-water storage unit. The extent of the Bennett Valley unit (B) is shown on figure 3. Lines showing the approximate 50-, 100-, and 200-foot depths to the top of the volcanic rocks were drawn and used as depth-zone boundaries, except near the southern end of the 200-foot line where an arbitrary line was drawn (fig. 3). Volumes of the three depth zones were computed by deriving the average area for each zone and multiplying by its thickness. The deposits underlying Bennett Valley contain a relatively large percentage of gravel; as a result, the unit has an estimated specific yield of 11 percent, which is the highest average specific yield for any unit in the area of this report. The soils overlying the unit are formed from younger alluvium and are probably at least moderately permeable.

Rincon Valley unit.—In the central part of the Rincon Valley, unit (C), water levels are about 10 feet below the land surface, or higher, during the spring; however, the water table slopes more gently than the land surface, so that spring water levels near the margins of the valley commonly are considerably more than 10 feet below the land surface. To make the storage volumes comparable with those in other areas, 190 feet of storage was computed for the entire valley—10–200 feet below the land surface in the central part of the valley and 190 feet below the springtime water table in the rest of the valley.

Kenwood Valley, north unit.—In the northern part of Kenwood Valley, unit (D), storage was computed, as in Rincon Valley, for three zones, 10–50, 50–100, and 100–200 feet. This unit has an estimated specific yield of 5.5 percent, which is the lowest average specific yield for all the units for which storage was computed.

Kenwood Valley, south unit.—In the southern part of Kenwood Valley, unit (E), the alluvial plain has a low slope and is flatter than in the northern part of the valley, and water levels are higher, probably averaging less than 10 feet below the land surface in the spring. Storage in the zones 10–50 feet and 50–100 feet below the land surface was computed. Because of an insufficient number of logs and lack of data on the vertical extent of the confined water body in the underlying Sonoma volcanics, computations were not made for the zone 100–200 feet below the land surface.

The storage in the southern part of Kenwood Valley, unit (E), was computed separately from that in the northern part, because the specific yield was estimated to be greater and because more data were available for the 100- to 200-foot depth zone in the northern part of the valley.

ESTIMATED STORAGE CAPACITY

The methods used to obtain the estimated gross ground-water storage capacity in the Santa Rosa Valley area are described below. These same methods were employed to obtain the storage estimates in the Petaluma Valley area. (See p. 131–132.) The steps involved in the computation of storage capacity are as follows:

1. The deposits beneath valleys were divided areally into eight units, designated *A*1–*A*4, *B*, *C*, *D*, and *E* in the Santa Rosa Valley area, as described in the preceding section, and into units *P*1 and *P*2 in the Petaluma Valley area.

2. Depth zones, generally 10–50, 50–100, and 100–200 feet below the land surface, were used. Where average springtime water levels were more than 10 feet below the land surface, the zones were taken from the water table to a maximum depth of 190 feet below it. The volumes of the zones in the units were obtained by multiplying the area by the thickness of each zone.

3. The logged materials in the wells in each depth zone were assigned to one of six specific-yield categories, based on the adaption by Poland and others (1951, p. 624–625) of work done by Eckis (1934)

TABLE 10.—*Categories used for classification of materials described by drillers, and estimates, by category, of specific yield in the Santa Rosa and Petaluma Valley areas*

Category [1]	*Assigned specific yield (percent)*
Gravel (boulders, cobbles, gravel, and shells)	25
Sand (clamshells, sand and gravel, gravelly sand)	20
Clay, sand, and gravel (dirty sand, quicksand, coarse sandstone, silt)	10
Clay and gravel (cemented gravel, hard sandstone)	5
Clay (decomposed rock, hardpan, shale—where probably clay)	3
Rock (hard shale, shale—if not clay, serpentine, basalt, or lava)	0

[1] First term or terms denote category in which drillers' terms, enclosed by parentheses, have been grouped.

and Piper and others (1939, p. 101–122). A total of nearly 500 well logs were used in the computations, and about 300 different drillers' terms were grouped into the six categories described in table 10.

4. The average specific yield was computed for each depth zone in each unit by multiplying the percentage of each type of material by the assigned specific-yield value and totaling the sums. The results are given in table 11.

TABLE 11.—*Average estimated specific yield of ground-water storage units in the Santa Rosa Valley area, California*

Depth zone [1] (feet)		Number of feet logged, percentage of feet logged, and average specific yield (percent) for indicated categories [2] of material							Number of logs in which depth zone is described
		Gravel	Sand	Clay, sand, and gravel	Clay and gravel	Clay	Rock	Total	
Storage unit A1									
10–50	feet logged	326	375	206	1,215	1,375	0	3,497	89
	percent logged	9.3	10.7	5.9	34.7	39.4	0	100.0	
	specific yield	2.32	2.14	.59	1.74	1.18	0	8.0	
50–100	feet logged	297	311	155	1,309	1,111	0	3,183	86
	percent logged	9.3	9.8	4.9	41.1	34.9	0	100.0	
	specific yield	2.32	1.96	.49	2.06	1.05	0	7.9	
100–200	feet logged	322	226	163	1,077	1,220	0	3,001	42
	percent logged	10.7	7.5	5.4	35.8	40.6	0	100.0	
	specific yield	2.68	1.50	.54	1.80	1.22	0	7.7	
Storage unit A2									
10–50	feet logged	764	550	250	2,095	3,575	60	7,294	185
	percent logged	10.5	7.5	3.4	28.7	49.1	.8	100.0	
	specific yield	2.62	1.50	.34	1.44	1.47	0	7.4	
50–100	feet logged	778	388	238	1,715	2,641	124	5,884	172
	percent logged	13.2	6.6	4.0	29.1	45.0	2.1	100.0	
	specific yield	3.30	1.32	.40	1.46	1.35	0	7.8	
100–200	feet logged	447	137	130	1,809	2,680	143	5,346	78
	percent logged	8.4	2.6	2.4	33.8	50.1	2.7	100.0	
	specific yield	2.10	.52	.24	1.69	1.50	0	6.0	
Storage unit A3									
10–50	feet logged	105	237	189	580	807	0	1,918	49
	percent logged	5.5	12.4	9.9	30.2	42.0	0	100.0	
	specific yield	1.38	2.48	.99	1.51	1.26	0	7.6	
50–100	feet logged	142	251	261	727	801	0	2,182	50
	percent logged	6.5	11.5	12.0	33.3	36.7	0	100.0	
	specific yield	1.63	2.30	1.20	1.66	1.10	0	7.9	
100–200	feet logged	199	304	164	733	1,294	10	2,704	38
	percent logged	7.4	11.2	6.1	27.1	47.8	.4	100.0	
	specific yield	1.85	2.24	.61	1.36	1.43	0	7.5	

See footnotes at end of table.

TABLE 11.—*Average estimated specific yield of ground-water storage units in the Santa Rosa Valley area, California*—Continued

Depth zone [1] (feet)		Number of feet logged, percentage of feet logged, and average specific yield (percent) for indicated categories [2] of material							Number of logs in which depth zone is described
		Gravel	Sand	Clay, sand, and gravel	Clay and gravel	Clay	Rock	Total	
		Storage unit *A4*							
10–50	feet logged	106	509	289	515	1,280	0	2,699	71
	percent logged	3.9	18.8	10.7	19.1	47.5	0	100.0	
	specific yield	.98	3.76	1.07	.96	1.42	0	8.2	
50–100	feet logged	228	603	607	609	738	0	2,785	71
	percent logged	8.2	21.6	21.8	21.9	26.5	0	100.0	
	specific yield	2.05	4.32	2.18	1.10	.80	0	10.4	
100–200	feet logged	60	593	801	683	479	0	2,616	41
	percent logged	2.3	22.7	30.6	26.1	18.3	0	100.0	
	specific yield	.58	4.54	3.06	1.30	.55	0	10.0	
		Storage unit *B*							
10–50	feet logged	106	15	22	160	165	0	468	12
	percent logged	22.6	3.2	4.7	34.2	35.3	0	100.0	
	specific yield	5.65	.64	.47	1.71	1.10	0	9.6	
50–100	feet logged	143	35	10	183	141	0	512	12
	percent logged	27.9	6.8	2.0	35.8	27.5	0	100.0	
	specific yield	6.98	1.36	.20	1.79	.83	0	11.2	
100–200	feet logged	94	47	20	142	87	0	390	7
	percent logged	24.1	12.1	5.1	36.4	22.3	0	100.0	
	specific yield	6.02	2.42	.51	1.82	.67	0	11.4	
		Storage unit *C*							
10–50	feet logged	93	126	86	671	415	169	1,560	39
	percent logged	6.0	8.1	5.5	43.0	26.6	10.8	100.0	
	specific yield	1.50	1.62	.55	2.15	.80	0	6.6	
50–100	feet logged	74	65	109	726	374	209	1,557	40
	percent logged	4.8	4.2	7.0	46.6	24.0	13.4	100.0	
	specific yield	1.20	.84	.70	2.33	.72	0	5.8	
100–200	feet logged	26	33	119	841	284	226	1,529	27
	percent logged	1.7	2.1	7.8	55.0	18.6	14.8	100.0	
	specific yield	.42	.42	.78	2.75	.56	0	4.9	
		Storage unit *D*							
10–50	feet logged	12	4	14	360	50	0	440	13
	percent logged	2.7	.9	3.2	81.8	11.4	0	100.0	
	specific yield	.68	.18	.32	4.09	.34	0	5.6	
50–100	feet logged	9	0	10	407	176	0	602	13
	percent logged	1.5	0	1.7	67.6	29.2	0	100.0	
	specific yield	.38	0	.17	3.38	.88	0	4.8	
100–200	feet logged	25	20	15	942	147	0	1,149	12
	percent logged	2.2	1.7	1.3	82.0	12.8	0	100.0	
	specific yield	.55	.34	.13	4.10	.38	0	5.5	
		Storage unit *E*							
10–50	feet logged	64	8	59	116	102	6	355	9
	percent logged	18.0	2.3	16.6	32.7	28.7	1.7	100.0	
	specific yield	4.50	.46	1.66	1.64	.86	0	9.1	
50–100	feet logged	39	11	20	184	178	14	446	9
	percent logged	8.7	2.5	4.5	41.3	39.9	3.1	100.0	
	specific yield	2.18	.40	.45	2.06	1.20	0	6.3	
100–200	feet logged	48	0	0	157	158	25	388	8
	percent logged	12.4	0	0	40.5	40.7	6.4	100.0	
	specific yield	3.10	0	0	2.02	1.22	0	6.3	

[1] In units *A1*, *C*, and *D*, storage was computed to a depth of 190 feet below the springtime high water table and divided into zone thicknesses of 40, 50, and 100 feet, so as to be comparable to the storage computed for other units (see p. 102–103).
[2] See table 10 for explanation of categories and the specific yields assigned to the categories.

5. Finally, the estimated gross ground-water storage capacity in each unit was obtained by multiplying the average specific yield, shown in table 11, by the volume of materials in the depth zone. Table 12 gives the estimated storage capacity for the eight storage units of the Santa Rosa Valley area. The storage capacity for each depth zone has been rounded to the nearest 100 acre-feet, and all unit and zone totals have been rounded to the nearest 1,000 acre-feet.

The table suggests that the gross ground-water storage capacity in the Santa Rosa Valley area is on the order of 1,000,000 acre-feet. In addition to the storage estimated for the area shown on figure 3, there is an undetermined volume of storage in the adjacent formations along the eastern and western sides of the valley for which data were insufficient for estimates.

The two largest sources of error in the storage computations are in the classification of drillers' terms into the six categories and in the specific-yield values assigned to the categories. Accordingly, the estimated storage may be considerably in error, but the total indicates the general order of magnitude of gross storage in the Santa Rosa Valley area.

TABLE 12.—*Estimated gross ground-water storage capacity, in acre-feet, in the Santa Rosa Valley area* [1]

Ground-water storage unit	Surface area (acres)[2]	Depth zone							
		10–50 feet		50–100 feet		100–200 feet		All zones	
		Average specific yield (percent)	Storage (acre-feet)	Average specific yield (percent)	Storage (acre-feet)	Average specific yield (percent)	Storage (acre-feet)	Average specific yield (percent)	Storage (acre-feet)
*A*1, Windsor-Fulton	11,100	8.0	35,500	7.9	43,800	7.7	85,500	7.8	165,000
*A*2, Santa Rosa	26,600	7.4	78,700	7.8	104,000	6.0	160,000	6.8	343,000
*A*3, Cotati plain	11,100	7.6	33,700	7.9	43,800	7.5	83,200	7.6	161,000
*A*4, Laguna	15,100	8.2	49,500	10.4	78,500	10.0	151,000	9.7	279,000
Total, *A* unit	64,000	7.7	197,000	8.4	270,000	7.5	480,000	7.8	948,000
B, Bennett Valley	[3] 1,600	9.6	5,900	11.2	7,400	11.4	10,900	11.0	24,000
C, Rincon Valley	2,000	6.6	5,300	5.8	5,800	4.9	9,800	5.5	21,000
D, Kenwood Valley, north	2,300	5.6	5,200	4.8	5,600	5.5	12,800	5.5	24,000
E, Kenwood Valley, south	1,300	9.1	4,600	6.3	4,000	6.3	7,900	6.5	16,000
Grand total	71,000		218,000		293,000		521,000		1,033,000

[1] Storage for each depth zone has been rounded to nearest 100 acre-feet; totals have been rounded to nearest 1,000 acre-feet.
[2] See footnote 1, p. 105.
[3] Surface area of zone between surface and debth of 50 feet; average areas used for each depth zone. (See Bennett Valley unit, p. 102.)

USABILITY OF STORAGE CAPACITY

Two general factors, which involve several specific factors, directly determine the usability of the ground-water storage capacity of an area. These are (1) the ease with which the materials composing the storage zone can be dewatered by gravity drainage (pumping), and (2) the ease with which the deposits can be resaturated so as to utilize cyclic recharge from sources such as surplus winter runoff in streams. Both time and economic factors enter into the general considerations, but the specific factors are the transmissibility of the water-yielding materials and the permeability of the surficial materials which control the rate of recharge.

Because water contained in the Merced formation in the large area underlying and forming the low hills adjacent to the alluvial plain on the western side of Santa Rosa Valley is continuous with water in the deposits beneath the valley floor, it would not be possible to dewater the entire zone for which the storage volume was computed without inducing additional inflow from the adjacent, saturated deposits of the Merced. Therefore, the usable ground water in storage that is available for withdrawal is potentially greater than the storage figures indicate, by the amount of the underflow that would be induced. Conversely, the volume of dewatered materials beneath the valley floor that could accept recharge would be considerably less than the amount of the withdrawals, for the same reason. However, large-scale pumping in the valley would result in additional dewatering of deposits in the upland area. Thus, obtaining adequate data concerning the transmissibility of the deposits of the Merced formation would be one necessary factor in determining usable storage capacity. Other formations not considered in the storage units would require similar studies.

Because the specific-yield values obtained were in a medium-to-low range for most of the storage units and because data on the lithology and water-yielding character of the deposits suggest that gravity drainage of the deposits would proceed relatively slowly—making the consideration of economic yield and drawdown pertinent factors—it might be difficult to utilize storage to the full 200-foot depth within a limited period of time.

Water quality probably would not be impaired by dewatering the ground-water reservoir to depths of 200 feet below the land surface in the Santa Rosa Valley area. However, in areas where faults are believed to cut the deposits at relatively shallow depths, local boron contamination might ensue as the head in the aquifers was drawn down and the head of the water in the faults became relatively greater. (See pl. 2 and section on quality of water.)

Lowering the water table in the Santa Rosa Valley area would result in increased recharge from rainfall or from streams in areas where the water table normally is close to the land surface, salvaging of some of the natural discharge now lost through evapotranspiration, ground-water outflow to streams, and subsurface flow from the area.

PETALUMA VALLEY AREA

The Petaluma Valley area of this report comprises Petaluma Valley; the small tributary valleys; and contiguous areas, which include the small alluvial valley southeast of Penngrove, upland areas adjoining the valley—especially areas underlain by deposits of the Merced formation in the northwestern and southeastern parts of the valley—and Novato Valley.

The principal water-bearing deposits are the younger and the older alluvium and the Merced formation. Locally, water occurs in the Petaluma formation and in the Sonoma volcanics; in a few places minor amounts of water are obtained from Cretaceous and Jurassic rocks.

In much of the Petaluma Valley area the ground-water reservoir has limited vertical extent, owing to faulting. East of Petaluma on the southwestern side of the Tolay fault the Franciscan group is penetrated at depths of only 400–800 feet. Northeast of the fault the Petaluma formation lies at the surface, or is encountered at shallow depth, and extends to a considerable depth, but the water-bearing beds it contains have low permeability.

In the Petaluma Valley area about 1,500 wells (1950) pump ground water, principally for domestic, public-supply, irrigation, industrial, and stock use. In the northern part of Petaluma Valley water wells range in depth from 10 to 688 feet, excluding converted oil and gas test wells in the Petaluma formation. Domestic wells on the valley floor are generally 75–150 feet deep; in the upland area they are commonly deeper, owing to the greater depth to water. Most of the wells are for domestic use; these wells yield 10–50 gpm and are not designed to produce large yields. The specific capacity of most domestic and stock wells is low—commonly about 1 gpm per foot or less—because most of the wells are perforated only near the bottom or have open-end casings only, so that much water-yielding material is cased off. In addition, wells other than those drilled for irrigation use generally are not developed for maximum yield. Irrigation, public-supply, and industrial wells are commonly 250–600 feet deep and yield 50–350 gpm.

In the central part of the valley east and southeast of Petaluma, the indicated range in average permeability, based on yield factors of 16 wells of relatively large yield tapping the principal water body, ranges from 5 to 145 gpd and averages about 50 gpd per square foot. On the basis of the yield factors of these wells it appears that, although larger yields are obtained from the deeper wells, the yield per foot of material that the well penetrates decreases with depth.

In the southern part of Petaluma Valley, wells range in depth from

15 to 736 feet, but most wells are 75–250 feet deep. Yields range from a few gpm to about 150 gpm.

In Novato Valley, in the vicinity of Novato, most wells are 30–60 feet deep and yield 10–50 gpm.

PRINCIPAL WATER-BEARING FORMATIONS

YOUNGER ALLUVIUM

The younger alluvium has a considerable thickness in Petaluma Valley, especially in the southeastern (lower) part. However, because most of the southern part of the valley is tidal, not everywhere does the younger alluvium form a usable part of the ground-water reservoir. The maximum thickness of the younger alluvium in the northern part of Petaluma Valley has not been definitely ascertained, but on the basis of well logs it is believed to be as much as 200 feet. In the extreme northern part the thickness is much less, decreasing to a featheredge at the margins of the alluvial plain.

In the southern or downstream part of Petaluma Valley the thickness of the younger alluvium may be as much as 300 feet, depending on the gradient of the pre-alluvial trench cut by ancestral Petaluma Creek. This trench doubtless was graded to the canyon cut through the Golden Gate of San Francisco Bay, which is 381 feet or more below sea level (Hinds, 1952, p. 170). No logs are available of deep wells in the southern part of Petaluma Valley except along the northeastern edge of the valley; thus the maximum thickness in that area is not known.

The younger alluvium yields small-to-moderate supplies of water of good quality to many wells in the northern part of Petaluma Valley and to a few in the southern part, but most wells that have large yields completely penetrate the younger alluvium and tap the older alluvium or the Merced formation, or both. Few data are available on the water-yielding character of the younger alluvium. Specific capacities computed from bailer tests run by drillers on a few wells in the northern part of Petaluma Valley range from less than 1 to as much as 5 gpm per foot of drawdown.

In the southern part of Petaluma Valley, according to logs of a few scattered shallow wells, the younger alluvium consists mostly of clay and silt, and the yields are relatively low. Wells 3/6–4D1 and 5A1 encountered 6 feet of gravel at a depth of about 80 feet; well 5A1 yielded 37 gpm of brackish water when pumped with a centrifugal pump. Well 4/6–33R1, 180 feet deep, across Petaluma Creek from the above wells, is reported to yield 150–200 gpm.

The quality of the water is poor in a large proportion of the southern part of the valley, and near Petaluma Creek and tidal sloughs the water is commonly brackish. On the central alluvial plain, wells yield fresh water only near the northeastern margin and in an area of reclaimed land at the southern margin near the bay. Younger alluvium locally may contribute some fresh water to wells along the northeastern margin, but at the southern margin the wells are all comparatively deep (mostly 200 feet or more). These facts suggest either that the shallow water is brackish or that the uppermost deposits are poorly permeable, so that the bulk of the water probably is supplied by basal younger alluvium or older deposits. The wells are all old and no logs are available. Many have been recased several times with liners, which suggests that water of poor quality occurs in the section tapped. Many of the wells flow and the water levels in the others are near the land surface.

Ground water in the younger alluvium occurs under essentially water-table conditions in the northern part of Petaluma Valley and is probably coextensive with water in the older alluvium; downstream it is semiconfined or confined. Some of the wells flow during high tide, and all respond to tidal fluctuations.

OLDER ALLUVIUM

The older alluvium makes up a principal part of the deposits comprising the ground-water reservoir in the Petaluma Valley area. The unconsolidated deposits of silty or sandy clay, sand, and gravel crop out only locally on the northeastern side of the valley but extend across the valley beneath the younger alluvium, where they overlap deposits of the Merced formation. Logs of wells that penetrate the older alluvium indicate a possible maximum thickness of about 200 feet.

The older alluvium supplies moderate to fair yields to wells in upper Petaluma Valley, but the specific capacities are low. In a well field in 5/7–28, the average specific capacity for 9 wells, which range in depth from 83 to 483 feet and obtain most of their water from older alluvium, is about 3.5 gpm per foot of drawdown. Possibly the capacity is lowered somewhat by interference between wells. The range in yield among the wells is 30–180 gpm, the deeper wells having the higher yields. Yield factors for these range from 0.2 to 9.0 and averaged 4.0, suggesting a range in permeability of 5–150 gpd and an average of about 70 gpd per square foot. The deepest four wells may tap the Merced formation also. Other wells tapping both the younger and the older alluvium yield as much as 300 gpm.

Water in the older alluvium is essentially unconfined, although the lenticularity and heterogeneity of the deposits causes poor interconnection and locally may produce slight confinement or zonation within the water body. Also, where overlain by fine-grained deposits in the younger alluvium, the older alluvium is confined. The quality of the water is good for most uses. (See section on quality of water.)

MERCED FORMATION

The Merced formation is the principal aquifer in the upland area northwest of the city of Petaluma, in the northwestern part of the valley, and on the northeastern flank of the lower valley, and the Merced is tapped by deeper wells near the center of the valley and near the bay.

Reported specific capacities generally are extremely low, many less than 1, because most wells are not constructed to obtain maximum yields from the fine sand of the Merced formation. However, when the development test was made of gravel-packed well 5/7–20C1, which appears to obtain a large part of its yield from the Merced, the well produced 650 gpm and had a drawdown of 140 feet, showing a specific capacity of 5 gpm per foot of drawdown. This well had the largest reported yield in the valley at the time of the well canvass by the Geological Survey. Yields of wells suggest that the permeability of the Merced is less in the southeastern part of the valley than in the northwestern part.

Water in the Merced formation is known to be confined in the northern part of Petaluma Valley (5/8–13, 24), where several wells flow during the spring. The head is only a few feet above the water table, and the water is probably confined by impermeable beds of local extent. The Merced formation is undoubtedly confined in other places, such as near the bay, by fine-grained alluvium. The quality of water in the Merced formation is generally satisfactory. Locally, near the bay, water in the Merced may be brackish.

SONOMA VOLCANICS

The Sonoma volcanics form only a small part of the ground-water reservoir in Petaluma Valley, but locally they supply moderate yields to a few wells, probably from tuff and fractured lava. South of Penngrove and southwest of Petaluma are the two principal areas in the Petaluma Valley area where wells penetrate volcanic rocks. Except in the immediate vicinity of outcrops (see pl. 1), volcanic rocks are not encountered in wells beneath the alluvial plain. The quality of water obtained from the Sonoma volcanics is generally satisfactory.

PETALUMA FORMATION

Near the northeastern margin of Petaluma Valley, supplies of water of good quality sufficient for domestic use generally can be obtained from the Petaluma formation, although wells tapping this formation may have to be deeper than average because the deposits are largely compact and fine grained. Locally, wells obtain enough water for small-scale irrigation developments. Well 5/7–25C1, which on the basis of the log appears to receive most of its water from the Petaluma formation, is 235 feet deep and when drilled was reported to have produced 350 gpm. Water analyses suggest that the formation may contribute to the yields of a few deep wells in the north-central part of Petaluma Valley. (See section on quality of water in the principal ground-water body.) In the upland area the yields are small, and the quality is generally poor—in places, too saline for human or animal consumption.

Considerable confinement or separation of water bodies occurs in the Petaluma formation. The head of water in the Petaluma formation is generally lower than in the younger and the older alluvium, locally by as much as 100 feet or more. However, some wells have artesian heads produced by deformed impermeable beds or by fault barriers. Because of the considerable disparity between the altitudes of water levels in wells tapping the Petaluma formation, water-level contours are drawn on the levels in the formation only in local areas (pl. 2).

PRINCIPAL WATER BODY

EXTENT, NATURE, AND DEPTH TO WATER

The principal water body in Petaluma Valley includes water in the younger and the older alluvium and in the Merced formation. Laterally, it underlies the alluvial plain of the upper part of Petaluma Valley and much of the adjoining upland area which is underlain by the Merced formation or older alluvium; vertically, it occupies those deposits overlying the Petaluma formation, and locally that formation where it is not confined.

In general the water body is either unconfined or semiconfined, although locally it is confined and may produce artesian heads. Also, there is some evidence of poor vertical connection locally within the water body. On April 4, 1951, the water levels in four closely spaced wells near the center of the valley—wells which had not been pumped since the autumn of 1950—are given in table 13.

TABLE 13.—*Comparison of water levels in closely spaced wells of different depth in the principal water body*

Well number	Depth (feet)	Perforated interval (feet)	Altitude of land surface (feet)	Depth to water (feet)
5/7—28A2	99		35	16.99
28A3	280	78–90, 220–260	35	15.79
28H1	483	154–315, 323–483	35	21.50
28H2	95		35	16.57

Water levels in shallow wells 5/7–28A2 and 28H2 and in well 5/7–28A3 of intermediate depth are similar and average about 16.5 feet, or about 5 feet higher than the water level in deep well 5/7–28H1. This difference in water levels suggests that locally the water body is separated vertically by impermeable beds which impede recharge to the deep part of the aquifer.

Because the alluvial deposits are highly lenticular, differences in head may occur in relatively short distances. Well 5/7–35B1, 28½ feet deep, reportedly "went dry" temporarily during the test pumping of well 5/7–26R1, 428 feet deep, despite the fact that the latter well was not perforated above a depth of 140 feet and was cemented from the surface to a depth of 118 feet. Thus it appears that in the vicinity of these wells there is no effective separation of deep and shallow water. The similar water-level fluctuations in wells 5/7–26R1, 428 feet deep, and 26R2, 35 feet deep, (pl. 14) support this conclusion.

The depth to water in the principal water body varies somewhat from place to place and is controlled largely by the local topography and well depth and construction. However, in the spring, water levels in most wells on the alluvial plain are generally 10–25 feet below the land surface, being closest to the surface toward the axis and the southern end of the valley. In the autumn, levels commonly are 15–40 feet below the surface, except where intensive development has temporarily lowered them still more.

South of the storage boundary shown on figure 3, the quality of water in much of that part of the principal water body contained in the younger and the older alluvium is such that the water cannot be used for most purposes. However, along the sides of the valley and locally beneath the alluvial deposits, water of fair or good quality is obtained in small quantity. The depths to water below the land surface are commonly a few feet in the valley trough and from 20 to 50 feet or more on the valley slopes.

FLUCTUATION OF WATER LEVELS

During the field study, periodic water-level measurements were made in a number of wells [19] to determine the general character and amount of the seasonal fluctuations of water level. These are given in table 24 of the appendix. In addition, an automatic water-level recorder was operated for several months in well 5/7–26R1 and briefly in well 3/6–5A1 to determine in more detail the character of the water-level fluctuations in the principal water body. The chief

[19] Water levels in six wells were measured periodically during the autumn of 1949, and in six additional wells during 1950 and 1951; measurements of one well were discontinued during 1950 and 1951. In 1952 measurements were made semiannually (spring and autumn), and in the autumn of 1952 the number of wells measured was decreased to five. Measurements have been continued in these wells since 1952.

causes of water-level fluctuations are the same as those discussed for the Santa Rosa Valley area (p. 75).

In the central and southern parts of Petaluma Valley, water levels fluctuate in response to tidal loading and, to some extent, in response to changes in ground-water discharge resulting from tidal fluctuations. The water-level fluctuations caused by changes in tidal stage may be of considerable magnitude, depending chiefly on the range in tides, proximity of tidal channels, and the nature of the aquifer tapped by the well. Tidal stages in the slough about 100 feet from observation well 3/6–5A1 were measured for 15 hours on January 27, 1950, for comparison with fluctuations recorded simultaneously in that well by an automatic water-level recorder equipped with an expanded time-scale graph. During the common period of observation, the fluctuation in tidal stage was 3.81 feet and the water-level fluctuation was 0.23 foot; therefore the tidal efficiency in the well was about 6 percent. The well is 83 feet deep and is perforated in a gravel stratum from a depth of 77 feet to a depth of 83 feet. In this area, where tide-induced fluctuations are relatively large, the small seasonal fluctuations of water level are masked. However, the hydrograph of well 3/6–1Q1 shows a definite seasonal trend. Tidal fluctuations amounting to only 0.01–0.02 foot were noted in well 5/7–26R1, about 1.4 miles from the nearest tidal water body.

Seasonal fluctuations.—The seasonal fluctuation depends on the balance between draft on the ground-water body and recharge to it. Except locally where a concentration of withdrawals may cause large seasonal declines, the seasonal fluctuations of water level in Petaluma Valley are relatively small ranging from less than 1 foot in the downstream part (well 3/6–5A1, table 24) to a maximum of about 20 feet in the upstream part (wells 5/7–20B1 and 35K1, table A7). In the northern part of Petaluma Valley the average yearly fluctuation is generally 10–15 feet; in the southern part, it varies depending on the proximity of tidewater. Near tidewater the seasonal fluctuation is small; near the valley margin, comparatively large.

The hydrographs on figures 8 (well 5/7–19N1) and 14 show the general nature of the water-level fluctuations in Petaluma Valley. Fluctuations in wells 5/7–26R1 and 5/7–26R2, which are paired deep and shallow wells, respectively, correspond closely except for a disparity at the beginning of the record in 1950. The maximum seasonal rise in both wells was between the autumn of 1951 and the spring of 1952 and amounted to 11.55 feet in well 5/7–26R1 and 12.71 feet in well 5/7–26R2. The 1952–53 recovery amounted to 7.42 feet in 5/7–26R1 and 7.34 feet in 26R2.

Long-term fluctuations.—Data on long-term fluctuations in the Petaluma Valley area, like those in the Santa Rosa Valley area, are

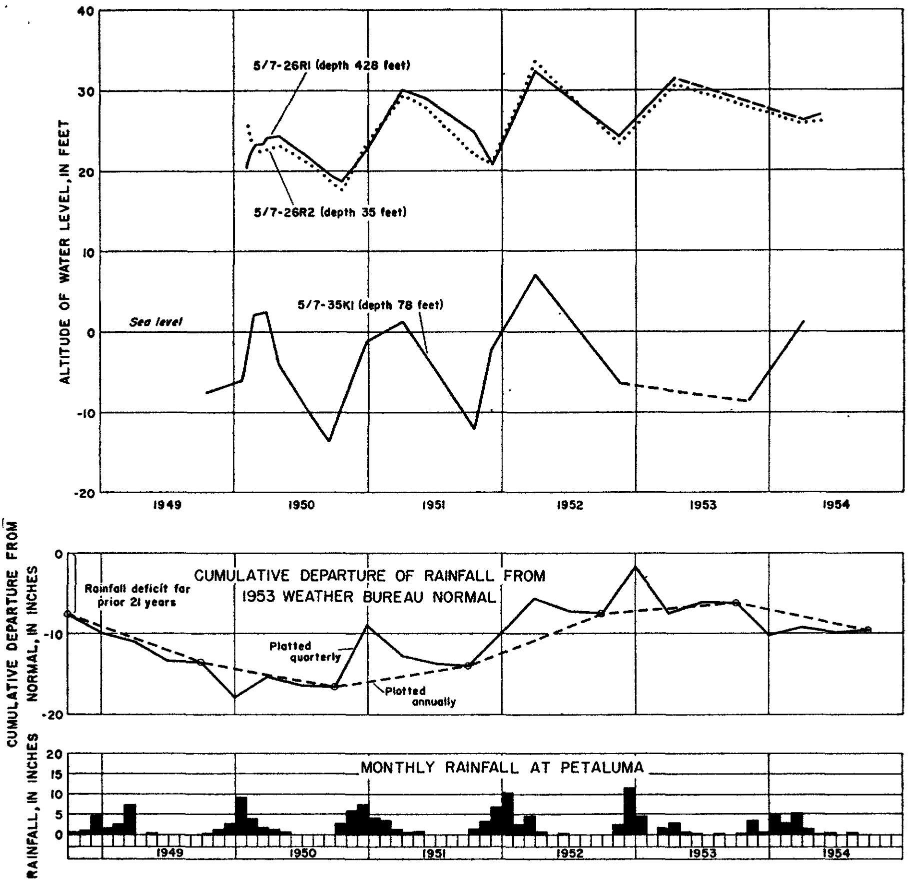

FIGURE 14.—Hydrographs for three wells in Petaluma Valley, 1949–54, and rainfall at Petaluma, Calif.

limited to the relatively short 4-year period, 1950–54. The most significant water-level trends in upper Petaluma Valley appear to be related to the rainfall regimen (fig. 14). Water levels in 5 wells that were measured during the springs of 1950, 1951, and 1952 showed a net rise averaging 5.4 feet in the 2 years. Rainfall during the period was above average. The levels in 3 of the wells that were measured in the spring of 1953, had declined 1–3 feet since the spring of 1952. Although the rainfall for the 1953 water year was slightly below that recorded in each of the preceeding 2 years, it was still about 1.4 inches above normal.

The period of record is too short to serve as a good index, especially because rainfall was generally above normal throughout. Also, the fresh-water body of the area is threatened with salt-water encroachment. Where water levels are depressed below sea level for considerable periods of time in areas near tidewater, a reversed water-level or hydraulic gradient may result in encroachment of sea water and in eventual deterioration of the ground-water quality. Continued periodic water-level measurements and chemical analyses would provide data on possiblities of sea-water encroachment.

OTHER WATER BODIES

Isolated water bodies in the Petaluma formation.—As previously indicated (p. 112), ground water in the Petaluma formation occurs locally in isolated bodies which are separated from the principal water body. Water-level fluctuations and depth to water commonly vary considerably between wells. Although a large number of wells tap the formation on the northeastern side of upper Petaluma Valley, their draft is relatively small.

Water body in Novato Valley.—The ground-water body in Novato Valley is essentially separate from that in Petaluma Valley. The water occurs principally in deposits of younger and older alluvium that rest on bedrock of the Franciscan group. The older alluvium is exposed only in a small area on the northern side of the upstream part of the valley, but it presumably underlies the younger alluvium in most of the valley. Well-log data are insufficient to permit an accurate estimate of the total thickness of the younger and older alluvium, but in the vicinity of Novato the thickness is locally at least 60 feet; it probably ranges from a few feet at the head of the valley to 200 feet or more at the mouth, downstream from Novato. The surfaces cut on rocks of the Franciscan group commonly are very irregular, so that even in the downstream part of the valley the thickness of the alluvium may vary considerably from place to place. Around the margins of the valley small supplies of ground water are obtained from the Franciscan group. In the hills north of the mouth of the valley the Novato conglomerate is tapped by some wells.

Confined and semiconfined conditions probably prevail in the water body, although fine-grained deposits in the downstream part of the valley may cause extensive confinement, as in Petaluma Valley. The depth to water is generally 5–10 feet below the land surface in the vicinity of Novato during the spring, and is less in the tidal area. The seasonal fluctuation is small and autumn levels near Novato are generally 10–25 feet below the land surface.

The pumpage by the North Marin Water Co., which serves the town of Novato, was 210 acre-feet in 1949. Other pumpage in the valley is chiefly for domestic and stock use, which includes use by several dairies. The total pumpage for 1949 was probably about 300 acre-feet, and, although the population of the area has increased considerably, the current annual pumpage (1954) probably is not more than 400 acre-feet.

Although the ground water normally moves down valley to discharge into San Pablo Bay, tidal fluctuations, which cause intrusion of brackish water into it, render much of the downstream part of the ground-water reservoir unusable. Even above the tidal reach, intensive withdrawals may cause deterioration of water quality by inducing brackish water to move into the fresh-water body. This factor reduces considerably the usable ground-water storage.

SOURCE OF WATER

The ground water in the Petaluma Valley area is recharged in large part by the deep infiltration of rainfall but also in part by seepage loss from streams that cross permeable deposits that lie above the water table. However, seepage gain occurs along the main stem of Petaluma Creek upstream from the tidal reach. Tributaries draining the Sonoma Mountains along the northeastern side of the valley supply recharge where their courses cross permeable beds. Some of this recharge is from low flows sustained by ground-water discharge from the Sonoma volcanics and Petaluma formation in the Sonoma Mountains. Along the course of Adobe Creek across the valley floor, water levels in wells are lower than the stream bed during most years, indicating that the creek is generally influent with respect to the ground water where the channel is permeable. Streams draining terrane of the Merced formation are mainly effluent; those draining the Sonoma Mountains are locally and intermittently influent. Rainfall records show that less rain falls in Santa Rosa Valley than in Petaluma Valley. Hence, the unit recharge available in the Petaluma Valley area is also less than that in the Santa Rosa Valley area, and the amount decreases in the direction of San Francisco Bay.

MOVEMENT OF WATER

Ground water in the principal water body in the Petaluma Valley area moves generally northeastward and southwestward toward Petaluma Creek and downstream toward the tidal sloughs (pl. 2). Ground water in the valley trough south of Petaluma moves in the same general directions. The water-level contours generally are more closely spaced than those in Santa Rosa Valley, suggesting lower permeability or smaller cross-sectional area of the deposits, or both. The hydraulic gradient in the northern part of Petaluma Valley is between 20 and 50 feet per mile except in the rolling upland area underlain by the Merced formation, where it is greater than 50 feet per mile.

In the southern part of the valley the local interchange of water between the water body and Petaluma Creek is related to tidal fluctuations. Also, in the vicinity of the city of Petaluma, heavy draft on the ground-water body locally results in reversal of the hydraulic gradient, which allows saline water to enter the water body, causing deterioration of water quality. Up to 1951 this deterioration was fairly limited in extent, mostly within a few hundred feet of the tidal channel.

Water in the Petaluma formation moves generally down dip and may discharge into the principal water body locally. However, movement of ground water in the Petaluma formation is controlled to a considerable degree by geologic structure, and no contours were drawn on the water levels in the isolated water bodies.

NATURAL DISCHARGE AND PUMPAGE

In the Petaluma Valley area ground water is discharged mainly by seepage into streams, evapotranspiration, and pumping from wells. During the spring, ground water in the northern part of Petaluma Valley discharges into Petaluma Creek and into the tidal sloughs. However, a west-trending trough in the water body probably results from the concentration of pumping east and north of the city of Petaluma, and it may intercept much of the water that under natural conditions would be discharged to the sloughs.

Because the water table is perennially close to the land surface beneath the alluvial plain near the tidal sloughs, evapotranspiration undoubtedly accounts for a large part of the ground-water discharge, especially where tules, reeds, and cattails flourish. Upstream, however, in the flat areas at the head of the valley where water is discharged from the Merced formation into thin fine-grained alluvium, most losses by evapotranspiration probably occur during the winter and spring when water levels are highest. Limited losses by evapotranspiration occur along Petaluma Creek and its tributaries, principally transpiration by willows and other vegetation.

Pumping is the only form of discharge for which quantitative data are available. Although no attempt was made to estimate the perennial yield of the valley, the relatively high water levels in the northern part of the valley indicate that there has been no basin-wide overdraft.

In Petaluma Valley the gross ground-water pumpage was estimated for the 5-year period 1945–49. (See table 14.) The pumpage for public supply was the water withdrawn by systems supplying Petaluma, Penngrove, and Two Rock Ranch Army Base. The California Water Service Co., which supplies the city of Petaluma and vicinity, furnished figures on metered pumpage from its wells. Because this pumpage accounts for about 90 percent of the total public-supply pumpage, the figure for public supply is believed to be fairly accurate. The pumpage for Penngrove was estimated on the basis of the population served; for Two Rock Ranch Army Base, from figures furnished by the post engineer.

TABLE 14.—*Ground-water pumpage, in acre-feet, in the Petaluma Valley area, 1945–49*

Use	1945	1946	1947	1948	1949
Public-supply	420	500	720	660	760
Irrigation	140	130	110	210	250
Industrial	80	130	140	130	120
Domestic, stock, and other	620	650	680	700	720
Yearly totals	1,300	1,400	1,600	1,700	1,800

Irrigation pumpage was computed on the basis of plant-efficiency tests and kilowatt-hours of electrical energy consumed, data on which were kindly made available by the Pacific Gas and Electric Co. Irrigation pumpage from wells for which electrical-power records were not available was estimated on the basis of acreages irrigated, using the same duty-of-water factors that were estimated for Santa Rosa Valley (table 8). This pumpage amounted only to 24 acre-feet in each year from 1945 through 1948 and 30 acre-feet in 1949. Pumpage for irrigation in Petaluma Valley during 1949 only amounted to about 14 percent of the total estimated pumpage for that year.

The pumpage for irrigation in the Petaluma Valley area was estimated in the following manner: The average efficiency of 12 wells, for which 26 plant-efficiency tests were available, was about 30 percent, which corresponds to an energy factor of about 3.5 kwhr per acre-foot of water pumped for each foot of lift. Although none of these tests were for irrigation wells, they were for wells having similar horsepower and type of pump, and their average efficiency was probably about the same as the average for the area. Pumping levels were measured or estimated from the available data. Because all irrigation was by sprinkler systems, which operate under a pressure of about 30 pounds per square inch, or 70 feet of water, the equivalent of 250 kwhr per acre-foot was added to the computed energy factor to account for lifting the water to pump-discharge level. Thus, the energy factor used to compute pumpage for irrigation in the Petaluma Valley area was 600 kwhr per acre-foot, which, when divided into the kilowatt-hours consumed in the area, gave the gross pumpage in acre-feet. Because of the broad assumptions involved in deriving the estimates, no allowances were made for seasonal fluctuations in pumping levels.

As a check on the irrigation pumpage, an estimate was made using reported and estimated size of acreages irrigated and a duty of water of 2.5 acre-feet per acre for pasture and 1 acre-foot per acre for garden truck. For 1949 this method suggests pumpage of 245 acre-feet, as compared with 230 acre-feet computed on the basis of electrical-power consumption and energy factors.

Only one industrial well that pumped an appreciable amount of water was canvassed. Probably most of the water pumped for industrial use, other than pumped for use by dairies, is furnished by public-supply wells or is included in the estimates made for domestic, stock, and other uses. It is estimated that there were 12–15 dairies operating in the Petaluma area during the period 1945–49. A unit factor of 5 acre-feet per year was applied, as in the Santa Rosa Valley area.

In 1950 about 1,500 wells were active in the Petaluma Valley area (exluding Novato Valley). Only about 2–3 percent of the wells were pumped for irrigation, public-supply, and industrial uses; the remainder were pumped for domestic, stock, and other uses. A factor of 0.5 acre-foot per well per year was used for these wells (see p. 87), and the number in use each year was derived by scaling down the number of wells in use in 1950 in proportion to the difference in population. The largest source of error in the estimate of total pumpage is probably in this last category, which consists of 40–50 percent of the total, because of the general assumptions that were necessarily made in the estimate.

Although the indicated draft for the period 1945–49 is fairly small, most of it is concentrated in an area of about 3,000 acres east and northeast of Petaluma which is only slightly above sea level. A substantial increase in the pumping might lower water levels below sea level, reverse the natural seaward hydraulic gradient, and induce sea-water encroachment into the pumping area.

QUALITY OF WATER

In order to determine the quality of ground water in Petaluma Valley, 67 analyses, of samples from 55 wells and 4 surface streams in the area, were assembled. These consist of 34 complete analyses and 33 partial analyses and are listed in table 15 and in tables 25 and 26 of the appendix to this report. A few analyses made available after completion of the tables are referred to and are available in the files of the Geological Survey.

The analyses show that the quality of the ground water varies widely from place to place. In general the quality of water obtained from wells tapping the principal water body in the northern part of Petaluma Valley is good. The water normally is of the calcium magnesium bicarbonate or sodium bicarbonate type, and generally contains between 250 and 500 ppm of dissolved solids (fig. 15). In the central part of Petaluma Valley, commencing a short distance southeast of Petaluma and continuing downstream, many wells tap water which seems to be contaminated by intrusion of brackish bay water or unflushed connate water of similar chemical character (figs. 15 and 17). This water is of the sodium chloride type, and the content of dissolved solids is greater than in the water farther up the valley.

SUITABILITY OF WATER FOR DOMESTIC, INDUSTRIAL, AND IRRIGATION USE

Excepting some water from the Petaluma formation and from that portion of the southern part of Petaluma Valley in which the ground water is contaminated by saline water, ground water in Petaluma Valley generally meets the standards set up by the U. S. Public Health Service (see p. 91) for drinking water. In uncontaminated waters the hardness ranges from about 40 to about 320 ppm and averages about 160 ppm ("moderately hard").

For many industrial uses, the ground water in Petaluma Valley would be objectionable because of hardness. For cooling purposes, the temperature of the principal water body, which averages about 63° F in shallow wells, is generally satisfactory.

Uncontaminated water in the principal water body is generally suitable for agricultural uses. (See p. 92 for general criteria.) Locally, especially in some deep wells, the percentage of sodium may exceed 50; but only a few of the waters for which analyses are available have sodium percentages that are dangerously high for irrigation water; and generally it is feasible to counteract the undesirable effect of the sodium by applying agricultural gypsum.

The capacity of plants to tolerate chloride varies considerably, so that the maximum permissible chloride concentration in irrigation water is dependent to some extent on whether the crops are adapted to the soil and climate of the area, as well as on the local soil-drainage conditions. The highest chloride concentration in water used for irrigation in upper Petaluma Valley is 362 ppm (well 5/7–34G1, September 1954). This concentration is far below a maximum permissible concentration for irrigation of pasture grasses, the most generally irrigated crop in the area, as waters containing more than 1,000 ppm of chloride have been used for irrigation in Sonoma Valley. During 1950, W. Q. Wright successfully irrigated a small test plot of Birdsfoot trefoil on reclaimed marshland soil in the southern part of Petaluma Valley near well 3/6–5A1; he used water having a chloride concentration of about 3,400 ppm. In the lower part of Petaluma Valley numerous wells yield water that contains more than 1,000 ppm of chloride, and some water containing more than 3,000 ppm of chloride is used for watering stock. In Australia (Calif. State Water Pollution Control Board, 1952, p. 154) it has been found that cattle may drink water containing 5,000–7,000 ppm of sodium chloride before suffering detrimental effects, and that adult sheep may safely drink water containing as much as 10,000 ppm of sodium chloride. However, water containing more than 5,000 ppm of sodium chloride may reduce the milk production of dairy cattle.

In Petaluma Valley, water containing large amounts of boron are known to occur only in the Petaluma formation. In the principal water body the highest concentrations of boron that have been reported are 1.1 ppm and 0.64 ppm, in wells 5/7–34A2 and 5/7–34G1, respectively. Inasmuch as water from these wells has a relatively high concentration of chloride, and because of the proximity of tidal Petaluma Creek, the greater part of the boron may have been introduced by encroaching saline water from San Francisco Bay.

PRINCIPAL GROUND-WATER BODY

The principal ground-water body comprises parts of the younger and the older alluvium and the Merced formation. The data are insufficient to define clearly the water quality in each formation beneath the alluvial plain in the northern part of Petaluma Valley, so that only the general quality within the water body as a whole has been considered. Water in the younger and the older alluvium is probably of similar character because of its essentially free movement within the body.

For study purposes, most complete analyses were plotted on a trilinear water-analysis diagram (fig. 15). On this diagram, analyses 5, 6, 9, 10, 11, 12, 17, and 18, which have been plotted on the lower left-hand area of the diamond portion of the diagram, are about typical for the water in the principal water body. Those plotted in the upper part of that sector are of calcium magnesium bicarbonate water, and those in the lower part are of sodium bicarbonate water. (See p. 90.) When analyses of water from a common water body are plotted in both the upper and lower parts of the lower left half of the diamond diagram (fig. 15), it is generally indicated that base exchange occurs in the water body. Figure 15 shows that, in general, the sodium percentage increases with depth in the water body; it is inferred that calcium and magnesium ions in the ground water are exchanged for sodium ions contained in fine-grained deposits with which the ground water comes in contact. Thus, in general, a softer water can be obtained from wells screened only in the deep water-yielding strata than from those tapping shallow deposits. On figure 15 a comparison of analyses numbered 9 and 5 demonstrates this phenomenon. Some of the analyses plotted on figure 15 appear to deviate from the above conditions; for example, numbers 11 (well 5/7–28A3, 280 feet deep) and 12 (well 5/7–28H1, 483 feet deep). In some cases the deviations can be explained by differences in perforated intervals. Concerning the above two wells, it is suggested that most of the yield of the deeper well may be contributed by a shallow zone;

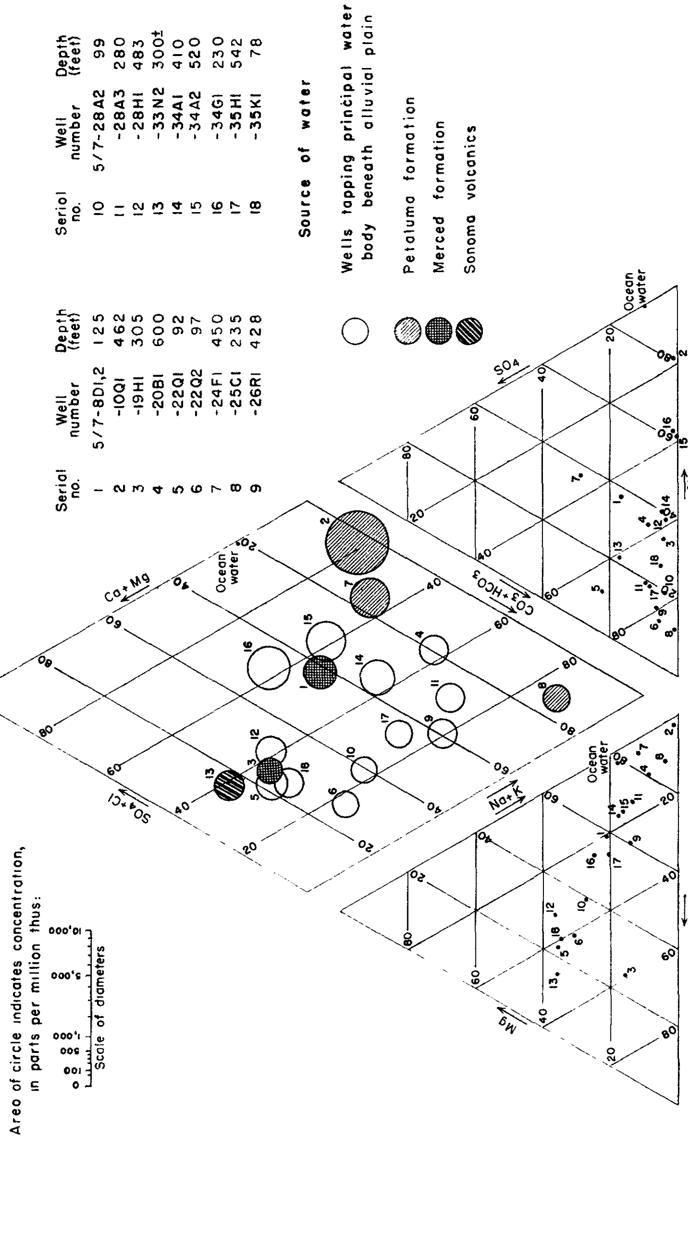

FIGURE 15.—Diagram showing the chemical character of ground waters in the Petaluma Valley area, California.

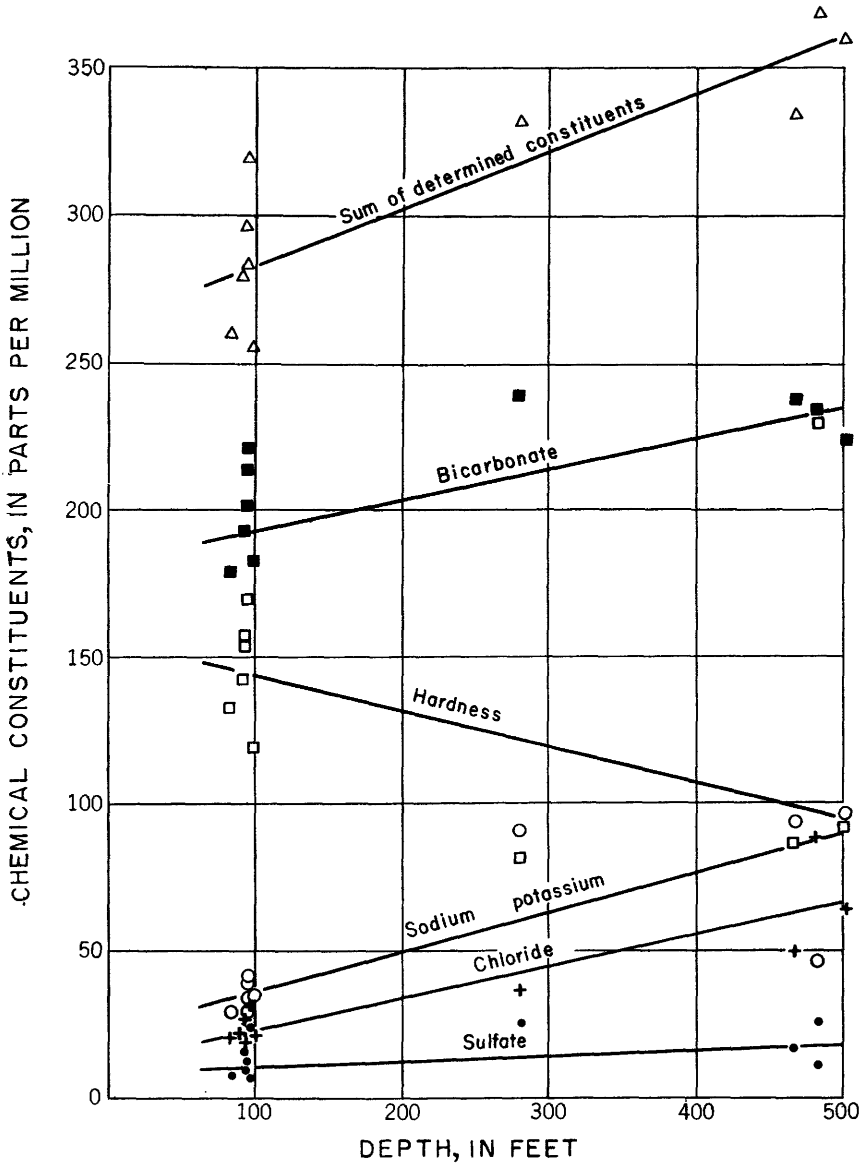

FIGURE 16.—Variation of chemical constituents with depth in water from ten closely spaced wells in the principal water body in the Petaluma Valley area, California.

whereas the well of intermediate depth may be supplied principally from strata near its bottom.

Figure 16 illustrates the differences in chemical character of water in the principal water body at different depths. These differences suggest that chemical changes in the water occur as the water moves downward or laterally at depth beneath Petaluma Valley. The dissolved solids, bicarbonate, sodium, and chloride increase with depth. On the other hand, the hardness decreases, and the amount of sulfate changes very little. The decrease in hardness and increase in sodium is inferred to represent natural softening by base exchange.

The chemical character of water from deep well 5/7–20B1 and from several others differs slightly from that of water from most deep wells. Possibly the difference is due to admixing of waters from the Petaluma formation and other, older, formations, either directly through the wells or indirectly by leakage of water from the older formations into this principal water body.

Analyses 14, 15, and 16, (fig. 15), which have been plotted between other analyses of water from the principal water body and analyses of marine or connate water, indicate contamination by brackish water. Figure 17 shows graphically three analyses of water samples collected in 1950, 1951, and 1954 from well 5/7–34A2 (analysis number 15). It is a gravel-packed irrigation well, 520 feet deep and about 0.7 mile north of Petaluma Creek. The analyses suggest that a progressive deterioration of the quality of the water has occurred locally in the water body, probably as a result of the relatively intensive local ground-water development. This development causes a seasonal depression of water levels below sea level, thereby inducing recharge to the aquifer from the brackish water of tidal Petaluma Creek. The analyses (table 25) show that from August 21, 1950, to February 26, 1954, the chloride concentration increased from 216 to 325 ppm, hardness from 150 to 205 ppm, and dissolved solids (excluding silica) from 404 to 721 ppm. The ratio of the equivalents per million (epm) of calcium to the equivalents of magnesium (calcium-magnesium ratio) shifted from 1.05 to 0.86 in the same period. A shift in this ratio showing an increased proportion of magnesium has been used as a criterion indicating contamination by water similar to sea water. (See Piper and Garrett, 1953, p. 88–90.)

In gravel-packed irrigation well 5/7–34G1, 230 feet deep and about 1,000 feet closer to Petaluma Creek than 34A2, the concentration of chloride increased from 310 ppm on August 27, 1951, to 362 ppm[20] on May 20, 1954; hardness increased from 320 to 358 ppm; dissolved solids (excluding silica) increased from 735 to 818; and the calcium-magnesium ratio changed from 0.94 to 0.98. The latter change is not diagnostic of sea water and it is possible that well 34G1, even though closer to Petaluma Creek than is well 34A2, is being contaminated from a different source. Sources to be considered are the Petaluma formation and the Franciscan group, from which water might be

[20] An analysis of water collected from well 5/7–34G1, August 22, 1954, showed the following: Chloride, 425 ppm; hardness, 448; dissolved solids (excluding silica), 909; calcium-magnesium ratio, 1.10.

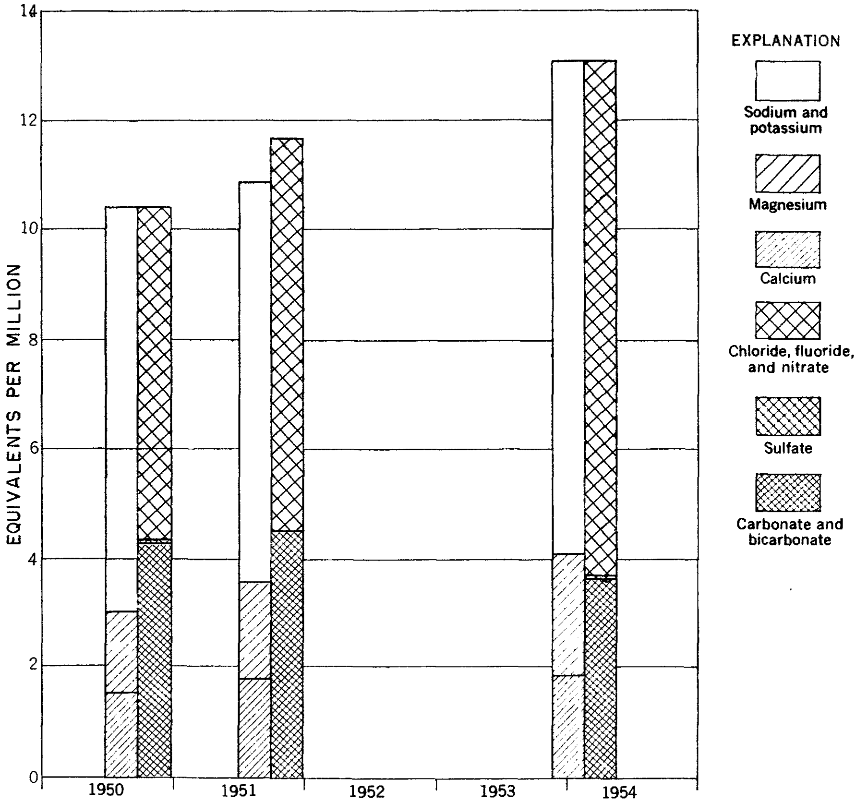

FIGURE 17.—Changes in quality of water in the principal water body in Petaluma Valley, as indicated by three analyses for well 5/7-34A2, near Petaluma, California.

moving up into the principal water body owing to the reduced hydrostatic head in the heavily pumped area. On the other hand, a change as small as from 0.94 to 0.98 does not rule out Petaluma Creek as a source.

Water from well 5/7–35K1, 78 feet deep and located about 0.8 mile from Petaluma Creek, showed the following changes from May 26, 1947, to May 20, 1954:[21] Chloride increased from 42 to 47 ppm, hardness from 214 to 242 ppm, dissolved solids from 337 to 423 ppm, and calcium-magnesium ratio from 1.14 to 1.68. The latter change is the reverse of what normally occurs when water quality deteriorates because of sea-water encroachment. It is possible that the changes reflect progressive changes caused by deep penetration of irrigation water or of rain that leaches from the soil the salts accumulated by evaporation of irrigation water.

[21] An analysis of water collected from well 5/7-35K1, August 22, 1954, showed the following: Chloride, 42 ppm; hardness, 224 ppm; sum of dissolved solids, 386; calcium-magnesium ratio, 1.26.

MERCED FORMATION

Analysis 3 (fig. 15) from well 5/7–19H1, which is 305 feet deep, is fairly typical of water in the Merced formation. It is of a calcium bicarbonate water having a hardness of 190 ppm. The percent sodium is only 25, which suggests that the character of the deposits is not conducive to base-exchange softening of the contained water. Analysis 1 is of a blend of water from wells 5/7–8D1 and –8D2, which presumably tap the Merced formation. However, the position on the diagram (fig. 15) and the higher sum of dissolved solids than normally is found in water from the Merced formation suggest that the wells may tap water also in the Petaluma formation. Partial analyses of waters from wells tapping the Merced formation in the southern part of Petaluma Valley indicate that the concentration of dissolved solids is slightly higher than in the northern part, possibly a result of slightly less rainfall or less thorough flushing of the formation.

PETALUMA FORMATION

In the Petaluma Valley area, water in the Petaluma formation has a considerable range in quality, depending on the hydrologic conditions of occurrence, which in turn depend largely on the local structural and stratigraphic relations. Generally, the dissolved solids content is relatively high, commonly 600 ppm or more, and some water is unpotable because of excessive sodium, chloride, and sulfate. The concentration of chloride is known to be as high as 2,400 ppm. The concentration of boron is as high as 7 ppm in water from some deep wells in 5/7–24. The occurrence may be related to faults, which are numerous in the Petaluma formation, or to connate waters.

Analyses 2 and 7 (fig. 15) for wells 5/7–10Q1 and 5/7–24F1, respectively, plot near an analysis of ocean water, suggesting that water in the Petaluma formation is locally contaminated by water of connate origin. Analysis 8 shows that water from well 5/7–25C1, which taps the Petaluma, is of the sodium bicarbonate type. By comparison with analyses 2 and 7, analysis 8 indicates that fairly thorough local flushing of the formation has occurred, and the water is similar to water in the Merced formation except that it has undergone considerable base exchange. Thus, in wells tapping the Petaluma formation, water of a wide range in quality can be expected to occur.

Partial analyses of water from deep abandoned oil-test well 5/6–29R1, which penetrates about 1,000 feet of the Petaluma formation, show a chloride content ranging from 2,400 to 2,530 ppm. This well has a head slightly above the land surface, about 100 feet above sea level, indicating a potential threat of contamination of the freshwater body by upward leakage. However, impermeable beds may largely impede any substantial upward movement into the overlying formations tapped by water wells. Deep test holes or wells should be properly plugged to prevent upward circulation of water of poor quality into the zones tapped by wells.

RELATION OF SPECIFIC CONDUCTANCE TO SUM OF IONIZED CONSTITUENTS

A curve showing the relation of specific conductance to the "sum of ionized constituents" [22] was plotted for ground water in the Petaluma Valley area on the basis of 26 fairly complete analyses (fig. 18 and table 25). The equation of the average curve is

$$S=0.55\ (K\times 10^6)$$

where S equals the sum of principal ionized constituents (calcium, magnesium, sodium and potassium, carbonate, bicarbonate, sulfate, chloride, nitrate, and fluoride) in parts per million and $K\times 10^6$ equals the specific conductance in micromhos at 25° C. The span of the analyses suggests that the maximum deviation is about 9 percent. Ground water contaminated by sea water has been plotted to the left of the average curve, so that the conversion factor becomes less than 0.55; however, within the range of the plotted graph no large error is introduced by using this factor. For some of the partial analyses (table 26) in which the results for specific conductance and chloride are high, the curve probably cannot be extrapolated without increasing the deviation considerably.

SURFACE WATER

Petaluma Creek, the principal stream in Petaluma Valley, is mainly an effluent stream in the area upstream from tidewater and therefore has essentially no effect on ground-water quality. In the tidal reach, some interchange of water does occur locally as a result of ground-water draft and tidal fluctuations, and the salty water in the creek intrudes the principal water body. Upstream from the tidal reach the low flow in the creek is maintained by and is representative of discharging ground waters. The analysis in table 15 shows that on January 28, 1954, the water had about equal concentrations (in epm) of calcium, magnesium, and sodium and potassium, and the principal anions (in epm) were bicarbonate (39.4 percent) and chloride (35.1 percent). The chloride concentration is higher than that in uncontaminated ground waters in the Merced formation and in the principal water body.

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[22] See footnote 17, p. 98.

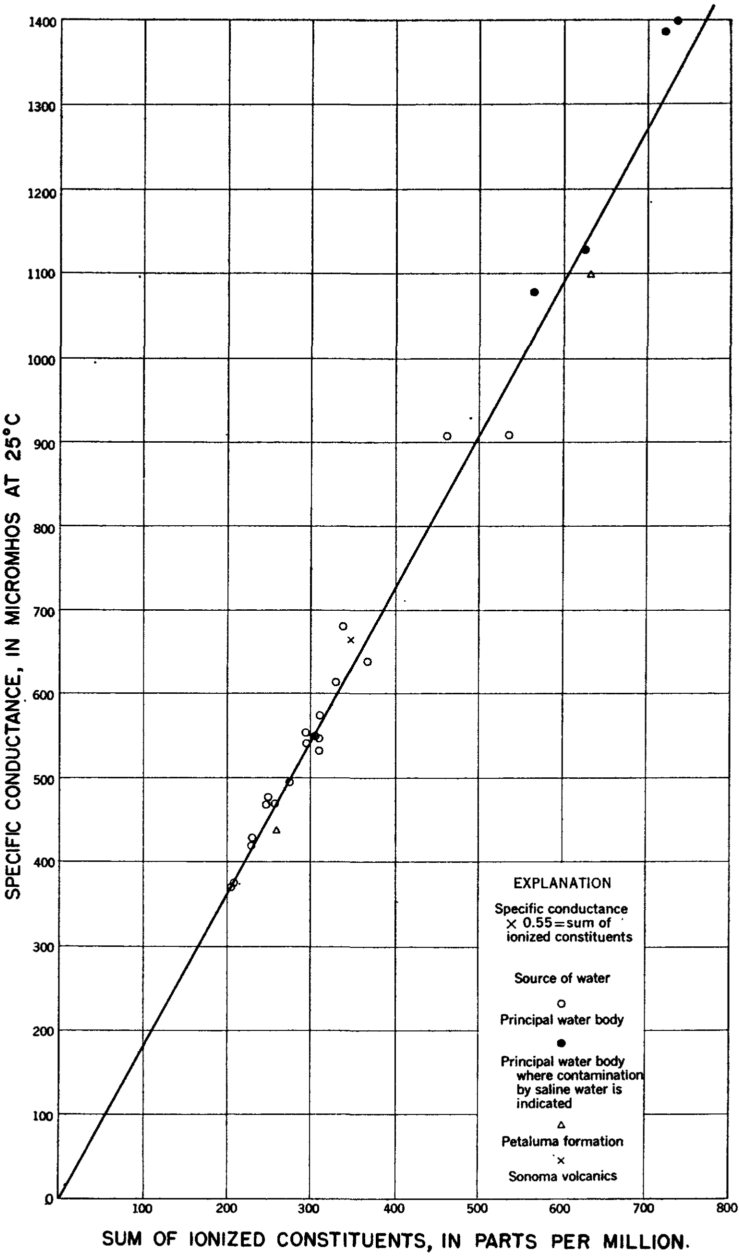

FIGURE 18.—Relation of specific conductance to sum of ionized constituents in ground waters in the Petaluma Valley area, California.

TABLE 15.—*Chemical analyses of surface waters in Petaluma Valley*

No.	Source	Date collected	Specific conductance (micromhos at 25° C)	Sum of determined constituents	Constituents in parts per million												Percent sodium
					Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Nitrate	Boron	Fluoride	Hardness	
1	Adobe Cr	4-1-52	265	[1] 175	24	9.2	15	----	----	----	----	----	----	0	----	98	25
2	do	1-28-54	289	187	25	11	15	4.3	128	0	13	14	5.1	0	0.1	108	22
3	do	3-11-54	244	163	19	11	12	4.3	93	16	9.6	10	1.0	.07	.2	93	21
4	Petaluma Cr	1-28-54	648	390	46	25	41	11	155	0	68	80	13	.16	.1	218	28
5	San Antonio Cr	1-28-54	323	177	13	20	14	4.9	110	0	22	26	7.6	.07	.1	115	20
6	Novato Cr	1-28-54	467	275	21	24	37	6.7	143	0	37	60	1.1	.08	.1	151	34
7	do	1-28-54	4,600	2,900	69	143	750	41	69	0	543	1,280	9.1	.51	.4	760	67

[1] Estimated.

1. In 5/7-35K, 15 feet west of well 5/7-35K1; flow, about 1 cfs.
2. At highway bridge in 5/7-35K, 350 feet upstream from (1) estimated flow, 3 cfs.
3. Same location as (2); flow, 3 cfs.
4. At Geological Survey gaging station 70 feet downstream from Corona Road Bridge in 5/7-20M; estimated flow, 10 cfs.
5. In 4/7-14Q at east side of bridge on U. S. Highway 101. Water clear; estimated discharge, 15 cfs.
6. In 3/6-19C at east side of bridge on U. S. Highway 101. Above tidal influence; estimated flow, 15 cfs.
7. In 3/6-21M at north side of bridge, on State Highway 37, 0.8 mile east of U. S. Highway 101. Estimated discharge, 100 cfs; murky appearance; apparently mixed with sea water.

Adobe Creek drains terrane of the Petaluma formation and of the Sonoma volcanics. The creek is mainly an influent stream and recharges the principal water body along much of its reach across the valley floor. The analyses in table 15 indicate that during the winter and spring the water is of the calcium magnesium bicarbonate type and is low in dissolved solids.

The analysis of water from San Antonio Creek (table 15) shows that the water is of the magnesium bicarbonate type. This type probably reflects the presence of serpentine and other ultrabasic rocks in the Franciscan group, which crops out over much of the drainage basin of San Antonio Creek.

Analyses 6 and 7 (table 15) are of samples of water collected from two different points along Novato Creek. Analysis 6 shows that the water above tidal influence is of the bicarbonate type, having magnesium as the principal cation (in epm, 41 percent) and having a relatively high percent sodium (34 percent). Analysis 7 is of water collected about 0.6 mile upstream from San Pablo Bay and suggests that considerable mixing of creek and bay waters occurs in the lower reach of the creek.

STORAGE CAPACITY

The area for which ground-water storage capacity was estimated in the Petaluma Valley area is essentially that underlain by the younger and the older alluvium as shown on plate 2. It includes the entire area of these deposits from the head of the valley near Penngrove southward to a locality about 2½ miles southeast of the city of Petaluma, where, on figure 3, a line was drawn across the valley to indicate the southern boundary of the area. This line coincides with a natural constriction of the valley between bedrock hills; it is near what would be the normal limit of tidewater in Petaluma Creek, if the channel had not been dredged; and it coincides roughly with the 1950 upstream limit of occurrence of brackish water in wells. The large alluvial area south of the boundary is excluded because, over its greatest part, it either now contains brackish water in at least some zones or it is subject to ready infiltration of the marsh water. Vertical boundaries were used for the storage units because the alluvium is bordered nearly everywhere by unconsolidated deposits which are water bearing and which supply water to wells near the edge of the alluvial plain.

The area for which ground-water storage capacity was estimated, as shown on figure 3, is divided into two units. Unit *P1* consists of the main Petaluma Valley and its small tributaries, and is bounded on the north by the Corona road crossing of the narrow valley neck about 1 mile south of Penngrove. Unit *P2* consists of the small valley area lying east of Penngrove and north of the Corona road. This area is contiguous with Petaluma Valley, but the yields of wells are much lower.

The methods used to derive the storage estimates are the same as those described for the Santa Rosa Valley area. A total of 39 well logs were used, 30 in storage unit *P*1 and 9 in unit *P*2, to obtain the percentages of the different types of material; and the specific-yield values assigned to the six categories in the Santa Rosa Valley area (p. 103–104) were used in the Petaluma Valley area. Table 16 shows the estimated gross storage capacity in the Petaluma Valley area.

Although the procedures followed in deriving the storage estimate warrant the reporting of the values as shown in table 16, it should be understood that for practical use the estimates are approximate and are for gross rather than usable storage.

The principal factors affecting the usability of the storage are the ease with which the deposits might be dewatered by means of

TABLE 16.—*Estimated gross ground-water storage capacity, in acre-feet, in the Petaluma Valley area* [1]

Ground-water storage unit	Surface area (acres)	Depth zones							
		10–50 feet		50–100 feet		100–200 feet		All zones	
		Average specific yield (percent)	Storage (acre-feet)	Average specific yield (percent)	Storage (acre-feet)	Average specific yield (percent)	Storage (acre-feet)	Average specific yield (percent)	Storage (acre-feet)
P1, Upper Petaluma Valley	11,100	10.9	48,400	10.7	59,400	8.1	89,900	9.4	198,000
P2, Penngrove	950	5.8	2,200	5.2	2,500	5.6	5,300	5.6	10,000
Total	12,050	10.5	51,000	10.3	62,000	7.9	95,000	9.1	208,000

[1] Storage for each depth zone has been rounded to nearest 100 acre-feet; totals rounded to nearest 1,000 acre-feet.

wells, the ease of recharge and availability of water for recharge, and the maintenance of water quality and prevention of salt-water encroachment. Although relatively high specific yields were obtained for the larger unit, the yields of wells in Petaluma Valley are very low, by comparison with those in some other areas, owing to the predominance of fine-grained materials in the deposits; thus, dewatering an appreciable amount of the storage volume might be difficult to accomplish within a short period. However, wells specifically constructed for dewatering the deposits above a depth of 200 feet might have considerably higher yields than the largest capacity wells now in use.

Recharge is accomplished by infiltration of the alluvial deposits by rainfall and stream water, and by infiltration of rainfall in those parts of the Merced formation that are contiguous with the valley and in which the ground water is in hydraulic continuity with that in the alluvial deposits. Recharge probably proceeds slowly; considerable time would be required to recharge, by natural means, deposits that had been dewatered to a depth of 200 feet. Most of the trough of Petaluma Valley lies between sea level and an altitude of 35 feet. Therefore, without providing some artificial barrier to the inflow of bay water from the south, utilization of the full storage would be unfeasible, as the depression of water levels necessary to utilize the storage would ultimately result in encroachment of bay water. At present the quality of the water is good throughout all except a small part of the area for which storage was calculated.

It is known that deep wells in the Petaluma formation locally reach water of poor quality. Whether large withdrawals and depletion of storage would cause this water to move up into the principal water body is not known.

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TABLES OF BASIC DATA

Tables of basic data consist of 11 tables (tables 17–27) comprising much of the data available for the wells that were canvassed during the investigation for this report. For convenience of the reader, data are presented by areas, the Santa Rosa Valley area being separated from the Petaluma Valley area. A brief description and explanation of the symbols used is given below.

DESCRIPTION OF WATER WELLS

Tables 17 and 23 present descriptive data most of which were gathered during the years 1949–52, on 970 water wells in the Santa Rosa Valley area and 180 water wells in the Petaluma Valley area respectively. Included are most irrigation, industrial, and public-supply wells that were in use at the close of the field canvass, and a large number of domestic, stock, and other wells for which logs, chemical, and other data were available. Locations of wells and springs are shown on plate 1.

Year completed.—Given in well logs or by owners. The year of original construction is reported for all wells, including those that have deepened since original construction.

Altitude of land-surface datum.—Altitude of the average land surface at the well. Most altitudes were obtained by interpolation from topographic maps having a contour interval of 25 feet and, generally, are reported to the nearest 5 feet, except where supplemental data on altitudes enabled closer interpolation. Altitudes of wells on the Sears Point 7½-minute quadrangle map (lower part of Petaluma Valley), which has a contour interval of 5 feet and altitudes of a few wells on the Petaluma NE quadrangle (NE¼ of the old Petaluma 15-minute topographic quadrangle map) are reported to the nearest foot. The altitudes of 5 wells in Petaluma Valley, 4 of which were used for periodic water-level observations, were determined by spirit leveling and are reported to the nearest one-tenth of a foot. Altitudes of wells in the vicinity of Santa Rosa Naval Air Base were taken from a map having a contour interval of 1 foot, and few altitudes determined by altimeter are reported to the nearest foot.

Depth.—Depths shown to the nearest foot were reported by owner or obtained from a drillers' log; those shown to the nearest one-tenth of a foot were measured by the Geological Survey.

Type of well and diameter of casing.—"Type of well" refers to method of construction and is indicated by symbol, as follows: B, bored (augered); D, drilled; Dug, dug; G, gravel-packed. For rectangular dug wells the largest dimension is listed. Where more than one casing size is used, the largest and the smallest are listed in that order.

Water-yielding zone or zones open to well.—Only the material that is opposite to or appears to be in hydraulic connection with a perforated interval, or is otherwise open to the well, is listed. All the water-bearing material is listed for gravel-packed wells, although for some wells it was necessary to consolidate or generalize the driller's description to fit the table. If perforation data are not available this column is left blank. Where only the number of feet of casing perforated is known, this figure alone is given. Bottom-hole data are given only where perforation data are known or the well is known to have an open-end casing with no perforations, as for some domestic wells in the Merced formation. Data for the uncased parts of wells in consolidated or semiconsolidated rocks are given. The material is reported in the order of the relative amounts present, the predominant materials being reported first. The geologic formation or formations from which the well is judged to obtain its water are given where possible. Symbols used are the same as those on the geologic map (pl. 2).

Water level.—All water levels and dates of measurement are listed for wells in which no more than 5 measurements were made. If 6 or more measurements were made in a single well the initial measurement is listed and the other measurements are given in tables 18 and 24. Measurements by the Geological Survey are referred to the "land-surface datum." Measurements made by the driller or owner are indicated by footnote and are reported verbatim, generally to the nearest foot. Not all these latter measurements are referred to the "land-surface datum."

Temperature.—Temperature of the pump discharge was measured at land surface with a mercury thermometer.

Type of pump and horsepower.—C, centrifugal; J, jet; L, lift; P, pitcher (suction); T, turbine; Ts, submersible turbine. The numeral indicates the rated horsepower of electric motors. "Gas" and "Wind" indicate that the source of power is a gasoline engine or windmill, respectively.

Pump discharge.—Rate at which the plant pumps under normal operating conditions (usually not the same as the "rated capacity"). Most of these data are reported by the owner or operator.

Results of tests.—The drawdown (pumping level minus static level) listed for most wells is the approximately stabilized drawdown produced by the bailing or pumping rate shown. Yields reported by the driller in gallons per hour have been converted to gallons per minute, rounding to the nearest whole number where necessary. Most of the bailer tests are for incompletely developed and partially perforated wells drilled for domestic use and, in general, probably do not indicate true aquifer performance.

Use.—A, abandoned and destroyed; D, domestic; Dy, dairy; Ind, industrial; Irr, irrigation (more than 5 acres); irr, irrigation (less than 5 acres); O, orchard; PS, public supply; RR, railroad; S, stock; Sw, swimming pool; U, unused.

Other data available.—Data available in the files of the Geological Survey. Most of the data are given in other tables of basic data. C, chemical analysis; Cp, partial chemical analysis; E, electric log; L, driller's log; W, additional water-level measurements.

PERIODIC WATER-LEVEL MEASUREMENTS IN WELLS

Tables 19 and 24 contain records of periodic water-level measurements made in 53 wells in the Santa Rosa Valley area and in 12 wells in the Petaluma Valley area from 1949 to April 1953. Except where noted, all measurements were made by the Geological Survey. Water levels are reported as depth below or above (+) land-surface datum. Levels that depart appreciably from static levels are not given, except where several pumping levels that may be compared are available. Distances of wells from roads or streets are measured from the centerline. Measurements are being continued in selected wells.

ANALYSES OF WATER

Tables 20 and 25 contain chemical analyses and tables 21 and 26 partial analyses of water. Table 20 contains analyses, 47 complete and 11 incomplete, of samples of water from 52 wells and 1 spring in the Santa Rosa Valley area; table 25 contains analyses, 29 complete and 3 incomplete, of samples of water from 27 wells and 1 stream in the Petaluma Valley area. The incomplete analyses include determinations and the three principal cations, and also the chloride and boron ions, and the hardness and conductivity; complete analyses include determinations of the three principal cations and anions and of other constituents, depending upon the source or purpose of each analysis. The partial analyses include specific conductance and determination of the chloride ion and the hardness.

Samples obtained from the Sonoma County Farm advisor were of water collected by personnel in the Farm Advisor's office or received from the well owner and transmitted to the University of California, Berkeley, where the analyses were made by the Division of Plant Nutrition, under the direction of J. C. Martin. These analyses were made primarily to determine the agricultural suitability of the water and the concentration of each constituent of most samples is reported to the nearest 5 ppm.

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The sum of determined constituents is the arithmetic sum of all constituents determined, with the following qualifications: (1) for all analyses except those indicated by the symbol "UC," bicarbonate was converted to carbonate equivalent by dividing by 2.03, and because analyses made by the University of California were somewhat approximate, bicarbonate was halved to convert to carbonate equivalent before summing constituents; (2) for many samples, boron and phosphate were not determined, and the standard practice of adding them only if they exceed 1.0 ppm was adopted. For many analyses, the figure for the sum of determined constituents as computed by the Geological Survey may differ from the figure for total dissolved solids listed on the original analyses, owing to slight differences in the manner in which the sum was determined; for some analyses, the original figure may represent total solids by evaporation.

With the exception of analyses by the Geological Survey and some by the University of California, most of the results for sodium were obtained by subtracting from the sum of the anions the sum of calcium and magnesium in equivalents per million, and multiplying the difference by 23, the combining weight of sodium. The value reported, therefore, includes the equivalent of the potassium concentration also, as sodium, as well as any error in the analysis.

For the University of California analyses, the sum of determined constituents and, in most cases, the hardness were computed by the Geological Survey. Percent sodium and sum of determined constituents were computed by the Geological Survey for some Brown and Caldwell analyses and for all California Water Service Co. analyses.

Because of the diversity among analyses in constituents determined the sum of determined constituents must be used only as a basis for general comparison of water.

The type of water as designated in this report is determined from the relative amounts, in equivalents per million, of the principal ionized constituents of the water. It does not take into account the silica concentration. For example, if the concentration of sodium makes up more than 50 percent of the total anions and bicarbonate makes up more than 50 percent of the cations, the water would be classified as a "sodium bicarbonate water" ($Na\text{-}HCO_3$). In a bicarbonate water in which calcium, magnesium, and sodium were present in about equal concentrations, the type would be given as "Ca, Mg, $Na\text{-}HCO_3$," the cations being listed in order of relative concentration.

DRILLERS' LOGS OF WELLS

Tables 22 and 27 contain drillers' logs: table 22, logs of 103 water wells and 1 oil-test hole in the Santa Rosa Valley area selected from about 900 logs collected during the investigation, of which 700 were located in the field; table 27, logs of 17 water wells in the Petaluma Valley area selected from 150 wells, of which 120 were located in the field. Most of these logs are available for inspection in the office of the Geological Survey or of the California State Department of Water Resources in Sacramento, Calif. Included in the tables are all logs shown on the geologic cross sections and additional logs to give general coverage of the area. The logs, as reproduced here, are in the same form as they were received from the drillers, except for minor changes in spelling and punctuation, and, in some logs, rearrangement of descriptive terms. In a few logs, explanations or interpretations of the drillers' terms have been entered in parentheses. Data on perforations and yield appear in brackets immediately above some logs. Stratigraphic assignments have been made where possible.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 5 N., R. 7 W.																		
5/7- 6E1	L. Haberer	1949	105	115	D 8				QTm	6- ?-49	[1] 37		J 1	20	23	26	D, S	L.
6E2	do	1915	105	[2] 100	D 6				do	12- 8-49 4- 4-51	17.48 9.10						U	
T. 5 N., R. 8 W.																		
5/8- 1B1	Otani Brothers.	1939	125	261	D 8	129 252	39 4	Gravel do	QTm do	5- ?-39	[1] 23		T 5		25	117	D, irr	L.
1B2	M. Ortesky	1948	115	90	D 8					11- ?-48	[1] 26		J 1		25	15	D	L.
1F1	D. Vourvoulis	1942	150	172	D 8	114	58	Clay and boulders.	QTm	9- ?-42	[1] 37		L		20	16	D	L.
1H1	R. H. Companey.	1937	125	232	D 8	151 224	25 6	Clay and gravel. Slightly cemented sand and gravel.	do do	12- 8-49 4- 6-51	126.56 97.6		L 3				D, PS	L.
1J1	Faletti	1948	135	290	D 8	44	5	Cemented gravel.	do	2-16-50 4- 6-51	33.97 26.17		J	30	18	[3] 120	D	L.
1L1	Mrs. Reeves	1945	240	253	D 8				do	10- ?-45 3- 2-50 4- 6-51	[1] 70 84.7 79.26		L		5	30	D	L.
1M1	J. Witmer	1948	200	118	D 8				do	6- ?-48	[1] 35		J 1		7½	65	D	L.
1Q1	C. Reiger	1939	160	18	D 8				do	9- ?-39 2-15-50 4- 6-51	[1] 100 100± 35.22		L		10	60	D	Cp, L.
3E1	T. Kane	1950	225	120	D 8	29	91	Gravel; sandstone; clay and gravel.	do	7-10-50	[1] 34				2½	36	D	L.

T. 5 N., R. 9 W.

5/9- 3A1	R. Matteri	1950	150	832	D 10			Uncased below 40 ft	QTm	8-30-51	[3] 94.9		T 10		60	[3] 95	Irr	
						3	743	Sandstone	do									
						749	3	Sandstone, streaks of rock.	do									
3G1	do	1950	85	1,010	D, G, 8-6	840	92	Clay and gravel; clay and boulders.	do	6- ?-50 8-30-51	(4) [3] 144	78	T 7½	140	140	[3] 144	irr	C, L.
						956	15	Coarse sandstone.	do									
3G2	do		85	110	D 8				do	8-30-51	[3] 78.3						U	

T. 6 N., R. 6 W.

6/6- 4J1	R. Heins	1949	405	190	D 10				Tsv	6- 6-49	[1] 7	72	T 15		280	[3] 80	D, Irr, S	L.
4Q1	J. W. Hicks	1950	375	56	D 6	7	49	Gravel; sand	QTge	6-18-50	[1] 15		J 1		5	30	D	L.
5E1	Mrs. Felsing	1940±	350	170	D 8				Tsv	7-26-50	(4)		T 3	[6] 10-15	[7] 100		Irr, PS, Sw	
5E2	do	1939	350	140	D				do				J 1	30			D, PS, Sw	
5L1	H. L. Morton	1926	350	107	D 8				QTge (?), Tsv	7-27-50	[3] 8.0	86	C 3		330	5	Sw	C.
6C1	H. Nygard	1949	425		D 8				do	7-27-50	(4)		J 1	[6] 200-250			D, irr	
6C2	Murry Oseplain	1949	450	115	D 8	90	25	Broken basalt	Tsv								D	L.
8E1	Bauer	1945	350	116	D 6				QTge	9-15-45	[1] 21		J 1		17	89	D	L.
8N1	M. F. Hellman	1948	325	490	D 12				QTge, Tsv (?)	7-26-50	[3] 98.45		T 15				Irr	Cp, L,
8P1	Hughson	1944	310	270	D 7				QTge	12-29-44 6-27-51	[1] 2 8.13		J 1		15	98	D	L.
9C1	J. Henno	1941	375	62	D 6	60	2	Gravel	do	8- 9-41	[1] 14		J 1		6	41	D	L.
9R1	I. B. Brown	1947	300	193	D 8	35	158	Clay and gravel, gravel.	do	12-? -47	[1] 46		J 2		30	34	D	L.
16B1	Miss I. Holt	1941	400	426	D 5				QTge, Tsv (?)	10-30-41 6-26-51	[1] 40 104.42	73	L 2		7	210	D	Cp,L.
16B2	J. G. Hamilton	1943	211	300	D 8				QTge	11-13-43 9-20-51	[1] 60 104.42		L 2		20	80	D	C,L
16H1	Glen Ellen Water Works.		300	210	D				QTge, Tsv (?)				L				PS	C.
16J1	Carback	1941	265	102	D 6	90	12	Sand	QTge	2-25-41 6-22-51	[1] 21 28.31		J ½		2½	59	D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 6 N., R. 6 W.—Continued																		
6/6-16J2	Panassie	1947	260	280	D 6					5-20-47 6-27-51	(1, 4) 10.39		J ½		8	70	D	C,L.
16J3	E. Massey	1946	235	101	D 6	89	12	Sand	QTge	8-10-46	[1] 21						D	L.
16J4	do	1946	235	90	D 6	84	6	"Quicksand"	do	8-10-46	[1] 20		J ¼				D	L.
16Q1	F. Steiger	1940	235	360	D 6	260	100	"Shale"	Tsv	6-22-51	48.00		L 1½		4	[3] 200	D	L.
16Q2	A. Berkland	1944	270	117	D 8	50	13	Sand	QTge	7-22-44 6-22-51	[1] 18 14.73		J ½		4	42	D	L.
17A1	H. Purcell	1949	290	150	D 8				do	6-30-49 6-26-51	[1] 18 15.5		J 1		10	72	D	L.
17A2	R. Horne	1949	295	40	D 6	32	18	"Shale" and gravel.	do	6- 2-49	[1] 17		J 1		17		D	L.
18C1	W. Bruning	1946	675	49	D 6	48	2	Gravel	Tsv(?)								O	L.
18E1	Sonner	1941	925	225	D 6	204	21	"Shale" rock	Tsv	5-27-41	(1, 4)						D, irr	L.
18E2	W. Bruning	1945	975	214	D 6	175	5	Rock	do	9- 8-45 7-26-50	(1, 4) (4)		J 2	60			D, irr	L.
21B1	C. Pagani	1940	225	125	D 6	40	85	Soft "volcanic rock".	QTge(?)	6-26-40	[1] 9		T 5		50	41	Ind	L.
21B2	W. Baker	1946	275	240	D 6	192	48	Very porous "volcanic rock".	do	4-12-46	[1] 55		J 2		10	65	D,Sw	L.
21C1	H. C. Miller	1944	365	231	D 6								L ½				D	L.

T. 6 N., R. 7 W.

6/7–2J1	T. Plant	1941	995	358	D	335		Rock	Tsv	10–?–41	[1] 335				24		D, S	L.
3H1	Mr. Walker	1949	575	520	D, G 10–8				Qyal, Tsv.	4–19–50	1.97				[1] 20		U	L.
3Q1	W. Jacobs	1949	555	417	D, G 12–10	27 98 125	23 12 292	Gravel "Wash" gravel White ash	QTge do Tsv	4–19–50	[3] 55.0		T 40		1,200 1,500	[3] 55	Irr	L.
4B1	C. M. Powell	1950	440	609	D			"Dry hole"	Tsv, Tp.						11		A	L.
7E1	J. Hoeck	1949	240	278	D 8				Tsv	2–7–50 4–4–51	114.28 112.0		L 1½				D	L.
7E2			265		D 8					4–4–51	106.4						U	
7P1	A. J. Gambonini.	1949	155	150	D 6	8 109 127	16 3 2	Clay and gravel Cemented gravel. do	QTge do do	9–?–49	[1] 10		J 1½		10	70	D, S	L.
7R1	Z. Graves	1947	205	265	D 8				QTge (?)	1–25–50 4–4–51	26.14 [1] 21.49		J ½		5		D, S	L.
9P1	M. L. Rucker	1946	775	38	D 8			Volcanic rock	Tsv	4–20–50	[8] 1.62		J 5	167			Dy, Irr, S	
10A1	W. Jacobs	1920–1930	600	350	D 12					4–19–50	49.40		T 10				Irr	
10E1	Strawberry School District.	1949	525	112	D	95	7	Sand and gravel; sandy clay.	Tp (?)	4–?–49	[1] 24		J		12½	12	PS	L.
10P1	J. H. Furlongworth.	1948	575	74	D 8	55	15	Sand	do	7–?–48	[1] 8				30	32	D, S	L.
16D1	A. L. Papworth	1949	660	38	D 8				Tsv	3–28–51	6.50		J ¾				D, Irr, S	C.
17E1	G. L. Crane	1950	225	650	D 8–6					3–1–50 4–4–51	[7] 10 8.88		L		35–40	130	Irr	L.
18H1	Griffen	1947	195	145	D 8	8	86	Clay and gravel.	Qyal, QTge(?).	2–7–50 4–4–51	17.76 [8] 10.41		J				D	L.
18R1	H. G. Comstock.	1939	160	250	D					9–?–39	[1] 24		J 2		7	126	D, S	L.
19D1	A. T. Pomerlo	1949	115	108	D 8					6–?–49 1–25–50 8–8–50 4–4–51	[1] 9 10.31 [1] 12 9.73		J 1½		75	45	irr	L.
19N1	B. Brians	1951	117	340	D, G 12				QTge(?). TQm.				T 50	1,000			irr	
29P1	F. Riebli		200	185	D 10	1 127	103 58	Rock; clay and gravel. Decayed rock	Tsv do	8–3–44 11–29–49 4–4–51	[1] 2.5 8.00 9.70		J 2		51	12.5	D	C, L.
29P2	do		200	30	Dug				do	11–30–49 4–4–51	7.96 4.71		L				U	
30L1	Allie Crane		145	22.4	Dug 36				Qyal	9–29–49	13.87						U	W.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 6 N., R. 7 W.—Continued										
6/7-30M1	B. Brians	1947	120	104	D 8				QTge (?).	12-13-49	16.34		T 3		33	24	D, irr	Cp, L, W.
31A1	C. G. Cannon	1947	165	130	D 8	55 100 115	20 12 9	Gravel Cemented gravel; gravel. Gravel	do do do	12- 8-49 4- 4-51	44.17 15.88		J ½		18	33	D, S	L.
31G1	J. Equi	1945	135	508	D 12					11-29-49 4- 4-51	21.62 5.63				75	[3] 60	Irr	L.
31H1	do	1945	160	298	D 8				Qyal, QTge (?).	11-29-49	40.44		T 15	80			D, Irr, S	C, L.
31H2	do	1949	160	176	D					4- 4-51	12.70		Ts 5		50	155	S	
31J1	Lavio Brothers.	1939	135	280	D 12	45 103 170 218	49 37 28 56	Sandy clay and gravel. Clay and gravel; cemented gravel. Boulders; clay and gravel. Sand; sandstone; sand and gravel.	QTge (?). do do QTm	11-30-49	27.01		T 20	125			Irr	L, W.
31J2	do		135	57+	D 8				Qyal, QTge (?).	6-14-50	16.55	62	L, Wind				S	Cp, W.
31L1	Waldo Rohnert Co.	1948	135	79	D 8	50	25	Sand; gravel	do	6- ?-48 2-23-49 4- 4-51	[1] 13 3.83 1.75		L, Wind		20	54	S	L.
31R1	Lavio Brothers.		128	100+	D 10					9-30-49 4-12-51	46.45 19.23		J 5				D, Dy	

32M1	W. B. Hussey	1949	145	1,163	D 12					11-22-49 4- 4-51	24.87 9.28				70	[3] 200	U	L.
32M2	do	1942	150	200	D 6	190	10	Coarse sand					J 3	50			D, S	
33M1	J. Krauskoph	1946	185	317	D 8	294	21	Cemented gravel; gravel.	TP(?)	3- ?-46 12- 6-49 4- 4-51	[1] 115 134 77.4		L 3	25	25	6	D, Dy, S	L.
								T. 6 N., R. 8 W.										
6/8- 1G1	M. J. Bankhead.	1949	225	276	D 8				Tsv	1-24-50 4- 4-51	108.3 110.0		Ts		134	15	D	L.
2C1	A. F. Boyrie	1946	115	98	D 6				QTge	10- 6-49	15.2		J ½				D	Cp, W.
2C2	W. J. Lucus	1945	115	90	D 8	11	4	Sand and gravel.	do	8- ?-45 2-16-50	[1] 17 12.17		J 1		25	16	D	L.
						76	87	Sand	do	4- 4-51	9.81							
2D1	J. Fickel	1950	110	140	D 8	80	60	(perforated interval.)	do	2-21-51 4- 4-51	5.80 5.79		T 7½		200	8	Irr	L.
2D2	T. Fanning	1950	110	79	D 6	N 68	11	Coarse sand and gravel.	do				J				D	L.
2F1	G. Gustafsson	1945	110	75	D 8	48	27	Clay and gravel.	do	9- ?-45 2-16-50 4- 4-51	[1] 12 5.30 2.80		J 1		13	28	D	L.
2K1	McCoy	1948	110	60	D 8				do	6- ?-48 2-16-50 4- 4-51	[1] 9 4.61 3.48		J 2		30	11	D, irr	L.
						50	23	Gravel, clay and gravel.	do									
2K2	C. Mode	1949	115	102	D, G 6	92	101	Sand and fine gravel.	do				J 1				D	L.
2N1	Klist	1948	102	52	D 8				do	9- ?-48 2-17-50 4- 5-51	[1] 12 3.20 3.17				27	14	D	L.
2Q1	B. E. Roettger	1948	105	66	D 8				do	7- ?-48	[1] 21		J		20	33	D, PS	L.
3B1	Miss G. Mallory.	1950	110	60	D 6	51	9	Fine sand; coarse gravel.	do	9-21-50	[1] 24		J				D	L.
3D1	V. F. Tarrantino.	1940	103	70	D				do	1-24-50 4- 5-51	2.6 1.98		J¾				D, S	
3L1	G. W. Nelson	1951	95	57	D 8	51	6	Coarse sand	do	2- 7-51	[1] 6						D	L.
3L2	R. A. Hallman.	1951	95	57	D 8	43	14	Coarse gravel	do	2- 8-51	[1] 8						D	L.
3N1	M. C. McKinney.		95	188	D10				do				T 5				Irr	
3R1	B. Zappa	1951	100	123	D 8	120	3	Coarse sand and gravel.	do								D, S	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
								T. 6 N., R. 8 W.—Continued										
6/8-5E1	J. Beretto	1951	85	638	D, G 12–8	0	100	Silt and gravel; sandy silt; sand.	QTge	5-22-51	10 [1]	67	T 50	-------	600	140	Irr	C, L.
						160	260	Gravel; sand and gravel; sand.	QTge, QTm.									
						310	400	Sand; sandy silt and gravel.	QTm									
						410	460	Sand; sandy silt; sand and gravel.	do									
						480	638	Sand; sand and gravel; sandy silt.	do									
6C1	Doyle Estate	1944	85	80	D 8	------	------	------	QTm(?)	1-12-50 4-11-51	26.57 23.44	------	L 2	------	------	------	D, Dy	
7A1	M. A. Whitt	1949	80	133	D 7	------	------	------	do	------	------	------	P	------	------	------	D	L.
7D1	H. Neles	1949	70	410	D 12	------	------	------	QTm	------	------	------	T 40	------	------	------	Irr	L.
7H1	S. C. Bengston.	1949	75	70	Dug, D 8.	------	------	------	QTge	2- 9-50 4-11-51	7.31 5.34	------	J 2	30	------	------	Dy, irr, S	L.
7K1	C. E. Lichens	1947	70	340	D 8	0	260	Sand and gravel "fill"; gravel; sandstone.	Qyal, QTm.	3-22-50 4-11-51	3.21 3.80	------	T 15	350	------	------	Irr	L.
7P1	J. Chiorino	1947	95	346	------	305	41	Sandy clay; sand.	QTm	10- ?-47	31 [1]	------	J	------	10	41	D	L.
7P2	J. Kardohely	1925±	95	120	D	100	20	Hard sand; coarse sandstone.	do	3-22-50	10.65	63	L 1	------	------	------	D, irr	Cp, L, W.

8A1	J. E. Ascoop	1944	90	248	D	8	30	218	Sandy clay; sand; sandy clay and gravel; clay and gravel.	QTge, QTm.				J				D	L.
8B1	E. Castelli	1930	90	90	D	8	80	3	Gravel	QTge	9-29-50 4-11-51	19.97 9.33		J				D, S	L.
8H1	P. Muelrath	1948	90	96	D	8	88	8	Gravel	do				J 1	13			D,Dy,S	Cp, L.
8Q1	Gerald L. Smith.		75	200+	D	8				QTge, QTm(?).	9-29-49	17.38		L 1				D, S	W.
8Q2	do		75	10.9	D					QTge	9-29-49	8.84						U	W.
9B1	E. Gobbi	1938	90	105	D	8				do	2-24-50	[8] 9.90		J 2		40	30	D,Dy,S	L, W.
9J1	Wilkinson	1937	90	82	D	8				do	2-24-50 4-5-51	6.49 5.43		L		8		D	L.
9R1	M. Loscotoff	1937	95	100	D	8	60 96	2 4	Gravel do	do do	5-?-37 2-17-50 4-5-51	[1] 4 12.54 7.09		L 1		33	22	D, S	L.
9R2	L. Wright	1948	95	114	D	8				do	5-?-48	[1] 57		J		4	13	D	L.
10B1	J. C. Brickhouse.	1951	95	60	D	6	54	6	Coarse sand and gravel.	do	3-8-51	[1] 12						D, S	L.
10E1	C. Hansen, Jr.	1951	90	126	D	8	66	60	Fine sand; sand; coarse sand and gravel.	QTm (?)	2-3-51 6-25-51	[1] 8 10.67		J 1½				D	Cp, L.
10R1	W. A. Kinser	1948	95	89	D	8				QTge	9-?-48	[1] 14		J		20	29	D	L.
11G1	W. L. Ehlert	1948	100	62	D	8				do	6-?-48	[1] 9		J ¾		30	28	D	L.
11K1	Mrs. Rayburn	1938	100	66	D	6				do	2-15-50 4-5-51	2.12 3.05		L ⅛				D	L.
11K2	H. W. Connely.	1949	100	104	D	8	48		(Depth of perforations.)	do	2-15-50 2-21-51 4-5-51	1.45 0.86 2.20						D	
12C1		1939	115	102	D					do	6-?-39	[1] 20		L 1		25	50	D	L.
12J1	G. W. Price	1939	130	223	D	8				do	6-?-39 2-15-50 4-5-51	[1] 20 22.40 22.6		J ½		30	40	D, O	Cp, L.
12K1	W. H. Sprague	1950	120	205	D	6	40 100 185	20 20 20	(Perforated interval.) do do	do	2-24-50	14.50		J 1½		30		D, Irr	
12K2	do		120	28	Dug					do	2-24-50 4-5-51	9.80 5.21						U	
13R1	Waldo Rohnert Co.	1936	115	[2] 675	D	12				Qyal, QTge, QTm (?).	1-25-50	[9] 12.46		J 1½		580		D	L, W.
14L1	A. Faraudo	1942	95	99	D	6	70	29	Clay and gravel; gravel.	QTge (?).	6-?-42 2-16-50 4-5-51	[1] 9 1.78 1.18		C		25	7	D	L.
14L2	J. Earles	1945	95	81	D	8				do	2-?-45 2-16-50 4-5-51	[1] 5 1.97 1.13				20	13	D	L.
14M1	DeCarlo	1951	90	93	D	6	90	3	Coarse sand	QTge	2-14-51	[1] 12		J				D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 6 N., R. 8 W.—Continued										
6/8-15F1	J. Pedranzini	1950	95	725	D, G 12-8.	50	600	Silt and gravel; sandy silt; gravel; sand.	QTge, QTm.	3-27-51	11.53				[3] 500	85	Irr	L.
						680	45	Gravel; muddy clay and gravel.	QTm									
15J1	do		95	61.4	D 12				QTge(?)	9-29-49	7.12		J ½				S	W.
15J2	Tom Yasuda		95		D 8				do	2-16-50	3.25		J				D	
										4- 5-51	3.75							
15J3	do		95	166	D 12	65	11	Clay and gravel; gravel and clay.	QTge	3- 1-50	1.31		C				Irr	C, L, W.
						80	52	Clay and gravel.	do									
						147	16	Gravel	do									
15Q1	J. Pedranzini	1950	95	914	D, G 12-8.	60	190	Sand and gravel; silt and sand.	do	3-27-51	5.35		T 50		[3] 550	150	Irr	L.
						400	300	Silt, gravel, and redwood.	do									
15R1	do	1950	95	1,028	D, G 12-8.	20	310	Silt and gravel; gravel and sand; silt and sand.	do	3-27-51	2.25		T 40		[3] 600	100	Irr	L.
						350	10	Medium gravel	do	4- 1-52	3.65							
						380	440	Gravel; sandy clay; sandy clay and gravel; silt and gravel.	do	4-17-53	5.64							

16C1	L. Cerfoglia	1950	85	96	D 8	55 78	11 18	Coarse sand Sand; pea gravel.	do do	9-11-50	[1] 35						D	L.
16E1	Whitehead	1950	85		D, G 10					4-18-51	32.23		T 20				Irr	
16F1	George Holland.	1948	85	542	D, G 8					2- 7-50	12.32		T 20	650	650	86	Irr	
16F2	F. Leisen	1941	85	76	D 8				QTge	10- ?-41	[1] 8		J		23	42	D, S	L.
16J1	W. Garris	1945	90	136	D 8	105	31	Clay and gravel.	do	11- ?-45	[1] 15				40	31	D	L.
16K1	H. Schulze	1948	85	710±	D 12				QTge, QTm.	4-13-51	32.42		T 20				Irr	L.
16K2	Mrs. R. Brown.	1950	90	90	D 6	58	32	Packed sand; "quicksand"; "clay silt."	QTge(?)	6-25-51	31.2		J ½				D	L.
16M1	J. Peterson	1948	85	147	D 8	97	50	Sand; sandy clay; sand and gravel.	QTm	8- ?-48 2-17-50 4-13-51	[1] 22 36.82 [8] 39.1		J 1½		17	113	D, S	Cp, L.
16R1	J. Pedranzini	1947	90	568	D 12				QTge, QTm.	2-16-50	22.35		T 20		[7] 300	100	Irr	C, L.
[10] 16R1	do	1950	90	1,204	D 8-6	794 930 1,050 1,150	11 7 15 54	Gravel and sand. do Sandy cemented gravel. Clay and gravel; boulders.	QTm do do do	6-14-50 4- 5-51	[1] 130 11.52		T 20		[3] 315	152	Irr	L.
17H1	Mazzoni	1938	80	120	D 8					2-24-50 4-11-51 8-29-51	8.63 27.59 40.3		J				D	Cp.
17K1	B. Woodworth.	1949	140	210	D 10				QTm	2- 9-50	[3] 49.65		J 2				Dy, Irr	L.
17K3	Ben Woodworth.	1950	75	132	D 12	6 50	4 82	Gravelly sand. Pea gravel and coarse sand; sand.	Qyal QTm	4-11-51 4-24-53	([4]) ([4])	66	T 20	[6] 10 [6] 75	500	[3] 90	Irr	Cp, L.
17M1	G. S. Azavedo	1949	80	84	D 8	68	16	Gravel	Qyal(?)	8- ?-49 2-21-51 4-11-51	[3] 9 1.23 1.78		T 10	100			Irr	L.
18G1	E. Johnson	1950	80	52	D 8	25	27	"Quicksand"; small gravel.	QTm	11-29-50	[1] 10				12	20	D	L.
18Q1	Elmer Cox	1950	185	139	D 7½	61	78	Sandstone; gravel and sand; sand; gravelly clay.	do	3-30-51	44.61		J 2	10		70	D, S, Irr	L.
20A1	H. Paine, Jr.	1942	130	103	D 8	22	81	Sand; gravel; sand and gravel; sandy clay.	do	12- ?-42 2- 9-50	[1] 19 17.56		J 1		25	61	D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 6 N., R. 8 W.—Continued										
6/8-20B1	F. J. Sorgenstein.	1945	110	95	D 8	22	73	Sand; gravel	Qtm	8- ?-45 3-22-50 4-11-51	[1] 12 [9] 9.45 6.25		J	15	8	68	D, irr	L.
20G1	Mrs. Ramos	1948	120	199	D 8	140	15	Clay and gravel; gravel.	do	4- ?-48 3-22-50 4-11-51	[1] 53 15.8 [8] 18.20		J	11	9	44	D	Cp, L.
20G2	E. Casey	1948	120	239	D 8				do	7- ?-48	[1] 13				5	201		L.
20J1		1938	125	302	D 8	62 104 178	24 20 12	Sandstone; sand and fine gravel. Sand and gravel; sandstone. Sand	do do do	8- ?-38	[1] 40				5	160	D, S	L.
20M1	P. L. Brown	1947	185	178	D 8	165	13	Gravel; gravelly sand; sand.	do	10- ?-47 3-29-50 4-11-51	[1] 77 56.75 [3] 80.90		J 1½		20	31	D, S, irr	L.
20N1	C. E. Gloeckner.	1944	145	80	D 6	70	10	Gravel; sand	do								D, S	L.
20P1	T. Shideler	1949	125	189	D 8				do	1- ?-49 3-29-50 4-11-51	[1] 13 13.93 12.05		L		8	165	D	L.
20Q1	Hirooka	1948	135	316	D				do						18	[3] 125	D, S	L.
20R1	R. A. Hankla	1949	125	163	D 8				do	3- ?-49	[1] 25		J 1		10	75	D	L.
20R2	do	1949	120	120	D 8				do	11-29-48 3-15-50 4-11-51	[1] 14 2.79 2.78						U	L.
20R3	Lockman	1945	120	104	D 8	87	17	Sand and gravel.	do	7- ?-45	[1] 10				4	50	D	L.
21H1	Castagnasso	1930±	85	183	D 8					2-24-50 4- 5-51	[9] 33.58 25.90		J 3				D, S	

21J1	Mrs. M. Ahl	1946	80	160	D				Qyal(?) QTm.				J 7½	140			Irr, S	
21L1	David Linn	1948	100	181	D 8	155	26	Gravel; sandy clay; clay and gravel.	QTm	8- ?-48 3-21-50 4-12-51	[1] 22 25. 30 33. 80		J 5	33	20	110	D, S	L.
21L2	do	1930	95	120	D 8				do	3-21-50 4-12-51	0. 79 +. 10						U	
21N1	R. J. Theiller	1945	165	115	D 8				do	8- ?-45	[1] 23		J 1½		20	27	D, irr, O	L.
21N2	do	1945	160	172	D 8			"Dry hole"									A	L.
22N1	E. Ponica	1942	120	200	D 8-7	185	15	Sandy clay; gravel.	do	3- ?-42	[1] 25		J		38	33	D	L.
23C1	Cotati Seed Farms.	1931	95	438	D				QTge, QTm.								A	L.
23C2	Cotati Seed Co.	1936	95	300-350	D 12			(Perforated near 100 feet and below.)	do	2-15-50 4- 5-51	. 42 +. 88		C		375		D	C, L.
23L1	U. S. Navy (Cotati Auxiliary Landing Field.)	1943	95	183	D 12				QTge	2-17-50 4- 6-51	+. 04 +1. 55		L 1½		60	[3] 18	U	L.
						34	6	Clay and gravel; gravel.	Qyal (?).	7- 2-48	[1] 8							
25K1	B. Scharf	1948	115	80	D 8	46	35	Gravel; clay and gravel; clay and sand.	QTge (?).	1-25-50 4- 5-51	5. 05 [8] 4. 78		C		150	21	Irr, S	L.
25Q1	Northwestern Pacific Railroad Co.		115		D												RR	C.
25Q2	J. Santero	1948	115	51	D 8					9- ?-48 12-19-49 4- 5-51	[1] 11 9. 45 3. 45		J ⅓		2½	28	D	L.
25Q3	Sims	1948	115	60	D 8				QTge(?)	9- ?-48 12-19-49	[1] 10 6. 77		L		30	19	D	L.
26K1	D. Kennedy	1941	100	203	D 8				QTm				J				D	L.
26N1	Runyon	1947	105	246	D 8				do	9- ?-47 12-19-49	[1] 15 8. 55		J 1		42	18	D	Cp, L.
26N2	F. Tompkins	1945	150	290	D 8				do	7- ?-45 4- 5-51	[1] 65 51. 20		L		25	5	D	Cp, L.
26N3	C. R. Snider	1948	110	139	D 8				do	1948	[1] 21		J		30	28	D	L.
26Q1	M. Burmeister.	1938	105	170	D 8	160	4	Sand and little gravel.	do	3- ?-38	[1] 14		J 2		11	74	D, PS	Cp, L.
26Q2	Sonoma Mattress Works.	1939	105	120	D 8					4- ?-39	[1] 14				8	46	A	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
T. 6 N., R. 8 W.—Continued																		
6/8-27B1	J. Rebrestelli	1949	95	107	D 8	41	66	Sand and clay; sand and gravel; gravel.	QTm (?).	6- ?-49	[1] 16	------	J 2	------	16	80	D, irr, S	L.
27C1	E. S. Wilson	1937	95	184	D 8	------	------	------	do	10- ?-37 3- 3-50 3-30-51	[1] 10 [8] 16.15 13.35	------	J ¾	------	17	30	D, S	L.
27D1	P. O'Neil	1949	95	157	D 8	------	------	------	QTm	6- ?-49 3- 3-50 4- 6-51	[1] 19 .54 +1.35	------	J 3	------	50	21	D, irr, S	Cp, L.
27F1	J. Mossi	1948	100	61	D 8	------	------	------	Qyal (?).	11- ?-48 3- 3-50 4- 6-51	[1] 15 6.67 6.15	------	J 1	------	30	80	D	L.
27K1	Chertok	------	100	185	D 8	170	10	"Free" gravel; clay and gravel.	QTm	12-21-49 4- 6-51	10.00 3.95	------	J 1½	------	10	60	D	L.
27M1	R. Malarich	1948	115	79	D 8	------	------	------	QTm (?).	9- ?-48 3- 3-50 4- 6-51	[1] 13 3.51 4.75	------	------	------	30	22	D	L.
27N1	Henry Larsen	1951	120	146	D, G 10	12 80 168	58 51 10	Sand Gravel Cemented gravel.	QTm do do	4- 5-51	9.92	------	T 5	------	200	[3] 108	Irr	L.
27P1	do	1950	120	582	D 12	360 435 498	62 38 74	Sand; gravel Clay and "lots of gravel"; hard cement gravel. Gravel and streaks of clay; gravel.	do do do	4-21-51 4- 6-51	+0.14 [8] 13.3	------	T 5	30	100	------	Irr	L.

28E1	A. J. Peterson	1949	195	200	D 8-6	65	83	Sandstone; clam shells.	do	9- ?-49 3- 2-50 4-12-51	[1] 45 34. 64 [8] 35. 03		J 2		20	45	D, Dy, S, O	L.
28R1	J. Maffia	1950	140	135	D 8	120 131	8 2	Gravel Sand and gravel.	QTm(?) do	8-10-50	[1] 26				8	89	D	L.
29A1	C. Jasperson	1941	135	259	D 7			(Upper perforations above 104 feet).	do	8- ?-41 3-21-50 4-12-51	[1] 31 15. 90 15. 15		L 1½		17	149	D, S	L.
29B1	W. C. Green	1949	140	1,949	D 8				do	5- ?-49	[1] 80				17	27	D	L.
29E1	H. T. Parker	1930±	200	285	D 8				do	3-29-50 4-12-51	22. 22 19. 89		J 2		[3] 40	30	Ind	L, W.
29F1	Harry Sugashawsi.		215	170	D				QTm								D, S	L.
30F1		1948	290	248	D 8	12	234	Sand	do	4- ?-48	[1] 86				4	12	D	L.
30F2	C. W. Kidd	1950	290	288	D, G 8	95 219	58 69	Sand Sandstone; sand and gravel.	do do	9-20-50	[1] 0				10	100	D, O	Cp, L.
32B1		1942	310	202	D 8				Tsv (?)								D, S	L.
32C1	A. Cleve	1947	300	190	D 8				QTm(?)	9- 5-47 3-29-50 4-12-51	[1] 27 32. 23 34. 52						D, S	Cp, L.
33E1	J. Bahnsen	1945	250	215	D 8				Tp	6- ?-45 4-11-51	[1] 12 103. 95				5	68	D, S	L.
33M1	W. J. Wheeler	1950	210	261	D 10	100	28	Clay and gravel, mixed.	QTm	9-25-50	[1] 40						D, irr	L.
33P1	S. E. Jenkins	1942	265	338	D 8-6-4	118	27	Sand; sand and fine gravel.	do	3-24-50 4- 6-51	[11] 79. 5+ 76. 03		L 1½				D, S	L.
34G1	E. Pintis	1948	190	213	D 8	207	6	Rock	Tsv (?)	10- ?-48	[1] 63		J 1		30		D	L.
34N1	J. Aggio	1949	195	82	D 8				QTm	3- ?-49 3- 2-50 4- 6-51	[1] 6 1. 42 0. 93		J		25	41	D	L.
34N2	I. Andreson	1950	205	119	D 8	101	18	Clay and gravel.	do	9- 5-50	[1] 6		J		11	54	D	L.
35A1	Cotati Public Utility District.		110		D												U	
35A2	do	1946	110	660	D 12				QTm	12- 9-49	8. 33						PS	L.
35A3	G. Woodson	1941	110	100	D 6	925		Sand and gravel.	do	10- ?-41	[1] 17		J ¾		8	73	D	L.
35C1	M. Mulligan	1948	125	75	D 8	67	8	Large water gravel.	do				J 1		33		D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
								T. 6 N., R. 8 W.—Continued										
6/8-35F1	N. F. Keyt	1949	165	509	D, G 8	76	20	Gravel	QTm	12- 1-49	49.00		L				Irr, S	L.
						139	4	Sand and gravel.	do	4- 6-51	47.94							
						153	7	Clay and gravel; cemented gravel.	do									
						308	54	Gravel; clay and gravel.	do									
						409	15	Gravel	do									
						426	21	do	do									
35G1	Mrs. M. Yriberri.		120	72	D 8	35	13	Gravel	do	12-19-49	18.90		L ¾		33	17	D	L.
						56	16	Cemented gravel: sand and gravel.	do	4- 6-51	11.32							
35L1	N. F. Keyt	1949	155	288	D 8				do	2- ?-49	[1] 30		L		12½	120	D	L.
										12- 1-49	40.73							
										4- 6-51	34.56							
35Q1	D. Biscarrett	1945	165	183	D 8				do	9- ?-45	[1] 45		J		11	55	D	L.
35Q2	H. Calkins	1939	180	60	D 8				QTm	10- ?-39	[1] 21		J 1½		17	2	D	L.
										12-19-49	23.39							
										4- 5-51	19.65							
35R1	J. C. Jensen	1945	185	143	D 8				do	9- ?-45	[1] 75		L	25	24	15	D	L.
										12-21-49	95.39							
										4- 5-51	96.64							

36A1	Cotati Seed Farms.	1935	115	695	D 14-12	60	4	Clay and gravel.	QTm(?)	11- ? 35 1-25-50 4- 6-51	[1] 8 11.44 5.38		T	600	375	[3] 137	Irr	C, L.
						178	7	Clay and little fine gravel.	QTm									
						324	14	Cemented gravel.	do									
						376	48	Cemented gravel; sandy clay.	do									
						471	35	Sandy clay; gravel.	do									
						506	6	Cemented gravel.	do									
36N1	Piazzi	1945	205	125	D 8				do	9- ?-45	[1] 65		L		31	15	D	L.
36P1	B. T. Steensen.	1941	130	255	D 8	237	18	Sand and gravel; gravel.	do	9- ?-41	[1] 32		J 1		23	48	D	L.
36P2	do		130	75	D 6				do	12-19-49	27.94		L				U	

T. 6 N., R. 9 W.

6/9-1A1	Doyle Estate	1944	75	120	D 8				QTm(?)				L				U	L.
1M1	A. Peterson	1950	190	60	D 6	18	42	"Quicksand"; fine gravel.	QTm	8-16-50	[1] 8						D	L.
1P1	R. Mariola	1950	95	68	D 8	20	48	do	do	11- 1-50	[1] 15		J		20	20	D	L.
1P2	R. Roberts	1951	90	248	D 8	25	223	do	do	2- 2-51	[1] 4		J		40	25	D, irr, S	Cp, L.
1Q1	Henderson	1950	70	70	D 8	21	47	do	do	11-17-50	[1] 15		J		20	25	D	L.
1Q2	A. J. Pratt	1950	70	85	D 6	24	61	do	do	11-27-50	[1] 15		J		20	15	D	L.
1Q3	Nickelson	1950	70	118	D 6	20	98	"Quicksand"; fine gravel.	do	11-24-50	[1] 15		J		20	15	D	L.
1Q4	R. Camp	1950	70	110	D 8	108	2	Small gravel	do	7-29-50	[1] 6				20	50	D	L.
1Q5	H. V. Gill	1951	70	60	D 6	60	7	Sand and gravel.	do	3-21-51	[1] 8		J		15	40	D	L.
2C1	City of Sebastopol.		120	600	D 12	304	95	Clam shells and sand.	do	4-16-51	70.72		T 50				PS	C, L.
						429	171	Shells and sand; sand, grit and shells; sediment and sand.	do									
2D1	Baumgartner	1941	160	178	D	175	3	Sand	do				L		30		irr, S	L.
2F1	City of Sebastopol.	1930	125	260	D 14	2	260	Soft Quicksand; dry sand; clam shells.	do	4-14-50 4-16-51	90.08 86.15		T 50		1,500		PS	C, L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 6 N., R. 9 W.—Continued										
6/9–2J1	Mrs. A. Steeves.	1947	110	130	D 8	30	100	Soft sand; shells.	QTm				J				D	L.
2L1	City of Sebastopol.	1951	140		D, G 16				do	8–8–51	11.83						PS	
2P1	F. Dannecker	1949	200	215	D 8	200	15	Sand	do								D, O	L.
2Q1	Crippen	1944	180	132	D 6	90	42	Soft "running" sand.	do				J				D	L.
2R1	R. E. Caniff	1944	150	125	D 7	40	85	Sand; shells and sand; hard shells.	do	4–6–50 4–16–51	32.22 [8] 31.65		J				D, S	L.
2R2	Fir Crest Water District.	1939	150	155	D 8	35	120	Sand and gravel; hard sand and clam shells.	do	4–6–50 4–16–51	26.70 25.61		T 7½	100			PS	L.
2R3	F. J. Hickey		125	112	D 8	4	108	Gravel and sand; sand; clam shells.	do								D	L.
2R4	Joseph Levoy	1943	130	120	D 7	64	56	Sand and gravel; gravel; clam shells.	do								D	L.
3A1	R. L. Browning.	1946	230	260	D 8	250	10	Sandstone	do				J		17		D, O	L.
3A2	Elliot		210	305	D	293	12	Black sand	do				L				D, S	L.
3H1	O'Leary Funeral Home.	1947	240	295	D 8	4	291	Sandstone; sand; gravel.	do	4–13–50 4–16–51	70.95 73.80		L 5				irr	L.
3M1	N. Shaeffer	1949	215	182	D 8				do	4–11–50 4–16–51	[8] 28.85 19.60		J ¾				D	L.
3M2	do	1947	210	126	D 8	100	26	Sand; coarse sand and some gravel.	do	4–11–50 4–16–51	38.20 37.58						U	L.

3N1	Paul Bondi	1934	240	165	D 8	80	85	Sandstone	do	3- ?-34	[1] 32		L 1		10	28	D, O	L.
4F1	Andrew Oandason.	1946	220	140	D 8	8	132	do	do				J 2				D, Ind	L.
4L1	W. E. Roberts.	1948	275	190	D 6	155	35	do	QTm								D	L.
4M1	O. Hagaman	1949	365	230	D 8	40	100	do	do	11- ?-49 4-16-51	[1] 142 151. 2		L 1				D	L.
5A1	C. Cunningham.	1950	160	165	D 8	21	144	Soft sandstone	do	8-22-50	[1] 0		J		15	40	D	L.
5C1	A. W. Anderson.	1944	280	190	D 7	130	60	Sand; sandstone.	do				L 1				D	L.
5F1	John J. Schmitt.	1945	290	155	D 8	60	100	Sandstone; clam shells.	do	4-26-50	59. 0		L 1				D, O	L.
5H1	Charles Robert.	1946	145	100	D 8	25	75	Sandstone	do	4-25-50 4-16-51	9. 07 8. 22		J 1				D	L.
5L1	Albright	1946	175	116	D 8	12	104	do	do	4-17-51	9. 05		J 1				D	L.
6G1	S. C. Hall	1947	240	100	D 6	8	92	do	do	4-27-50 4-16-51	10. 73 7. 67		J				D	L.
7D1	John Cotella		590	170	D 8	70	100	Blue sandstone with layers of black rock.	QTm(?)								D	L.
7F1	H. Sutliff	1946	725	280	D 8	3	277	Sandstone	QTm								U	L.
7L1	A. W. Warner	1947	530	120	D 8	80	40	do	do	4-27-50 4-14-51	46. 65 46. 42		J ½				D	L.
8F1	H. D. Johnson	1948	445	190	D 6	5	185	do	QTm; JK (?)	4-26-50 4-14-51	93. 90 79		L 1				D, O	Cp, L.
8F2	O. P. Joseph	1946	420	112	D 6	40	67	Sand; sandstone.	QTm								D	L.
8K1	A. B. Sexton	1947	255	40	D 8				do				J ¾				D	L.
8K2	do	1943	280	120	D 7	55	65	Sandstone	do				L	12			irr	L.
8N1	Gold Ridge Co.	1946	560	168	D 8	90	75	do	do						8	[3] 35	O	L.
8R1	Dr. J. H. D. Roger.	1941	430	140	D	135	5	Black sand	do						7		U	L.
9E1	C. E. Van Horne.	1946	435	280	D 6	0	280	Sandstone: sand.	do	7-31-46	[1] 150			2½			D	L.
9N1	Youngberg	1946	520	250	D 8-6	16	234	Sandstone	do					7			D	L.
10B1	D. A. McDonald.	1944	285	180	D 8	160	18	do	do								'D, O	CP, L.
10H1	Carl Schowalter.	1945	315	400	D 8	178	222	Clay and sandstone; "sticky stone"; sandstone.	do				L 3	38	25		D, O	L.
11A1	H. W. Gates	1945	180	195	D 8	183	12	Sandstone	do	4- 4-50 4-14-51	[8] 85. 5 46. 60		L	7			D	L.
11A2	S. S. Blair	1947	130	110	D 8	2	108	Sand; clamshells.	do	4- 6-50 4-14-51	25. 77 24. 62		J ¾	12			D	L.
11A3	P. J. Alkire	1948	170	220	D 8	105	115	Sand; sandstone.	do								D	L.
11B1	H. Gerkin	1950	170	420	D 6	50	370	Fine sand; fine sand and gravel.	do	6-30-50	[1] 35				2	100	D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
T. 6 N., R. 9 W.—Continued																		
6/9-11C1	James Logan	1946	225	220	D 8	155	65	Sandstone; sand and gravel.	QTm								D, S	L.
11C2	K. Christopher	1948	240	190	D 8	180	10	Sand and gravel.	do								D	L.
11D1	L. C. Stuart	1945	340	280	D 8	175	105	Sandstone	do	3-30-50 4-14-51	89.80 84.26				10		D, O	L.
11D2	A. G. Pilcher	1948	225	338	D 8	278	60	do	do	4- 6-50	29.47		L 1				D, irr	Cp, L, W.
11F1	E. H. Hollman	1947	330	235	D 8	142	93	do	do	4- 4-50 4-14-51	39.17 76.40		J 2				irr, O	L.
11H1	Wallington	1948	160	105	D 8	50	65	Sandstone; sand.	do	4- 4-50 4-14-51	14.57 12.40		J				D	L.
11H2	Bracharez	1947	160	110	D 8	2	108	Soft sand; sandstone.	do								D	L.
11K1	J. Moresi	1951	195	120	D, G 6	20	30	"Quicksand"; large gravel.	do						10	40	D	L.
						90	30	Sand and gravel.	do									
12D1	H. P. Rothel	1941	115	105	D 6	55	50	Hard sand and gravel; gravel and clam-shells.	do				J 1				D, irr	L.
12D2	do		115		D 6				do	3-22-50 4-14-51	8.82 7.11						U	

12D3	R. L. LaBlue	1951	130	278	D 6	35	243	"Quicksand" and clamshells; "quicksand"; partly-cemented clamshells.	do.	3-17-51	[1] 32				20	25	D	L.
12G1	E. W. McDaniel.	1948	95	104	D 8				do.	9- ?-48 3-22-50	[1] 40 ([4])		J	[6] 2	8	20	D, S	Cp, L.
12G2	Bassignani Brothers.	1939	85	155	D 8	130	25	Sand; cemented gravel.	do.	8- ?-39 4-14-50	([1], [4]) ([4])		L	[6] 2	15	[3] 20	D	C, L.
12K1	H. Scholz	1951	125	84	D 8				do.								D	L.
12N1	J. B. Hamilton	1950	215	65	D 8	9	54	Sand; sand and gravel.	do.	12-28-50	[1] 23				8	27	D	L.
13A1	J. Krause	1942	185	101	D 8				do.	3-22-50 4-14-51	35.90 32.65		J 1				D, irr, S	L.
13A2	J. S. Sharp	1935	195	126	D 6	4	106	Sand; hard sand and water gravel.	do.	3-22-50	[8] 74.05		L				D	L.
13A3	Hanzel	1948	150	114	D 8				do.	6- ?-48	[1] 39				10	33	D	L.
13A4	Ray Fredricks.	1943	175	185	D 7	60	135	Sand and gravel; sand; gravel.	do.								D, S	L.
13B1	W. G. Stone	1943	175	212	D 6	200	12	Sand; gravel and sand.	do.	3-30-50 4-14-51	25.97 21.25		J 1		8		D, S	L.
13C1	R. Kolby	1950	235	204	D 8	32	172	"Quicksand"; gravel.	do.	9-15-50	[1] 35				15	50	D	L.
13D1	F. F. Scott	1947	260	471	D 8-6				do.	11- ?-47 3-30-50 4-14-51	[1] 50 47.04 42.48		J		8	24	D	L.
13G1	A. C. Eddy	1950	240	133	D 8	60	73	"Quicksand"; fine gravel.	do.	12-13-50	[1] 50				15	35	D	L.
13H1	Lloyd Graham.	1938	190	88	D	58	26	Sand; gravel and Sand; gravel.	do.						3		D, S	L.
13J1	A. Valentine	1946	200	280	D 8	239	41	Sand and gravel.	do.	2- ?-46 3-30-50 4-16-51	[1] 55 58.0 55.95		L		25	15	D	Cp, L.
13L1	J. Matteri	1950	260	360	D 8-6	0	360	"Quicksand"; sand and gravel; sand.	do.								D	L.
14C1	C. Stefan	1945	325	365	D 8				do.	11- ?-45 4- 6-50 4-16-51	[1] 50 62.58 55.46		L 2		8	170	D, O	L.
14J1	Mrs. E. Burbank.	1939	330	394	D 8				do.				L				O	L.
14M1	Harry Hennig	1949	370	181	D 8	9	172	Sandstone	do.	3-30-50	63.92		L				D	L.
14R1	Langford	1946	255	185	D 6				do.				L				D, S	L.
14R2	Higginbotham	1949	325	200	D 8				do.								D, S	L.
15B1	A. Lorenzo	1947	300	100	D 8	298		Sandstone	do.				J 1				D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
T. 6 N., R. 9 W.—Continued																		
6/9-15D1	Tom Furusho	1948	395	200	D 8	25 116	67 84	Sandstone; sand. Clay and sandstone; sandstone and clamshells.	QTm do	4-11-50 4- 5-51	19.87 15.68		J 1				D, O	L.
15F1	Ray White	1946	470	136	D 8	90 120	15 16	Sandstone Sand	do do	3-12-46 3-31-50 4- 5-51	[1]75 60.3 71.5	60.5	L 1				D	Cp, L.
15G1	M. Nelson	1946	440	200	D 8	65	135	Sandstone	do				J 1	18			irr, S	L.
15J1	Geo. Kennedy	1945	390	180	D 12-8	12	168	do	do								D, O	L.
15L1	C. P. Roberts		480	190	D 6	25	165	Sand; hard sand; gravel and sand.	do	3-31-50	10.4						U	L.
15L2	do		480	30	Dug 48				do	4- 5-51	10.79		J 1½				D	
15R1	John Kemmerus.	1945	260	130	D 8	0	130	Sandstone	do								D	L.
15R2	H. Nielson	1944	235	130	D 8	70	60	do	do	3-30-50	18.20		J 1		[7]20	25	D, irr, S	Cp, L.
18H1	Spradley	1951	585	115	D 6	20	95	Clay and sandstone; sandstone.	do	1-10-51	[1]20		J		5	50	D	L.
18J1	R. Redfern	1947	575	175	D 6	2	173	Sandstone; sand.	do	11- ?-47	[7]62		J 2				D	L.
22A1	M. E. Callan	1951	120	360	D 10	20	340	Sandstone; sandstone containing shells; sand and shells.	do	6- 6-51	(1, 4)		T 5	[6]½	85	[3]200	Irr	Cp, L.
23H1	Withers	1951	200	120	D 8	63	57	Fine sand; sandstone.	do	3-17-51	[1]35		J				D, O	L.

23M1	H. W. Keeler	1944	260	107	D 7	42	65	Sandstone; sand and clay; "shell rock."	do				J				D, O	L.
24A1	Harold Naylor	1930±	150	130	D 7				do				L 1				D, Dy, S	L.
24D1	J. E. Baker	1940±	235	167	D 8	70	97	Sand; sandstone.	do								U	L.
27G1	J. Mattos	1950	265	105	D 8	18	78	Packed sand; "hard sandstone."	do	8-27-50	[1] 18		J		15	30	D, S	L.
T. 7 N., R. 6 W.																		
7/6-19F1	A. B. Knowles	1947	575	585	D 12	35	530	Clay and gravel.	QTge, Tsv (?).	7- 5-50	39.03				10	187	U	L.
19N1	Harold Horton	1950	465	149	D 10	28	9	Coarse gravel and clay; clay and small gravel "water strata."	QTge(?)	3-29-51	5.00		J 1	7		80	D	L.
						130	19	Gravelly clay; coarse packed gravel.	QTge									
19N2	McDonald	1944	475	334	D 8				do								D	L.
19R1	Frank Gemini	1950	465	300	D 8	220	40	Small boulders and coarse sand.	do				T 7½	100		80	Irr	L.
						260	40	Volcanic ash	Tsv (?)									
29K1	Sherwood Coffin.	1948	435	130	D 12				Tsv	7-26-50	[8] 3.00	70	J 10	200+	[6,7] 30		D, Irr, S	Cp.
29M1	O. L. Permenter.	1948	415	400	D				Qyal, QTge (?), Tsv (?)	7- 5-50	15.30		T 20	500—600			Irr	
29N1	do	1948	405	155	D 8	80	5	Gravel	QTge(?)	7- 5-50	6.08		J ¼				D	L.
						119	36	Gravel; gravel and clay.	QTge									
29P1	A. C. Hogan	1948	415	112	D 10	63	12	Gravel	do	7- 7-50	10.78		J 1		20		D	L.
						102	10	do	do									
30A1	Richards	1949	450	105	D 8										10		D	L.
30A2	do		445	25	Dug 48				Qyal	7-21-50	11.60		J ½	20			D, irr	
30B1	Sam Ricci	1930±	440	137	D 8					7-27-50	3.34		T 5				Irr	
31N1	Newhall	1949	495	90	D 8				Tsv				J 1		65		D, S	L.
31P1	Col. Whiteside.	1949	470	205	D 8				do	7-27-50	30.36		J 1		20	1	D	L.
32A1	H. Q. Hawes		430		D				do	7- 5-50	[8] 15.45		T 5				D, Irr, Sw	
32A2	do	1951	445	390	D 10				do	8-29-51	[3] 85		T 10				Irr	

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 7 N., R. 6 W.—Continued										
7/6-32F1	Burton Cochrane.	1946	395	190	D 12	21	49	Cemented gravel; clay and gravel; rock and gravel.	Qyal, QTge.	10-27-50	2.60				180	67	Irr, U	L.
						99	4	Gravel	QTge									
						137	53	Clay, gravel, and rock; cemented gravel.	do									
32G1	Robert Erding.	1950	405	118	D 8	21	68	Silt and gravel; cemented gravel; gravel; conglomerate.	Qyal, QTge (?).	11-15-50	[1] 8	[1] 62	J ¾	15		3	D	L.
						108	4	Cemented gravel.	QTge									
						114	4	Gravel	do									
32H1	H. Q. Hawes	1950	415	406	D 12	100	300	(Perforated interval.)	Tsv	7-5-50	([4])	78	T 20	1,000	[6] 200		Irr	Cp, L.
32M1	H. G. Makelim.	1940	400	96	D 8			(All casing perforated.)	do	9-20-40 7-26-50	[1] 18 17.05		J 7½		120	52	D, irr, S	L.

T. 7 N., R. 7 W.

7/7- 5C1	Almon Jones	1947	345	142	D				QTge	12- ? -47	[1] 49				2½	77	D	L.
5D1	W. Chalmers	1950	330	130	D 8	62	8	Sand and fine gravel.	do	7- 2-50	[1] 25				20	45	D, irr	L.
						120	10	"Packed gravelly."	do									
5F1	F. C. Haen	1948	340	164	D 8	117	47	Clay and gravel; gravel.	do	5- ? -48 6-22-50 4-10-51 8-15-50	[1] 71 45.91 42.00 [1] 50		L 1		4	59	D	L.
5F2	A. G. Walker	1950	325	275	D 8	65	10	"Packed gravel."	do									
						160	15	"Medium packed gravel."	do	3-29-51	27.26		J 1	6		50	D, irr, S	L.
5N1	L. A. Mealman	1949	275	89	D 8	4	18	"Boulder and sand", fine gravel.	Qyal									
						55	2	Sand	QTge(?)	6-21-50 3-29-51	9.40 6.15		T 1½		35	50	D, irr	L.
						72	16	Large packed gravel; coarse sand.	do									
6A1	Magers	1950	315	180	D, G 10	0	177	Pea gravel; gravel and clay.	Qyal, QTge.	4-20-50 4-10-51	31.45 [8] 41.95						D, Irr, S	L.
6G1	S. H. Strong	1950	295	338	D, G 8	3	38	Fine sand; clay streaked by gravel.	QTge									
						87	21	Sand and gravel.	do									
						124	17	do	do	6- 5-51	12.73				40	22	D, Irr	L.
						172	31	Clay streaked by gravel.	do									
						310	23	Sand and gravel.	do									
6H1	Binkeley	1947±	295	101	D 8				Qyal, QTge (?).	4-20-50 6-21-50 4-10-51	26.13 [8] 47.6 [8] 30.79		T 3				D, Irr	
6J1	Harold Estes	1950	295	160	D 7½	16	32	Sandy clay; gravel packed clay.	do									
						60	32	"Packed gravel"; sand.	QTge(?).	3-29-51	26.75		J 1	50		50	D, irr, S	L.
						130	30	Loose boulders; small boulders.	do									

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 7 N., R. 7 W.—Continued																		
7/7- 6K1	Guido Lorenzini.	1948	280	103	D 8				Qyal (?), QTge.	6- ?-48 6-21-50 4-10-51	[1] 16 16.96 10.55		L 1½		50	23	S	L.
6K2	E. Collins	1950	280	54	D 8	26	16	Sandy clay; gravel; clay and gravel.	do	3- 5-50	[1] 14		J		12	26	D	L.
6K3	Kestenholz	1951	275	63	D 6	57	6	Coarse sand and gravel.	QTge(?)	4-17-51	[1] 12		J				D	L.
6R1	T. C. Kerr	1950	275	133	D 7½	63 123	7 10	Fine gravel Small gravel	do do	3-29-51 11-21-52 4-13-53	4.35 11.38 6.49		J 1½	15		60	D, Irr	L.
7A1	H. Walker	1950	265	60	D 6	15 53	18 5	"Medium packed gravel"; silt. "Medium packed gravel."	Qyal QTge	10-11-50	[1] 15				30	25	D	L.
7F1	L. H. Cheek	1949	265	180	D 8				Tsv	10- ?-49 6-22-50 4-10-51	[1] 76 68.47 70.62		J 1½		19	74	D	L.
7F2	E. J. Throndson.	1950	245	320	D, G 8				Tsv						20	70	D	L.
7J1	J. T. Allison	1950	245	69	D 6	66	3	Gravel and clay.	QTge	5- 8-50	[1] 20						D	L.
7L1	B. H. Hardister.	1950	240	214	D, G 6				Tsv						10	60	D	L.
7M1	R. Emenegger.	1950	250	154	D, G 6				do								D	L.
7N1	R. E. Kirk	1950	250	204	D, G 8				do				J		25	120	D	L.

7R1	Lewis Grace	1947	260	190	D 8	112 162	3 8	Clay and gravel. Sand	QTge Tsv (?)	12- ?-47 5-24-50	[1] 36 41.70		J 2		12	119	D	L.
7R2	Myra King	1938	255	162	D 8					8- ?-38	[1] 33				25	5	D	L.
7R3	C. D. Mainert.	1950	260	245	D 8-6	228	17	(Perforated interval.)	Tsv	8-10-50	[1] 90		L 1		20	85	D, irr	L.
8A1	Capt. H. A. Anderson.	1947	315	385	D 8				QTge	5- ?-47 6-22-50 4-10-51	[1] 128 60.8 [11]57.5+		L				D	L.
8A2	M. W. Schefer	1948	360	230	D 8	210 224	7 4	Cemented gravel; gravel. Clay and gravel	do do	11- 3-48	([1], [4])			[6] ½	30	117	D	L.
8D1	W. L. Walker	1949	270	60	D 6								J ½	11	12		D	L.
8D2	J. M. Delz	1950	270	70	D 6	30	36	Coarse sand and fine gravel; coarse sand.	QTge(?)	9-16-50	[1] 12		J		20	25	D	L.
8E1	C. A. Hougen	1950	265	56	D 6	28	28	Clay and sand; sand and gravel; coarse gravel.	do	7-14-50	[1] 18		J				D	L.
8E2	H. T. Stedman.	1950	265	51	D 6	23	28	Loose gravel	do	5-20-50	[1] 10						D	L.
8E3	J. Moligiani	1951	265	60	D 6	54	6	Coarse sand and gravel.	do	4- 9-51	[1] 12						D	L.
8E4	McConnell	1950	265	57	D 6	19	38	Sand and gravel; dirty brown sand	do	12-29-50	[1] 9						D	L.
8G1	Joseph Massini.	1940	290	120	D				do				J	3⅓			Dy	L.
8G2	do	1949	290	425	D 10				QTge	5-26-50 4-10-51	6.64 2.47		T 3		50		Dy, Irr	L.
8H1	L. W. Layton	1951	295	152	D 6	127	25	Hard clay and gravel.	do	1-31-51 6-26-51	[1] 5 25.70		J ½		6	90	D	L.
8K1	Pricketts Nursery.	1947	285	189	D 8					5-26-50 4-10-51	[8] 36.10 42.0		J 2				Irr	
8L1	Rincon Valley Union School.	1949	250	278	D 8	208	15	Volcanic ash	Tsv				L 3		12	90	PS	L.
8L2	H. Carter	1951	275	54	D 6					4- 5-51	[1] 12		P				D	L.
8M1	Rincon Valley Fire Dept.	1949	255	193	D 6					8- ?-49 6-21-50 4-10-51	[1] 44 40.45 44.87		J 1		16	23	D	L.
8M2	J. Groom	1949	250	211	D 8					12- 8-49 6- 5-51	[1] 54 19.41		J ½		8	66	D	L.
8M3	do	1910±	250	22	Dug 48				Qyal	6- 5-51	9.01		J				U	
8M4	Keefer	1950	255	85	D 6					11- 3-50	[1] 17				24	14	D	L.
8N1	Arthur I. Rice.	1949	250	121	D 8				QTge	5-22-50 4-10-51	46.55 52.71		J 1½				D	L.
8N2	A. Barbera	1947	280	152	D 8				do	11- ?-47	[1] 58				10	42	D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
								T. 7 N., R. 7 W.—Continued										
7/7- 8N3	Cram	1945	280	182	D				QTge	7- ?-45	[1] 55		J		20	10	D	L.
8P1	A. Gowans	1949	285	195	D 8	193	2	Sandy gravel	do	5-26-50 4-10-51	[8] 74.6 65.95	70	L 1	7	6		D	Op, L.
8P2	F. C. Montgomery.	1951	285	250	D 6	233	17	Volcanic ash	Tsv	2-15-51	[1] 50				9	60	D	L.
9D1	J. D. Ramsey	1950	380	245	D 8	35 230	10 15	Fine packed gravel and sand. Coarse gravelly sand.	QTge do	8-17-50	[1] 32		J		15	60	D	L.
9D2	Leland Decker.	1950	375	323	D 6	275	25	Hard gravel; loose gravel.	do	11-31-50 3-29-51	[1] 15 16.41		J ¼		10	40	D	L.
9D3	P. Wegesser	1948	400	319	D 8	70 241 252 271 289	60 2 4 4 20	Sandy clay and gravel; cemented gravel. Gravel Cemented gravel. Sandy clay, some gravel. Cemented gravel.	do do do do do	11-26-48	[1] 11				20	154	D	L.
9R1	Santa Rosa Golf and Country Club.	1930±	435	100±	D 12				do	5-26-50	21.00		J 7½				Irr	
10M1	do	1925±	525	300±	D 8				do	5-26-50	[8] 164.29		T 7½				Irr	
13N1	P. X. Smith	1949	475	490	D 8-6				Tsv (?)	Fall 1949.	[7] 10.12		T 15			75	Irr	
14P1	J. J. Coney	1951	430	828	D, G 12				Qyal, QTge.	5- 3-51 8-10-51	[1] 20 60		T 30		240	220	Irr	L.

15C1	Mrs. Mead Clark.	1939	375	397	D				QTge	5-26-50	([4])		T 7½	[6] 1	20	[3]160	D, irr	L.
15C2	F. Banducci	1950	365	205	D 8	40 150 185	25 20 20	Sand, gravel, and clay; pea gravel. Sand and gravel. do	do do do	11- 1-50	18				7	130	D	L.
15M1	R. C. Hanspeter.	1949	435	250	D 8				do	5-26-50	101.9		L 1½	10	35	59	D	L.
16A1	E. Jackson	1951	325	263	D 8-6	50	263	(Perforated interval.)	do	3- 6-51	[1] 60		J		30	5	D	L.
16C1	J. C. Violetti estate.	1949	335	190	D 6				Tsv	4-20-50 4-10-51	6.45 9.44		J 3				D, irr	
16C2	Frank Silvestri.	1940	310	278	D 8			("All casing perforated.")	QTge(?)	4-20-50	([4])	73	J 3	[6] 10	35	[3] 40	D, irr	
17A1	City of Santa Rosa (Lake Ralphine well).	1947	290	846	D 12				Tsv. QTm (?), Tsv.	6- ?-47	[1] 84		T 25		485	64	PS	C, L.
17A2	City of Santa Rosa.	1952	285	1,018	D, G 16				do	4-29-52	22.16				290	264	PS	E, L.
17N1	E. W. Carlson.	1949	220	104	D, G 6				Tsv	1-26-50 4-10-51	33.42 [8] 36.90		J 1				D	L.
17N2	Shuker	1948	220	111	D 8				do	7- ?-38 2- 1-50 4-10-51	[1] 32 1.64 27.20		J ¾		50	3	U	L.
17N3	do		220		D 8				do	2- 1-50 4-10-51	30.37 26.52						D	
17P1	F. Eliggi	1948	260	139	D 8				do	2- ?-48 2- 2-50 4-10-51	[1] 79 71.22 78.22		J 2		12	40	D, S	L.
18D1	H. Keats	1950	245	104	D 8	74 89	10 12	Soft volcanic ash. Porous volcanic rock; soft volcanic ash.	do do	9-22-50	[1] 70		L 1		15	15	D	L.
18E1	M. Galeazzi	1950	240	183	D 6	60 125 90 130	23 25 22 146	(Perforated interval.)	do	2-13-50	[1] 58				30	12	D	L.
18E2	do	1950	245	157	D 8			do	do	1-18-50	[1] 78		J		16	44	D	L.
18E3	Bert Reed	1930±	240	70.0	D 6				do	12-10-49 6-26-51	[1] 58 43.13		J 1		17	2	D	([12])
18F1	H. Stearns	1945	220	170	D 8-6	144	26	Rock	do	4- ?-45 5-24-50 4-10-51	[1] 25 29.7 34.8		J 1½		40	0	D, O	L.
18J1	Tex Carley		215	300+	D 16 (?)					1-26-50 3- 1-50	21.74 21.60		J 1½				D, Irr	
18L1	L. F. Applegate.	1947	215	161	D 12	36 78	42 79	Gravel Clay and gravel.	Qyal Qoal (?)	9- ?-47 1-26-50 4-10-51	[1] 31 35.70 26.53		T 15	550	100	16	Irr	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 7 N., R. 7 W.—Continued																		
7/7-18N1	W. R. Carrithers & Son, Inc.	1946	205	140	D				Qyal, Qoal(?)				T 15	230			Irr, PS	Cp, L.
18Q1	J. S. Barham	1922	205	249	D 12			(All casing perforated.)	do	1-26-50	8.71		T 5	150			Irr	W.
18R1	City of Santa Rosa (Peter Springs well).	1928	210	160	D 12					10-12-49 4-10-51	46.3 14.5		T 25	575			PS	C.
18R2	Tex Carley	1949	210	206	D 12			(Below 50 ft. alternate casing joints are perforated.)	Qoal (?), Tsv.	10- ?-49 1-26-50 4-10-51	[1] 78 21.32 17.30		T		700		Irr	L.
19C1	O'Connor	1949	200	90	D 6				Qyal, Qoal(?)	1949	[1] 35		J 1		16⅔	20	D	L.
19F1	T. P. Ahern	1940	205	91	D				do	12- ?-40	[1] 22				3⅓	43	D	L.
19L1	H. Cordsen	1945	210	95	D 8				do	10- ?-45 2- 1-50 4-10-51	[1] 35 [3] 43.0 38.0		J 1		30	6	D	L.
19M1	N. Post	1950	235	113	D 8	87	20	Gravel	QTge				J ½		10	61	D	L.
19Q1	Victor Sartori.	1947	225	680	D, G 12-10.				Qyal, Tsv.	4-18-50 4-10-50	29.12 [3] 47.98		T 25				Irr	L.
19R1	do	1947	225	670	D 12-10				do	4-10-50	[3] 66.80		T 25				Irr	
20C1	H. Zwick	1948	250	112	D 8	77	35	Rock	Tsv	2- ?-48	[1] 61		J 1		12	31	D	C, L.

20D1	W. R. Warren	1949	220	[14]91.0	D, G 8	16 73	36 63	Gravel and boulders; sand and gravel; clay and sand. Sand; sand and gravel; cobbles· sand and clay.	Qyal Tsv	1-26-50 4-10-51	38.04 32.70	----	----	----	25	[3]70	Irr	L.
20D2	Cornelius	1950	215	96	D 8	65	31	Sand	Qoal(?)	10-22-50	[1]65	----	----	----	10	12	D	L.
20F1	R. Reed	1939	235	95	D 8	----	----	----	Tsv	6- ?-39 1-26-50 4-10-51	[1]36 47.36 49.82	----	J 1½	----	40	11	D	L.
20F2	H. Bertolani	1950	235	109	D 8-6	85	17	Clay and gravel.	do	11- 6-50	[1]80	----	J	----	48	0	D	L.
20P1	J. de Barbe	1947	245	243	D 10	----	----	(Uncased below 40 ft.)	do	1-26-50 4-10-51	42.06 50.88	----	T 15	600	----	----	Irr	L.
23A1	P. X. Smith	1945	475	365	D 8	250 303	50 62	Clay and gravel; gravel; sandy clay and gravel. Sand and gravel; cemented gravel; sandy clay and gravel.	QTge do	11- 3-44 7- 5-50	[1]25 [3]172+	----	T 3	10-15	27	[3]170	Irr	L.
23A2	do	1948	450	337	D 8	----	----	----	do	5- ?-48 7- 5-50	[1]6 [3]120+	----	L 1½	6-8	32	207	Irr	L.
23C1	J. J. Coney	1948	420	1,300+	D	----	----	----	Qoal(?) QTge.	----	----	----	T 20	125	----	----	Irr	E, L.
23F1	do	1941	420	440	D 12	----	----	(Below 75 ft. alternate 20-ft. joints are perforated.)	do			----	T 15	150	100	[3]55	Irr	L.
23G1	do	1948	430	1,100+	D 12¼	----	----	----	QTge	6-22-50	6.25	----	----	----	----	----	U	E, L.
23K1	do	1945	475	52	D 6	----	----	----	----	9-11-45	[1]10	----	L	----	6	40	S	L.
24A1	State of California (Los Guilucos School for Girls).	1931	565	622	D 12	----	----	(Cased to 208 feet; no perforations.)	Tsv	7- 5-50	[3]73.25	----	T 15	----	----	----	Irr, PS	C, L.
24B1	do	----	565	585	D	----	----	----	----	7- 5-50	49.55	----	T 10	----	100	[3]137	Irr, PS	L.
25A1	C. E. Gunn	1949	450	400+	D 10	----	----	----	----	7- 5-50	1.15	----	T 20	60	----	----	Irr	
29B1	E. F. Bethards.	1948	380	240	D 8	----	----	----	Tsv	4- ?-48 6-16-50 4-10-51	[1]178 179.5 194.55	----	L 2	----	20	0	D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 7 N., R. 7 W.—Continued										
7/7-29D1	do	1947	240	588	D, G 8	40 130 410	20 50 130	Loose gravel Sand and gravel; shale; boulders. Volcanic ash	Qoal(?). QTge(?). Tsv	4-18-50 4-10-51	46.55 [8] 51.86		T 15				Irr	E, L.
29L1	C. F. Dedekam.	1947	265	365	D 8-6				do				T 15	700			D, Irr, S	C, L.
29L2	do	1949	265	365	D 10				do	4-18-51 4-10-51	0.45 [8] 36.25	72			750		Irr	C.
30B1	V. Sartori		265	88	D 8-6				QTge									(12)
30C1	Holland Heights Water Co.	1951	255	448	D, G 8				QTge, QTm (?).	7-23-51	[1] 55		T		200	120	PS	L.
32B1	Hans Schonewald.	1950	325	266	D, G 8				Tsv	3-29-51	17.84		T 1½	35		165	D	L.
32G1	Mrs. Edith Mitchell.	1950	325	403	D, G 12-8.	0 210	40 182	Gravel Volcanic ash; volcanic ash and basalt; ash and clay.	Qyal Tsv	4-18-50	(4)	74	C	[6] 150			Irr	C, L.
33N1	F. W. Porter	1949	465	174	D 8				Tsv(?)	8-?-49 4-19-50 4-10-51	[1] 31 [3] 63.0 29.5		J 2		50	19	D, Irr, S	L.
33R1	O. M. Powell	1950	510	438	D, G 6	82	95	Cemented gravel.	do						6	[3] 170	D	L.

36A1	Coleman	1942	615	284	D 8	60	45	Gravel; coarse gravel; clay and gravel.	do	1- ?-42	[1] 97		L		11	3	D, S	L.
						177	9	Boulders	do									
36J1	M. W. Carden	1948	525	102	D 8				Tsv	10-27-48	[1] 7				16⅔	63	D	L.
								T. 7 N., R. 8 W.										
7/8-3C1	E. Petoud	1946	175	235	D 8	47	68	Clay and gravel.	QTge	8- 3-46	[1] 11		J 3		10	189	D, S	L.
3D1	J. Bell	1937	160	88	D 8					8- ?-37	[1] 13				33	27	D	L.
										3-10-50	[1] 3				30	27		
3D2	do	1951	160	65	D 8	48	10	Gravel	QTge	1-16-51	[1] 9		J 1		20	31	D	L.
										6-22-51	7.53							
3L1	W. E. Samuelson.	1946	150	150	D 8	20	32	Sand and gravel; sand; gravel.	do	5- 8-46	[1] 24		J 1		5	66	D	Cp, L.
						86	34	Sand and gravel; gravel; sand; sandy clay.	do	6-21-51	44.0							
						130	20	Sandy clay; gravel.	do									
3L2	do	1926	150	61.5	D 6					6-21-51	7.25		L 1				U	
3M1	B. E. Mitchell.	1950	140	75	D 6	62	13	Gravel	QTge	6-23-50	[1] 18				24	42	D	L.
3M2	King	1951	140	72	D 6	69	3	Coarse gravel	do	5- 9-51	[1] 6		J				D	L.
3Q1	G. Foster	1950	145	171+	D 10					3-28-51	12.54						U	
3Q2	Lewis Velde	1940±	160	150	D				QTge				J					L.
4B1	Martin Lambert.	1900±	150	21.4	D 5				Qyal(?)	9-29-49	10.60		L				U	W.
4B2	do	1944	150	74	D 8	70	4	Gravel	QTge				J 1	19	25	18	D, O	L.
4B3	H. A. Weinland.	1941	150	152	D 8				do	9-23-41	[1] 33.8		T 7½		120	72.7	Irr	L, W.
										9-29-49	13.22							
4E1	V. C. Rasmussen.	1949	145	102′	D 8	60	42	Sand and gravel.	do	11-22-49	13.26		T 3		100	18	Irr, S	L.
										4-18-51	7.89							
4H1	A. G. Haswell.	1951	145	63	D 8	21	42	Sand; coarse sand and gravel; coarse gravel.	do	3-24-51	[1] 12		J 1½				D, irr	L.
										6-22-51	5.07							
5C1	A. Lucchesi	1949	135	153	D 8				do				T 7½		60		Irr	L.
5G1	C. Bordessa	1943	140	110	D 8	87	5	Gravel	do				J 1				D	L.
						105	3	do	do									
5G2	B. Re Bernardo.	1940	135	70	D 6	64	6	Gravel, "channel".	do	12-12-41	[15] 11		J				D, S	L.
										1-23-50	8.16							
										4-18-51	8.25							
5G3	W. E. Kieser	1950	140	60	D 6	54	6	Coarse gravel	do								D	L.

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TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
T. 7 N., R. 8 W.—Continued																		
7/8-5K1	C. R. Cox	1950	140	66	D 8	10	22	Gravel	QTge(?)	10-7-50	[1] 17		J½		5	47	D	L.
						35	31	"Sand and small gravel".	QTge									
5K2	W. Selligo	1946	138	96	D 8	88	3	Gravel	do	7-2-46	[1] 16				23	14	D	L.
5L1	A. Copes		140	75	D 8				do				J 1		20	22	D, S	Cp, L.
5L2	E. L. Johnson	1947	135	110	D 8	81	30	Clay and gravel; gravel.	do	11-22-49	[8] 16.85		J 3				D, S, irr	L.
										4-18-51	[8] 38.83							
5L3	J. Shurier	1950	135	88	D 6	63	9	Gravel and sand.	do	7-29-50	[1] 20				25	10	D, S	L.
						78	2	do	do									
6G1	J. Nihil	1943	135	30	Dug 42	110	2	Gravel	do	11-25-41	[15] 14		L				D	L.
				112	D 8-6					12-13-49	17.30							
										14-18-51	12.14							
6H1	Carl L. Voight	1948	135	104	D	98	6	do	do				J				D	L.
6H2	E. A. Lovell	1950	135	397	D, G 10	26	56	Sandy clay; sandstone; loose boulders.	do	3-15-51	9.18	[1] 70	T 5		125	100	Irr	L.
						145	42	Gravelly clay	do									
						232	3	Small loose boulders.	do									
						275	55	Hard sandstone; gravelly clay; loose sandstone.	do									

6Q1	A. Maccario	1949	130	150	D 10	38 80 138	9 10 12	Pebbly sand Gravel Gravel; cemented gravel.	QTge do do	11-22-49 4-18-51	[1] 18. 20 10. 31						Irr	L.
8C1	E. Babbini	1945	135	63	D 8				do	12-13-49 4-18-51	15. 47 9. 95		C 1½		67		D, S, irr	L.
8K1	J. Laiho	1944	130	30	D 6	24	6	"Hardpan and gravel."	do				J ½				D	L.
8K2	do	1947	130	60	D 8				do				J ½				S	
8L1	Piner School District.	1949	130	72	D 8	60	8	Gravel	do	1-23-50	0013. 56		J	10			PS	Cp, L, W.
8P1	W. D. Pacheco.	1943	125	81	D 6				do	8-26-43	[1] 20		J ½		30	3	D	L.
8Q1	C. Williams	1943	130	67	D 6	65	2	do	do				J 1½				D	L.
9D1	George Galea	1949	130	200	D 10				do	12-13-49 4-18-51	12. 83 4. 86		T 15	150			Irr, S	L.
9H1	Margaret B.	1937	125	80	D 8					8- ?-37 12-13-49 4-12-51	[1] 9 10. 49 4. 57		L ½		50	2	D	L.
9H2	Sawyer E. Giuseponi	1950	125	51	D 6	5 44	26 6	Gravel; sand Coarse sand and gravel.	do do	9- 9-50	[1] 22						D	L.
9H3	R. Johnson	1950	125	60	D 6	48	12	Gravel	do	9-19-50	[1] 14		J		20	18	D	L.
9L1	George Avellar.	1940	125	119	D 8				do				J 1				D, S	L.
9P1	A. Larsen	1951	125	52	D 6	48	4	Coarse gravel	QTge	4-30-51	[1] 9						D	L.
9Q1	B. W. McGrath.	1949	120	140	D 12				do	12- 9-49 4-12-51	6. 37 1. 79	[7] Warm	T		100	[3] 20	Irr	Cp, L.
9Q2	Schurer	1951	115	40	D 6	22	18	Coarse gravel	do	3-28-51	[1] 7		J				D	L.
9R1	Carl Rasmussen.	1948	120	210	D 10	35 136 162 180	15 3 3 7	Sand and gravel. Gravel do do	QTge do do do do	8- ?-48	[1] 9		T		100	20	Irr	Cp, L.
10E1	Mrs. Lambert	1950	150	57	D 6	50	7	Hard gravel	do	10-27-50	[1] 20				24	10	D	L.
10L1	E. E. Hardies	1935	135	212	D 12	100	14	"Light gravel" and some coarse sand.	do	10-13-49	21. 60		T 15	337	276	47. 5	U	W.
10M1	Paulson	1950	125	51	D 6	44	3	Sand and gravel.	do	6-21-50	[1] 18				31	30	D	L.
10M2	D. C. Moore	1950	125	68	D 6	57	9	Sandy clay	do	9-26-50	[1] 21				10	26	D	L.
10P1	B. Marcus	1941	130	150	D 8	139	7	Gravel	do	3-19-41 6-20-51	[1] 10 18. 70		J ½		42	33	D, S	Cp, L.
11B1	O. Heino	1948	295	194	D 8	122	2	Gravel	do	4- ?-48	[1] 57		L		8	137	D	L.
11G1	L. R. Jensen	1949	290	237	D 8				do	2- ?-49 4- ?-50 4-19-50	[1] 90 [3] 94 [8] 190+		L		7	155	D	L.
11K1	R. B. Midgeley.	1941	300	254	D 8	238	16	Sandstone	do	7- 2-41	[1] 100				22		D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

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								T. 7 N., R. 8 W.—Continued										
7/8-11M1	N. B. Owen		160	55.0	D 8					12-15-49	1.08		J ½				U	W.
12E1	Sonoma County Hospital.	1939	245	51 164	Dug 66 D 10				Tsv	10-13-49	35.1		T 10	100			PS	L.
12E2	do	1948	245	298	D 12	80	218	(Perforated interval).	do				T 15	300	450	[3]171	PS	L.
12G1	Mrs. K. C. Baumann.	1950	375	175	D 8-6	{83 124 154	20 22 21	do	}do	10-6-50	[1]65				9	52	D	L.
12H1	F. Morris	1950	460	255	D 6	{160 208	24 47	do	}do	2-27-50	[1]75				15	50	D	L.
12K1	C. Dont	1949	480	347	D 5	273	74	Sand, clay and gravel; sand and rock.	do	11-14-49	165				8	13	D	L.
12N1	Cummings	1946	190	80	D 12				QTge, Tsv (?).	4-19-50 4-11-51	[16]+0.70 [3]15.24	[7]Warm	C	[6]½	75-80	[3]20-22	Irr	L.
12Q1	W. Forni	1949	405	200	D				Tsv	8-?-49	[1]87		J		20	43	D	L.
12Q2	Romero	1949	430	220	D 8	125	95	Sandy clay and gravel; clay and gravel.	do	10-13-49	[1]123				20	27	D	L.
13C1	A. Koch	1951	190	70	D 6	26	36	Silt; sandy silt.	Qyal(?)	5-21-51	[1]9		J				D	L.
13D1	Laura Murray.	1947	185	115	D 10				Tsv	4-19-50	+0.01		J 3		58		Irr	
13D2	I. O. O. F. Cemetery Association.	1925±	200	75	D 8				do				J 3				Irr	

13D3	do	1930±	200	90	Dug D12.				do				T 5				Irr	
13E1	Whitehead	1951	185	49	D 6	20	22	Fine sand; silt.	Qyal (?)	5-23-51	[1] 9		J				D	L.
						45	4	Silt										
13F1	Deghi	1951	190	54	D 6	26	28	Soft silt; coarse gravel; silt and wood.	do	4-11-51	[1] 4						D	L.
13F2	E. B. Schneck	1951	190	60	D 6	31	12	Fine sand	Qyal	5-22-51	[1] 9						D	L.
						55	5	Silt	do									
13H1	E. E. Rothert	1950	200	146	D 8	12	35	Fine gravelly clay; packed medium gravel; silt.	Qyal (?)	10-23-50	[1] 35		J	12			D	L.
						56	8	Packed medium gravel.	QTge (?)									
						68	78	Packed gravel and boulders.	do									
13H2	J. K. Bryant	1950	200	100	D 71½	36	32	Fine packed gravel; sand.	Qyal, QTge(?)	11- 1-50	[1] 28		J		10	57	D	L.
						70	30	Silt; volcanic ash and gravel; gravelly clay.	QTge									
13H3	R. J. Vanderbeck.	1951	200	49	D 8	34	15	Coarse gravel	Qyal	5-15-51	[1] 12		J				D	L.
13J1	Von Grafen	1948	20	85	D 8				QTge(?)	7- ?-58 6-22-50 4-11-51	[1] 22 19. 58 27. 23		T 3		33	43	D, irr	L.
[10] 13J1	do	1952		253		148	105	(Perforated interval.)	QTge(?)						50	[3] 61		L.
13J2	do	1946	210	210	D	188	18	do	Tsv(?)	5-27-47	[1] 7		T 3		60	30	Irr	L.
13J3	W. J. Jackson	[17] 1950	200	60	D 8	43	4	Sand and gravel.	QTge(?)	9-28-50	[1] 20						D	L.
						56	4	Coarse sand and gravel.	do									
13K1	Dr. Michaelson.	1943	200	529	D 12	129	6	Cemented gravel.	QTge	4-20-50	6. 77	[7] Warm	T				Irr	L.
						272	159	Clay and gravel; cemented gravel; corase gravel, clay.	do									
13M1	George Proctor, Sr.	1948	180	100	D 8	65	30	Gravel; boulders.	QTge (?)				J		50		D, irr	L.
13N1	Dr. C. M. Carlson.	1941	180	77	D 8				do	10-25-41 1-26-50 4-11-51	[1] 26 18. 9 [8] 19. 40		J 1		17	26	Irr	L.
14A1	I. O. O. F. Cemetery Association.	1948	175	360	D 12-10				QTge	12- ?-48 10-11-49	[1] 0 5. 85				12	140	U	L.
[10] 14A1	do	1950		901	D 8				Tsv	4-11-51	(+)0. 07				23	[3] 160		L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 7 N., R. 8 W.—Continued																		
7/8–14D1	Santa Rosa Junior College.	1945	155	300	D 12	95	15	Cemented gravel.	QTge	10- ?-45	[1] 12		T 30		270	56	Irr, PS	Cp, L.
						146	54	Gravel; clay and gravel.	do									
						265	35	Hard cemented gravel; hard clay and gravel.	do									
14E1	do	1930±	155	761	D 12				do	12-20-49	[8] 22.5		T 15	127			Irr, PS	
14F1	A. McDonald	1950	160	147	D 8	118	15	Sand and gravel.	do	9-19-50	[1] 40		J 2		40	20	PS	L.
						138	9	Gravel	do									
14M1	Santa Rosa High School.	1929±	155	227.8	D 10				do	6-20-51	22.98						U	L.
14M2	do	1940±	155	148.3	D 10				do	6-20-51	16.0		T 7½				PS, irr	
15G1	W. Hook	1946	146	65	D 6	45	20	(Perforated interval.)	do	3-30-51	8.35		J				D	C.
15L1	W. Adams	1951	130	45	D 6	42	3	Coarse gravel	do	5-16-51	[1] 12		J				D	L.
15M1	J. A. Fowler	1951	130	48	D 6	38	10	Corase sand and gravel.	do	4- 2-51	[1] 8						D	L.
15R1	Nehi Bottling Co.	1950	145	146	D 10			H	do	4- ?-50	[1] 35		T 10		75–100		Ind	
16F1	C. Norton	1948	110	60	D 6				do	6- ?-48	[1] 13		J½		12	42	D	L.
16G1	Arthur Upp	1943	120	65	D 6	60	5	Gravel	do								U	L.
16Q1	W. Francis	1944	120	72	D				do	4- 9-44	[1] 9				21	18	D	L.
17H1	T. W. Webb	1943	115	40	D 6	30	10	Gravel	QTge(?)				J 1				D	L.
17K1	G. A. Gillette	1941	90	51	D 6	30	11	Sand and gravel.	do	10- ?-41 12- 9-49 4-13-51	[1] 12 13.12 7.40		J 1		12	28	D	L.
17K2	C. R. Wertz	1951	105	70	D 8	55	5	Sand	QTge	1- 9-51	[1] 26		J		45	10	D	L.
						65	5	do	do									

17L1	Akehurst	1947	90	44.0	D 12				do	11-8-49 4-13-51	10.70 4.05		T 3	35			Irr	
						3	33	Soft sandstone; gravel.	Qyal									
						52	10	Gravel	QTge									
						162	2	Cemented gravel.	do									
						234	34	Sandy clay; soft streaks with gravel; cemented gravel.	do									
17N1	Earl Peterson	1933	85	544	D 12					11-30-49 4-13-51	13.75 9.68		T 25				Irr	L.
						376	8	Cemented gravel.	do									
						424	6	do	do									
						506	10	Sandstone	do									
17R1	J. A. Vaughan		95	16.7	Dug 48				Qyal	9-29-49	7.31						U	
17R2	E. Bourdens	1936±	100	190	D 10-6				QTge	12-20-49 4-13-52	14.25 7.64		T 10	250			Irr	L.
17R3	J. A. Vaughan		95		D					4-4-51	5.29						D	
						20	14	Sand and gravel.	QTge(?)									
18K1	K. Rich	1950	85	420	D, G 10					5-25-50 8-9-51	[1] 8 20.33		T 20		100	15	Irr	L.
						40	2	Gravel	QTge									
						330	86	do	do									
18M1	R. Wendel	1951	80	640	D, G 12				QTge	4-29-52	.99						Irr	C.
18M2	do	Old	90	75	D				do								D	C.
						50	5	Sandy clay and gravel.	do									
						130	23	Cemented gravel; sand and clay.	do									
18Q1	F. Siemer	1941	80	811	D 12								T 30				Irr	L.
						192	6	Coarse cemented gravel.	do									
						222	14	Clay and gravel.	do									
19C1	B. F. Drake	1947	90	196	D 8	175	21	Sandy clay and fine gravel.	do	1-20-47 6-20-51	[1] 37 27.5		T 1.5		15	43	D, S	L.
19H1	William Strebel.	1933	90	100	Dug 84 D 12-10				do	11-30-49 4-13-51	10.42 4.44		T 5		25	[7] 53	irr, S	L.
19J1	Harry Peterson.	1949	80	186	D 8				do	9-?-49	[7] 8.10		T 20		200	65	Irr	Cp, L.
19K1	K. Straub	1949	90	176	D 10				do	12-6-49 4-13-51	19.53 14.39		T 5	130			Irr	Cp, L.
						20	12	Sand; gravel	do									
						45	20	Gravel; cemented gravel.	do									
19P1	W. N. Irwin	1947	85	245	D 8					11-30-49 4-13-51	21.56 15.77		T 15		94	[7] 39		
						150	30	Sand, gravel; sand, sediment.	QTm									
						219	16	Gravel	QTge									

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
								T. 7 N., R. 8 W.—Continued										
7/8-19P2	O. Young	1944	80	65	D 7				Qtge	2- 7-50	6.14		J	12			D, Dy,	S. L.
										4-13-52	10.17							
19P3	G. Steiner	1951	90	60	D 10	50	10	Gravel	QTge	2- 5-51	[1] 5				50	10	D	L.
20C1	Mrs. Elaine Healy.	1933	90	625	D 12-10	77	3	do	do	11-30-49	14.89		T 15		320	73	Irr	Cp, L.
						230	1	do	do	4-13-51	9.27							
						539	3	do	do									
						580	2	do	do									
						591	32	Sand containing trace of soft clay; gravel.	do									
20D1	F. Hansen	1950	90	484	D, G 10	190	104	Clay and gravel	do	6-21-50	[1] 12		T 15		100	20	Irr	L.
						446	30	Cemented gravel.	do	8- 9-51	[18] 12.8							
20K1	F. Siemer	1939	98	626	D 12				do	10- 4-49	20.4		T 30	450			Irr	Cp, L, W.
20L1	A. Fistolera		95	57.7	D 12				do	9-29-49	9.57		T 3				U	W.
20Q1	F. Siemer		95	40±	D 6				do	1-11-50	[18] 10.7		T 2				D, O	
										4-13-51	5.59							
21B1	D. W. Wilson	[17]1950	120	51	D 6	47	4	Course gravel	do	12-23-50	[1] 10						D	L.
21C1	City of Santa Rosa.	1951	110	310	D 8				do								Ind	L.
21D1	Calif. State Division of Forestry.	1936	105		D 8	80	10	Coarse gravel	do	6- ?-36	[1] 8				40		D	L.
										12-28-41	[15] 10							
21D2	E. LaFont	1949	105	80	D 6					2- 2-50	0.17						D	
										4-13-51	2.07							
21K1	City of Santa Rosa.		115	155	D 8	50	5	Gravel	QTge	10-13-49	18.90				20	35	U	L.
						150	5	Clay and gravel.	do	4-13-51	13.33							
21P1	I. D. Wood	1941	105	78	D 5				do	do					20		D	L.

21P2	R. Albini	1949	105	70	D 6	65	5	Gravel	do				V		20		D	L.
						32	24	Clay and gravel.	do	12-20-49	13.28		J 1				D, S	L.
22C1	R. Acquista-pace.	1938	130	108	D 6	62	46	Sandy clay; clay and gravel.	do	4-11-51	10.82							
22H1	W. A. Taylor & Co.	1930±	145	31	D 14								T 3	150			Ind.	Cp.
22J1	Christian estate.	1939	140	46	D								J ½				D	L.
22K1	J. Imwalle	1928	135	285	D 12					1-23-50 4-12-51	14.99 15.14		T 10	125			Irr	
22Q1	do	1925	140	360	D 12								T	125			Irr	
22Q2	do	1944	140	86	D 12					1-23-50 4-12-51	5.23 [8] 9.97						irr	
22R1	A. E. Bobbett.	1940	140	98	D 6								L				U	L.
22R2	Paul Bertoli	1930±	145	205	D 12					1-23-50 4-12-51	4.10 9.33		T 7½	90			Irr	
22R3	Mrs. Peter Bogdanoff.	1941	140	60	D 6					1-24-50 4-12-51	7.47 9.10		J ½		20		U	L.
23E1	Grace Bros. Ice & Cold Storage Co.	1944	145	56.3	D 12				QTge	10- 5-49	[3] 19.55		T 5	150	75		Ind.	
[10] 23E1	do	1951		100	D 10					4-12-51	[7] 5.5				100	35		L.
23L1	Grace Bros. Brewing. Co. (Davis St. well).		155	300	D 10-8	48	4	Gravel	QTge	7- 9-47	[7, 8] 79.2	[7] 66	T 10	35			Ind	L.
						132	1	do	do	1935	[1] 35							
						273	5	do	do									
						54	66	Clay contain-ing streaks of sand and gravel; gravel.	QTge (?)	9- 2-48	[7] 100.1		Ts 40	450	295	[7] 201.7	Ind	C, L.
23M1	Grace Bros. Brewing Co. (New well).	1947	155	990	D, G 12-10.	320	15	Sand and gravel.	QTge	10-11-49	[9] 190+							
						500	127	Sand and red gravel; sand.	QTm (?)	4-12-51	[8] 137.85							
						751	63	Sand	do									
						955	15	do	do									
23M2	Grace Bros. Brewing Co. ("Pomona well").	1942	155	210	D 10-8				QTge (?)	5- ?-42	[1] 65		T 10	135	20	115	Ind	C, L.
23M3	Grace Bros. Brewing Co.	1936	155	[3] 300	D 10					11-21-49	27.86						U	
23M4	Sonoma Valley Wholesale Grocery Co.	1920±	150	1,279	D 14					6- 5-51	52.12						U	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone or zones open to well: Thickness (feet)	Water-yielding zone or zones open to well: Character	Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
T. 7 N., R. 8 W.—Continued																		
7/8–23N1	National Ice and Cold Storage Co.	------	145	37 150±	Dug 72 D	------	------	------	Qyal(?) QTge(?).	10–13–49	17.65	------	T 5	------	------	------	Ind	W.
23N2	do	------	145	17?	Dg 60, D.	------	------	------	do	10–13–49 4–12–51	14.72 9.85	------	T 5	------	------	------	Ind	
23P1	R & L Beverage Co.	1940	150	266	D 8	90 116 258	5 22 6	Clay and gravel. Clay and gravel; cemented gravel; gravel. Clay and gravel.	QTge do do	4–1–40 11–9–49 4–12–51	[1] 16 26.7 [8] 40.52	------	T 5	------	43	40	Ind	L.
24A1	City of Santa Rosa (No. 1).	1900±	195	[19] 49.9	Dug 60	------	------	------	Qyal	10–12–49	44.68	------	T10	------	------	------	PS	
24A2	City of Santa Rosa (No. 2).	1918	195	930	D 14–5¾.	------	------	------	Qyal, QTge, Tsv(?).	5–26–49 10–9–49	[7] 159 [7] 166	[7] 84	T 30	------	------	------	PS	C.
24A3	City of Santa Rosa (No. 3).	1904	195	300	D 12–10	------	------	------	Qyal, QTge.	------	------	[7] 70	T 30	278	------	------	PS	C.
24A4	City of Santa Rosa (No. 4).	1940	195	1,000	D 16–10	------	------	------	Qyal, QTge, Tsv(?).	5–26–49 10–9–49	[7] 240 [7] 240	[7] 86	T 75	1,004	------	------	PS	C, L.

24A5	City of Santa Rosa (No. 5).	1947	190	291	D	50 186	120 102	(Perforated interval).	QTge	7-10-49 10- 9-49	[7] 105 [7] 143	[7] 66	Ts 15	382			PS	L.
24A6	City of Santa Rosa (No. 6).	1950	190	1, 200	D, G 30-16.				Qyal(?) QTge, Tsv (?).	7- 3-50	[1] 59				1, 994	138. 5	PS	C, E, L.
24H1	Weckerly	1949	190	102	D 8	43	55	Gravel	QTge	11- ?-49 2- 1-50 11-21-52 4-13-53	[1] 60 28. 25 57. 25 24. 35		J 1½	16	25	25	D	L.
24H2	do	1947	190	74	D 8					4-12-51 11-21-52 4-13-53	28. 18 55. 75 26. 41		J				D	
24K1	C. Harpold	1950	180	238	D 8-6	234	2	Coarse sand and gravel.	QTge	12-19-50	[1] 60		J		8	160	D	L.
25E1	C. J. Castelli	1949	160	100	D 8					4-12-51	14. 61		J				D	L.
25E2	do		160	40	D 6				do	2- 7-50	17. 75						U [20]	
25F1	D. E. Sutter	1950	190	102	D 8	98	4	Large boulders (Cased to 46 feet).	do	9- 8-50	[1] 4		J ½		10	80	D	L.
25F2	do	1950	190	136	D 10				Tsv(?)	9- 1-50	[1] 16				2	20	U	L.
25G1	Standiford	1951	190	175	D 8	165	10	Boulders	do	6-16-51	([1, 4])	[1] 70			20	[3] 20	D	L.
25L1	G. K. Hardt	1950	175	745	D, G 8	270 545	100 200	(Perforated interval.)	QTge	6- 5-51	10. 65				100	745	U	L.
25R1	E. M. Weaver	1947	235	320	D 8	30	120	(Perforated interval.)	Tsv(?)				J 3				Dy	L.
26H1	W. S. DeWitt	1950	155	60	D 6	40	18	Gravel and sand.	QTge	7-31-50	[1] 20				6	11	D	L.
26J1	J. Bongi	1950	150	79	D 6	60	20	Sand and gravel.	do	10-11-50	[1] 12				30	30	D, irr	L.
26L1	W. Van Aalsti	1940	135	36. 5	D 8				do	12-22-49 4-12-51	14. 41 6. 04		J 1				D	L.
27A1	J. H. Peebles	1943	140	50	D 6	48	2	Gravel	do	12-20-49 4-12-51	11. 6 6. 07		J				U	L.
27A2	M. S. Whitaker.	1940	135	60	D 8	55	5	Gravel	do	12-22-49	[8] 11. 65		J 1	30			D	L.
27A3	L. G. Bonar	1939	135	50	D 8				do	11- ?-39	[1] 21		C 1		12	10	D	L.
27G1	H. W. Peterson.	1949	125	64	D 8	54	10	Gravel	do	2- 7-50 4-12-51	7. 37 8. 43		C				D	L.
27H1	E. R. Mecchi	1951	130	57	D 6	48	9	Coarse sand and gravel.	do	1- 4-51	[1] 12						D	L.
27J1	C. F. Conners	1949	135	56	D 8	{18 {42	18 14	Gravel do	do do	11-28-49	[1] 24		J		25	6	D	L.
27J2	C. Blucher	1951	130	53	D 8	22	31	Coarse sand and gravel.	do	2- 3-51	[1] 8						D	L.
27M1	G. Fitch	1944	115	100	D 8				do	12-21-49 4-12-51	11. 99 11. 7		J 1	16			D	L.
27M2	Q. Campbell	1925±	115	100+	D 10				do	1-24-50 4-13-51	2. 5 4. 37						U	
27M3	C. F. Borbe	1949	115	78	D 6				do					13			D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 7 N., R. 8 W.—Continued										
7/8-27N1	Fred W. Buss	1941	115	95	D 8				QTge	5- ?-41 12-21-49	[1]9 12.22		T 2	21			D, irr	L.
27P1	Fred Kuhne	1940	120	60	D 8	57	3	Gravel	do				J 1				D	L.
28E1	Muirhead	1951	100	48	D 6	41	7	Coarse sand and gravel.	do	1- 3-51	[1]12						D	L.
28F1	J. C. Antone	1943	100	67	D 8	55	9	Gravel	do	12-19-49 4-12-51	9.03 2.80		J 1		25	23	D	L.
28F2	H. Solomanson.	1943	105	57	D 8				do	12-20-45 4-12-51	8.11 1.09		J ½		25	23	D	L.
28G1	Mansfield	1950	110	63	D 6	33	27	Gravel; sand and gravel.	do	12-20-50	[1]6				45	20	D	L.
28M1	West Coast Livestock Auction.	1940±	100	75	D 8				do				J 1	16			S	L.
28M2	Mrs. Ruth W. Finley (Radio Station KSRO).	1940±	95	90	D				do	12-21-49 4-12-51	10.25 5.10		J				U	L.
28R1	Erwin Brunt	1933	110	57	D 8	28	22	"Wash" gravel; fine sand.	do	4-20-50 4-12-51	3.63 [8]5.24		J ½				D, irr	L.
29C1	A. Fistolera	1935±	101		D 6				do								D	
29E1	J. E. Valentine.	1945	95	70	D 8				do	12-29-49 4-12-51	12.11 4.76		J				D	L.
29F1	V. Arnett	1951	95	67	D 6	30 61	22 6	Sand and silt Sand and gravel.	do do	4-21-51	[1]5				25	30	D	L.
29G1	F Gordon		95		D 8				do					20			D	L.

29H1	C. J. Weinberger.	1939	95	58	D 6				do	9- ?-39 12- 1-41 12-20-49 4-12-51	[1] 12 8.5 9.60 2.79		J 1	16			D, S	L.
29J1	Santa Rosa Naval Air Base.	1943	94	700	D, G 12-10			(Casing cemented 0-20 ft.)	do	10- 4-49 4-12-51 4- 4-52	22.14 16.10 15.48		T 20	450	450	192	PS	C, Cp, L.
29M1	Johnson	1943	90	86	D 8				do	12-29-49 4-12-51	12.26 5.21		J 1	37	23	35	D, irr	L.
29N1	G. A. Jones	1943	90	64	D 6	62	2	Gravel	do				J½				D	L.
29P1	S. Grossi	1942	95	90	D 8				do	3- 8-42 12-20-49 4-12-51	[15] 1 9.87 4.79		L				D, S	L.
29P2	L. E. Deitle	1942	88	70	D 6				do	1-11-50 4-12-51	12.42 4.93		J	27			D	L.
29P3	Jahorstorfer	1950	90	60	D 6	55	5	Loose gravel	do	5-23-50	[1] 6				20	25	D	L.
29Q1	Santa Rosa Naval Air Base.	1925	88	61.7	D 8					11-17-49	10.94						U	W.
						110	10	Cemented gravel.	do									
						130	15	Clay, gravel, boulders.	do									
						150	7	Sandy clay and gravel.	do									
29R1	do	1943	93	682	D 12-10	175	22	Clay and gravel.	do	10- 4-49	20.86		T 20	480	450	90	PS	C, L, W.
						238	15	Cemented gravel.	do									
						650	29	Fine free gravel; sandy sediment.	do									
29R2	do	1943	94	801	D 12												A	L.
30D1	T. J. Menne	1944	90	62	D 6				QTge				J				D	L.
30D2	do	1900±	90	35.5	D 6				do	12-19-49 4-12-51	26.51 21.90		P				U	
30E1	D. Grossi	1947	90	150	D 8				do				J				D, S	L.
30E2	L. O. Moses	1951	92	148	D 6	60 140	10 8	Clay and gravel Sandstone and gravel.	do do	3- 3-51	[1] 10		J		8	40	D	L.
30J1	S. Johnson	1943	95	70	D 6				do								D	L.
30P1	C. Dotti	1949	85	205	D 8				TQge, TQm (?).	12-21-49 4-12-51	10.45 [8] 4.81		T 5		[7] 160	33	Irr, S	L.
30P2	Morelli	1943	90	90	D 8				QTge				T 2				D	L.
30P3	do		90	43.5	D 6				do	12- 1-41 12-21-49 4-12-51	[15] 13 14.96 7.25						U	
31B1	C. Dotti	1943	85	80	D 6				do	12-21-49 4-12-51	10.67 5.04		L				S	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
								T. 7 N., R. 8 W.—Continued										
7/8-31C1	Marino La Franchi.	------	85	170+	D 12-10				QTge(?), QTm.	8-11-50	14.40			250			U	W.
31E1	J. M. Ford	1945	75	80	D 6				QTge	12-29-49	6.40		L				D	L.
										4-11-51	2.75							
31E2	R. M. Isola	1949	80	80	D 6				do	2-9-50	8.82						U	L.
										4-11-51	8.45							
32D1	W. B. Johnson	1937	90	60	D 8				do				J 1				D, S	L.
32F1	C. S. Mott	1948	95	80	D 8				do	12-14-49	10.85		J 2				Irr	L.
										4-11-51	5 73							
32H1	J. X. Wilson	1941	95	84	D 6				do	12-19-49	9.35		L				D, S	L.
										4-11-51	3.99							
32L1	B. H. Roark	1947	95	157	D 10				do	12-21-49	11.06		T 7½	120			Irr	
										4-11-51	5.40							
32P1	I. Goldstein	1948	93	89	D 8				do	6-?-48	[1] 11		T 1½		35	29	D, S	L.
33H1	R. Thornley	1951	105	42	D 6	39	3	Sand and gravel.	do	4-4-51	[1] 4		J				D	L.
33H2	W. C. Northcutt.	1951	105	60	D 6	46	14	Coarse sand	do	4-12-51	[1] 9		J		15	35	D	L.
33H3	C. M. Streng	1951	105	42	D 6	39	3	Coarse sand	do	5-11-51	[1] 10		J				D	L.
33J1	S. Kiendl	1950	105	70	D 8	45	25	Sandy clay; clay and gravel.	do	6-14-50	[1] 6				30	19	D	L.
33K1	A. D'Adam	1951	100	42	D 6	39	3	Coarse gravel	do	9-11-51	[1] 8		J				D	L.
33M1	A. Marx	1950	95	452	D, G 10	40	23	Gravel	QTge	11-2-50	[1] 20				500	195	PS	C, L.
						87	17	Sand and gravel.	do									
						146	7	do	do									
						172	119	Gravel	do									
						346	29	Sand and gravel.	do									
						422	30	do	do									

33N1	Mrs. J. Kremesec.	1951	95	74	D 8	60 72	7 2	Coarse gravel Coarse sand and gravel.	do. do.	4-23-51	[1] 12						D	L.
33R1	P. Falco	1951	100	70	D 8	32	38	Sand; coarse gravel.	do.	1-26-51 6-25-51	[1] 12 6.73		J ½				D	L.
34K1	J. Marshall	1950	115	62	D 6	57	5	Coarse sand and gravel.	do.	11-8-50	[1] 10						D	L.
34M1	C. A. Derho	1951	105	45	D 6	32	12	Coarse gravel	do.	1-5-51	[1] 12		J				D	L.
35A1	Schmidt	1938	155	102	D 8				do.	1-24-50 4-11-51	37.66 34.29		L 1				D	L.
35B1	W. Hulsman	1949	140	133	D 8	35 60 122	5 12 8	Sandy clay and gravel. Gravel Sand and gravel.	do. do. do.	12-16-49	[1] 23		L 1	7		87	Ind	L.
35C1	J. W. Carrothers.	1937	135	114	D 8	44	44	(Perforated interval.)	do.	7-?-37	[1] 20				8	40	D	L.
35G1	J. W. Miller	1948	140	52	D 6				do.	10-?-48 1-24-50 4-11-51	[1] 30 16.45 17.69		J ⅛		31	13	D	L.
35H1	R. O. Phelps	1930±	150	270	D 12-8				do.	1946	[7] 42		T 3½		33	24	D, Irr, S	
35M1	Taylor	1950	120	152	D 10				do.	4-20-50 4-11-51	10.73 8.34		T 7½		100	[3] 30	Irr	
35Q1	H. O. Newberry.	1925±	120	75	D 8								L ½		30	[7] 3	D, S	
36C1	F. T. Adshade.	1951	180	194	D 7½	160	34	Small boulders	do.	5-12-51	[1] 23		J		9	120	D	L.
36D1	Howard Wells.	1949	166	140	D 8				QTge(?).	1-?-49 1-24-50 4-11-51	[1] 46 47.2 40.98	60	J 1		17	74	D	Cp, L.
36D2	R. R. Todd	1946	165	252	D 8	241	8	Coarse sand	Tsv(?)	6-24-46	[1] 42				42	8	D	L.
T. 7 N., R. 9 W.																		
7/9—1C1	P. W. Bussman.		90	110	D 10				Qyal, QTge.	10-5-49	18.1		J 3				D, Ind, PS.	Cp, W.
1F1	Dan Baldocchi.	1944	100	80	D				QTge	12-10-41 12-13-49 4-10-51	[15] 35 18.89 15.25		T 2				D, Ind	L.
2C1	Mrs. H. Meuh.	1932	70	610	D 12				Qyal, QTge, QTm.	11-16-49 4-13-51	14.01 12.59		T 20	1,000			Irr	
2C2	do.		65		D 12				Qyal, QTge (?).	11-18-49 4-13-51	10.50 7.60		J 2				D	
2F1	John Rued	1939	100	145	D 8				QTge, QTm (?).	Fall 1939. 12-10-41	[1] 30 [15] 35		J 1				D, S	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
								T. 7 N., R. 9 W.—Continued										
7/9-3E1	David Papera	1944	150	130	D 12-8	37	93	Clam shells and gravel; sandstone; clam shells.	QTm	11-18-49 4-10-51	41.45 34.55		J 1	5			D	Cp, L.
3M1	G. Bertolucci	1949	100	61 131	Dug 72 D 8.	127	4	Gravel	do	4-?-49 7-14-50 4-10-51	[7] 35 36.12 34.92		J ½	12	17		D	L.
3Q1	Stanley Denner.	1947	80	88	D 8				do	7-?-47 9-?-50 11-3-50 4-10-51	[7] 17 [7] 26 32.5 31.79		J 1				D	L, W.
4B1	Aristo Pelletti.	1940	125	185	D				QTm(?)								A	L.
4C1	do	1940	90	28	Dug 36	7	21	Sandstone	QTm	11-21-49 4-10-51	13.5 12.66		L ¾				D, O	L.
4N1	Dolph Hill, Sr.	1950	280	120	D 8	30	90	Soft sand; sandstone.	do	4-18-51	15.83		L 2		6		D, O	L.
4N2	do		280		D 6				do	7-14-50	2.42						U	
5D1	Dominic Papera.	1949	230	119	D 8	56	42	Sandstone	do				L 2				D	L.
5G1	W. H. Godfrey.	1944	275	120	D 8			Open-end casing.	do	7-12-50 4-10-51	78.06 75.73		L 1				D	L.
5L1	Dee Winter	1944	205	175	D 8	40	135	Sandstone	do	7-20-50 4-12-51	15.85 13.87		L				U	L.
5M1	Mrs. John VanKeppel.	1939	200	95	D 8	85	10	do	do				J				D	L.
5N1	Petri Wine Co.	1947	170	292	D 12			(Cased to 75 feet, perforated at 58 ft.)	do	7-20-50	32.62		T 7½		74	[3, 7] 100	Ind	Cp, L, W.

7G1	Ralph Smith	1950	250	331	D 6			(Cased to 40 ft.)	KJu	7-20-50	150+		L 1½		8		D, Dy	L.
										4-13-51	16.88							
8D1	Dolph Hill, Sr.	1949	105	100	D 10				TQm	7-14-50	1.19				85		Irr	
										4-13-51	0.02							
8J1	C. E. Templeman.	1948	215	250	D 8	160	114	Sandstone	do	8-10-50	52.04		J 1				D, O	Cp, L.
										4-13-51	48.40							
8K1	A. Pasquinelli	1948	225	350	D 8-6	276	74	do	do	Fall 1949	[7] 90		L 1		3	[3, 7] 200	D, O	L.
9F1	C. W. Gilbert	1938	280	226	D 7	186	40	Sand; sandstone.	do	12-?-38	[7] 46		L 1	5			D	L.
										7-14-50	[8] 18.90							
										8-10-50	50.22							
										4-13-51	[8] 65.7							
10E1	W. A. Taylor Wine Co.	1935±	200	260	D 8	160	100	Sandstone; sand.	do	7-14-50	46.75	62	T 10					Cp, L, W.
10E2	do	1939	190	60	D				do								A	L.
11H1	V. Saitone	[17] 1944	100	33	Dug 60	52		Gravel	QTge	12-10-41	[15] 12.6		J 1				D	L.
				105	D 7	95	10	Sand and fine gravel.	QTm(?)	3-7-42	[15] 8							
										12-13-49	[21] 11.76							
										4-13-51	[21] 6.29							
11H2	H. M. Shaw	1951	100	85	D 6	65	10	Sandy gravel	QTge	1-6-51	[1] 15		J1		30	30	D	L.
						76	7	Clay and gravel.	do	6-25-51	9.3							
11N1	J. E. Baxman		75	100	D 12					2-2-50	9.84		J 2				Dy, S	
										4-13-51	10.12							
12H1	Dewey Baldocchi.	1944	105	24	Dug				do	12-8-49	[8] 14.05		J				D	L.
				60	D 7					4-13-51	10.35							
12J1	O. Lee	1950	110	70	D 8	5	53	Fine sand: coarse gravel.	do	6-25-51	6.58		J ½				D	L.
12K1	E. R. Lofgren	1937	100	96.0	D 6					4-13-51	15.64		J 1		15	6	D	L.
12P1	George Williams.	1944	95	52.0	D 7	50	4	Gravel	do	2-2-50	4.60		J ¾				D, Dy	L.
										4-13-51	4.36							
13B1	H. J. Brabec	1950	110	142	D 8	14	5	Gravel	do	Spring 1951	[7] 25	66	T 5		83	27	Irr	Cp, L.
						72	70	Fine sand	QTm	6-23-51	34.75							
13C1	A. Pelletti	1949	95	68	Dug				QTge	12-11-41	[15] 12.5		J				D	L.
					D 8					3-7-42	[15] 5							
13M1	Chris Ketelsen.	1941	70	320	D 12-8	235	57	Sandy clay	QTm	10-5-49	26.02		T 10	200	40	13	Irr, Dy	Cp, L, W.
13M2	do	1900±	85	60	B 5				QTge	10-5-49	19.83		L ½	3			D, S	W.
13M3	do		75	45	D 6				do	3-29-50	7.40		J ¾				D, Dy	W.
13R1	Alfred Santell	1948	70	375	D 12	37	9	Sand and gravel; clay and gravel.	do	5-?-48	[1] 3		T 25	350	355	178	Irr	C, L.
						70	11	Clay and gravel; gravel.	do	12-9-49	8.83							
						94	26	Clay and gravel.	do	4-13-51	2.53							
						130	40	do	do									
						265	10	do	do									
						330	45	Sandy clay and gravel; gravel.	do									

See footnotes at end of table.

Table 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 7 N., R. 9 W.—Continued										
7/9-14H1	R. A. Kucich	1944	90	85	D 8				QTge	2- 2-50	26.95		J				D	Cp, L.
14H2	L. C. Mohar	1947	100	75	D 8				do				J 1				D	L.
14H3	E. E. Tiggs	1950	110	92	D 8	48	2	Sand	QTm(?)	8-19-50	[1] 18						D	L.
						74	4	Sand and gravel.	do									
14H4	J. C. Arro	1950	100	72	D 8	42	30	Fine sand; coarse sand and gravel.	do	6-23-51	26.03		J 1				D	L.
14K1	A. Luers	1949	80	636	D, G 16-12.	16	24	Sand; fine gravel; clay.	QTge	10-18-49	[1] 18.6		T 50	625	750	53	irr	C, Cp, L.
						86	24	Clay, small gravel, and sand.	do	12- 8-49	23.79							
						138	446	Shells and gravel; sand; sand and small gravel; small gravel.	QTm	8-11-50	[3] 42.87							
14K2	do	1938	75	162	D 8								J 3		50	[7] 10	D, S, Dy	L.
15A1	J. Avilla	1947	75	90	D 8				QTm	6-15-50	[8] 63.94		J 1				D	L.
										4-13-51	29.20							
15C1	F. J. Freitas	1941	115	100	D 6	82	18	Shells; sand and shells; sandstone.	do	6-15-50	42.12		J		13		D	Cp, L.
										4-13-51	39.67							
15D1	F. Elmore	1950	115	107	D 8	105	2	Sand	do	10-30-50	[1] 30		J		25	15	D	L.
15E1	H. Higgins	1940	120	110	D 6				do				J 1				D, S	L.
15E2	do	1945	125	220	D 8	215	5	Sand and shells	do				J 1½				D	L.
15G1	E. L. Graham	1948	185	190	D 8	80	110	Sand; sand and shells.	do	6-15-50	120.5		J 1½				D	L.

15Q1	Frei Bros.	1920±	75	200+	D 8				do.				L 3				Ind, O	
16L1	H. H. Schlossman.	P 1950	220	255	D 8-6				do.	2- 9-50 6- 5-51	[1] 65 65.35		L		3	10	D, O	L.
16Q1	Garcia and O'Connell.	1946	225	268	D 8				do.				J 2		20	22	Ind	L.
16Q1[10]	do.			321						7- 3-46	[1] 76							
17B1	K. Parnell	1948	190	165	D 8	90	75	Sandstone	do.				J 1		20	[3] 7 60	D	L.
17B2	do.		170	32	Dug 48				do.	7-12-50 4-13-51	24.3 20.53						U	
17J1	F. W. Dahlbom.	1944	110	140	D 7	115	25	Sandstone	do.								D	L.
17J2	Coughlan	1942	120	130	D				do.								D, S, irr	L.
17M1	E. G. Widdoes	1946	85	40	D 8	18	17	Gravel	Qyal	7- 7-50 4-13-51	[3] 18.9 3.89		T 5	40			Irr	L.
17R1	Sebastopol Apple Grower's Union (Plant No. 6).		110		D 8				QTm	5-15-50 4-13-51	[18] 9.50 6.99		L 3				Ind	
17R2	do.		110	165	D 8				do.				L 3				Ind	L.
18E1	P. Code	1946	340	75	D 8				do.								D	L.
18J1	J. S. Williams	1950	115	650	D 10				KJu	8- 8-51	13.6						U	
18K1	do.	1950	115	266	D, G 6			(Reported "dry hole".)	KJu(?)	8- 8-51	7.1						U	L.
18L1	M. E. Shanks	1949	180	12	Dg 48	0	10	Soft sandstone; sandstone and clam shells.	QTm	7- 7-50 4-13-51	7.5 4.33						D	L.
20A1	R. E. Oehlmann.	1940±	115	73	D 8				do.	7- 6-50 4-13-51	17.54 20.51						U	
20A2	do.	1949	115	80-90	D 8				do.	4-13-51	20.76		J 1½				Ind	
20A3	do.	1945	115	81	D 8				do.	7- ?-45 7- 6-50 8- 9-50	[1] 17 16.95 27.25		J 2		14	57	Ind	L.
20B1	Thomas Fish	1950	100	159	D 8			(Cased 0-20 ft.)	do.	7-12-50 7-12-50 4-13-51	[3] 54 [22] 40.2 (4)		T 10		100	[3] 7 85	Irr	Cp, L.
20C1	R. E. Oehlman.	1945	120	130	D 8	92	38	Sandstone	do.	7- ?-45 7- 7-41 4-13-51	[1] 32 27.41 16.99		J 3		6	83	D, Ind	L.
20D1	do.	1945	85	144	D 12				do.	7- 7-50 4-13-51	2.11 1.30				35		U	L.
21B1	Garcia and O'Connell.	1944	240	550	D 8-7				do.								A	L.
21C1	H. S. Wheeler	1944	225	325	D 8	290	35	Sandstone	do.				L				D, O	L.
21F1	C. O. Barlon	1942	200	320	D 9-5-3				do.	5- ?-42 6-23-50	[1] 48 62.95	64	J 3		22	75	D, irr	Cp, L, W.
21G1	F. Schell	1942	240	530	D 8			(Cased to 515 feet; no perforations.)	do.	2- ?-42 6-15-50 4-13-51	[1] 88 [3] 169 84.99		J 3	6	4	52	D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 7 N., R. 9 W.—Continued										
7/9-21G2	E. W. Arnold	1947	205	240	D 8				QTm				J 2				D, O	L.
21G3	T. W. Nussbaum.	1946	215	408	D 8-5	390	18	Sandstone	do	8- 6-46	[1] 62		J 2		8	40	D, S	Dp, L.
21J1	Hornbuckle		230	205	D 7	195	10	Sandstone	do				L				D	L.
21L1	Dawson	1944	185	175	D 7				do				J ½				D	L.
22F1	R. Winkler	1951	125	575	D, G 10	42	215	Fine sand	do	8-30-51	70.4				666	120	Irr	L.
						383	17	Small boulders with shells.	do									
						481	31	do	do									
						517	58	Fine gravel; coarse gravel.	do									
22F2	do	1951	150	380	D 10			(No perforations.)	do	8-30-51	53.78						D	
23F1	C. Whitlatch	1951	70	610	D 12-10-8.	15	22	Sandstone; sand.	do	6-20-51	[8] 78.3	[1] 73	T gas	325	400	85	Irr	C, Cp, L.
						48	22	Coarse sandstone; sand; "quicksand."	do									
						70	540	Sandstone and shells; sand and shells; sand and gravel.	do									
23H1	R. S. Lovelace.	1946	75	70	D 6				QTge	2- 2-50	19.32		J 1				D	L.
23K1	C. E. Stone	1920±	85	200	D				QTge, QTm.	11-28-41	[15] 27		T 3		300		D, Irr	L.
										12- 8-49	22.45							
										4-18-51	32.12							
23M1	E. Grenz	1949	70	70	D 6	65	5	Gravel	QTge	11- 1-50	27.55		J 1				D	L.
										4-13-51	21.36							

23Q1	E. Bloom-quist.	1950	65	39.5	D 8					11-1-50 4-13-51	14.21 7.04						D	
23R1	Fred Harding	1949	70	150	D 8				QTge, QTm.	12-6-49 4-18-51	11.95 11.10		C 2½	130	[23] 60	[23] 12	S	Cp, L.
24L1	Lee Ramondo	1945	100	140	D 8				QTge(?)	11-30-49 4-18-51	[3] 17.3 20.47		J 2				D, S	L.
24L2	do	1949	95	330	D, G 10				QTge, QTm (?).	4-18-51	[3] 33.30				350	35	Irr	
24M1	Fred Harding	1947	100	160	D 10	37 65 95	11 22 37	Cemented gravel. Sandstone; cemented gravel; gravel. Sandstone; gravel.	QTge do QTm(?)	12-6-49 4-18-51	[3] 39.27 40.69		J 3	60	100		D	L.
24M2	do	1946	100	145	D 8												U	L.
24M3	S. R. Murray	1950	100	63	D 6	58	5	Gravel	QTge	7-27-50	[1] 19		J				D	L.
25A1	Gino B. Rossi	1948	80	86	D 8	20 65	10 20	Clay and gravel. Gravel	do do	2-2-50	9.15		L 1		50	[7] 30	D, Dy	L.
[10] 25A1	do	1951		256		90 190	16 16	Sand do	QTm do	4-18-51 4-31-51	7.34 [1] 9				100	30		L.
25H1	Ben Piezzi	1945	95	138	D 8				QTge	12-19-49 4-18-51	20.17 17.48		T 2				D, S	L.
25J1	E. Mantua	1949	90	140	D 8				do				J 1				D, S	L.
25R1	W. A. Duer	1944	85	190	D 7				do								D, S	L.
26M1	Ruth W. Finley.	1935±	80	206	D 8				QTm	4-12-50 4-18-51	19.93 20.30		J 2	17			D, S	L.
26N1	Fulgham	1944	100	145	D 6	35	110	Sand; "soft clam shells."	do				J 1				D	L.
26P1	Ruth W. Finley	1946	75	110	D 8				do	4-12-50 4-18-51	19.63 27.50						U	L.
26P2	do	1949							do	4-18-51	26.49		J				D	L.
27E1	Molino Apple Coop.		145	260	D 8	12	248	Sandstone and clam shells; sand and gravel; sand.	do								Ind	L.
27E2	Sebastopol Apple Growers Union (Plant No. 5).	1951	165	370	D, G 8	0 90	47 280	Sand and gravel; quicksand. Sandstone; gravel and sand.	do	5-?-51	[1] 9		T 7½		300	100	Ind	L.
27F1	do		150	200	D 8				do	6-23-50 4-18-51	10.62 7.33		L		100		Ind	L.
27G1	L. H. Wells	1940	170	185	D 8				do				J 1				D, O	L.
27J1	H. A. Gruene-wald.	1945	120	154	D 8	110	44	Sandstone and shells; sand and shells.	do								D, S	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 7 N., R. 9 W.—Continued										
7/9-27K1	C. Lindgren	1951	175	90	D 6	89	1	Free sand and gravel.	QTm	4-17-51	[1] 25		J		26	15	D	L.
27Q1	H. C. Colvin	1949	225	87	D 8				do						8			
28G1	Silveria and O'Connell Apple Products Co.	1944	120	260	D 8	90	170	Sandstone	do	4-13-50 4-17-51	[4] +2.0 [4] +2.0		J 3	[6] 5	40		Ind	L.
28G2	do	1950	115	240	D 8	40	200	Sandstone; sandstone and clam shells.	do	4-17-51	(4)						Ind	L.
28L1	A. Helwig	1951	110	565	D 12	5	537	Sandstone (20 ft. of surface casing).	do	8-30-51	[3] 130.8	70	T 15				Irr	Cp, L.
28P1	L. C. Miller	1950	115	585	D 12			(Uncased below 100 ft.)	do	4-17-51	[4] +2.0	69	T 30	[6] 30	400	150	Irr	Cp.
28P2	do	1950	115	100	D 12			(Uncased below 20 ft.)	do	4-17-51	[4] +2.0	60	J 5	[6] 5			D,S,Dy	Cp.
29H1	Glen Winkler	1947	105	175	D 10				do	7-12-50 4-18-51	[3] 111.9 (4)		T 5	[7] 55 [6] 6			Irr	
29J1	Albert Helwig	1950	120	400	D 12			(Uncased below 60 ft.)	do	7-6-50 4-18-51	[8] 55.95 2.76		T 15	300			D, Dy, Irr, S	L.
29J2	do	1951	120	657	D 12	46 548	453 109	Sandstone Soft sandstone; sand with shells.	do do	8-30-51	[3] 118.5	70	T 30	200			Irr	C, L.
30A1	N. O. Lindberg.	1945	135	260	D 12				do	4-12-44 7-5-50 4-18-51	[1] 10 7.05 4.16		J ½		[3] 75		D	L.

30G1	Eleanor Rued	1949	155	133	D 14			(Cased to 49 ft.; perforated.)	Qyal (?), QTm.	6-23-50 4-18-51	[3] 28.4 [3] 21.26		J 5	40			Irr	L.
30G2	do	1949	200	200	D 12			(Cased to 114 ft.)	QTm	7- 6-50 4-18-51	35.87 33.76						U	L.
30H1	V. Wells	1947	210	100	D 6	0	100	Sandstone; soft sand.	do	5- 4-50 4-10-51	8.87 8.10		J ¾				D	L.
30J1	Bruce Fredericks.	1948	285	200	D 8	160	40	Sandstone	do								D	L.
30R1	George Butler	1944	375	140	D 6	80	60	do	do	5- 4-50 4-10-50	51.70 [8] 81.91		L				D	L.
31A1	G. Prigmore	1946	410	240	D 8-6				do	2- ?-56 5- 4-50 4-10-50	[1] 85 86.70 86.91		L		13	45	D, O	L.
31J1	D. Klauder	1950	465	352	D, G 6	40 185 296	22 56 56	Fine sand Sandstone with clam shells. Sandstone containing streak gravel.	do do do				L 1		10	[7] 100	D	Cp, L.
31L1	M. Ameral	1948	500	120	D 6	8	112	Sand; "hard sandstone."	do	4-27-50 4-10-51	46.15 42.2		J				D	L.
31Q1	Martin	1944	480	235	D 7	90	145	Sandstone	do	4- ?-44	[7] 70				8		D	L.
31Q2	Peyser	1947	450	150	D 8			(Uncased below 5 ft.)	do	6- ?-47	[7] 14						D	L.
31Q3	William Wierdsma.	1947	470	250	D 8			(Uncased below 8 ft.)	do	Fall 1949 4- 1-51	[7] 145 68.5		L 1		5	[3 7] 205	D	L.
32E1	C. Mellinger	1945	485	200	D 8			(Uncased below 6 ft.)	do	7- ?-45	[1] 180						D	L.
32F1	R. E. Doran	1944	390	182.0	D 7	170	20	Sandstone	do	4-25-50 4-10-51	127.80 126.6		L 1				D	L.
32F2	T. Ludlam	1946	395	365	D 8-6				do				L 1½	7			D	L.
32G1	Donald Martin	1947	290	180	Dug, D 6.	80	100	Sandstone	do	7- 6-50 4-10-51	67.17 64.67		J 1				D	L.
32H1	E. Marsh	1946	245	170	D 8	90	77	do	do	7- 6-50 4-10-51	76.95 77.06		L 1		7		D, irr	L.
32Q1	C. A. Altman	1947	205	140	D 6	15	125	Sandstone; sand.	do	4-25-50 4-10-51	1.85 2.96		L	13			D	L.
33A1	Capt. A. T. Swanson.	1943	225	245	D 7				do	4-13-50	[11] 36+						U	L.
33D1	Sarah Sollars	1945	170	170	D 8	160	10	Sandstone	do				J 1				O	L.
33D2	L. C. Miller	1947	155	300	D 12				do	4-17-51	[8] 18.2	61	J 3				Irr	Cp.
33F1	L. B. Walker	1946	165	200	D 8	0	200	Sand; sandstone.	do	4-13-50	3.70		T 2				D, irr	Cp, L.
34B1	G. A. Page	1935±	200	160	D 6			(Cased to bottom; no perforations.)	do	4-13-50 4-11-51	34.65 30.97		L				D, S	L.
34G1	J. D. Hornbuckle.	1951	195	358	D 8-6	349	9	Coarse soft sandstone.	do	4-11-51	[1] 40				26	30	D	L.
34J1	H. A. Hutchinson.	1940	190	230	D 8			(Cased to 204 ft.)	do	6-23-50 4-11-51	53.1 47.71		L 2				D, Ind	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 7 N., R. 9 W.—Continued																		
7/9-34J2	N. H. Ansell	1946	175	350	D 8	310	20	(Perforated interval.)	QTm	7-25-46	[1] 39				20	50	PS	L.
34L1	David L. Sanders.	1948	190	315	D 8-6	300	15	Sand	do	4-13-50 4-11-51	28.32 25.40		J 1½				D, irr	L.
34P1	C. A. Little	1943	190	180	D 6	70	110	Soft sand; sandstone.	do	4-13-50 4-11-51	31.14 27.36		L 1				D	L.
35D1	I. D. Harris	1944	100	140	D 6				do	4-12-50	22.18		J 1				D, irr	L.
35D2	P. Brunwin	1948	135	167	D 8	30	137	Sand; sand and clam shells; gravel sand, and clam shells.	do	4-11-51 4-12-50	21.65 35.70		J 1	10	10	33	D, S	Cp, L. W.
35D3	L. G. Bullis	1945	135	120	D 8				do								D	L.
35E1	Howard Williams		150	253	D 8				do	4-12-50 4-11-51	59 60.92		L 1				D, O	L.
35F1	Wilson	1947	95	133	D 8	4	129	Sand; soft clam shells; hard clam shells.	do	4-12-50	27.00		J 1½				D	L.
35F2	A. C. Ehlert	1945	90	115	D 8	4	111	Sand; sand and shells; "hard" sandstone and shells.	do	4-13-50 4-11-51	26.60 23.18		J				D	L.
35G1	J. A. Aguire	1941	75	68	D												U	L.
35G2	do	1950	75	116	D 6	0	114	Sand; gravel and sand; clam shells.	do	2-28-50 4-13-50 4-11-51	[1] 25 16.77 13.95		J 1		13	25	D	L.
35M1	John Clifford		165		D 8				do	4-13-50 4-11-51	29.97 28.35		L 1		5		D	

35R1	Barlow Bros	1948	60	90	D 10	42	28	Sand and gravel; gravel; sand, clay and gravel;	do	4-12-50 4-10-51	.5 1.18						U	L.
36A1	J. Equitkhanoff.	1941	85	46	D 4				QTge	12-29-49	13.77		L				S	L.
36F1	W. L. Hepworth.	1949	85	270	D, G 10	40 60 160 200	5 90 18 70	Pea gravel Fine gravel; large gravel. River sand Fine and coarse gravel; quicksand.	do do QTm do	10- 4-49	31.35		T 25	460	550	26	Irr	Cp, L, W.
36G1	do		80	80	D 8				QTge	12- 1-41 10- 4-49 12-28-49	[15] 14 [8] 32.55 26.96		J 1½				D, Dy	L.
36H1	J. Equitkhanoff.	1950	85	568	D, G 12	70 280	32 230	Gravel Sandstone; gravel and sand; sand.	do QTm	7-14-50 11-10-50 4-10-51	[1] 15 24.60 13.27				100	40	Irr	L.
36M1	Sebastopol Meat Co.	1937	70	88	D 8					8- ?-37 12- 1-41 3- 7-42 10- 4-49 4-10-51	[1] 11 [15] 14 [15] 9 [8] 16.51 [8] 18.20		T 5		33	34	Ind	L.
T. 8 N., R. 8 W.																		
8/8- 5P1	E. Rich	1950	310	147	D 8	90 135	35 10	Clay and gravel. Coarse sand; cemented gravel.	QTge do	6-22-50 3-28-51	[1] 25 18.53		J		37	35	S	L.
17L1	Mrs. A. Blasi	1947	185	278	D 8				do	5- ?-47 4-21-50	[1] 103 74.8		L 3	6	10	132	D, O	Cp, L.
18E1	Mr. Beek	1950	125	147	D 8	80	67	"Loose bog", sand and gravel; sand and gravel.	do	7-22-50 5-25-51	[1] 40 22.75		J 1		20	80	D	L.
18F1	Mrs. L. Proctor.	1939	130	120	D 8				do	9- ?-39 4-21-50 4-12-51	[1] 32 22.85 16.25		J ½		25	30	D, O, S.	L.
18F2	do		130	16	Dug 48					11-10-41 3- 5-42 4-21-50 4-12-51	[15] 11 [15] 1.4 3.5 .92						U	

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
T. 8 N., R. 8 W.—Continued																		
8/8-18L1	C. Lentz	1946	125	133	D 8	114	19	Clay and gravel; gravel.	QTge	10-30-46	[1] 38		J 1		11	42	D	L.
19A1	Lange	1950	130	70	D 8	61	9	Sand and gravel.	do	6-4-50	[1] 26		J		30	29	D	L.
19B1	G. W. Sahr	1944±	125	110	D 8					11-16-49 4-12-51	23.61 [8] 32.5		J 3				D, irr	
19E1	J. Dragoman	1949	105	142	D 10			(Casing reported to be perforated opposite all water-yielding strata)	do	11-8-49	10.47		T 7½		125	111	Irr	L, W.
19G1	Zimmerman	1950	120	52	D 6				do	4-21-50 4-12-51	11.56 10.93		J				D	L.
19J1	L. E. Douhit	1947	135	76	D 8			(Perforated from 50 to 55 ft. and near bottom of casing)	do	4-21-50 4-12-51	19.28 18.83		J 1		150		D, Irr	
19J2	Haskins	1950	130	61	D 6	35	26	Sand and gravel.	do	8-20-50	[1] 35		J		12	5	D	L.
19M1	Industrial Manufactures, Ltd.	1950	105	260	D, G 12	27 115 160 205	18 15 25 55	Sand and fine gravel; coarse packed gravel. Small boulders. Fine gravel and sand. Coarse packed gravel; medium gravel.	do do do do	10-19-50 4-12-51	23.27 8.82	[1] 68	T 5		280	70	D, Ind	Cp. L.

						27	18	Packed fine sandy gravel: coarse packed gravel.	do									
19N1	B. Griggs	1951	105	249	D, G 10	105	15	"Small bouldery" sand	do	4-19-51 8-30-51	[1] 12 17. 30				290	51	Irr	L.
						150	25	Fine gravel and coarse sand.	do									
						200	49	Packed coarse gravelly sand.	do									
19R1	Mattei	1950	120	130	D 10	20	110	Clayey gravel; coarse sand; coarse gravel.	do	4-21-50 4-12-51	7. 95 8. 68		T 5		210	[3] 100	Irr	L.
20B1	E. D. Seaton	1944	190	88	D 8	48	40	Gravel; clay and gravel.	do	11-22-44 5-25-51	[1] 7 10. 8		J 1		6	60	D	L.
20B2	do	1946	185	231	D 8	202	25	Sand clay and gravel; gravel.	do	8-15-46 5-25-51	[1] 35 55. 94		L 2		20	120	D, O	L.
20D1	J. Henningsen	1949	145	260	D 10				do	4-28-50	38. 02	70	T 7½		200	[3, 24] 150	Irr	Cp, L, W.
20E1	do	1944±	145	[24] 100	D 8				do	11-21-49	36. 88		J 3				S, O	Cp, W.
20E2	do	1938	145	100	B 6				do	2-28-50	16. 63		L				D, O	Cp, W.
20F1	Ann Berg	1950	150	101	D 6	73	26	Sand and gravel.	do	12-16-50	[1] 50		J		15	20	D	L.
20Q1	H. A. Faught	1950	140	310	D, G 10	20	275	Gravel and sand; gravel and some clay: gravel.	do	6- ?-50 8-30-51	[1] 20 [3] 103	65	T 40		300	10	Irr	C, Cp.
27K1	John Grepe	1949	180	117	D, G 6				Qyal, Tsv(?).				J ½				D	L.
29C1	Waggoner	1950	135	68	D 6	60	8	Gravel	QTge	11-21-50	[1] 30		J		20	10	D	L.
29C2	M. O. Ellsworth.	1951	135	63	D 6	60	3	do	do	do	[1] 30		J		20	10	PS	L.
29D1	C. B. Hurst	1951	125	57	D 6	50	6	Sand	do	1- 4-51	[1] 8		J		30	16	D	L.
29E1	W. D. Watterson.	1950	125	51	D 6	15	36	Sand and gravel.	do	6-15-50	[1] 7		J ½		17	30	D	L.
29G1	Williams and Rice.	1950	140	81	D 7½	36	10	Packed medium gravel.	do	7-20-50	[1] 8				10	10	PS	L.
						66	14	Coarse sand; fine gravel.	do									
29G2	M. Rasmussen.	1950	135	68	D 6	45	8	Gravel	do	12-22-50	[1] 30				6	30	D	L.
						63	3	do	do									
29G3	R. L. Hinchman.	1951	135	67	D 6	47	17	Sand; fine gravel.	do	2-2-51	[1] 8		J		30	35	D	L.
						42	8	Sand and gravel.	do	9- 3-50	[1] 16	[1] 62						
30C1	C. Wulf	1950	110	154	D 10	94	6	do	do	6-21-51	[3] 45. 5	66	T 15		200	84	Irr	Cp, L.
						142	11	Sand	do									
30E1	W. W. Howe	1950±	110	54	D 8	46	8	Coarse gravel and sand.	do								D	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
						T. 8 N., R. 8 W.—Continued												
8/8-30G1	C. Wulf	1950	115	140	D 8	40	20	(Perforated interval).	QTge	8-15-50	[1] 15	-------	J 1	-------	40	65	D, irr	Op, L.
						80	40	do										
30L1	Sonoma County Airport.	1942	120	463	D 12	90	98	Clay and gravel; gravel.	do	10-21-44	[7] 32	-------	T 26	500	400	[3] 69	Ind	L.
						204	259	Sandy clay and gravel; sandy clay.	do	11- 4-49	18.29							
										4-13-51	12.54							
30N1	Alfred Finnila.	1942	120	455	D, G 12	60	38	Clay and gravel.	do	8-17-42	23	[7] 72	T 27	480	400	[3] 89	Ind	Op, L.
						119	104	Clay and gravel; gravel.	do	11- 4-49	21.03							
						231	8	Cemented gravel.	do	4-31-51	20.90							
						253	97	Sandy clay and gravel.	do									
						405	45	do	do									
30N2	Sonoma County Airport.	1942	120	600	D, G 12-8.	62	121	Clay and gravel: gravel.	do	3-27-51	21.71	[3] 89	-------	-------	-------	-------	U	L, W.
						190	200	Clay and gravel; sandy clay and gravel.	do									
						425	11	Sandy clay; clay and gravel.	do									
						580	5	Clay and gravel.	do									

31B1	A. Gilardoni	1947	115	210	D 8	188	18	Gravel; clay and gravel.	do	5-3-47 11-18-49 4-10-51	[1]22 18.14 16.92		J 1		50	[7]31	D, Dy, irr	Cp, L.
31D1	Dolph Camilli.		110		D 10				do	11-18-49 4-11-51	19.52 15.55		J 10				D, Irr	
31L1	W. B. Wood	1948	110	89	D 8					11-18-49 4-10-51	9.57 10.00		J ¾		20	37	D	L.
32G1	A. H. Dukes	1950	140	46	D 6	24 40	6 6	Sand and gravel. do	do	12-23-50	([1]) 4		J ½		30	20	Ind	L.
32G2	A. H. Dukes	1950	140	53	D	40	12	Gravel	do	12-21-50	[1]5		J		30	35	D, O	L.
33A1	Finley Ranch	1939	180	102	D 8					6-12-39 4-21-50 4-12-51	[1]28 18.83 [8]15.70		J 3		40	27	D, PS, O	L.
33D1	Mark West Union School.	1950	150	127	D 8	116	11	Gravel	do	5-1-50	[1]20	[1]62	J 3		200	47	PS	L.
33D2	do		150	40.7	D 6					3-15-51 4-12-51	2.40 5.05		C¼				PS	
34L1	Kiergaard	1951	225	85	D 6	80	5	Coarse sand	do				J 1	10			D	L.
34Q1	J. W. Anderson.	1948	345	285	D 8-6				do								D	L.
36H1	Wallace School District.	1942	375	165	D 8				do				J				PS	L.

T. 8 N., R. 9 W.

8/9-1M1	S. R. De Magio.	1950	185	315	D 6	250 261 281 298	2 1 1 2	Sand and gravel. do do do	do do do do	3-27-51	69.7		L 2		12	28	D, O	L.
2H1	J. B. Moore	1940	160	135	D 8				do	11-3-49 4-12-51	66.82 57.84		J 1				D, O, S	L.
2Q1	Jean Spence	1945	130	101	D				do	5-?-45 11-3-49 4-12-51	[1]25 33.62 31.00	69	J 1		17	25	D	Cp, L.
2R1	L. M. Arata	1942	135	154	D 8	147	6	Sand and gravel.	do	7-?-42	[1]37		J 1½		23	1	D, irr	L.
3P1	R. Remoliff	1950	75	110	D 10	35 85	17 13	Gravel; sand and gravel. Sand	do do	5-25-50 4-12-51	(+)0.72 (+)0.99	[1]65			90	63	Irr, S	L.
4H1	Morrish	1940±	60	45	D 12				Qyal	5-25-50 4-12-51	[3]18.93 17.60		T 15	500			Irr	
9H1	R. Remoliff	1949	70	40	D 10	2	36	Loose sand and gravel.	Qyal	5-25-50 4-12-51	12.23 11.70	[1]64			350	3	Irr	L.
9J1	Mrs. W. H. Calhoun.	1935±	65	25	D 6				do	5-25-50 4-12-51	9.53 9.43		C Gas				Irr	L.
9J2	do	1935±	65	29.5	D 12				do	5-25-50 4-12-51	7.78 7.13		C Gas				Irr	
9R1	do	1935±	65	35	D 6				do	5-25-50 4-12-51	10.81 9.56		C Gas				Irr	

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 8 N., R. 9 W.—Continued										
8/9-10H1	G. Wiederhold.	1949	150	81	D 6	75	6	Sand	QTge	5-25-50	61.43		J ½				D	L.
										4-12-51	56.09							
10N1	Mrs. W. H. Calhoun.	1935±	65	38.0	D 12				Qyal	5-25-50	7.37						Irr	
										4-12-51	6.51							
10P1	do		70	52	D 8				do	11-29-49	9.49		J 1½				D, O	
										4-12-51	3.56							
10R1	R. Hogan	1938	165	400	D 10				QTge	1-10-50	80.15		T 20	200	200	32	D	C, W.
11A1	M. M. Feigley.	1945	135	116.8	D 8				do	5- ?-45	[1] 24		J ½		20	26	D	L.
										11- 3-49	33.25							
										4-12-51	32.60							
						65	4	Gravel	do									
11B1	L. R. Dennahoe.	1950	130	90	D 6	79	2	Sand and gravel.	do	9- 9-50	[1] 26				12	35	D	L.
						84	4	Gravel and sand.	do									
11E1	Mrs. Isabel Johnson.	1950	130	87	D 6	71	16	Gravel	do	7- ?-50	[1] 40				12	17	D	L.
11F1	M. L. Sparks	1941	130	97	D 8	78	18	Clay and gravel; gravel.	do	11-10-41	[1] 27		J 1½		25	29	D	L.
										11-17-41	[15] 27							
										6-30-50	31.68							
										4-12-51	32.6							
11F2	W. Ford	1950	135	98	D 8	70	28	Clay and gravel; sand gravel.	do	5-12-50	[1] 33		J		10	45	D	L.
11L1	J. A. Cole	1950	125	100	D 8	35	63	Coarse gravel and sand.	do	8-11-50	[1] 35		J 5		40	11	Irr	L.
										6-27-51	29.2							
11P1	V. Rafanelli	1948	120	150	D 8	110	40	Gravel	do				T 10		120		Irr	L.
11Q1	H. Hughes	1950	110	126	D 6	120	3	Gravel	do	7-31-50	[1] 45				100	10	D	L.
12C1	P. Brobelli	1940±	145	184	D 6				do	11-14-41	[15] 33	63	L				D	Cp, L.
										6-13-51	[8] 29.88							
12C2	do		145	30	Dug 48				do	6-13-51	(4)	63.5	P				U	Cp.

12E1	J. Trischan	1943	130	140	D 8	90	30	Sandy clay; gravel and clay.	do	4-30-43	[1] 20		J ½		20	55	D	L.
						130	10	Clay and gravel.	do	6-28-51	33.14							
12N1	Blasi Transportation Co.	1950	120	109	D 8	106	3	Sand	do	9-9-50	[1] 26		J 1½		20	9	D, Ind	L.
12Q1	D. DuVander	1946	115	124	D 8	115	9	Gravel	do	9-5-49	19.42		J 2	30			D, O	L.
13A1	Windsor School District.	1939	115	107	D				do	9-?-39	[1] 37				13	23	PS	L.
13B1	R. Coppedge	1939	110	95	Dug, D				do								D	L.
13B2	A. Johnson	1950	115	74	D 6	41	14	Coarse gravel	do	7-31-50	[1] 30				12	15	D	L.
						63	7	Gravel and coarse sand.	do									
13C1	Windsor School District.	1950	105	202	D, G 10	65	137	Clay and gravel; gravel.	do	6-?-50	[1] 12				100	88	PS	C, L.
										6-30-50	13.17							
										4-12-51	9.23							
13H1	Mrs. Locton	1939	125	87	D 8				do	9-?-39	[1] 30		L 1		30	22	D	L.
										11-18-41	[15] 18							
										6-30-50	23.15							
										4-12-51	17.98							
13H2	D. E. Proteau.	1950	125	94	D 6	45	49	Loose gravel and sand; loose coarse sand; coarse gravel.	do	8-8-50	[1] 35		J		6	10	D	L.
13H3	D. Camp	1950	125	84	D 6	55	26	Sand; gravel	do	6-24-50	[1] 18		J		17	42	D	L.
13J1	Mrs. Moe	1941	115	92	D 8	85	5	Sand	do	10-?-41	[1] 20				20	20	D	L.
13K1	F. Moscon	1950	115	50	D 8	24	26	Sand and gravel; "water and clay."	do	6-29-50	[1] 7				7	4	D	L.
13K2	do	1950	115	84	D 6	75	5	Gravel and sand.	do	7-11-50	[1] 30				4	20	S	L.
13N1	A. Botto	1946	90	208	D 12	14	26	Gravel	do	11-8-49	27.42		T 25		425	[3] 105	Irr	C, L, W.
						70	4	do	do									
						82	4	do	do									
						98	12	Sand and gravel.	do									
									do									
						130	6	Sand, clay, and gravel.	do									
						152	32	Gravel	do									
14B1	A. E. Conner	1950	100	46	D 6	7	39	Sand and gravel.	do	6-27-50	[1] 14		P				U	L.
14B2	J. M. Wells	1951	115	77	D 6	69	8	Coarse gravel	do	1-24-51	[1] 16						D	L.
14C1	Lolla	1945	125	84	D 8				do	10-?-45	[1] 40		J 1		17	8	D	L.
14C2	Castleberg	1951	115	119	D 8	98	21	(Perforated interval.)	do	3-22-51	[1] 25				20	50	D	L.
14J1	Windsor Winery, Inc.	1943	100	193	D 10				do				J 1½		40	11	Ind	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 8 N., R. 9 W.—Continued																		
8/9-14L1	H. H. Rodgers	1950	95	265	D 8	53	5	Loose gravel	QTge	11-9-50	[1] 13	66	T 10		220	88	Irr	L.
						83	6	Cemented gravel.	do	3-27-51	4.85							
						106	3	Loose gravel	do									
						242	11	Pea gravel	do									
14P1	George Olivera	1949	95	264	D, G 10	11	5	Sand and gravel.	do	11-16-49	10.68		T 7½		400	[3] 110	Irr	C, L.
						19	18	Large gravel	do									
						60	5	Sand	do									
						118	2	Gravel	do									
						176	8	Fine gravel	do									
						253	11	Pea gravel	do									
15D1	C. D. Thompson.	1950	65	134	D 10				Qyal, QTge (?).	4-26-50	[1] 8		C 15		75	15	[25] Irr	L.
										5-25-50	[3] 23.41							
15F1	W. Richardson.		75	100	D 8				do	11-29-49	[3] 32.51		T 3				D, S	Cp, W.
15M1	L. S. Quinan	1930±	70	42.0	D 12				Qyal	11-23-49	14.90		C 10	[7] 450			Irr, O	W.
16J1	do	1930±	65	38.5	D 10				do	11-23-49	13.64			[7] 450			Irr	
16R1	Mrs. W. Jones		65	90	D				do				T	1,000			Irr	
21A1	W. Doyle	1949	55	25	Dug 36	0	25	Gravel	do	11-23-49	14.59		C 5				Ind	
										4-12-51	[3] 16.02							
21J1	Mitchell Estate.	1949	60	105	D 12				do	11-22-49	8		T 15				Irr	
21J2	do	1948±	60	67.0	D 12				do	11-22-49	8.9						U	
										4-12-51	8.39							
22G1	M. J. Murray	1949	100	85	D 8				QTge				J 1		10		D, S	L.
23B1	J. Penner	1950	90	100	D 6				do				J ½		5	[3] 60	D	L.
23F1	Clarence Wright.	1875±	90	96	D 6				do								D, irr, S	C.

						18	10	Gravel	do	11-16-49	4.48				200	[3] 70	Irr	C, L.
						37	15	Sand; pea gravel.	do	4-12-51	[3,26] 16.53							
23G1	P. Zenzunen	1949	75	225	D, G 10	79	16	Fine gravel	do									
						128	10	Sand and gravel.	do									
						200	23	Gravel	do									
[10] 23G1	do	1952		440		276	4	do	do	11-26-52	[1] 18							L.
23J1	J. R. Haskins	1950	95	71	D 6	57	11	do	do	8-17-50	[1] 38				8	12	D	L.
						15	36	Coarse gravel; sand.	do	11-16-49	28.54	65	T 30		750	[3] 69	Irr	C, Cp, L.
						56	14	Coarse gravel	do	4-12-51	15.21							
23L1	Clarence Wright.	1949	75	[27] 429	D, G 12	74	11	do	do									
						306	45	Gravel	do									
						376	27	Coarse sand and washed shale.	do									
24A1	Vernon Dado	1945	100	190	D 12				do				T 15	225			Irr	
24B1	M. Sartori	1945	90	120	D 10				do	11-8-49	13.07		T 10	200			Irr	
										4-12-51	3.00							
24E1	Frank Balbi	1945	80	330	D 12-10				Qyal(?), QTge.	1-11-50	3.09		T 15		600	[3,7] 60	Irr	
										4-12-51	[4]							
24L1	Mr. Autru	1950	105	150	D 8-6	70	80	(Perforated interval).	TQge	10-20-50	[1] 40		T 5		125	35	Irr	Cp, L.
										6-27-51	35.05							
25B1	Ralph Brooks	1949	105	161	D 10	100	61	Coarse gravel	do	4-21-50	8.92		T 10		240		Irr	L.
										4-12-51	9.95							
26B1	V. L. Kirk-patrick.	1950	110	80	D 6	67	13	Sand	QTm(?).	6-15-50	[1] 35				15	30	D	L.
						60	8	Sand and gravel in clay.	QTge									
26B2	R. E. Williams	1950	90	84	D 6					9-21-50	[1] 18				10	32	D	L.
						75	9	do	do									
26C1	C. A. Klemm	1944	100	145	D 6	90	50	Sandstone	QTm (?).			60	J 1½				D	Cp, L.
						240	40	Sandy clay and gravel; gravel.	QTge	2-?-48	[1] 20							
26D1	G. H. Silk	1948	75	464	D 12					11-15-49	25.95	66	T 20	450	485	70	D, Irr	C, Cp, L.
						394	68	Clay and gravel; gravel.	do	4-11-51	20.68							
26E1	Edward Knecht.	1947	120	188	D 8	177	11	Fine gravel	QTge	11-16-49	[28] 58	65	T 7½	130			D, Irr	Cp, L.
										4-11-51	[28] 58							
26F1	Badger	1951	115	80	D 6	74	6	Sand	do	4-27-51	[1] 22						D	L.
						50	2	Sand and gravel.	do	11-13-41	[15] 12							
27K1	H. A. Faught	1934	60	333	D 12					3-5-42	9		T 25	800			Irr	C, L.
						303	30	Gravel and clam shells.	QTm	11-16-49	[18] 16.1							
										4-11-51	12.07							
27L1	do		80	74.0	D 8			do		11-22-49	32.00		L				D, S	
										4-11-51	29.18							
28B1	J. T. Grace		75	30	D 6				do				L 3				D, S	
33G1	A. F. Emert	1949	100	358	D			(Uncased test hole.)									U	L.

See footnotes at end of table.

TABLE 17.—*Description of water wells in the Santa Rosa Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 8 N., R. 9 W.—Continued										
8/9-33H1	A. F. Emert	1945	75	120	D 8				QTm	9- ?-45 11-21-49 4-10-51	[1] 20 [8] 40.10 43.46		T 7½	110	50	25	D, Dy	L.
33J1	do	1945	45	325	D 12										70		U	L.
34D1	O. B. Stanley	1950	70	150	D 8	10	140	Sandstone	do	11- 2-50	5.01		C 7½		60	[7] 20	Irr	L.
34E1	A. Muchow	1948	70	150	D 12				do	11- 2-50	8.09		T 7½				Irr	L.
[10] 34E1	do	1951		170	12				do	4-10-51	[3] 17.88							L.
34R1	B. Steele	1933	65	360	D 12				Qyal, QTge, QTm.				T 25	900	900	35	Irr	L.
34R2	do	1949	65	490	D, G 12	20	50	Pea gravel, sand.	Qyal	10- ?-49	[1] 9		T 30				Irr	L.
						118	41	Clay and gravel; small gravel.	QTge	11-17-49	8.91							
						190	160	Small gravel; sand; shell and gravel; shells.	QTm	10-19-50	18.60							
										4-13-51	12.70							
34R3	do		65						Qyal	4-13-51	4.08		L				D	
35K1	E. Slusser	1933	80	498	D 12	50	22	Cemented gravel.	QTge	11-16-49	28.30		T 10	300			Irr	L.
						198	10	do	do	4-11-51	24.61							
						268	52	Sandstone; clay and gravel.	QTge, QTm.									
						398	27	Sandstone; cemented gravel.	do									
						465		Sandstone; cemented gravel; sand and gravel.	do									

35M1	J. I. Haas	1934	65	475	D 12				Qyal, QTge, QTm.	11-16-49 4-11-51	15.18 11.12		T 25	800			Irr	
36G1	F. W. Wood	1935	100	642	D 12				QTge, QTm.	11-17-49 4-11-51 5-23-51	16.08 14.27 14.05		T 25				Irr	
36G2	do		100	24.7	D 6				Qyal, QTge (?).	11-17-49 4-11-51 5-23-51	17.32 11.83 12.88		P				U	
36K1	Cameron Brothers.	1947	95	1,325	D 12					11-17-49 4-11-51 5-23-51	45.98 47.03 47.78		T 20	500	750	[8] 75	Irr	C.
36L1	Mrs. Peggy Talmadge.	1933	95	565	D 12-8				QTge	11-18-49 4-11-51	35.5 28.72		T 25	450		[8] 90	Irr	L.
36N1	P. W. Buss-man.		90	89.0	D 12				Qyal, QTge.	10-14-49	10.25						U	W.
36N2	do		90	185	D 12				do	11-24-41 11-17-49	[15] 9 10.70		T	150			Irr	
36P1	do	1945	90	1,048	D 12-10				QTge, QTm.	10- 5-49	22.56		Ts 40	650		150	Irr	Cp, L, W.
									T. 9 N., R. 9 W.									
9/9-34B1	Frank Diany		110	60	D 8				Qyal	10-20-49 4-10-51	34.22 28.34		L 1				D	
34D1	Louis Fop-piano.	1922	105	120.5	D 10				Qt, QTge.	10-20-49	30.19						U	W.
34N1	W. C. Beau-mont.	1946	85	198	D 12				Qyal(?), QTge.	10-20-49	14.82		T 15	400	500	[7] 20	Irr	L, W.
34Q1	E. H. Reiman		110	55.2	D 6				QTge	10-20-49	23.61		P				S	Cp, W.
35D1	George Ricci	1944	175	103	D 8	5	35	Gravel	do								D	L.
						85	13	do	do									
35D2	do		175	24.6	Dug 24				do	10-20-49	22.8						U	
35L1	E. H. Reiman	1942	175	50	D 6				do				L				D	
36E1	Roy Jacobs	1948	300	127	D 8				do	2- ?-48 11- 3-49	[1] 81 39.84		T 1½	20	11	[8] 127	D, S	Cp, L.

[1] Reported by driller.
[2] Original depth; now partly filled by cave-in.
[3] Pumping level.
[4] Well flowing; static level above land-surface datum.
[5] Well pumping nearby.
[6] Estimated natural flow.
[7] Reported by owner.
[8] Pumping recently.
[9] Pumping.
[10] Data for deepened well.
[11] Obstruction encountered at depth indicated.
[12] Driller's reconditioning record available.
[13] Test.
[14] Test hole drilled to 200 feet; owner reports casing cut off at 103 feet and hole filled with gravel to 101 feet.
[15] Measured by Bureau of Reclamation.
[16] Water flowed up outside of casing.
[17] Date of deepening.
[18] Measured to top of oil floating on water surface.
[19] Timbered drift, 5 feet high, 5 feet wide, and reported to be several hundred feet in length; at a depth of 50 feet. It is the original source of municipal water supply for the city of Santa Rosa.
[20] Well reported and filled covered, 4-9-51.
[21] Measurement made in dug portion of well.
[22] Measurement made 15 minutes after pump turned off.
[23] Measured by the Geological Survey.
[24] Approximate.
[25] Well destroyed between 5-25-51 and 4-12-51.
[26] Well reported to have flowed during previous winter and until pumping began.
[27] Plug set at depth of 227 feet, September 1950, to shut off high-boron water.
[28] Airline measurement.

TABLE 18.—*Description of representative developed springs in the Santa Rosa Valley area, California*

No. on pl. 1	Owner	Occurrence	Associated geologic formation	Altitude	Temperature (° F.)	Discharge (gpm)	Date measured	Use	Remarks
6/8-17K2	Ben Woodworth.	Near base of old road cut through sand and sandy clay in area of intermittent ground-water discharge.	Merced	85	55	4+	Feb. 9, 1950	Domestic irrigation	Pipe driven into bank connects to sump. Partial chemical analysis in table 21.
					-----	3+	Feb. 21, 1951		
					-----	(1)	May 21, 1951		
					61	5±	Apr. 24, 1953		
7/6-33N1	H. Q. Hawes	Seep in bottom of small drain. Andesite terrane.	Sonoma volcanics	425	-----	4-5	July 21, 1950	Stock	Sump about 4 feet square, 3 feet deep. Owner reports that discharge shows no seasonal fluctuation.
6/6-5L2	H. L. Morton	Issues from fissure in tuffaceous rock in east bank of Sonoma Creek.	Glenn Ellen	340	90	2	July 27, 1950	Swimming	No improvements. One of series of springs known as Los Guilucos Warm Springs.
6/6-5L3	do	Fissures in tuffaceous conglomerate on east bank of Sonoma Creek.	do	345	[2] 82	-----	May 8, 1952	Domestic heating	Brick-curbed sump 8 feet deep, 30 inches in diameter. Overflows through pipe 2 feet below top. Complete chemical analysis in table 20.
7/9-16A1	L. K. and E. Lands.	Seepage area marked by flattening of ravine; probably at intersection with water table. Soft sandstone terrane.	Merced	120	-----	[3] 50	July 14, 1950	Irrigation	Wood-curbed sump, 3 feet square, 4 feet deep. Collects ground-water discharge and intercepts flow from spring at head of ravine. Irrigates 7 acres. 7½-hp centrifugal pump.
7/9-16B1	do	Sump in sandstone at head of small ravine.	do	140	60	[5] 4	July 14, 1950	Domestic, orchard, irrigation.[4]	1-hp jet pump installed in sump.
7/9-33F2	L. B. Walker	Above stream valley on gently sloping hillside underlain by soft sandstone.	do	165	-----	[6] 5½	-----	Domestic	Rock-walled reservoir 4 feet in diameter, 5 feet deep. Top 1.0 foot above land-surface datum. Reported to fluctuate only during driest part of year. Apr. 13, 1950, water level in reservoir was 0.2 foot above land-surface datum and slightly below overflow pipe after recent pumping.
						(7)	Apr. 17, 1951		

[1] Flowing; discharge not measured.
[2] Temperature taken after water had circulated through heating coils beneath floor of dwelling.
[3] Estimated.
[4] Overflow from sump flows through natural channel to downstream sump and is used for irrigation.
[5] Average discharge with intermittent pumping to pressure system.
[6] Reported normal flow.
[7] Not flowing this date.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*

Well 6/7-30L1

[A. Crane. About 1.8 miles east-northeast of Cotati, 0.52 mile west of Petaluma Hill Road, 110 feet south of Cotati Avenue, 10 feet southwest of foundation of destroyed dwelling, 6 feet north of tank tower. Unused dug well; dimensions, 3 x 3 feet; depth, 24.4 feet. Measuring point: top of wood curbing, south side at land-surface datum, which is 145 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Sept. 29, 1949	13.87	Jan. 31, 1950	13.57	Oct. 18, 1950	16.73
Oct. 14	15.13	Feb. 23	4.88	Dec. 28	6.40
21	15.93	Mar. 28	2.08	Apr. 4, 1951	1.74
Nov. 4	17.52	May 3	3.57	June 5	4.62
10	18.17	June 14	5.58	Oct. 16	15.48
Dec. 1	20.67	July 13	7.57	Dec. 7	5.98
27	23.01	Aug. 9	9.90	Apr. 1, 1952	1.41
Jan. 12, 1950	24.2	Sept. 7	12.73		

Well 6/7-30M1

[B. Brians. About 1.3 miles east-northeast of Cotati, 200 feet south and 75 feet east of intersection of Cotati Avenue and Snyder Lane, 100 feet southeast of dwelling, 40 feet east of fence. Domestic and irrigation well; diameter, 8 inches; depth, 104 feet. Measuring point: top of casing, north side, 1.5 feet above land-surface datum, which is 120 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Dec. 00, 1947	[1] 14.5	Sept. 7, 1950	16.45	Nov. 20, 1952	17.86
13, 1949	16.34	Oct. 18	15.77	Apr. 17, 1953	10.40
Jan. 31, 1950	13.69	Dec. 28	11.40	Nov. 3,	19.05
Feb. 23	[2] 11.26	Apr. 4, 1951	9.83	Apr. 2, 1954	[2] 19.66
Mar. 28	9.83	June 5,	13.88	1, 1955	11.94
May 3	10.77	Oct. 16	16.64	3, 1956	11.79
July 13	14.72	Dec. 7	14.51	Mar. 15, 1957	15.74
Aug. 9	15.13	Apr. 1, 1952	8.92		

[1] Reported by driller.
[2] Pumping recently.

Well 6/7-31J1

[Lavio Brothers. About 1.5 miles north of Penngrove, 0.25 mile north of Railroad Avenue, 0.25 mile west of Petaluma Hill Road, 12 feet north and 40 feet east of quarter-section fences, 22 feet east of well 6/7-31J2. Irrigation well; diameter, 12 inches; depth, 280 feet. Measuring point: bottom of notch in south side of casing, 0.9 foot above land-surface datum, which is 135 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Nov. 30, 1949	27.01	June 14, 1950	[1] 47.07	Apr. 4, 1951	5.68
Dec. 28	19.30	July 13	22.65	June 5	10.72
Jan. 31, 1950	14.82	Aug. 9	20.29	Oct. 16	18.97
Feb. 23	10.12	Sept. 7	[1] 46.78	Dec. 7	11.47
Mar. 28	8.21	Oct. 18	18.09	Apr. 1, 1952	5.77
May 3	8.05	Dec. 29	10.10		

[1] Pumping recently.

Well 6/7-31J2

[Lavio Brothers. About 1.5 miles north of Penngrove, 0.25 mile north of Railroad Ave., 0.25 mile west of Petaluma Hill Road, 3 feet north and 15 feet east of quarter-section fences, 9 feet south and 22 feet west of well 6/7-31J1, beneath windmill tower. Stock well; diameter, 8 inches; reported depth, "over 57 feet." Measuring point: bottom of pump base, west side, 0.5 foot above land-surface datum, which is 135 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
June 14, 1950	16.55	Oct. 18, 1950	19.00	Oct. 16, 1951	12.54
July 13	16.18	Dec. 29	6.65	Dec. 7	[1] 9.31
Aug. 9	12.30	June 5, 1951	6.79	Apr. 1, 1952	2.27
Sept. 7	20.84				

[1] Pumping.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 6/8-2C1

[A. F. Boyrie, 3247 Redwood Highway South. About 2.9 miles south of Santa Rosa, 0.22 mile south of Bellvue Avenue, 150 feet west of U. S. Highway 101, in northeast corner of garage attached to west side of dwelling. Measuring point: top of casing, west side, 1.0 foot above land-surface datum, which is 115 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 6, 1949	[1] 15.20	Mar. 1, 1950	10.57	Oct. 18, 1950	16.75
14	[1] 15.91	28	9.93	Dec. 29	11.37
21	[1] 15.22	Apr. 28	11.13	Apr. 5, 1951	8.77
Nov. 4	[1] 15.44	June 14	13.02	June 5	11.86
10	14.70	July 13	14.68	Oct. 16	15.10
Dec. 27	15.15	Aug. 9	15.08	Dec. 7	14.88
Jan. 12, 1950	14.76	Sept. 7	16.80	Apr. 1, 1952	7.82

[1] Pumping.

Well 6/8-7P2

[J. Kardohely, 80 Stone Road. About 2.8 miles southeast of Sebastopol, 375 feet north-northwest of Stone Road at a point 350 feet southwest of Gravenstein Highway, 80 feet west of Gravenstein Highway, 15 feet east and 15 feet north of northeast corner of chicken house, in frame pump house. Domestic well; diameter, 8 inches; depth, 120 feet. Measuring point: top of casing, west side, 1.3 feet above land-surface datum which is 95 feet above sea level. Measurements from beginning of record through December 9, 1949, made by owner]

Date	Water level	Date	Water level	Date	Water level
June 16, 1945	22.7	July 13, 1950	20.10	Apr. 4, 1952	10.55
Sept. 2	22.2	Sept. 15	33.54	Nov. 20	26.04
Oct.	25.7	Oct. 18	24.54	Apr. 17, 1953	[2] 20.23
July 1949	48.7	Dec. 29	12.75	Nov. 3	19.05
Nov. 2	27.7	Apr. 11, 1951	11.59	Apr. 2, 1954	13.70
Dec. 9	19.7	June 7	20.28	Apr. 1, 1955	14.85
Mar. 22, 1950	10.65	Oct. 16	23.09	Apr. 4, 1956	17.96
May 13	[1] 20.50	Dec. 6	20.88	Mar. 14, 1957	16.53
June 15	[2] 29.20				

[1] Pumping.
[2] Pumping recently.

Well 6/8-8Q1

[G. L. Smith, 3970 Llano Road. About 5.4 miles southwest of Santa Rosa, 0.77 mile south of Todd Road, 205 feet east of Llano Road, 75 feet east of tank tower, at southwest corner of wagon shed. Domestic and stock well; diameter, 8 inches; depth, more than 200 feet. Measuring point: top of casing, north side, 0.4 foot above land-surface datum, which is 75 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Sept. 29, 1949	17.38	Mar. 29, 1950	4.73	Dec. 28, 1950	12.25
Oct. 14	[1] 17.70	Apr. 28	6.33	Apr. 11, 1951	10.35
21	[2] 22.16	June 14	16.05	June 7	10.10
Nov. 4	20.58	July 13	[1] 21.98	Oct. 16	19.52
10	13.80	Aug. 8	14.05	Dec. 6	2.44
Feb. 9, 1950	4.16	Sept. 15	18.34	Apr. 4, 1952	2.87
Mar. 1	5.45	Oct. 18	17.60		

[1] Pumping recently.
[2] Pumping.

Well 6/8-8Q2

[G. L. Smith, 3970 Llano Road. About 5.4 miles southwest of Santa Rosa, 0.77 mile south of Todd Road, 130 feet east of Llano Road, beneath tank-house floor, 75 feet west of well 6/8-8Q1. Unused well; depth, 10.9 feet. Measuring point: top of concrete floor, 0.5 foot above land-surface datum, which is 75 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Sept. 29, 1949	8.84	Feb. 9, 1950	1.58	Aug. 8, 1950	7.15
Oct. 14	7.99	Mar. 1	2.88	Sept. 15	7.77
21	[1] 8.01	29	1.52	Oct. 18	8.28
Nov. 4	8.09	Apr. 28	4.50	Dec. 28	2.13
10	8.09	June 14	5.92	Apr. 11, 1951	4.13
Dec. 7	8.19	July 13	6.66	June 7	6.48
28	8.04				

[1] Nearby well pumping.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 6/8–9B1.

[E. Gobbi, 1030 Todd Road. About 4.2 miles south-southwest of Santa Rosa, 0.43 mile west of Stony Point Road, 325 feet south of Todd Road, 20 feet west of driveway in large frame pump house. Domestic and stock well; diameter, 8 inches; depth, 105 feet. Measuring point: top of casing, south side, 0.5 foot above land-surface datum, which is 90 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Mar. 11, 1942	[1] 4	July 13, 1950	[3] 24.55	Apr. 4, 1951	5.91
Feb. 24, 1950	[2] 9.90	Aug. 8	14.12	June 7	[2] 15.91
Mar. 29	6.00	Sept. 15	[2] 23.00	Oct. 16	[2] 24.59
Apr. 28	9.40	Oct. 18	[2] 17.75	Dec. 6	10.52
June 14	[2] 12.98	Dec. 28	[3] 7.95	Apr. 4, 1952	[2] 13.0

[1] Measurement by U. S. Bureau of Reclamation.
[2] Pumping.
[3] Pumping recently.

Well 6/8–13R1.

[Rohnert Seed Co. About 3.2 miles northeast of Cotati, 1.7 miles north of Cotati Avenue, 380 feet west of Snyder Lane, 100 feet south of unnamed creek, 36 feet west of corral, at west edge of field road, in frame pump house. Domestic well; diameter, 15 inches; original depth, 675 feet; reported to be filled below depth of about 250 feet. Measuring point: top of casing, east side, 1.2 feet above land-surface datum, which is 115 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Mar. 12, 1942	[1] 7	Sept. 7, 1950	12.69	Nov. 20, 1952	14.72
Jan. 25, 1950	[2] 12.46	Oct. 18	13.07	Apr. 17, 1953	9.72
Mar. 1	9.83	Dec. 28	10.09	Nov. 3, 1953	16.55
28	[2] 10.92	Apr. 5, 1951	8.13	Apr. 2, 1954	10.51
May 3	8.82	June 5, 1951	8.43	Apr. 1, 1955	11.70
June 14	[2] 12.52	Oct. 16	14.50	Apr. 3, 1956	11.40
July 13	11.43	Dec. 7	13.04	Mar. 15, 1957	15.94
Aug. 9	12.00	Apr. 1, 1952	8.41		

[1] Measurement by U. S. Bureau of Reclamation.
[2] Pumping recently.

Well 6/8–15J1.

[J. Pedranzini, about 5.4 miles south of Santa Rosa, 355 feet east of Langner Avenue, 315 feet south of Wilfred Avenue, 50 feet north of fence, in field. Stock well, diameter, 12 inches; depth, 61.4 feet. Measuring point: top of casing, north side, at land-surface datum, which is 95 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Mar. 12, 1942	[1] 2	May 3, 1950	1.85	Nov. 6, 1951	15.82
Sept. 29, 1949	7.12	June 14	4.40	Dec. 7	9.83
Oct. 14	6.69	July 13	7.02	Apr. 1, 1952	2.42
21	6.61	Aug. 9	[2] 10.05	Nov. 20	16.30
Nov. 4	6.02	Sept. 7	8.34	Apr. 17, 1953	5.22
10	5.68	Oct. 18	9.07	Nov. 3	15.54
Dec. 27	4.81	Dec. 28	4.82	Apr. 2, 1954	4.91
Jan. 31, 1950	3.49	Apr. 5, 1951	5.08	Apr. 1, 1955	5.20
Mar. 1	2.08	June 5	18.44	Apr. 3, 1956	5.01
Mar. 28	1.05	Oct. 16	19.59	Mar. 15, 1957	7.22

[1] Measurement by U. S. Bureau of Reclamation.
[2] Pumping.

Well 6/8–15J3.

[T. Yasuda, 4528 Langner Avenue, about 5.3 miles south of Santa Rosa, 520 feet east of Langner Avenue, 375 feet north of Wilfred Avenue, 30 feet north and 24 feet west of fence corner. Irrigation well; diameter, 12 inches; depth, 166 feet. Measuring point: top of casing, east side, 0.5 foot above land-surface datum, which is 95 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 14, 1946	[1] 8	Apr. 1, 1952	2.32	Apr. 1, 1955	8.74
Mar. 1, 1950	1.31	Nov. 20, 1952	19.12	Apr. 3, 1956	11.57
Apr. 5, 1951	2.53	Apr. 17, 1953	5.40	Mar. 15, 1957	16.16
Nov. 6, 1951	16.84	Nov. 3	25.90		
Dec. 7	11.95	Apr. 2, 1954	8.21		

[1] Reported by driller.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 6/8-20A1

[Henry Paine. About 3.6 miles nearly northwest of Cotati, 0.37 mile east of Gravenstein Highway along Bartleson Road, 220 feet south of Bartleson Road, 5 feet south of garage beneath small pump shelter. Domestic well; diameter, 8 inches; depth, 103 feet. Measuring point: top of casing, north side, 1.0 foot above land-surface datum, which is 140 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Dec. 19, 1942	[1] 19	May 21, 1951	17.77	Dec. 6, 1951	22.11
Feb. 9, 1950	17.56	Aug. 29	20.67	Apr. 4, 1952	14.62
Apr. 11, 1951	17.78	Oct. 16	23.13		

[1] Reported by driller.

Well 6/8-26N1

[Runyon. About 0.8 mile west-northwest of Cotati, 150 feet south-southwest of Gravenstein Highway, 75 feet southwest of Cotati Avenue, 50 feet east of dwelling, at east side of hedge. Domestic well; diameter, 8 inches; depth, 246 feet. Measuring point: hole in casing, south side, 0.7 foot above land-surface datum which is 105 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Dec. 19, 1949	8.55	June 14, 1950	6.76	Dec. 28, 1950	5.03
Feb. 9, 1950	[1] 5.87	July 13	8.80	Apr. 5, 1951	3.72
Mar. 1	5.19	Aug. 8	11.25	June 7	4.39
29	4.42	Sept. 15	9.35	Dec. 6	3.3
Apr. 28	5.55	Oct. 18	9.06	Apr. 4, 1952	1.42

[1] Pumping.

Well 6/8-29E1

[H. T. Parker. About 4.7 miles southeast of Sebastopol, at Turner Station, 450 feet north of Blank Road, 150 feet east of Hessel Road, 25 feet south of frame factory building. Industrial well; diameter, 8 inches; depth, 285 feet. Measuring point: top of casing, east side, 0.5 foot above land-surface datum, which is 200 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Mar. 29, 1950	22.22	Sept. 15, 1950	21.84	June 7, 1951	18.78
May 3	20.77	Oct. 18	22.54	Oct. 16	22.03
June 15	20.18	Dec. 29	19.54	Dec. 6	19.89
July 13	21.35	Apr. 12, 1951	19.89	Apr. 4, 1952	18.92
Aug. 9	22.52				

Well 6/9-11D2

[A. G. Pilcher, 475 Lynch Road. About 1.1 miles south-southwest of Sebastopol, 0.19 mile east and 200 feet south of the intersection of Pleasant Hill and Lynch Roads, in frame pump house which is 25 feet south and 15 feet west of southwest corner of dwelling. Domestic well; diameter, 8 inches; depth, 337 feet. Measuring point: top of casing, east side, 1.0 foot above land-surface datum, which is 225 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Apr. 6, 1950	29.47	Sept. 15, 1950	[1] 53.07	June 7, 1951	33.60
June 15	32.57	Oct. 18	31.23	Oct. 16	32.64
July 13	[1] 39.03	Dec. 29	30.86	Dec. 6	28.49
Aug. 10	37.97	Apr. 4, 1951	31.19	Apr. 4, 1952	29.42

[1] Pumping recently.

Well 7/6-19N1

[H. Horton, 7750 Sonoma Highway. About 1.9 miles northwest of Kenwood, 0.48 mile northwest of Lawndale Road, 0.16 mile south of Sonoma Highway, 50 feet east of Creek, in corrugated-metal pump house. Domestic well; diameter, 10 inches; depth, 190 feet. Measuring point: top of casing, south side, 1.0 foot above land-surface datum, which is 465 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
July 18, 1950	[1] 16	Apr. 1, 1952	4.17	Apr. 13, 1954	3.73
Mar. 29, 1951	5.00	Nov. 21, 1952	63.46	Apr. 1, 1955	10.39
Oct. 18	28.34	Apr. 13, 1953	5.38	Apr. 4, 1956	4.62
Dec. 6, 1951	5.67	Oct. 27	6.82	Mar. 14, 1957	4.46

[1] Reported by driller.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 7/6–32F1

[B. Cochrane. About 0.2 mile southwest of Kenwood, 54 feet northwest of Rohrer Avenue, 51 feet northeast of Mervyn Avenue (Warm Springs Road), in field. Unused irrigation well; diameter, 10 inches; depth, 190 feet. Measuring point: top of casing, north side, at casing cover lock, 1.5 feet above land-surface datum, which is 395 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 1, 1946	[1] 3	Apr. 1, 1952	+0.44	Apr. 13, 1954	+0.51
Oct. 27, 1950	2.60	Nov. 21	2.56	Apr. 1, 1955	+.17
Nov. 6, 1951	3.34	Apr. 13, 1953	+0.19	Apr. 4, 1956	+.34
Dec. 6	0.21	Oct. 27	2.61	Mar. 14, 1957	+.41

[1] Reported by driller.

Well 7/7–18Q1

[J. S. Barham. About 2.2 miles east-northeast of Santa Rosa, 0.20 mile southeast of Sonoma Avenue, 460 feet northeast of Yulupa Avenue, 400 feet north of creek, in corrugated-metal pump house. Unused well; diameter, 12 inches; reported depth, 250 feet. Measuring point: top of casing, southwest side, 0.5 foot above land-surface datum, which is 205 feet above sea level. (During the early summer of 1953 shallow strata were sealed off so that subsequent measurements reflect the head in the deep zone only, while earlier measurements reflect the composite head.)]

Date	Water level	Date	Water level	Date	Water level
Jan. 26, 1950	8.71	Oct. 17, 1950	16.62	Apr. 13, 1953	7.77
Mar. 1	3.25	Dec. 27	2.52	Nov. 3	41.33
29	3.25	Apr. 10, 1951	4.49	Apr. 1, 1954	24.30
Apr. 28	5.25	June 6	7.64	June 22	27.64
June 7	8.65	Nov. 6	15.95	Apr. 1, 1955	26.86
July 12	12.95	Dec. 6	.82	Apr. 4, 1956	23.91
Aug. 11	13.52	Apr. 1, 1952	2.42	Mar. 14, 1957	34.33
Sept. 7	14.57	Nov. 21	23.81		

Well 7/8–4B1

[Martin Lambert, 3964 Coffee Lane. About 3.6 miles north-northwest of Santa Rosa, 0.22 mile south of 90-degree turn in Coffee Lane, 185 feet east of Coffee Lane, beneath north edge of tank tower and windmill. Unused well; diameter, 5 inches; depth, 21.4 feet. Measuring point: top of casing, north side, 0.7 foot above land-surface datum, which is 150 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Mar. 8. 1942	[1] 4.5	Jan. 12, 1950	10.57	Oct. 16, 1950	10.80
Sept. 29, 1949	10.60	Feb. 28	3.65	Dec. 27	3.24
Oct. 14	10.92	Mar. 29	[2] 3.98	Apr. 12, 1951	4.48
21	11.04	Apr. 28	5.07	June 7	5.51
Nov. 4	11.25	June 7	6.50	Oct. 18	9.35
10	11.20	July 7	7.33	Dec. 6	2.84
Dec. 7	11.58	Aug. 9	8.49	Apr. 2, 1952	3.44
28	11.71	Sept. 7	10.08		

[1] Measurement by U. S. Bureau of Reclamation.
[2] Nearby well pumped recently.

Well 7/8–4B3

[H. A. Weinland, 3955 Coffee Lane. About 3.7 miles north-northwest of Santa Rosa, 0.19 mile south of 90-degree turn in Coffee Lane, 570 feet west of Coffee Lane, 900 feet west-northwest of well 7/8–4B1, in vineyard. Irrigation well; diameter, 8 inches; depth, 161.4 feet. Measuring point: hole in pump base, south side, 1.0 foot above land-surface datum, which is 150 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Sept. 29, 1949	13.22	Feb. 28, 1950	7.01	Dec. 27, 1950	6.77
Oct. 14	13.49	Mar. 29	6.88	Apr. 12, 1951	6.62
21	13.76	Apr. 28	7.48	June 7	7.83
Nov. 4	14.00	June 7	8.81	Oct. 18	11.71
10	13.91	July 7	9.85	Dec. 6	7.35
Dec. 7	14.12	Aug. 9	11.02	Apr. 2, 1952	5.53
28	14.32	Sept. 7	12.16		
Jan. 12, 1950	13.86	Oct. 16	13.32		

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 7/8-8L1

[Piner School District. About 3.5 miles northwest of Santa Rosa, 0.13 mile south of Piner Road, 200 feet west of Fulton Road, 100 feet north of school building, 6 feet east of red frame pump house. Public supply well; diameter, 8 inches; depth, 72 feet. Measuring point: top of casing, west side, 0.5 foot above land-surface datum, which is 130 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Jan. 23, 1950	13.56	July 6, 1950	14.60	June 6, 1951	12.93
Feb. 28	12.94	Aug. 8	15.35	Oct. 16	17.14
Mar. 29	11.88	Oct. 16	17.09	Dec. 4	13.78
Apr. 28	12.60	Dec. 28	11.93	Apr. 2, 1952	10.12
June 7	13.48	Apr. 18, 1951	12.30		

Well 7/8-10L1

[E. E. Hardies, 2519 Hardies Lane. About 2.1 miles northwest of Santa Rosa, 0.3 mile north of Steele Lane, 125 feet west of Hardies Lane. Unused irrigation well; diameter, 12 inches; reported depth, 212 feet. Measuring point: hole in pump base, south side, 1.0 foot above land-surface datum, which is 135 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
July 12, 1949	[1] 17.1	Feb. 28, 1950	8.69	Oct. 16, 1950	19.66
Oct. 13	21.60	Mar. 29	7.06	Dec. 27	15.86
21	20.34	Apr. 28	10.75	Apr. 12, 1951	8.26
Nov 4	18.22	June 7	14.88	June 7	17.25
10	18.10	July 7	18.48	Oct. 18	15.71
Dec. 7	15.24	Aug. 8	21.01	Dec. 6	9.83
28	15.21	Sept. 7	23.13	Apr. 2, 1952	3.46
Jan. 12, 1950	12.19				

[1] Measurement from Pacific Gas & Electric Co. pump test furnished by Water Dept., City of Santa Rosa.

Well 7/8-11M1

[N. B. Owen, 2500 Mendocino Avenue. About 1.7 miles north of Santa Rosa, 0.3 mile north of Steele Lane, 200 feet northeast of Mendocino Avenue, 22 feet southeast of centerline of driveway, 6 feet west of garage. Unused well; diameter, 8 inches; depth, 55 feet. Measuring point: hole in pump base, northwest side, 0.1 foot above land-surface datum, which is 160 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Dec. 15, 1949	11.08	Apr. 13, 1950	9.18	June 7, 1951	8.88
21	11.00	28	10.24	Oct. 18	12.62
29	10.79	June 7	9.63	Dec. 6	9.62
Jan. 26, 1950	10.12	July 13	11.14	Apr. 2, 1952	7.52
Feb. 3	9.77	Aug. 10	12.08	Nov. 21	10.21
7	9.50	Sept. 7	12.76	Apr. 17, 1953	7.86
9	9.45	Oct. 31	12.53	Nov. 6	10.29
15	9.35	Dec. 27	9.40	Apr. 2, 1954	7.08
23	9.53	Mar. 16, 1951	9.01	Apr. 1, 1955	7.83
Feb. 28	9.43	Apr. 11	8.58	Apr. 11, 1956	7.04
Mar. 29	9.37				

Well 7/8-20K1

[Fred Siemer. About 2.8 miles nearly west of Santa Rosa, 0.21 mile east and 0.09 mile south of the intersection of Fulton and Hall Roads, 450 feet south of road to Siemer labor camp, 20 feet west of drainage ditch, at east edge of hopyard. Irrigation well; diameter, 12 inches; depth, 626 feet. Measuring point: top of hole in east side of pump base, 1.1 feet above land-surface datum, which is 98 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 4, 1949	20.40	June 7, 1950	[1] 30.35	Dec. 6, 1951	14.54
Nov. 10	17.66	Aug. 8	29.32	Apr. 2, 1952	8.25
23	17.47	10	28.05	Nov. 20	23.20
Dec. 9	17.03	Sept. 15	24.17	Apr. 17, 1953	10.72
29	16.69	Oct. 16	20.74	Nov. 3	24.76
Jan. 12, 1950	16.34	Dec. 28	12.80	Apr. 1, 1954	11.62
Feb. 28	13.67	Apr. 11, 1951	8.99	Apr. 1, 1955	12.85
Mar. 28	12.53	June 6	9.47	Apr. 4, 1956	6.88
Apr. 28	12.31	Oct. 16	26.40	Mar. 14, 1957	9.95

[1] Pumping recently.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 7/8-20L1

[A. Fistolera, 675 Wright Road. About 3.1 miles nearly west of Santa Rosa, 400 feet south of Hall Road, 27 feet west of Wright Road, in open field. Unused well; diameter, 12 inches; depth, 57.7 feet. Measuring point: top of casing, south side, 1.0 foot above land-surface datum, which is 95 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Sept. 29, 1949	9.57	Mar. 28, 1950	2.12	Oct. 16, 1951	9.15
Oct. 14	9.93	Apr. 28	3.91	Dec. 6	2.86
21	9.91	June 7	5.86	Apr. 2, 1952	2.22
Nov. 4	10.02	July 6	6.50	Nov. 20	10.19
10	10.05	Aug. 8	7.63	Apr. 17, 1953	3.74
23	10.15	Sept. 15	9.14	Nov. 3	10.05
Dec. 9	10.09	Oct. 16	9.98	Apr. 1, 1954	1.22
28	10.16	Dec. 28	1.98	Apr. 1, 1955	3.91
Jan. 12, 1950	9.92	Apr. 11, 1951	3.60	Apr. 4, 1956	3.44
Feb. 28	2.56	June 6	5.07	Mar. 14, 1957	4.17

Well 7/8-23N1

[National Ice and Cold Storage Co., 8 Sebastopol Avenue. In Santa Rosa, 270 feet south of Sebastopol Avenue, 250 feet east of Northwestern Pacific Railroad tracks, 60 feet east of plant buildings, 130 feet north of well 7/8-32D2. Commercial and industrial well; 6 feet square in dug portion, 37.0 feet deep (dug portion), reported to be 150 feet deep (including drilled portion). Measuring point: lower edge of access hole in well cover, 0.2 foot above land-surface datum, which is 145 feet above sea level. Well is pumped steadily daily, the dug portion acting as a sump; (most measurements were made during first part of morning to obtain highest level of the day)]

Date	Water level	Date	Water level	Date	Water level
Oct. 13, 1949	17.65	Feb. 28, 1950	[1] 9.28	Oct. 18, 1950	17.20
21	18.10	Mar. 29	9.38	Dec. 29	8.40
Nov. 4	18.25	Apr. 28	10.77	Apr. 12, 1951	9.65
10	17.65	June 15	12.69	June 6	11.51
Dec. 7	17.39	July 14	14.70	Oct. 18	23.56
28	15.18	Aug. 10	22.72	Dec. 4	14.62
Jan. 12, 1950	[1] 16.73	Sept. 8	24.59	Apr. 2, 1952	8.33

[1] Afternoon measurement.

Well 7/8-29Q1

Santa Rosa Naval Air Base. About 3.3 miles southwest of Santa Rosa, 0.10 mile south of Finley Avenue, 155 feet east of Wright Road, in frame pump house. Unused well; diameter, 8 inches; depth, 61.7 feet. Measuring point: top of casing, south side, at land-surface datum, which is 94 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Nov. 17, 1949	10.94	May 9, 1950	6.03	Oct. 20, 1950	11.27
23	10.89	16	6.18	27	11.13
30	10.82	24	6.77	Nov. 3	10.96
Dec. 7	10.69	June 1	7.55	10	10.90
14	10.63	8	7.88	17	10.67
21	10.49	16	8.29	24	9.005
28	10.38	23	8.41	30	8.38
Jan. 4, 1950	10.30	30	9.20	Dec. 8	6.18
11	10.11	July 7	9.55	15	4.80
18	8.77	14	9.44	22	4.28
25	7.30	20	10.03	29	4.29
Feb. 1	6.00	28	9.78	Jan. 5, 1951	4.36
8	4.56	Aug. 4	10.40	12	3.68
15	4.08	11	11.03	19	2.96
22	4.08	18	11.05	26	2.58
Mar. 1	4.35	25	11.06	Feb. 2	3.14
8	4.48	Sept. 1	11.31	7	2.80
14	4.63	8	11.61	15	2.48
21	4.55	15	11.235	21	2.67
28	3.48	22	11.315	Mar. 1	2.96
Apr. 6	3.86	29	11.38	9	2.73
13	4.02	Oct. 8	11.73	15	2.84
21	4.50	16	11.35		
28	5.12				

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 7/8-29R1

[Santa Rosa Naval Air Base. About 2.9 miles southwest of Santa Rosa, 0.09 mile west and 0.09 mile south of intersection of Finley and Fresno Avenues, 400 feet south and 200 feet east of well 7/8-29J1, 40 feet south of three wooden storage tanks, in white frame pump house designated by letter "T" on west end. Public supply well; diameter, 12 inches (reduced to 10 inches); depth, 682 feet. Measuring point: bottom-edge of pump base, east side, 1.3 feet (including horizontal distance of 0.3 foot from measuring point to top of casing) above land-surface datum, which is 97 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 4, 1949	[1] 20.86	Jan. 12, 1950	19.64	Sept. 8, 1950	24.27
14	21.00	Feb. 28	17.53	Oct. 16	21.25
21	[1] 24.83	Mar. 28	15.30	Dec. 29	18.17
Nov. 4	20.79	Apr. 28	15.16	Mar. 15, 1951	16.68
10	20.18	June 7	18.35	Apr. 12	15.85
17	20.12	July 7	[2] 21.34	June 6	20.05
Dec. 7	20.44	Aug. 11	[2] 31.13	Dec. 6	33.77
28	[1] 18.73				

[1] Well nearby being pumped.
[2] Well nearby pumped recently.

Well 7/8-31C1

[M. LaFranchi (C. H. Dotti, tenant). About 2 miles east-northeast of Sebastopol, 0.22 mile northeast of intersection of old Sebastopol Road and State Highway 12, 30 feet southeast of old Sebastopol Road, in frame pump house. Unused well; diameter, 12 inches (reduced to 10 inches); depth, 320 feet. Measuring point: top of casing, north side, at land-surface datum, which is 85 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Aug. 11, 1950	[1] 14.40	Jan. 19, 1951	6.31	July 17, 1951	12.22
18	16.22	26	5.93	26	[2] 13.06
25	[1] 15.33	Feb. 2	6.15	Aug. 2	[2] 13.56
Sept. 1	15.30	15	5.49	9	13.02
8	15.65	21	5.61	15	12.86
15	14.03	Mar. 1	5.70	24	12.54
22	13.85	9	5.46	31	12.75
29	14.05	16	5.60	Sept. 13	16.75
Oct. 8	13.98	23	5.98	Oct. 16	14.71
16	13.88	30	6.31	24	15.05
20	13.84	Apr. 6	6.65	Nov. 7	13.87
27	[1] 13.73	12	7.01	16	13.45
Nov. 3	13.595	18	7.09	Dec. 4	12.48
10	13.60	26	7.41	Jan. 4, 1952	7.50
17	13.355	May 1	7.29	Feb. 7	5.93
24	12.11	8	7.00	Apr. 4	5.77
30	11.59	15	7.31	May 7	7.05
Dec. 8	9.31	23	7.72	16	7.71
15	7.925	June 2	12.09	July 27	13.13
22	7.53	10	11.59	Nov. 20	16.56
29	7.48	14	10.65	Apr. 4, 1956	10.46
Jan. 5, 1951	7.53	June 22	[1] 11.16	Mar. 14, 1957	4.17
12	7.09	28	[1] 13.31		

[1] Nearby well being pumped.
[2] Nearby well pumped recently.

Well 7/9-1C1

[P. W. Bussman. About 2.2 miles west-southwest of Fulton, 0.33 mile north and 0.56 mile east of the intersection of Woolsey and Olivet Roads, 360 feet north of abandoned railroad fill, 30 feet west of field road, at edge of hopyard, in frame pump-house tool shed. Domestic and industrial well: diameter, 10 inches; reported depth 110 feet. Measuring point: top of casing, southeast side, 0.4 foot above land-surface datum, which is 90 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Nov. 24, 1941	[1] 4	Mar. 29, 1950	7.00	Dec. 4, 1951	19.62
Oct. 5, 1949	18.10	Apr. 28	12.72	Apr. 2, 1952	15.48
14	[2] 14.91	June 14	23.99	Nov. 20	18.46
21	[2] 12.69	July 13	26.70	Apr. 16, 1953	12.36
Nov. 4	[2] 12.45	Aug. 9	30.44	Nov. 4,	20.44
10	[2] 11.74	Sept. 15	18.65	Apr. 1, 1954	[2] 13.50
17	11.49	Oct. 17	14.04	Apr. 1, 1955	18.56
Dec. 28	14.04	Dec. 28	9.50	Apr. 4, 1956	18.41
Feb. 1, 1950	9.76	Apr. 10, 1951	11.45	Mar. 14, 1957	19.29
28	9.24	Oct. 18	23.44		

[1] Measurement by U. S. Bureau of Reclamation.
[2] Pumping recently.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 7/9-5N1

[Petri Wine Co. In Forestville, 140 feet north of State Highway 12, 200 feet east of Covey Road, 20 feet west and 25 feet south of winery office, in corrugated-metal pump house. Industrial well; diameter, 12 inches; depth, 292 feet. Measuring point: hole in south side of pump base, 1.5 feet above land-surface datum, which is 170 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
July 20, 1950	32.62	Dec. 29, 1950	23.00	Oct. 16, 1951	[1] 51.8
Aug. 9	[1] 46.96	Apr. 13, 1951	[1] 33.5	Dec. 6	25.54
Sept. 15	34.91	June 6	35.60	Apr. 4, 1952	[2] 25.7
Oct. 18	[1] 48.90				

[1] Pumping.
[2] Pumping recently.

Well 7/9-10E1

[W. A. Taylor Wine Co., 2119 Laguna Road. About 7.6 miles west-northwest of Santa Rosa, 300 feet west of Laguna Road, 275 feet south of School Road, in eastern storage room of winery, 40 feet west of east wall, 65 feet north of south wall. Industrial well; diameter, 8 inches; depth, 260 feet. Measuring point: top-inside edge of curbing at air line at west side of casing, 2.4 feet above land-surface datum, which is 200 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
July 14, 1950	46.75	Oct. 18, 1950	[1] 51.87	June 6, 1951	49.20
Aug. 10	50.75	Dec. 29	51.33	Dec. 4	50.02
Sept. 15	[1] 51.35	Apr. 13, 1951	49.84	Apr. 4, 1952	47.45

[1] Pumping recently.

Well 7/9-13M1

[C. Ketelsen, 3772 Guerneville Road. About 3.5 miles north-northeast of Sebastopol, 0.20 mile east and 0.10 mile south of the intersection of Guerneville and Olivet Roads, 300 feet southeast of dairy barn, at north side of earthen reservoir, beneath frame pump house. Irrigation well; diameter, 12 inches (reduced to 8 inches); depth, 316 feet. Measuring point: bottom of pump base, esat side, 1.1 feet (includes horizontal distance of 0.4 feet from edge of pump base to inside edge of casing) below land-surface datum, which is 75 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Aug. 1941	[1] 14	Dec. 28, 1949	23.15	Aug. 9, 1950	26.17
Oct. 5, 1949	26.02	Feb. 1, 1950	22.16	Oct. 16	30.17
14	[2] 26.00	28	22.90	June 6, 1951	28.78
21	23.55	Mar. 29	21.03	Oct. 16	35.74
Nov. 4	23.60	Apr. 28	19.99	Dec. 4	21.5
10	23.29	June 14	22.57	Apr. 2, 1952	[3] 23.01
Dec. 7	23.17	July 13	25.02		

[1] Reported by driller.
[2] Nearby well being pumped.
[3] Pumping recently.

Well 7/9-13M2

[C. Ketelsen, 3772 Guerneville Road. About 3.5 miles north-northeast of Sebastopol, 0.22 mile east of Olivet Road, 100 feet south of Guerneville Road, 60 feet southwest of windmill, 175 feet northeast of well 7/9-13M3, beneath small wooden pump shelter. Domestic well; diameter, 5 inches; reported depth, 60 feet. Measuring point: top of casing, west side, 0.5 foot above land-surface datum, which is 85 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 5, 1949	19.83	Dec. 7, 1949	18.08	June 14, 1950	16.59
14	20.70	28	18.33	Apr. 13, 1951	14.79
Nov. 4	18.67	Feb. 1, 1950	14.74	Oct. 16	12.91
10	19.44	Mar. 29	12.72		

Well 7/9-13M3

[C. Ketelsen, 3772 Guerneville Road. About 3.5 miles north-northeast of Sebastopol, 0.20 mile east and 250 feet south of the intersection of Guerneville and Olivet Roads, 150 feet north and 50 feet east of well 7/9-13M1, 10 feet north and 70 feet east of southeast corner of milking shed, in the open. Auxiliary dairy well; diameter, 6 inches; reported depth, 45 feet. Measuring point: top of casing, east side, 1.0 foot above land-surface datum, which is 75 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Mar. 29, 1950	[1] 7.40	Aug. 9, 1950	17.28	Oct. 16, 1951	12.41
Apr. 28	[1] 13.42	Oct. 16	12.8	Dec. 4	3.62
June 14	[1] 13.28	Dec. 28	3.53	Apr. 2, 1952	2.80
July 13	15.42	Apr. 13, 1951	5.06		

[1] Pumping.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Date	Water level	Date	Water level	Date	Water level

Well 7/9-21F1

[C. O. Barion, 3950 Mueller Road. About 3.4 miles northwest of Sebastopol, 0.09 mile north of the intersection of Graton, Mueller, and Hicks Roads, 50 feet east of Hicks Road, 125 feet west and 10 feet north of dwelling, 10 feet south of tank house. Domestic well; diameter, 8 inches; depth, 320 feet. Measuring point: top of notch in east side of casing, 1.0 foot above land-surface datum, which is 200 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
June 23, 1950	62.95	Dec. 29, 1950	56.61	Oct. 16, 1951	69.66
Aug. 9	76.50	Apr. 13, 1951	59.5	Dec. 6	58.21
Sept. 15	65.28	June 6	62.04	Apr. 4, 1952	51.39
Oct. 18	66.40				

Well 7/9-35D2

[P. Brunwin, 680 East Hurlbut Road. About 1.0 mile northwest of Sebastopol, 0.22 mile east of Hurlbut Avenue, 0.08 mile north of East Hurlbut Avenue, 20 feet northeast of dwelling, at southeast end of pump house. Domestic and stock well; diameter, 8 inches; depth, 167 feet. Measuring point: top of casing, south side, 1.0 foot above land-surface datum, which is 135 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Apr. 12, 1950	35.70	Apr. 11, 1951	37.6	Nov. 3, 1953	17.90
June 15	36.39	June 7	34.07	Apr. 2, 1954	36.4
July 13	38.03	Oct. 16	35.50	Apr. 1, 1955	34.5
Aug. 9	37.10	Dec. 6,	35.97	Apr. 4, 1956	30.16
Sept. 15	37.68	Apr. 4, 1952	33.42	Mar. 14, 1957	30.83
Oct. 18,	38.10	Nov. 20	30.10		
Dec. 29	36.73	Apr. 17, 1953	36.11		

Well 7/9-36F1

[W. L. Hepworth. About 1.1 miles east-northeast of Sebastopol, 0.6 mile southwestward, along State Highway 12 from Llano Road, 0.25 mile northwest of State Highway 12, 600 feet north-northwest of dwelling, 17 feet west of fence, in frame pump house. Irrigation well; diameter, 10 inches; depth, 270 feet. Measuring point: top of casing, east side, 0.6 foot above land-surface datum, which is 85 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 4, 1949	31.35	Jan. 12, 1950	29.26	Aug. 8, 1950	[1] 40.47
14	31.45	Feb. 28	27.48	Sept. 15	[2] 60.60
21	31.42	Mar. 29	26.82	Dec. 29	31.06
Nov. 4	[1] 33.85	Apr. 28	[2] 45.95	Apr. 10	[1] 40.66
10	32.37	June 14	[2] 51.55	Dec. 6	35.10
Dec. 29	32.23	July 13	[2] 55.40	Apr. 4, 1952	28.23

[1] Pumping recently.
[2] Pumping.

Well 8/8-19E1

[J. Dragoman, Route 1, Box 197. About 1.8 miles southeast of Windsor, 0.12 mile east of Hembree Lane, 0.09 mile north of Shiloh Road, 85 feet north and 25 feet west of dwelling, in the open. Irrigation well; diameter, 10 inches; depth, 142 feet. Measuring point: bottom-edge of pump base, west side, 1.0 foot above land-surface datum, which is 105 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Nov. 8, 1949	10.47	July 13, 1950	[1] 39.05	Apr. 2, 1952	4.20
Dec. 7	9.22	Aug. 9	[1] 38.30	Nov. 20	17.74
28	6.88	Sept. 8	[1] 41.21	Apr. 16, 1953	7.99
Feb. 1, 1950	6.59	Oct. 17	14.73	Nov. 4	17.90
28	5.13	Dec. 28	6.65	Apr. 1, 1954	7.98
Mar. 29	4.90	Apr. 12, 1951	7.70	Mar. 31, 1955	9.93
Apr. 28	4.86	Oct. 18	15.62	Apr. 4, 1956	10.97
June 13	[1] 37.66	Dec. 4	9.85	Mar. 14, 1957	16.50

[1] Pumping.

Well 8/8-20D1

[J. Henningsen, 6030 Redwood Highway North. About 2.3 miles north of Windsor, 0.27 mile north and 0.18 mile east of the intersection of U. S. Highway 101 and Shiloh Road, 250 feet north and 210 feet east of dwelling, at east edge of orchard. Irrigation well; diameter, 10 inches; reported depth, 260 feet. Measuring point; tapped hole in top of pump base, northeast side, 1.0 foot above land-surface datum, which is 145 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Apr. 28, 1950	38.02	Oct. 17, 1950	47.86	Oct. 18, 1951	46.39
June 14	[1] 42.06	Apr. 12, 1951	[1] 43.8	Dec. 4	42.80
Aug. 9	44.67	June 6	41.88	Apr. 2, 1952	37.63

[1] Pumping recently.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 8/8-20E1

J. Henningsen, 6030 Redwood Highway North. About 2.3 miles north of Fulton, 0.2 mile north and 0.2 mile east of the intersection of U. S. Highway 101 and Shiloh Road, 230 feet east of dwelling, 20 feet north of branch of small creek, in frame pump house. Stock and orchard-spray well; diameter, 8 inches; reported depth, 100–110 feet. Measuring point: ½-inch hole in pump base, northwest side, 1.0 foot above land-surface datum, which is 145 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Nov. 21, 1949	36.88	July 13, 1950	31.63	Apr. 12, 1951	24.63
Feb. 28, 1950	28.14	Aug. 9	[3] 35.70	June 6	27.30
Mar. 29	[1] 32.25	Sept. 7	34.36	Oct. 18	34.63
Apr. 28	26.82	Oct. 17	35.15	Dec. 4	28.14
June 14	[2] 35.25	Dec. 28	28.34	Apr. 2, 1952	25.91

[1] Nearby well being pumped.
[2] Nearby well pumped recently.
[3] Pumping recently.

Well 8/8-20E2

[J. Henningsen, 6030 Redwood Highway North. About 2.3 miles north of Fulton, 0.20 mile north and 0.13 mile west of the intersection of U. S. Highway 101 and Shiloh Road, 80 feet south of dwelling, beneath north edge of elevated storage tank and windmill. Domestic well; diameter, 6 inches; reported depth, 100 feet. Measuring point: bottom of irregularly broken hole in west side of pump, 2.1 feet above land-surface datum, which is 145 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Feb. 28, 1950	16.63	Aug. 9, 1950	27.74	June 6, 1951	20.88
Mar. 29	14.39	Sept. 7	32.19	Oct. 18	28.85
Apr. 28	16.73	Oct. 17	34.08	Dec. 4	11.32
June 14	20.84	Dec. 28	14.77	Apr. 2, 1952	[1] 22.18
July 13	17.98	Apr. 12, 1951	15.47		

[1] Probably pumping recently.

Well 8/8-30N2 (former Fulton Air Base Well 3)

[Nagy. About 1.6 miles west-northwest of Fulton, 0.37 mile south of Lone Redwood Road, 65 feet west of paved road (designated "B" street by Army), 60 feet east of swimming pool. Unused well; diameter, 12 inches; depth, 600 feet. Measuring point: hole in top of steel plate welded over casing, at land-surface datum, which is 120 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Mar. 27, 1951	21.71	June 14, 1951	25.41	Sept. 20, 1951	29.08
Apr. 5	21.95	22	25.62	Oct. 18	28.59
13	22.53	28	27.00	23	27.67
18	22.41	July 17	27.16	Nov. 9	27.62
26	22.59	27	27.44	16	27.36
May 1	22.61	Aug. 2	27.91	Dec. 6	25.85
8	22.42	10	28.42	Jan. 4, 1952	24.48
15	22.41	15	28.35	Feb. 7	22.88
23	22.86	24	29.54	Apr. 2	22.14
June 2	23.96	31	29.44	May 7	22.73
10	25.11	Sept. 13	29.07	July 15	27.70

Well 8/9-10R1

[R. Hogan. About 1.1 miles west of Windsor, 0.58 mile west of Starr Road, 650 feet north of River Road, 100 feet north and 300 feet east of elevated storage tank, in frame pump house. Domestic well; diameter, 10 inches; depth, 400 feet. Measuring point: top of westernmost of two horizontal holes in south side of pump base, 1.5 feet above land-surface datum, which is 165 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Jan. 10, 1950	80.15	July 13, 1950	73.53	Apr. 12, 1951	70.61
Feb. 1	79.03	Aug. 9	72.92	June 6	74.96
28	82.01	Sept. 7	73.55	Oct. 18	74.33
Mar. 29	77.80	Oct. 17	74.02	Dec. 4	72.88
Apr. 28	77.86	Dec. 28	72.07	Apr. 2, 1952	79.82
June 14	76.02				

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 8/9-12Q1

[D. DuVander, Route 1, Box 86. About 0.6 mile due east of Windsor, 400 feet north and 350 feet east of intersection of U. S. Highway 101 and Brooks Road, 200 feet east of dwelling, on north side of ranch road and at south edge of orchard. Domestic and orchard-spraying well; diameter, 8 inches; reported depth, 124 feet. Measuring point: west edge of 2-inch pipe entering casing on west side, 0.5 foot above land-surface datum, which is 115 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 5, 1949	19.42	June 14, 1950	16.97	Dec. 28, 1950	16.03
Dec. 7	20.53	July 13	22.10	Apr. 12, 1951	18.62
Feb. 1, 1950	16.79	Aug. 9	[1] 32.40	Oct. 18	21.60
28	14.43	Sept. 9	[2] 30.97	Dec. 4	18.34
Mar. 29	13.54	Oct. 17	22.30	Apr. 2, 1952	12.06
Apr. 28	[1] 25.05				

[1] Pumping.
[2] Probably pumping recently.

Well 8/9-15F1

[Warren Richardson. About 1.7 miles west-southwest of Windsor, 0.46 mile south of River Road, 35 feet west of Eastside Road, beneath elevated pump house. Domestic and stock well; diameter, 8 inches; depth, 100 feet. Measuring point: bottom outside edge of notch in casing, east side, 5.0 feet above land-surface datum, which is 75 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Nov. 29, 1949	32.51	July 13, 1950	18.10	Oct. 18, 1951	24.08
Dec. 7	33.79	Sept. 7	18.00	Dec. 4	13.76
28	33.8	Oct. 17	17.05	Apr. 2, 1952	11.49
Feb. 1, 1950	[1] 26.17	Dec. 28	11.83	Nov. 20	16.03
28	11.85	Apr. 12, 1951	15.14	Apr. 16, 1953	14.32
Mar. 29	11.32				

[1] Pumping recently.

Well 8/9-15M1

[L. S. Quinan. About 1.9 miles west-southwest of Windsor, 0.63 mile south of River Road, 0.18 mile west of Eastside Road, 35 feet south of field road, in orchard. Irrigation and orchard-spray well; diameter, 8 inches; depth, 420 feet. Measuring point: bottom-inside edge of notch in casing, east side, 0.5 feet above land-surface datum, which is 70 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Nov. 23, 1949	14.90	June 13, 1950	15.23	June 6, 1951	14.64
Dec. 7	14.92	July 13	[1] 18.35	Oct. 18	17.59
28	14.81	Aug. 9	15.66	Dec. 4	15.83
Feb. 1, 1950	11.06	Sept. 7	15.81	Apr. 2, 1952	12.81
28	13.06	Oct. 17	15.75	Nov. 20	14.91
Mar. 29	[1] 10.42	Dec. 28	11.65	Apr. 16, 1953	12.98
Apr. 28	[1] 13.67	Apr. 12, 1951	13.44		

[1] Pumping recently.

Well 8/9-36N1

[P. W. Bussman. About 2.4 miles west-southwest of Fulton, 0.46 mile north and 0.44 mile east of the intersection of Woolsey and Olivet Roads, 1,145 feet north-northwest along field road from abandoned railroad grade to road crossing field, 440 feet south-southwest along road crossing field, thence 60 feet north-northwest, 18 inches southwest of used well 8/9-36N2. Unused well; diameter, 12 inches; depth, 89.0 feet. Measuring point: top of casing, south side, 0.2 foot above land-surface datum, which is 90 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 14, 1949	10.25	Mar. 29, 1950	4.89	June 6, 1951	6.59
21	10.27	Apr. 28	5.71	Apr. 2, 1952	4.38
Nov. 4	10.42	June 14	6.80	Nov. 20	10.30
10	10.41	July 13	[1] 23.53	Nov. 4, 1953	9.41
17	10.48	Aug. 9	[1] 24.25	Apr. 1, 1954	3.90
Dec. 7	10.63	Sept. 15	9.15	Apr. 1, 1955	7.21
28	10.78	Oct. 16	9.67	Apr. 4, 1956	4.79
Feb. 1, 1950	6.90	Dec. 28	3.48	Mar. 14, 1957	7.70
28	4.19	Apr. 11, 1951	5.49		

[1] Nearby well being pumped.

TABLE 19.—*Water levels in wells, 1949–57, Santa Rosa Valley area, California*—Continued

Well 8/9-36P1

[P. W. Bussman. About 2.3 miles west-southwest of Fulton, 0.46 mile north and 0.51 mile east of intersection of Woolsey and Olivet Roads, 1,020 feet north-northwest along field road from abandoned railroad fill, 600 feet north-northwest along field road from well 7/9-1C1, 10 feet west of field road, in hopyard. Irrigation well; diameter, 12 inches (reduced to 10 inches); depth, 1,048 feet. Measuring point: top north side of casing at east side of notch cut for electric cable access, 0.8 foot above land-surface datum, which is 90 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 5, 1949	[1] 22.56	Mar. 29, 1950	17.37	Apr. 2, 1952	34.58
14	22.64	Apr. 28	17.82	Nov. 20	30.58
21	21.86	Aug. 9	[1] 48.7	Apr. 16, 1953	25.42
Nov. 4	22.14	Sept. 15	24.95	Nov. 4	40.39
10	21.60	Oct. 16	24.30	Apr. 1, 1954	31.00
17	21.80	Dec. 28	18.02	Apr. 1, 1955	33.65
Dec. 7	21.60	Apr. 13, 1951	17.29	Apr. 4, 1956	31.70
Dec. 28	20.87	May 23	17.53	Mar. 14, 1957	38.25
Feb. 1, 1950	19.34	Oct. 18	41.82		
28	17.80	Dec. 7	39.27		

[1] Pumping recently.

Well 9/9-34D1

[Foppiano Wine Co., Route 2, Box 222A. About 1.8 miles southeast of Healdsburg, 0.15 mile northwest of Limerick Lane, 235 feet west of U. S. Highway 101, 20 feet north of winery driveway, in 4-foot by 3-foot shelter built onto east end of workshop. Unused well; diameter, 10 inches; depth, 120.5 feet. Measuring point: top of casing, north side, 0.8 foot above land-surface datum, which is 105 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 20, 1949	30.19	Apr. 28, 1950	23.80	Dec. 28, 1950	8.90
Nov. 10	30.39	June 13	26.63	Apr. 10, 1951	22.01
Dec. 7	31.09	July 13	28.04	June 6	24.58
28	33.53	Aug. 9	28.97	Oct. 18	29.53
Feb. 1, 1950	14.70	Sept. 7	29.68	Dec. 4	5.96
28	10.45	Oct. 17	30.15	Apr. 2, 1952	11.23
Mar. 29	17.27				

Well 9/9-34N1

[W. C. Beaumont, Route 1, Box 399. About 2.5 miles south-southeast of Healdsburg, 0.8 mile south of Limerick Lane, 0.34 mile west along field road from U. S. Highway 101, in 8-foot by 8-foot frame pump house. Irrigation well; diameter, 12 inches; reported depth, 198 feet. Measuring point: ½-inch hole in pump base, east side, 3.3 feet above land-surface datum, which is 85 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 20, 1949	14.82	June 13, 1950	17.32	Dec. 28, 1950	12.02
Nov. 10	[1] 16.28	July 13	15.04	June 6, 1951	15.18
Dec. 7	15.28	Aug. 9	16.08	Apr. 2, 1952	12.56
28	15.35	Sept. 7	15.12	Nov. 20	16.67
Feb. 28, 1950	14.05	Oct. 17	15.13	Apr. 16, 1953	14.7
Mar. 29	11.68				

[1] Pumping recently.

Well 9/9-34Q1

[E. H. Reiman. About 2.6 miles southeast of Healdsburg, 0.7 mile south of Limerick Lane, 450 feet south of railroad underpass, 150 feet east of railroad, in old orchard. Stock well; diameter, 6 inches; depth, 55.2 feet. Measuring point: notch in casing, east side, 1.0 foot above land-surface datum, which is 110 feet above sea level]

Date	Water level	Date	Water level	Date	Water level
Oct. 20, 1949	23.61	Apr. 28, 1950	21.77	Dec. 28, 1950	23.26
Nov. 10	24.88	June 13	25.53	Apr. 10, 1951	22.21
Dec. 7	24.14	July 13	[1] 26.53	June 6	26.18
28	25.56	Aug. 9	28.17	Oct. 18	27.02
Feb. 1, 1950	23.65	Sept. 7	27.84	Dec. 4	8.27
28	22.69	Oct. 17	28.5	Apr. 2, 1952	19.41
Mar. 29	22.02				

[1] Pumping recently.

TABLE 20.—*Chemical analysis of water from wells in the Santa Rosa Valley area, California*

[The laboratories which analyzed the samples are indicated by symbols as follows: GS, U. S. Geological Survey, Quality of Water Branch; U. C., University of California, Division of Plant Nutrition; CWS, California Water Service Co.; BC, Brown and Caldwell, consultants]

Sum of determined constituents: the arithmetic sum, in parts per million, of all constituents determined, except for bicarbonate, for which the figure was halved before addition. Boron and phosphate, if determined, are included only when they exceed 1.0 part per million. The concentration of sodium was computed by difference and includes the concentration of potassium plus any error of analysis.

Well or location No.	Analysis by—	Date of collection	Depth of well (feet)	Specific conductance (micromhos at 25°C)	pH	Sum of determined constituents (ppm)	Constituents in parts per million															Percent sodium	Type of water
							Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Boron (B)	Fluoride (F)	Hardness as calcium carbonate ($CaCO_3$)		
5/9- 3G1	GS	8-30-51	1,010	550	9.1	342	20			7.6	3.9	118	0.4	21	236	23	32	0	0.54	0.5	35	88	Na-HCO_3.
6/6- 5L1	BC	9-20-51	133	568	7.6	375	57	0.18	0.14	18	8.3	105		0	273	.8	51	0		.7	68	77	Do.
5L1	GS	6- 5-52										90							2.5				
5L3 [1]	GS	5- 8-52	6	611	8.0	430	81			15	6.2	112	13	0	282	.3	58	1.2	3.5	.8	63	75	Na-HCO_3.
16B2	GS	9-19-51	211	672	8.2	442	74			3.7	4.6	134	9.0	0	300	.8	60	.5	7.7	.3	28	88	Do.
16H1	UC	5-22-51	210	550	8.3	314				5	<5	120		5	195	<5	80		6.2		15	95	Do.
16J2	UC	10-25-49	280	550	8.6	316				15	10	90		20	120	23	90		7.7		80	70	Na-Cl-HCO_3.
6/7-16D1	UC	2-23-50	38	300	7.0	145				10	15	30			130	<5	20		.64		87	43	Mg,Na-HCO_3.
29P1	CWS	5-26-47	197	434	7.6	274	44	.14	.03	30	17	39			242	3	19	2.5			145	37	NaCa,Mg,-HCO_3.
31H1	CWS	5-26-47	298	286	7.3	196	42	.03	.07	28	12	14			144	2	13	14			120	20	Ca,Mg-HCO_3.
6/8- 5E1	GS	8-29-51	638	451	7.8	302	47			20	12	64	1.0	0	246	1.7	26	8.7	.23	0	100	58	Na-HCO_3.
15J3	CWS	5-27-47	166	339	8.0	226	41	4.7	.03	32	14	19			204	6	9	0			137	22	Ca,Mg-HCO_3.
6/8-16R1	CWS	5-27-47	568	588	7.7	368	67		.03	33	16	66			244	3	62	.6			149	49	Na-HCO_3.
23C2	CWS	5-27-47	(2)	357	8.2	228	43	0.10	.03	31	21	14			214	4	9	.7			163	15	Mg,Ca-HCO_3.
25Q1	CWS	5-26-47		455	7.7	289	35	0	.09	39	21	27			212	11	22	30			183	24	Ca,Mg-HCO_3.
26N1	GS	4- 4-52	246	282						14	9.2	35					33				73	51	
36A1	CWS	5-26-47	636	278	7.2	191	46	1.6	0	18	3.7	33			108	3	30	2.5			61	53	Na-HCO_3.
6/9- 2C1 [3]			260																				
2F1 [3]	UC	10-10-51	600	360	8.3	205				50	10	20		15	140	15	20	5	.04		145	20	Ca-HCO_3.
7/7-17A1	BC	6-19-48	846	597	7.6	[4] 329		.06	.12	31	25	68		0	339	2.5	32	3.5			180	45	Na,Mg,Ca-HCO_3.
18R1	BC	1-22-48	160	610	8.1	404	95	.33	.10	34	21	64		0	346	2.9	16	1.0			172	45	Do.
24A1	(5)	3-19-45	622			93				4	8	23			98	3	6				43	53	Na-HCO_3.
29L1	UC	5-27-51	365	450	8.5	270				30	15	45		25	240	5	30		.28		135	43	Na,Ca,Mg-HCO_3.
29L2	UC	5-22-51	365	500		290				30	15	50			320	5	30		.36		145	44	Do.
32G1	UC	10-26-51	403	490	8.3	292				30	10	75		25	265	<5	20		.32		115	59	Na-HCO_3.
7/8- 9Q1	BC	2-18-50	140	464	8.0			.32	.20								13				130		
9R1	BC	2-10-50	210	447	7.7			.86	<.32								10				146		
14D1	BC	2-10-50	300	449	7.2			.98	.54								10				168		

7/8-15G1	UC	3-14-50	65	810	7.2	427	----	----	----	50	65	25	----	----	385	45	50	----	0.06	----	390	13	Mg-HCO_3.
18M1	UC	12-23-51	640	480	7.2	262	----	----	----	15	5	85	----	----	265	<5	25	----	.20	----	70	73	Na-HCO_3.
19J1	BC	2-10-50	186	524	7.7	----	----	.90	.44	----	----	----	----	----	----	----	45	----	----	----	202	----	
20C1	BC	2-14-50	625	722	7.6	----	----	.93	.77	----	----	----	----	----	----	----	69	----	----	----	278	----	
20K1	BC	2-17-50	626	475	7.9	----	----	.06	.22	----	----	----	----	----	----	----	22	----	----	----	170	----	
24A2	BC	1-26-48	930	542	8.0	339	86	.23	.09	28	17	52	----	0	286	.4	14	0	----	----	140	45	Na,Mg,Ca-HCO_3.
24A3	BC	1-19-48	300	517	8.0	344	89	.29	.13	30	19	48	----	0	280	2.1	18	0	----	----	153	41	Do.
24A4	BC	1-19-48	1,000	550	8.0	364	93	.33	.09	28	16	59	----	0	285	.9	27	0	----	----	144	47	Na,Ca,Mg-HCO_3.
24A6	BC	8-31-50	912	479	7.4	392	89	.27	.07	29	18	68	----	0	290	9.9	28	7.0	----	----	147	50	Na-HCO_3.
29J1	(6)	2-26-45	685	----	7.4	301	45	----	.1	20	17	61	----	----	258	5.4	25	----	----	----	120	52	Do.
29J1	BC	2- 8-50	----	460	7.6	----	----	.39	.28	----	----	----	----	----	----	----	23	----	----	----	105	----	
7/9-13M1	GS	4- 2-52	325	250		----	----	----	----	14	6.6	32	----	----	----	----	14	----	.06	----	62	53	Na.
13R1	UC	2-14-52	375	600	7.1	350	----	----	----	15	5	120	----	----	350	<5	35	----	.36	----	70	78	Na-HCO_3.
14K1	UC	10-23-50	588	580	----	336	----	----	----	15	10	110	----	----	230	<5	85	----	1.3	----	75	76	Do.
23F1	UC	8-27-51	610	350	7.2	205	----	----	----	15	5	65	----	----	180	<5	30	----	.16	----	40	78	Do.
29J2	GS	8-30-51	657	420	8.2	286	49	----	----	30	13	40	2.2	0	183	43	18	0.8	.20	.2	128	40	Na,Ca,Mg-HCO_3.
8/8-20Q1	GS	8-30-51	312	530	7.6	378	88	----	----	23	25	51	7.5	0	271	21	29	0	.21	.2	160	40	Na,Mg,Ca-HCO_3.
8/9-10R1	GS	4- 2-52	400	214	8.4	197	84	----	----	4.8	4.1	31	7.1	0	116	1.8	7.0	.1	.63	.2	29	64	Na-HCO_3.
13C1	GS	4- 2-52	202	246	7.2	227	102	----	----	9.6	12	23	2.8	0	110	1.0	22	0	.43	.2	73	39	Na,Mg,Ca-HCO_3.
13N1	UC	7-26-50	175	270	7.3	152	----	----	----	15	15	25	----	----	145	<5	25	----	.12	----	100	40	Mg,Na,Ca-HCO_3.
14P1	UC	7-26-50	264	200	7.1	106	----	----	----	15	10	15	----	10	75	<5	20	----	.04	----	80	32	Ca,Mg,Na-HCO_3.
15F1	GS	4- 2-52	100	560	----	----	----	----	----	18	27	78	----	----	----	----	56	----	.36	----	156	52	Na.
23F1	UC	7-26-50	130	300	7.3	190	----	----	----	15	15	45	----	15	150	<5	25	----	.16	----	100	51	Na-HCO_3.
23G1	UC	7-26-50	224	470	7.6	278	----	----	----	15	10	85	----	25	215	5	30	----	.60	----	80	70	Do.
23L1	UC	7-12-50	410	400	8.1	267	----	----	----	15	10	75	----	20	160	<5	45	----	22	----	80	71	Do.
23L1	UC	7-26-50	----	400	7.5	----	----	----	----	----	----	----	----	----	----	----	----	----	22	----	----	----	
23L1	UC	9- 8-50	[7] 227	440	7.7	258	----	----	----	30	25	25	----	----	100	105	33	----	.44	----	178	22	Mg,Ca-HCO_3.
26D1	UC	7-20-50	456	380	7.3	200	----	----	----	15	10	55	----	20	170	<5	25	----	.40	----	80	56	Na-HCO_3.
27K1	UC	7-26-50	333	430	7.8	251	----	----	----	10	5	85	----	15	220	<5	25	----	1.0	----	45	80	Do.
36K1	UC	7-25-50	1,325	700	7.7	407	----	----	----	15	5	150	----	25	300	<5	60	----	[8] 2.4	----	60	86	Do.
	UC	Fall 1950	----	550	----	333	----	----	----	15	15	100	----	----	335	----	35	----	[9] .80	----	100	68	Do.

[1] Spring.
[2] Reported depth, 300–350 feet.
[3] Sample from reservoir supplied by these two wells.
[4] Total solids by evaporation, 401 ppm.
[5] California State Division of Highways, Materials and Research Department.
[6] Department of Public Works, Twelfth Naval District.
[7] Plug set in well at indicated depth.
[8] Sampled during pumping season.
[9] Sampled several months after end of pumping season. Possibly not pumped for sufficient time to obtain representative sample.

TABLE 21.—*Partial chemical analyses of water from wells and springs in the Santa Rosa Valley area, California*

[Analyses by or under the supervision of A. A. Garrett. Dissolved solids may be estimated from specific conductance by use of figure 13]

Well or location number	Date of collection	Depth (feet)	Specific conductance (micromhos at 25° C)	Chloride (Cl)	Hardness as $CaCO_3$
				parts per million	
5/7- 6P2	12-20-49	114	628	94	180
5/8- 1Q1	2-15-50	180	981	133	240
6/6- 8N1	7-26-50	490	426	23	80
16B1	6-26-51	102	690	93	15
6/7-30M1	10-18-50	104	298	8.8	125
31J2	10-18-50	(1)	440	32	175
6/8- 2C1	10-18-50	98	590	63	211
5E1	8-29-51	638	457	27	115
7P2	10-18-50	120	248	26	48
8H1	2- 7-50	96	787	78	240
10E1	6-25-51	126	446	21	125
12J1	2-15-50	223	357	41	75
16M1	2-17-50	147		54	
17H1	8-29-51		1,390	274	405
17K2 (spring)	2- 9-50		1,220	28	310
17K3	4-11-51	132	281	25	82
20G1	3-22-50	199	498	105	100
26N2	12-21-49	290	334	62	110
26Q1	12-19-49	170	630	159	140
27D1	3- 3-50	157	345	44	65
30F2	8- 7-51	286	882	53	420
6/8-32C1	3-29-50	190	663	99	180
6/9- 1P2	7-27-51	248	133	22	30
8F1	4-27-50	190	1,250	9.6	682
10B1	4- 7-50	180	214	15	82
11D2	10-18-50	337	186	15	54
12G1	3-22-50	104	164	13	35
12G2	4-11-51	155	147	14	30
13J1	3-30-50	280	177	8.6	55
15F1	3-31-50	136	277	32	95
15R2	3-30-50	130	655	62	225
22A1	8-30-51	360	506	24	220
7/6-29K1	7-25-50	130	224	7.8	76
32H1	10-16-50	400	207	8.8	72
7/7- 8P1	5-25-50	195	259	11	103
20C1	2- 2-50	112	854	48	310
7/8- 3L1	6-21-51	150	501	26	159
5L1	11-22-49	75	439	51	150
8L1	10-16-50	72	309	30	101
10P1	6-20-51	150	439	12	150
19K1	12- 6-49	176	474	38	160
7/8-36D1	2-10-50	140	385	28	125
7/9- 1C1	10-16-50	110	454	33	93
3E1	11-21-49	130	1,240	42	620
5N1	10-18-50	292	231	8.8	88
8J1	8-10-50	274	134	8.8	35
10E1	10-18-50	260	228	13	77
13B1	6-23-51	142	252	22	90
14H1	2- 2-50	85	334	22	100
14K1	8-10-50	588	545	74	52
15C1	6-15-50	100	231	6.5	100
16B1 (spring)	7-14-50		129	9.2	31
20B1	7-12-50	159	326	17	135
21F1	10-18-50	320	136	7.0	34
21G3	8- 8-51	408	239	12	100
22G	8-30-51	(2)	237	9.5	95
23F1	6-20-51	610	351	29	33
23R1	12- 6-49	150	565	28	175
28L1	8-30-51	565	325	13	130
28P1	4-17-51	585	316	20	105
28P2	4-17-51	100	116	12	23
7/9-31J1	8- 8-51	352	142	11	55
33D2	4-17-51	300	400	25	130
33F1	4-17-51	200	210	14	59
33F2 (spring)	4-17-51		92.2	11	13
35D2	10-18-50	167	324	9.8	143
36F1	8-11-50	265	284	16	89

See footnotes at end of table.

TABLE 21.—*Partial chemical analyses of water from wells and springs in the Santa Rosa Valley area, California*—Continued

Well or location number	Date of collection	Depth (feet)	Specific conductance (micromhos at 25° C)	Chloride (Cl)	Hardness as $CaCO_3$
				parts per million	
8/8-17L1	4-21-50	278	132	11	40
19M1	10-18-50	250	501	56	153
20D1	10-17-50	260	461	18	----------
20E1	10-17-50	[3] 100	289	20	----------
20E2	10-17-50	[3] 100	381	33	130
20Q1	10-18-50	310	467	34	----------
30C1	6-21-51	154	265	11	70
30G1	6-21-51	140	348	19	135
30N1	6- 3-51	485	338	12	91
31B1	11-18-49	210	308	8.8	90
8/9- 2Q1	11- 3-49	101	244	22	65
12C1	6-13-51	184	271	38	71
12C2	6-13-51	30	242	10	80
23L1	11-16-49	410	361	32	85
8/9-24L1	6-27-51	150	537	29	235
26C1	11-16-49	145	219	17	65
26D1	11-16-49	464	322	14	85
26E1	11-16-49	188	192	13	65
36P1	7-13-50	1,015	964	99	54
9/9-34Q1	10-17-50	55	200	9.4	62
36E1	11- 3-49	127	295	23	95

[1] Not measurable. Reported length of pump column 57 feet.
[2] Sample from irrigation sump at edge of Laguna de Santa Rosa; principal source is spring discharge from Merced formation.
[3] Reported depth.

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*

Well 5/7-6E1. L. Haberer

[Drilled by N. F. Keyt. Altitude, 105 feet. On alluvial plain. Bailer test: static level, 37 feet; bailing level, 63 feet at 1,400 gallons per hour]

	Thickness (feet)	Depth (feet)
Younger alluvium and Merced formation:		
Loam, black	3	3
Clay, yellow	21	24
Sand, yellow; and gravel; water	16	40
Clay, blue	45	85
Younger alluvium and Merced formation—Continued		
Sand and clay, gray; water at 85 feet	7	92
Sand and gravel, gray	12	104
Clay, blue	11	115

Well 5/8-1H1. R. H. Companey

[Drilled by N. F. Keyt. Altitude, 125 feet. At edge of alluvial plain. Casing perforated between depths of 151 and 176 feet and at bottom]

	Thickness (feet)	Depth (feet)
Younger alluvium and Merced formation:		
Soil	2½	2½
Clay, yellow	32½	35
Clay, blue	8	43
Clay, yellow	7	50
Clay, blue	12	62
Clay, yellow	16	78
Clay, blue	10	88
Clay, yellow	10	98
Clay, blue	12	110
Clay, yellow	6	116
Clay, blue	20	136
Younger alluvium and Merced formation—Continued		
Clay, yellow	4	140
Clay, blue	11	151
Clay, blue, and gravel	25	176
Clay, blue	10	186
Clay, yellow	4	190
Clay, sandy, blue	29	219
Clay, blue	5	224
Sand and gravel, slightly cemented	6	230
Clay, blue	2	232

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 5/8-1J1. Faletti

[Drilled by A. J. Oberto. Altitude, 135 feet. On hillside. Casing perforated between depths of 44 and 60 feet. Bailer test: bailing level, 120 feet at 1,100 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
No record	27	27	Gravel, cement	10	180
Clay, blue	17	44	Clay, blue	100	280
Gravel, cement	5	49	Gravel, cement	10	290
Clay	121	170			

Well 5/8-1L1. Mrs. Reeves

[Drilled by N. F. Keyt. Altitude, 240 feet. On side of ridge. Bailer test: static level, 70 feet; bailing level, 100 feet at 280 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Topsoil	3	3	Clay, blue, and gravel	45	155
Clay, yellow, and rock	19	22	Clay, sandy, blue	15	170
Clay, blue	8	30	Clay, sandy, blue, and gravel	5	175
Clay, yellow, and rock	17	47	Clay, blue	27	202
Gravel and clay, blue; 1st water, 52'	5	52	Clay, blue, sandy	3	205
Clay, blue	30	82	Gravel and clay, blue	6	211
Gravel	8	90	Petaluma(?) formation:		
Clay, blue, and gravel	15	105	Clay, blue, jointed	15	226
Clay, yellow, and gravel	5	110	Clay, blue	27	253

Well 5/8-13B1. S. Pozzi

[Drilled by N. F. Keyt. Altitude, 45 feet. On alluvial plain. Bailer test: static level, 12 feet; bailing level, 48 feet at 25 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Merced formation:			Younger alluvim and Merced formation—Continued		
Abode soil	3	3	Sand, blue and gravel	80	172
Sand; first water at 22 feet	89	92			

Well 6/6-4J1. Mr. R. Heins

[Drilled by J. Larbre. Altitude, 405 feet. At foot of low ridge. Cased between surface and depth of 86 feet. Dump test: static level 7 feet; pumping level, 100 feet at 400 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sonoma volcanics:			Sonoma volcanics—Continued		
Volcanic conglomerate formation (probably includes thin interval of terrace or fan deposits)	80	80	Rock, black volcanic	73	153
			Rock, red and black volcanic	37	190

Well 6/6-8N1. M. F. Hellman

[Drilled by O. J. Pearson. Altitude, 325 feet. On stream terrace]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Surface	16	16	Boulders and gravel	10	205
Gravel	4	20	Volcanic rock, soft (probably tuffaceous Glen Ellen strata)	240	445
Clay, sandy, blue	45	65	Sonoma volcanics:		
Gravel and boulders	20	85	Lava rock, blue	45	490
Boulders	15	100			
Clay, yellow	95	195			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 6/6-9R1. B. Brown

[Drilled by N. F. Keyt. Altitude, 300 feet. On low hill in valley. Casing perforated between depths of 65 and 170 feet. Bailer test: static level 46 feet; bailing level, 80 feet at 30 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Rock, brown	35	35	Clay, blue, and gravel	94	172
Clay, yellow, and gravel; water at 70 feet	43	78	Gravel	18	190
			Clay, yellow, and gravel	3	193

Well 6/6-10F1. V. M. Alvord

[Drilled by J. Larbre. Altitude, 335 feet. On dissected stream terrace. Cased between surface and depth of 232 feet. Bailer test: static level, 31 feet; bailing level, 150 feet at 300 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Sonoma volcanics:		
Hardpan and boulders	102	102	Rock, decomposed; not hard	238	350

Well 6/6-16B1. Miss I. Holt

[Drilled by J. Larbre. Altitude, 400 feet. On hillside. Cased between surface and depth of 422 feet. Bailer test: static level, 40 feet; bailing level, 250 feet at 400 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Clay and rock	87	87	Clay, yellow	77	317
Clay, yellow	41	128	Shale, blue	35	352
Clay, blue	22	150	Clay, volcanic, red; includes gravel	74	426
Clay, yellow	34	184			
Clay, blue	56	240			

Well 6/6-17A1. H. Purcell

[Drilled by J. Larbre. Altitude, 290 feet. On stream terrace. Cased between surface and depth of 129 feet. Bailer test: static level, 18 feet; bailing level, 90 feet at 600 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Quaternary terrace (?) deposits:			Glen Ellen formation—Continued		
Dirt and boulders	33	33	Clay and gravel	30	128
Glen Ellen formation:			Gravel	2	130
Clay, yellow, and boulders	65	98	Clay and gravel	20	150

Well 6/7-3Q1. W. Jacobs

[Drilled by Precision Drilling Co. Altitude, 555 feet. On bank of small creek. Gravel packed. Reported yield, 1,200-1,500 gpm at pumping level of 55 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Clay	27	27	Gravel, wash	12	110
Gravel	21	48	Sonoma volcanics:		
Gravel, brown, washed	2	50	Basalt	15	125
Clay	48	98	Ash, white	292	417

Well 6/7-19D1. A. T. Pomerlo

[Drilled by N. F. Keyt. Altitude, 115 feet. On alluvial plain. Pumping test: static level, 10 feet; pumping level, 55 feet at 75 pgm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Top soil	8	8	Clay and gravel	4	104
Clay, blue	13	21	Clay, sandy, brown	4	108
Clay, sandy, brown, gravelly	89	100			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 6/7-29P1. F. Riebli

[Drilled by N. F. Keyt. Altitude, 200 feet. On low hill at edge of alluvial plain. Casing perforated between depths of 3 and 21, 30 and 39, 48 and 54, 60 and 63, 69 and 72, 78 and 81, and 102 and 108 feet. Bailer test: static level, 2½ feet; bailing level, 15 feet at 51 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sonoma volcanics:			Sonoma volcanics—Continued		
"Hill formation"	1	1	Decayed rock	13	140
Rock	77	78	Decayed rock, yellow	28	168
Clay, blue, and gravel	26	104	Decayed rock, blue	17	185
Blue clay	23	127			

Well 6/7-31G1. J. Equi

[Drilled by N. F. Keyt. Altitude, 135 feet. On alluvial fan]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Merced(?) formation—Continued		
Black soil	6	6	Sand	1	446
Clay, yellow, and gravel	34	40	Hard shell (probably cemented sand)	1	447
Clay, yellow	232	272	Saud	21	468
Sonoma volcanics(?):			Hard	2	470
Volcanic rock	27	289	(No record)	10	480
Volcanic rock	35	324	Clay, blue	10	490
Merced(?) formation:			Petaluma formation(?):		
Clay, blue	121	445	Shale, blue	18	508

Well 6/7-31H1. J. Equi

[Drilled by N. F. Keyt. Altitude, 160 feet. On alluvial fan]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Soil	5	5	Clay, yellow, and gravel	35	115
Clay, yellow	7	12	Clay, yellow	60	175
Clay, yellow, and gravel	6	18	Clay, yellow, and boulders	77	252
Clay, yellow	11	29	Clay, yellow	3	255
Clay, yellow, and gravel	15	44	Clay, blue	43	298
Clay, yellow	36	80			

Well 6/7-31J1. P. Bleish

[Drilled by N. F. Keyt. Altitude, 135 feet. On alluvial plain. Casing perforated between depths of 45 and 94, 103 and 183, 189 and 198, and 225 and 228 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Adobe	6	6	Boulders	15	198
Gray clay	13	19	Merced formation:		
Yellow clay	26	45	Blue clay	20	218
Sandy yellow clay and gravel; water at 80 feet	49	94	Blue sand and gravel	2	220
Yellow clay	9	103	Sand and gravel	1	221
Yellow clay and gravel	25	128	Blue sand, packed	20	241
Yellow cemented gravel	12	140	Blue sand	10	251
Yellow clay	30	170	Blue sandstone	23	274
Yellow clay and gravel	13	183	Blue clay	6	280

Well 6/7-31L1. Waldo Rohnert Co.

[Drilled by N. F. Keyt. Altitude, 135 feet. On alluvial plain. Casing perforated between depths of 54 and 65 feet. Bailing test: static level, 13 feet; bailing level, 67 feet at 20 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Loam, black	3	3	Clay, yellow	20	50
Sand, gray	5	8	Sand, yellow	13	63
Clay, yellow, and gravel	10	18	Gravel	12	75
Gravel	3	21	Clay, yellow	4	79
Clay, yellow, sandy	9	30			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 6/7-32M1. W. B. Hussey

[Drilled by N. F. Keyt. Altitude, 145 feet. On alluvial fan. Casing perforated between depths of 33 and 100, 209 and 220, 240 and 260, and 290 and 335 feet. No record of lower perforations]

	Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:		
Soil, black	2	2
Sand, blue, and gravel	1	3
Soil, black	2	5
Clay, yellow, and gravel	34	39
Gravel	1	40
Boulders	30	70
Clay and gravel	5	75
Clay, yellow, and gravel	20	95
Merced formation:		
Clay, blue	13	108
Sand, yellow	3	111
Sand, blue, and yellow clay	16	127
Sand, blue; streak of blue clay	4	131
Clay, blue	78	209
Clay, blue, and gravel	11	220
Clay, blue	20	240
Clay, blue, sandy	20	260
Clay, blue	30	290
Clay, sandy, blue, and streaks of sandstone	35	325
Sandstone, blue, and fine gravel	7	332
Merced formation—Continued		
Clay, sandy, blue	3	335
Clay, blue	62	397
Clay, yellow	11	408
Clay, blue	17	425
Clay, yellow	35	460
Clay, blue	17	474
Clay, blue, and gravel	1	475
Clay, blue	22	497
Clay, yellow	5	502
Clay	298	800
Gravel, hard, cemented	15	815
Soft	35	850
Clay and streaks of gravel	70	920
Clay	43	963
Sonoma volcanics:		
Rock	17	980
Clay and gravel	28	1,008
Rock	2	1,010
Clay and gravel	28	1,138
Rock	9	1,147
Petaluma formation(?)		
Clay, hard	16	1,163

Well 6/8-5E1. Joe Beretto

[Drilled by Precision Drilling Co. Altitude, 85 feet. On rolling plain. Gravel packed. Pumping test: static level, 10 feet; pumping level, 140 feet at 600 gpm]

	Thickness (feet)	Depth (feet)
Glen Ellen formation:		
Coarse, brown sand	10	10
Brown sand and gravel	10	20
Gray silt and gravel	10	30
Gray sandy silt	10	40
Gray silt and gravel	10	50
Coarse dark-green sand	10	60
Silt and fine gravel	10	70
Silt and gravel	20	90
Sandy silt and gravel	10	100
Blue clay	20	120
Blue clay and gravel	20	140
Blue clay	10	150
Blue clay and coarse gravel	10	160
Gravel, medium	10	170
Gravel	50	220
Sand and gravel	30	250
Merced formation:		
Gray sand	10	260
Clay and gravel	20	280
Merced formation—Continued		
Gray sandy silt	20	300
Blue clay	10	310
Sandy silt and gravel	20	330
Gravel	10	340
Blue sand and gravel	10	350
Gray sand	20	370
Sandy silt and gravel	10	380
Sand	10	390
Sand and gravel	10	400
Blue clay	10	410
Sandy silt	20	430
Sand and gravel	10	440
Blue sand	20	460
Blue clay	20	480
Sandy silt	10	490
Sand	20	510
Sand and gravel	20	530
Sand, medium coarse	108	638

Well 6/8-7D1 H. Neles

[Drilled by N. F. Keyt. Altitude, 70 feet. On flood plain of Laguna de Santa Rosa]

	Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation(?):		
Top soil	4	4
Clay, sandy, yellow	13	17
Sand, yellow, and gravel	7	24
Clay, blue	11	35
Clay, sandy, blue	7	42
Merced formation:		
Clay, sandy, yellow	88	130
Clay, yellow	5	135
Sand, yellow, and some gravel	3	138
Sand, yellow, and little gravel	2	140
Merced formation—Continued		
Clay, sandy, yellow	85	225
Sand, yellow, fairly coarse	11	236
Sand, yellow	40	276
Clay, blue, and streaks of black	39	315
Sandstone, yellow, soft	10	325
Clay, sandy, blue	7	332
Clay, blue, and streaks of black gravel	28	360
Sand, blue, and gravel; good looking gravel	11	371
Sand, blue, and gravel	39	410

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 6/8-12J1. G. W. Price					
[Drilled by N. F. Keyt. Altitude, 130 feet. On plain. Bailer test: static level, 20 feet; bailing level, 60 feet at 30 gpm]					
Glen Ellen formation:			Glen Ellen formation—Continued		
Soil	7	7	Yellow clay and gravel	4	76
Sandy. yellow clay	20	27	Yellow clay	34	110
Yellow clay and gravel	1	28	Yellow clay and gravel	25	135
Yellow clay	11	39	Yellow clay	70	205
Blue clay	11	50	Sandy yellow clay and gravel	18	223
Yellow clay	22	72			
Well 6/8-16R1. J. Pedranzini					
[Drilled by N. F. Keyt. Altitude, 90 feet. On low hummock. Casing liner perforated between depths of 781 and 802, 930 and 951, 1,054 and 1,076, 1,097 and 1,120, and 1,144 and 1,204 feet. No record of upper perforations. Pumping test: static level, 130 feet; pumping level, 152 feet at 315 gpm]					
Glen Ellen formation:			Merced(?) formation—Continued		
Sandy, yellow clay	15	15	Blue clay	268	794
Blue clay	25	40	Gravel and sand	11	805
Yellow clay	32	72	Blue clay and some gravel	110	915
Blue clay	12	84	Blue clay	15	930
Blue clay and gravel	16	100	Gravel and sand	7	937
Sandy yellow clay	1	101	Blue clay and streaks of yellow clay	113	1,050
Clay and gravel	22	123	Sandy blue cement gravel	15	1,065
Merced(?) formation:			Blue clay	20	1,085
Sandy yellow clay	262	385	Blue clay and gravel	30	1,115
Blue clay	15	400	Rock	35	1,150
Sandy blue clay	20	420	Blue clay and gravel	48	1,198
Blue clay	92	512	Boulders	6	1,204
Blue sand	14	526			
Well 6/8-17K1. C. Knudtsen					
[Drilled by N. F. Keyt. Altitude, 135 feet. On nose of ridge]					
Merced formation:			Merced formation—Continued		
Clay, yellow, and gravel	10	10	Clay, sandy, blue, and gravel	5	134
Clay, sandy, yellow, and gravel	35	45	Sand, blue, and gravel	2	136
Sand, yellow, and gravel	5	50	Clay, blue, and gravel	9	145
Sand, blue; some gravel	5	55	Sand, blue, and gravel	11	156
Sand, blue, and gravel	74	129	Clay, sandy, blue	7	163
			Sand, blue, and gravel	47	210
Well 6/8-22N1. E. Ponica					
[Drilled by N. F. Keyt. Altitude, 120 feet. Low isolated hill in valley. Casing perforated between depths of 180 and 201 feet. Bailer test: static level, 25 feet; bailing level, 58 feet at 2,250 gallons per hour]					
Merced formation:			Merced formation—Continued		
Soil	3	3	Clay, sandy, blue	8	155
Clay, pink, sandy	12	15	Clay, sandy, yellow	15	170
Clay, sandy, white, and gravel	6	21	Clay, yellow	15	185
Sand and gravel	7	28	Sand, and clay, red	5	190
Clay, sandy, yellow	42	70	Clay, sandy, yellow	5	195
Clay, sandy, blue	25	95	Gravel	5	200
Clay, blue	52	147			
Well 6/8-23C1. Waldo Rohnert Co.					
[Drilled by N. F. Keyt. Altitude, 95 feet. On Cotati plain]					
Younger alluvium and Glen Ellen(?) formation:			Merced formation—Continued		
			Clay, blue	4	198
Adobe	3	3	Clay, yellow, sandy, and gravel	62	260
Clay, yellow	12	15	Very soft streak	5	265
Clay, yellow and gravel; some water	10	25	Clay, yellow, sandy, and gravel	71	336
Clay, blue and yellow	35	60	Sand, soft, wet	6	342
Gravel	5	65	Clay, yellow, and sand	8	350
Clay and gravel	65	130	Clay, yellow and gravelly; sticky last 10 feet	61	411
Merced formation:			Clay, blue	19	430
Clay, yellow, and gravelly sand	42	172	Clay, yellow	8	438
Clay, sandy yellow	22	194			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 6/8-33E1. J. Bahnsen

[Drilled by N. F. Keyt. Altitude, 250 feet. On hillside. Bailer test: 280 gallons per hour at bailing level of 80 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Petaluma formation:			Petaluma formation—Continued		
Topsoil	3	3	Gravel, cemented	8	125
Clay, sandy, yellow	14	17	Sand and clay, blue	21	146
Clay, sandy, blue	18	35	Gravel, free	7	153
Clay, blue	45	80	Gravel, cemented	12	165
Gravel, first water	10	90	Sand and clay, blue	10	175
Gravel, cemented	7	97	Clay, blue and yellow, sticky	20	195
Gravel, cemented, blue	20	117	Clay and rock, jointed clay	20	215

Well 6/8-35A2. Cotati Public Utility District

[Drilled by N. F. Keyt. Altitude, 110 feet. On alluvial plain]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Merced formation—Continued		
Soil	3	3	Clay, blue	70	368
Clay, yellow	25	28	Redwood	1	369
Clay, blue	10	38	Clay, blue, and gravel	31	400
Clay, blue, and gravel	4	42	Clay, blue	25	425
Merced formation:			Clay, sandy, blue	90	515
Clay, yellow	38	80	Sand, yellow	13	528
Clay, sandy, yellow, and gravel	21	101	Sandstone	20	548
Clay, sandy, yellow	24	125	Clay, brown, and redwood	6	554
Clay, blue	12	137	Clay, blue	10	564
Clay, yellow	20	157	Clay, blue, and gravel	3	567
Rock (probably cemented sand)	4	161	Clay and gravel	18	585
Clay, yellow	74	235	Clay, blue	20	605
Clay, yellow, sandy	3	238	Clay and gravel	10	615
Clay, yellow, sandy; little gravel	2	240	Sand, blue, and gravel	8	623
Clay, blue	6	246	Clay, blue, tough	12	635
Clay, yellow	52	298	Clay, blue, tough; some gravel	12	647
			Clay, blue	3	650
			Shale	10	660

Well 6/8-36A1. Waldo Rohnert Co.

[Drilled by N. F. Keyt. Altitude, 115 feet. On alluvial plain. Casing perforated between depths of 60 and 64, 180 and 185, 324 and 338, 350 and 353, 376 and 402, 474 and 476, and 506 and 512 feet. Pumping test: pumping level, 137 feet and 375 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Merced formation:			Younger alluvium and Merced formation—Continued		
Soil	4	4	Clay, yellow	6	344
Clay, yellow	3	7	Clay, blue	3	347
Clay, yellow, and gravel; mixed	24	31	Clay, yellow	3	350
Clay, yellow	9	40	Clay, yellow, and small amount gravel	3	353
Clay, yellow, and gravel	2	42	Clay, yellow	7	360
Clay, yellow	18	60	Clay, blue	16	376
Clay, yellow, and gravel	4	64	Gravel, blue, cemented	15	391
Clay, sandy, yellow	16	80	Clay, blue	1	392
Clay, sandy, yellow, and gravel	5	85	Gravel, blue, cemented	10	402
Clay, yellow	23	108	Clay, sandy, yellow	22	424
Sand, yellow	20	128	Clay, yellow	9	433
Clay, yellow	12	130	Clay, yellow	10	443
Clay, sandy, yellow, and gravel	6	136	Clay, sandy, blue; little gravel, 471-476 feet	33	476
Clay, sandy, yellow	14	150	Clay, sandy, green	14	490
Sand, yellow, and sandy gravel	8	158	Clay, sandy, blue	10	500
Clay, yellow	20	178	Clay, blue	6	506
Clay, yellow, and little fine gravel	7	185	Gravel, cemented	6	512
Clay, yellow	55	240	Clay, hard, blue	10	522
Clay, sandy, yellow	24	264	Clay, sandy, blue	8	530
Sandstone, yellow	18	282	Gravel, cemented	17	547
Clay, yellow	2	284	Clay, blue	27	574
Sand, fine, yellow	3	287	Clay, blue, sandy; little gravel	24	598
Clay, yellow, and gravel; small amount	3	290	Gravel, cemented	5	603
Clay, sandy, yellow	34	324	Clay, blue	19	622
Gravel, yellow, cemented	14	338	Clay, blue, gravel, and clam shells	16	638
			Petaluma(?) formation:		
			Clay, blue	57	695

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 6/9-2C1. City of Sebastopol

[Drilled by H. L. Wilkinson Co. Altitude, 125 feet. On hillside. Well is cemented and casing perforated between depths of 332 and 335, 345 and 350, 487 and 499, 512 and 514, 530 and 539, and 590 and 600 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Topsoil, red	45	45	Sand, blue and shells	10	268
Sandstone	3	48	Sand rock, gray	5	273
Sand	4	52	Sand rock, blue, and shells	29	302
Sandstone	1	53	Clam shells, fair	2	304
Sand	6	59	Sand, blue	18	322
Sandstone	2	61	Clam shells, fair	1	323
Sand	3	64	Clay and sand, blue	9	332
Sandstone	2	66	Clam shells, good	3	335
Sand	4	70	Shells, petrified	2	337
Sandstone	1	71	Clam shells and sand	5	342
Sand	5	76	Sand rock	3	345
Sandstone	1	77	Clam shells, good	5	350
Sand, yellow	3	80	Sand, blue	11	361
Sandstone	2	82	Sand rock	1	362
Sand	4	86	Clam shells and rock	2	364
Sandstone	1	87	Sand, blue	10	374
Sand	23	110	Rock and shells	4	378
Sandstone	2	112	Sand, blue	21	399
Sand, yellow	60	172	Clay, blue	30	429
Rock, lime	3	175	Sand, blue	15	444
Shells and sand, blue	29	204	Sediments, blue	36	480
Shells, petrified	6	210	Sand, shells, and rock	7	487
Sand, blue	6	216	Shells and sand	12	499
Sand rock	2	218	Sand rock	6	505
Sand, blue	4	222	Sand, blue	7	512
Sand rock, blue	8	230	Sand, grit, and shells	2	514
Sand, blue, and shells	5	235	Sand, blue	16	530
Sand rock, blue	1	236	Rock, sand, and shells	3	533
Sand, blue	7	243	Shells, sand, and grit	6	539
Sand rock, blue	1	244	Sediment, blue, and blue sand	51	590
Sand, blue	11	255	Clam shells and sand	10	600
Sand rock, blue	3	258			

Well 6/9-3A1. R. L. Browning

[Drilled by W. A. Duer. Altitude, 230 feet. On hill. Cased between surface and depth of 183 feet. Yield, 1,000 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Soil	4	4	Clay, blue, and sand	95	250
Sand, dry	26	30	Sandstone, blue	10	260
Sand, yellow	125	155			

Well 6/9-22A1. M. E. Callan

[Drilled by Weeks Hardware Co. Altitude, 120 feet. At foot of slope. Cased between surface and depth of 35 feet (no perforations). Pumping test: static level, 0 (small natural flow); pumping level, 200 feet at 85 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Topsoil, sandy loam	8	8	Blue sandstone, medium hard	46	226
Clay, hard sandy yellow	12	20	Hard gray rock	2	228
Blue sandstone, medium hard	74	94	Hard gray sandstone	19	247
Blue sandstone with shells	18	112	Blue sandstone, medium hard	41	288
Blue sandstone, medium hard	46	158	Blue sandstone with shells	72	360
Blue sandstone with shells	22	180			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/6-19N1. Harold Horton

[Drilled by H. Nutting. Altitude, 465 feet. On alluvial plain. Casing perforated between depths of 30 and 40 and 130 and 149 feet. Bailer test: static level, 16 feet; bailing level, 96 feet at 7 gpm]

	Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen (?) formation:		
Soil	1	1
Gravel, coarse yellow	3	4
Brown silt	2	6
Yellow clay and small gravel	15	21
Coarse packed gravel	4	25
Sandy yellow clay	3	28
Coarse gravel and yellow clay	6	34
Blue clay and small gravel water strata	3	37
Coarse gravelly yellow clay	20	57
Younger alluvium and Glen Ellen (?) formation—Continued		
Small boulders and yellow clay	30	87
Coarse gravelly yellow clay	25	112
Blue clay and small boulders	6	118
Small boulders and yellow clay	7	125
Yellow shaly rock	5	130
Coarse gravelly yellow clay	10	140
Fine gravelly yellow clay	5	145
Coarse packed gravel water strata	4	149

Well 7/6-19R1. F. Gemini

[Drilled by H. Nutting. Altitude, 465 feet. On low hummock. Casing perforated between depth of 200 and 300 feet. Bailer test: static level, 35 feet; bailing level, 115 feet at 100 gpm]

	Thickness (feet)	Depth (feet)
Older alluvium(?) and Glen Ellen formation:		
Soil, small, brown, gravelly	3	3
Medium yellow gravelly clay	32	35
Fine packed gravel	5	40
Medium gravelly yellow clay	70	110
Medium yellow packed gravel, small amount of water	10	120
Soft yellow shaly rock	80	200
Older alluvium(?) aud Glen Ellen formation—Continued		
Small yellow boulders and coarse sand, water strata	20	220
Hard yellow volcanic ash	40	260
Sonoma volcanics(?):		
Blue volcanic ash, water in a large quantity	40	300

Well 7/6-32F1. B. Cochrane

[Drilled by J. Larbre. Altitude, 395 feet. On alluvial plain. Cased between surface and depth of 175 feet. Pumping test: static level, 3 feet; pumping level, 70 feet at 180 gpm]

	Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:		
Tule mud	21	21
Rock and gravel	8	29
Clay, yellow, gravel, water	16	45
Gravel, cement	25	70
Shale, blue, clay	10	80
Clay, blue	19	99
Yonnger alluvium and Glen Ellen formation—Continued		
Gravel, some water	4	103
Clay, blue	17	120
Shale rock	17	137
Clay, yellow, gravel, and rock	23	160
Clay, rock, and gravel	15	175
Gravel, cement	15	190

Well 7/7-5F1. F. C. Haen

[Drilled by M. F. Keyt. Altitude, 340 feet. On low slope to alluvial plain. Casing perforated between depths of 100 and 164 feet. Bailer test: static level, 71 feet; bailing level, 130 feet at 220 galons per hour]

	Thickness (feet)	Depth (feet)
Glen Ellen formation:		
Loam, black	2	2
Rock	2	4
Clay, yellow, and gravel; water at 12 feet	43	47
Gravel	5	52
Clay, yellow, and gravel	20	72
Glen Ellen formation—Continued		
Gravel, water	2	74
Clay, yellow, and gravel	23	97
Clay, yellow	20	117
Clay, yellow, and gravel	12	129
Gravel, water	28	157
Clay, yellow, and gravel	7	164

Well 7/7-5N1. L. A. Mealman

[Drilled by H. Nutting. Altitude, 275 feet. On alluvial plain. Casing perforated between depths of 20 and 88 feet. Bailer test: static level, 8 feet; bailing level, 58 feet at 35 gpm]

	Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation(?):		
Soil adobe,	4	4
Fine gravel	6	10
Boulder and yellow sand	12	22
Sandy yellow clay	23	45
Large yellow gravel hardpan	10	55
Younger alluvium and Glen Ellen formation(?)—Continued		
Brown sand vein	2	57
Medium gravelly clay	15	72
Large brown packed gravel	14	86
Brown coarse sand	2	88

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/7-6G1. S. H. Strong

[Drilled by Weeks Hardware Co. Altitude, 295 feet. On nose of low ridge. Casing perforated between depths of 120 and 160, 240 and 260, and 300 and 338 feet. Gravel packed. Pumping test: drawdown, 22 feet after 6 hours pumping at 40 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Top soil	3	3	Blue clay	31	172
Fine sand	27	30	Clay with streaks of gravel	31	203
Blue clay with streaks of gravel	11	41	Blue clay	26	229
Blue clay	46	87	Sandy clay	14	243
Sand and gravel	21	108	Blue clay	67	310
Blue clay	16	124	Sand and gravel	23	333
Sand and gravel	17	141	Blue clay	5	338

Well 7/7-7F2. E. J. Throndson

[Drilled by Weeks Hardware Co. Altitude, 245 feet. On hillside. Casing perforated between depths of 80 and 100, 180 and 200, and 260 and 320 feet. Gravel packed. Pumping test: drawdown, 70 feet after 5 hours pumping 20 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sonoma volcanics:			Sonoma volcanics—Continued		
Top soil	4	4	Red volcanic ash with boulders	5	221
Black volcanic rock	32	36	Red volcanic ash	13	234
Boulders	6	42	Black volcanic ash	49	283
Black volcanic rock	88	130	Red volcanic ash	31	314
Boulders with red volcanic ash	25	155	Black volcanic rock	6	320
Black volcanic rock	61	216			

Well 7/7-8L1. Rincon Valley School District

[Drilled by N. F. Keyt. Altitude, 250 feet. On low ridge. Cased between surface and depth of 198 feet

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Sonoma volcanics:		
Yellow clay and boulders	25	25	Rock	24	208
Yellow clay and gravel	50	75	Red volcanic ash	15	223
Yellow clay and boulders	5	80	Hard volcanic rock	55	278
Yellow clay and gravel	92	172			
Yellow clay and boulders	5	177			
Yellow clay and gravel	1	178			
Hard boulders	6	184			

Well 7/7-9D2. Lelland Decker

[Drilled by Crislip Drilling Co. Altitude, 385 feet. On hillside. Casing perforated between depths of 290 and 323 feet. Bailer test: static level, 15 feet; bailing level, 55 feet at 10 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Surface	1	1	Yellow sticky clay	5	250
Sandy clay and gravel	14	15	Soft yellow sandy clay	5	255
Yellow sandy clay	10	25	Gray clay and gravel	8	263
Yellow clay and gravel	65	90	Yellow clay	4	267
Yellow clay, soft	40	130	Hard clay and gravel	8	275
Yellow clay, sticky	30	160	Loose gravel	5	280
Cement gravel	25	185	Hard gravel	20	300
Yellow clay and gravel, sticky	20	205	Light blue mud	7	307
Hard gravel	5	210	Hard gravel and clay	5	312
Yellow clay and gravel	31	241	Soft gray clay	8	320
Loose gravel	4	245	Hard yellow clay	3	323

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/7-15C1. Mrs. Mead Clark

[Drilled by N. F. Keyt. Altitude, 375 feet. On alluvial terrace. Bailing test: static level, slightly above land surface; bailing level, 160 feet at 20 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Glen Ellen formation—Continued		
Soil	1	1	Boulders and rock	47	258
Boulders	19	20	Yellow clay and boulders	19	277
Glen Ellen formation:			Yellow clay and gravel	12	289
Clay, yellow	6	26	Boulders	4	293
Yellow clay, hard, sandy	22	48	Yellow clay and boulders	15	309
Boulders	6	54	Red clay and gravel	3	312
Clay, yellow; water at 55 feet	54	108	Red clay	10	322
Yellow clay and gravel	11	119	White sandy clay and gravel; well flowed 20 gallons per hour at 342 feet	20	342
Yellow clay and gravel	20	139	White sandy clay	3	345
Boulders	21	160	Gravel and sand	18	363
Yellow clay and boulders	19	179	Sandy clay and gravel	34	397
Boulders, yellow clay, and gravel	10	189			
Clay and boulders	22	211			

Well 7/7-16A1. E. Jackson

[Drilled by Crislip Drilling Co. Altitude, 375 feet. On hillside. Casing perforated between depths of 50 and 263 feet. Bailer test: static level, 60 feet; bailing level, 65 feet at 30 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
No record	200	200	Hard yellow clay and gravel	6	249
Loose gravel boulders	7	207	Soft, sandy yellow clay	4	253
Yellow clay and gravel	23	230	Hard yellow clay	2	255
Hard gravel and clay	5	235	Soft, sandy yellow clay	7	262
Soft gravel and yellow clay	8	243	Hard yellow clay	1	263

Well 7/7-17A1. City of Santa Rosa

[Drilled by N. F. Keyt. Altitude, 300 feet. On alluvial flat. Pumping test (made when well was 307 feet deep): static level, 80 feet; pumping level, 110 feet at 150 gpm. Pumping test (completed well): static level, 84 feet; pumping level, 148 feet at 485 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older(?) alluvium:			Merced formation:		
Topsoil	3	3	Sandstone, blue	6	425
Clay, yellow, and gravel; small boulders	41	44	Sandstone, blue, and boulders	70	495
Gravel	4	48	Sandstone, blue	10	505
Clay, yellow, and gravel	28	76	Clay, blue, and gravel	17	522
Boulders and gravel	9	85	Sonoma volcanics, containing interbeds of Merced formation:		
Sonoma volcanics:			Rock, black	1	523
Rock	5	90	Rock	8	531
Rock, basalt	6	96	Clay, blue, and gravel	7	538
Ash, red, volcanic	14	110	Rock, blue	22	560
Ash, red, volcanic, and gravel	35	145	Rock, red, volcanic	5	565
Clay, yellow, and rock	20	165	Rock, blue	75	640
Ash, red, volcanic, and boulders	40	205	Rock, red, volcanic	16	656
Rock, black	8	213	Rock, black	13	669
Ash, red, volcanic, and boulders	45	258	Rock, blue, and clamshells (much of blue rock reported is probably sandstone)	6	675
Rock, black	5	263	Rock, blue	72	747
Ash, red, volcanic, and boulders	5	268	Rock, blue, little red	18	765
Rock, black	2	270	Rock, blue	3	768
Rock, blue	6	276	Rock, blue, volcanic	15	783
Ash, red, volcanic, and boulders	4	280	Rock, red, hard	24	807
Rock, red, volcanic	27	307	Rock, blue	34	841
Rock	57	364	Blue and red	5	846
Clay, yellow, and gravel	28	392			
Gravel, blue cement, and boulders	27	419			

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TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/7-18L1. Sam Hartley

[Drilled by N. F. Keyt. Altitude, 215 feet. On alluvial plain. Casing perforated between depths of 35 and 144 feet. Bailer test: static level 31 feet; bailing level, 47 feet at 100 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older (?) alluvium and Glen Ellen formation:			Sonoma volcanics:		
			Rock	4	161
Clay, yellow, and gravel	36	36			
Gravel	42	78			
Clay, blue, and gravel	79	157			

Well 7/7-18N1. W. R. Carithers and Son, Inc.

[Drilled by N. F. Keyt. Altitude, 205 feet. On alluvial plain. Yield: 230 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older (?) alluvium and Glen Ellen formation:			Younger and older (?) alluvium and Glen Ellen formation—Con.		
Soil	11	11	Gravel	2	80
Clay, yellow	17	28	Clay and rock	7	87
Rock	2	30	Clay, sandy, blue	21	108
Gravel, free	20	50	Gravel	3	111
Gravel	15	65	Clay, sandy	4	115
Sand, gray	4	69	Gravel	18	133
Clay, blue	6	75	Clay and rock	7	140
Clay, blue	3	78			

Well 7/7-18R2. C. Carley

[Drilled by N. F. Keyt. Altitude, 210 feet. On alluvial plain. Casing perforated from depth of 50 feet to bottom, alternate joints. Pumping test: static level, 78 feet; yield, 700 gpm. No record of pumping level]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older (?) alluvium and Glen Ellen formation:			Sonoma volcanics:		
			Volcanic rock, soft	23	88
Adobe	4	4	Volcanic rock, hard	2	90
Clay, blue	16	20	Volcanic rock, streaks of soft	33	123
Clay, sandy, blue, some gravel	10	30	Volcanic rock	83	206
Clay, sandy, blue, and gravel	5	35			
Gravel and wood	5	40			
Sand and gravel	1	41			
Clay, blue	9	50			
Gravel, blue, cemented	15	65			

Well 7/7-23A1. P. X. Smith

[Drilled by N. F. Keyt. Altitude, 475 feet. On hillside]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Topsoil	3	3	Sandy blue clay and gravel	8	258
Boulders	15	18	Gravel	12	270
Clay and boulders	12	30	Gravel	3	273
Clay and rock	33	63	Blue clay and gravel	27	300
Rock	10	73	Clay and rock	3	303
Clay and gravel	21	94	Cemented gravel	17	320
Gravel cemented	74	168	Blue sand and gravel	17	337
Cemented gravel and boulders	22	190	Blue clay and gravel	3	340
Blue clay and boulders	17	207	Sandy yellow clay and gravel	25	365
Red clay and boulders	43	250			

Well 7/7-23A2. Paul X. Smith

[Drilled by N. F. Keyt. Altitude, 450 feet. On alluvial plain]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued	6	256
Topsoil	2	2	Gravel	24	280
Clay, yellow, and gravel	177	179	Clay, yellow, and gravel	24	304
Clay, blue, and gravel	23	202	Clay, yellow	33	337
Clay, yellow, and gravel	48	250	Clay, yellow, and gravel		

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/7-23G1. J. J. Coney

[Drilled by J. Larbre. Altitude, 430 feet. On alluvial plain]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older (?) alluvium and Glen Ellen formation:			Younger and older (?) alluvium and Glen Ellen formation—Con.		
Hardpan	49	49	Blue clay	5	515
Clay, yellow	9	58	Shale	46	561
Blue shale	28	86	Shale rock	15	576
Yellow clay	29	115	Very hard rock and gravel	8	584
Blue shale	11	126	Shale formation	61	645
Blue clay	20	146	Gravel cement very hard	27	672
Blue shale and gravel	4	150	No record	168	840
Blue shale	5	155	Coarse gravel	30	870
Shale and gravel	59	214	Boulders, sand, and gravel	15	885
Shale and sand	31	245	Boulders and gravel	25	910
Yellow clay and coarse gravel	20	265	Sonoma volcanics:		
Hardpan boulders	13	278	Fractured basalt rock	75	985
Shale rock	22	300	Blue shale and gravel	20	1,005
Blue shale	2	302	Boulders	10	1,015
Shale rock	43	345	Gray shale and boulders	10	1,025
Blue shale	4	349	Fine gravel	30	1,055
Volcanic clay and rock	21	370	Boulders and fine gravel	10	1,065
Gravel cement	9	379	Sandy clay	20	1,085
Gravel and shale	38	417	Boulders, lime	5	1,090
Blue shale	28	445	Sandy clay	10	1,100
Yellow clay	12	457	Gray shale	70	1,170
Blue shale	53	510			

Well 7/7-24A1. State of California Youth Authority

[Drilled by Beedie. Deepened by Norris. Altitude, 565 feet. On slope above alluvial plain. Cased between surface and depth of 208 feet. No perforations. Pumping test: static level, 40.7 feet; pumping level, 126.2 feet at 154 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Sonoma volcanics—Continued		
Soil (described in log of well 7/7-24B1 as yellow clay and boulders, 0-18 feet, and brown clay and gravel, 18-90 feet)	80	80	Hard brown rock with many seams	153	434
Sonoma volcanics:			Soft yellow-brown rock with many seams	54	488
Rock, soft, brown	40	120	Hard red rock, very seamy	92	580
Soft red rock	88	208	Harder red rock, very seamy	40	620
Dark brown rock	14	222	Very hard red rock, very seamy	2	622
Hard red rock with many seams	59	281			

Well 7/7-29D1. E. F. Bethards

[Drilled by Precision Drilling Co. Altitude, 240 feet. On alluvial plain. Lithology by C. H. Chamberlain. Gravel packed]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation(?):			Sonoma volcanics—Continued		
Adobe and yellow clay	15	15	Basalt, dense, hard drilling	10	270
Clay, yellow, becoming sandy at bottom	25	40	Basalt, vesicular	30	300
Loose gravel	20	60	Red ash	10	310
Blue shale, hard streak of sand	70	130	Basalt, vesicular	30	340
Sand and gravel	30	160	Basalt, hard drilling	10	350
Blue shale, fine sand, and gravel; bottom basaltic boulders as in order	20	180	Basalt, drilled like fractured, but it is vesicular under glass	50	400
Sonoma volcanics:			Red vesicular lava	10	410
Top of basalt, drills very hard first foot	--------	180	Gray ash, appears to have had stream action; drilled a foot per minute	130	540
Basalt, shows vesicular under glass	80	260	Basalt, very hard	10	550
			Basalt, vesicular	20	570
			Basalt, dense	18	588

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/7-30C1. Holland Heights Water Co.

[Drilled by Weeks Hardware Co. Altitude, 280 feet. On upland beside ravine. Casing perforated between depths of 242 and 262, 282 and 302, 322 and 342, 362 and 382, and 402 and 422. Gravel packed. Pumping test: static level, 55 feet; pumping level, 175 feet after pumping 8 hours at 200 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen and Merced(?) formations:			Glen Ellen and Merced(?) formations—Continued		
Topsoil, adobe	5	5	Blue clay	5	365
Boulders, hard	70	75	Blue sandstone with shells	10	375
Coarse sand	18	93	Blue clay	2	377
Blue clay	5	98	Gravel, sand, streaks of sandstone with shells	8	385
Rock	24	122	Coarse sand	12	397
Coarse sand	16	138	Blue clay	3	400
Blue clay	2	140	Coarse sand	8	408
Rock	8	148	Blue clay	2	410
Blue clay with streaks of sand and gravel	162	310	Brown clay	12	422
Coarse sand	10	320	Blue clay	20	442
Blue clay with streaks of sand and gravel	22	342	Sonoma volcanics:		
Coarse sand	18	360	Hard rock (probably basalt)	6	448

Well 7/7-32G1. Mrs. Edith Mitchell

[Drilled by Precision Drilling Co. Altitude, 325 feet. On alluvial plain. Lithology determined from driller samples. Casing cemented between surface and depths of 4½ feet and perforated between depths of 20 and 403 feet. Gravel packed. Natural flow April 18, 1950 estimated 150 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Sonoma volcanics—Continued		
Gravel	40	40	Dark gray volcanic ash	30	370
Glen Ellen formation(?):			Gray volcanic ash, and dark gray clay (also woody material reported by driller as redwood log)	20	390
Clay, blue	70	110	White volcanic ash	12	402
Clay and volcanic ash	20	130	Basalt	1	403
Sonoma volcanics:					
Basalt	80	210			
Ash, white, volcanic	50	260			
Basalt and white volcanic ash	10	270			
White volcanic ash	60	330			
White volcanic ash and basalt cuttings (probably basalt boulders in basaltic tuff)	10	340			

Well 7/8-4B3. H. A. Weinland

[Drilled by N. F. Keyt. Altitude, 150 feet. On alluvial plain. Pumping test: static level, 33.8 feet pumping level, 106.5 feet at 120 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Top soil	4	4	Gravel, yellow, cemented	10	95
Clay, sandy	6	10	Clay, sandy, blue	23	118
Clay, yellow, and gravel	3	13	Clay, sandy, blue, and gravel	2	120
Gravel	12	25	Clay, blue	5	125
Gravel, cemented	24	49	Clay, sandy, yellow	9	134
Clay, yellow, and sandy gravel	5	54	Clay, yellow, and gravel	16	150
Clay, sandy, yellow	16	70	Gravel, yellow, cemented	2	152
Clay, blue	15	85			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/8-6H2. E. Lovell

[Drilled by H. Nutting. Altitude, 135 feet. On low hummock. Casing perforated between depths of 25 and 35, 75 and 104, 125 and 169, 231 and 239, and 275 and 304 feet. Cable-tool gravel pack. Pumping test: static level, 10 feet; pumping level, 120 feet after 12 hours pumping 125 gpm]

	Thickness (feet)	Depth (feet)
Glen Ellen formation:		
Soil	2	2
Hardpan, gravelly	6	8
Brown clay	18	26
Loose boulders	5	31
Brown sandy clay	29	60
Blue sandstone	22	82
Blue clay	21	103
Blue hard clay	7	110
Brown and blue clay	15	125
Gravelly clay	42	167
Small boulder blue clay	65	232
Glen Ellen formation—Continued		
Small loose boulders	3	235
Brown clay	40	275
Blue gravelly clay	20	295
Merced formation:		
Gray loose sandstone	2	297
Blue hard sandstone	33	330
Blue clay	12	342
Gray sandstone	10	352
Glen Ellen formation:		
Blue gravelly clay	4	356
Blue gravelly clay	41	397

Well 7/8-9R1. C. Rasmussen

[Drilled by N. F. Keyt. Altitude, 120 feet. On plain. Bailer test: static level, 9 feet; bailing level, 29 feet at 100 gpm]

	Thickness (feet)	Depth (feet)
Glen Ellen formation:		
Topsoil	3	3
Hardpan	3	6
Clay, sandy brown	14	20
Clay, blue, and gravel	8	28
Sand and gravel	4	32
Clay, gray	3	35
Sand and gravel	15	50
Clay, yellow, and gravel	68	118
Glen Ellen formation—Continued		
Clay, blue	18	136
Gravel	3	139
Clay, creamy	5	144
Clay, brown	18	162
Gravel	3	165
Clay, brown	15	180
Gravel	7	187
Clay, yellow, and gravel	------	------

Well 7/8-14A1. Odd Fellows Cemetery Association

[Drilled by N. F. Keyt. Altitude, 175 feet. On small alluvial flat. Gravel packed. Bailer test: static level, 0 feet; bailing level, 160 feet at 1,400 gallons per hour]

	Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:		
Adobe	3	3
Ash, black	15	18
Ash, yellow	7	25
Ash, brown	112	137
Clay, blue	16	153
Clay, yellow	32	185
Clay, blue	85	270
Clay, blue and gravel	80	350
Clay, blue	10	360
Sonoma volcanics:		
Rock	110	470
Clay, blue	19	489
Clay, blue, and rock	59	548
Rock	73	621
Clay	19	640
Rock	31	671
Clay	128	899
Rock	2	901

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/8-14D1. Santa Rosa Junior College

[Drilled by N. F. Keyt. Altitude, 155 feet. On alluvial plain. Casing perforated between depths of 95 and 110, 146 and 162, 188 and 200, and 283 and 300 feet. Pumping test: static level, 12 feet; pumping level, 68 feet at 270 gpm]

	Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:		
Soil	4	4
Clay	13	17
Gravel	3	20
Clay, yellow	65	85
Clay, yellow, and gravel	10	95
Gravel, cemented	15	110
Clay, yellow	36	146
Younger alluvium and Glen Ellen formation—Continued		
Gravel	16	162
Clay, and gravel	26	188
Gravel, free	12	200
Clay and gravel mix	50	250
Clay, sandy	15	265
Gravel, cemented, hard	20	285
Clay and gravel, hard	15	300

Well 7/8-20K1. F. Siemer

[Drilled by N. F. Keyt. Altitude, 100 feet. At edge of alluvial plain]

	Thickness (feet)	Depth (feet)
Younger alluvium:		
Soil	4	4
Glen Ellen formation:		
Yellow clay and gravel	12	16
Yellow clay	19	35
Blue clay	25	60
Yellow clay and gravel	5	65
Yellow clay	14	79
Gravel	5	84
Sandy yellow clay	15	99
Blue clay	11	110
Gravel	10	120
Yellow cement	3	123
Yellow clay	22	145
Blue clay	25	170
Glen Ellen formation—Continued		
Yellow sand and gravel	3	173
Yellow clay	12	185
Sandy yellow clay	13	198
Blue clay	17	215
Yellow clay	41	256
Blue clay	52	308
Blue clay and little mixed gravel	16	324
Blue clay	138	462
Sandy blue clay	9	471
Tough blue clay	88	557
Blue clay and gravel, mixed	58	615
Blue clay and little gravel	9	626

Well 7/8-23M1. Grace Bros. Brewing Co.

[Drilled by Roscoe Moss Co. Altitude, 155 feet. On alluvial fan. Casing cemented between surface and depth of 54 feet, perforated between depths of 324 and 408 and 414 and 990 feet. Gravel packed. Pumping test: drawdown, 201.7 feet after 24 hours pumping at 295 gpm]

	Thickness (feet)	Depth (feet)
Younger and older (?) alluviums and Glen Ellen formation:		
Soil, black, adobe	6	6
Clay, yellow	18	24
Sand and gravel	30	54
Clay, yellow; include sand and gravel streaks	52	106
Gravel, pea	14	120
Clay, gray	36	156
Merced(?) and Glen Ellen(?) formations:		
Clay, yellow, sandy	60	216
Clay, yellow, sandy	104	320
Sand and gravel	15	335
Clay, yellow, sandy	21	356
Merced(?) and Glen Ellen(?) formations—Continued		
Clay, yellow	24	380
Clay, yellow, sandy; includes gravel streaks	62	442
Clay, yellow; includes gravel streaks	58	500
Sand, brown	30	530
Sand and pea gravel	97	627
Clay, yellow	73	700
Clay, blue, sandy	51	751
Sand	63	814
Clay, blue, sandy	141	955
Sand	15	970
Shale, blue	30	1,000

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/8-23M4. California Packing Co.

[Altitude, 150 feet. On bank of Santa Rosa Creek]

	Thickness (feet)	Depth (feet)
Younger and older(?) alluviums and Glen Ellen formation:		
Clay, sticky	24	24
Cemented gravel	8	32
Clay	11	43
Gravel	15	58
Clay	7	65
Clay and gravel	70	135
Blue clay	10	145
Clay and gravel	8	153
Glen Ellen(?) and Merced(?) formations:		
Sandstone	3	156
Clay with gravel	46	202
Sandstone	8	210
Hard and soft clay and gravel layers	93	303
Sandstone	7	310
Hard and soft clay with gravel layers	102	412
Sandstone	11	423
Blue and yellow clay with small amounts of gravel	152	575
Volcanic ash	15	590
Glen Ellen(?) and Merced(?) formations—Continued		
Blue shale	60	650
Clay and gravel	5	655
Sonoma volcanics(?) and Merced(?) formation:		
Volcanic rock	15	670
Blue clay, shale, and minor amounts of gravel	135	805
Lava rock	15	820
Blue clay	10	830
Lava rock	5	835
Clay and lava	7	842
Blue clay with "iron" deposit 860–864	36	878
Cement gravel, water	5	883
Blue clay with gravel	37	920
Clay, sand, and gravel	5	925
Blue clay with some gravel and rock	45	970
Hard yellow clay	11	981
Clay, gravel, sand, limestone(?), and lava	298	1,279

Well 7/8-24A4. City of Santa Rosa

[Drilled by N. F. Keyt. Altitude, 195 feet. On alluvial plain]

	Thickness (feet)	Depth (feet)
Younger and older(?) alluviums and Glen Ellen formation:		
Topsoil	5	5
Hardpan	12	17
Clay, blue	5	22
Sand and gravel, first water	4	26
Blue clay	4	30
Gravel and boulders	20	50
Clay and gravel	6	56
Gravel and boulders	18	74
Gravel, cemented	16	90
Solidified sand and gravel	11	101
Blue clay	25	126
Coarse gravel	6	132
Clay and gravel, boulders	10	142
Loose gravel	4	146
Glen Ellen(?) and Merced formations:		
Sand and gravel	17	163
Volcanic gravel	18	181
Solidified sand	15	196
Basalt and boulders	11	207
Sand and gravel, solidified	20	227
Gravel and boulders	12	239
Sand, solidified	13	252
Gravel and boulders	3	255
Sand and gravel, solidified	6	261
Cemented gravel	66	327
Brown clay	7	334
Gravel	29	363
Blue clay, sticky	28	391
Glen Ellen and Merced formations—Continued		
Gravel and boulders, cemented	37	428
Black shale	13	441
Gravel, cemented	21	462
Clay and boulders	68	530
Boulders, cemented	24	554
Blue clay, very tough and sticky	52	606
Sonoma volcanics:		
Volcanic ash	36	642
Lava and basalt trap	50	692
Blue rock	14	706
Volcanic ash, red	3	709
Rock, blue	25	734
Clay, blue, and boulders	11	745
Rock	10	755
Clay, blue	15	770
Gravel, cemented	40	810
Limestone	32	842
Sandstone	8	850
Volcanic clay, red	38	888
Rock, blue	43	931
Volcanic ash, red	4	935
Clay, red, and boulders	5	940
Rock	35	975
Clay, blue, and boulders	7	982
Clay, blue and gray	16	998
Rock	2	1,000

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/8-28F1. J. Antone

[Drilled by N. F. Keyt. Altitude, 100 feet. On plain. Casing perforated between depths of 42 and 66 feet. Bailer test: static level 7 feet; bailing level, 30 feet at 25 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Adobe	5	5	Blue clay	25	55
Hardpan	10	15	Gravel	9	64
Clay, sticky brown, and gravel; water at 15 feet	15	30	Brown clay	2	66

Well 7/8-29J1. Santa Rosa Naval Air Base

[Drilled by R. B. Howk. Altitude, 97 feet. On plain. Casing cemented between surface and depth of 20 feet, gravel-packed between depths of 20 and 680 feet. Pumping test: drawdown, 130 feet at 300 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Top soil and sediment	4	4	Gravel, tight, and clay	4	256
Clay, soft, brown	6	10	Clay, hard, sticky	50	306
Sand, brown, coarse	2	12	Gravel, small, and clay, soft	3	309
Sand, black, fine	4	16	Clay, hard, sticky	35	344
Clay, blue, some gravel	13	29	Gravel and clay; poor	1	345
Clay, soft blue	21	50	Clay	10	355
Gravel, tight, cemented	4	54	Gravel and clay; poor	2	357
Gravel, tight; clay, sticky; shale, black	11	65	Clay, soft	3	360
Gravel, small; fair	6	71	Gravel, medium; fair	6	366
Clay	4	75	Clay, hard, with soft streaks of white clay	42	408
Gravel, small, and sand; shale, black; good	4	79	Clay, hard, sticky, with streaks of gravel and soft clay	22	430
Clay	5	84	Clay, soft	2	432
Gravel, medium, loose; shale, black; fair	2	86	Gravel and sand; fair	2	434
Clay, hard	6	92	Clay and gravel	1	435
Clay and gravel	3	95	Sand and small gravel; fair	8	443
Clay	5	100	Clay, hard, cemented	7	450
Gravel, small, free	3	103	Clay, soft	3	453
Clay, hard	7	110	Sand and gravel; fair	3	456
Clay and gravel	5	115	Sandy clay and gravel; poor	16	472
Clay	6	121	Sand and gravel; fair	4	476
Clay and some gravel	7	128	Clay, hard	39	515
Gravel and clay; poor	3	131	Clay, hard, with soft streaks	21	536
Clay	5	136	Clay, soft	10	546
Gravel, light, with clay	2	138	Gravel, small, and sand; poor	3	549
Clay, sticky and hard	46	184	Clay	11	560
Clay, soft	4	188	Sand	3	563
Gravel, loose; fair	1	189	Gravel, medium; good	6	569
Clay, soft	2	191	Clay, hard, sticky	22	591
Clay, hard	36	227	Clay and gravel	1	592
Gravel, small, and sand; good colors; good	7	234	Clay, hard, sticky	30	622
Gravel and clay; poor	2	236	Gravel, tight; fair	5	627
Clay with streaks of gravel	10	246	Clay and gravel	5	632
Gravel, medium, loose; good colors; good	6	252	Clay	15	647
			Gravel, large, loose, good	14	661
			Clay	39	700

Well 7/8-30P1. C. Dotti

[Drilled by W. A. Duer. Altitude, 85 feet. On rolling plain]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Merced formation:		
Soil	2	2	Sand and clay	19	142
Hardpan	10	12	Clay, blue	3	145
Water sand	3	15	Sandstone	19	164
Clay, brown	10	25	Glen Ellen formation:		
Clay, blue	23	48	Clay and gravel	14	178
Gravel	6	54	Gravel, cement	5	183
Clay, blue	9	63	Clay, blue	22	205
Clay, brown	9	72			
Gravel	4	76			
Clay, blue	47	123			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/8-31C1. M. La Franchi

[Drilled by H. Nutting. Altitude, 85 feet. On rolling plain]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Merced formation:		
Old well (no record)	--------	190	Yellow sandstone	115	305
			Gravel	15	320

Well 7/8-36D2. R. R. Todd

[Drilled by N. F. Keyt. Altitude, 165 feet. On alluvial slope. Casing perforated between depths of 229 and 252 feet. Bailer test: static level, 42 feet; bailing level, 50 feet at 2,500 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Soil	8	8	Yellow clay	71	185
Yellow clay	20	28	Yellow sandy clay	40	225
Cemented gravel, first water at 77 feet	49	77	Clay	16	241
Hard rock	15	92	Coarse sand, water	8	249
Rock	22	114	Yellow clay	3	252

Well 7/9-3E1. D. Papera

[Drilled by W. A. Duer. Altitude, 150 feet. On hillside]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Soil	4	4	Clam shells, blue	8	63
Yellow clay	33	37	Clam shells and gravel (probably in sand matrix)	67	130
Blue sandstone	18	55			

Well 7/9-3M1. G. Bertolucci

[Drilled by W. A. Duer. Altitude, 100 feet. On hillside. Yield, 25,000 gallons per day]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Old dug well	61	61	Clay, blue, sandy	4	106
Clay, blue, sandy	11	72	Sandstone	19	125
Clay, sticky, blue	6	78	Clay, blue, sandy	2	127
Clay, sandy, blue	16	94	Gravel	4	131
Clay, blue, sticky	8	102			

Well 7/9-4N1. D. Hill, Sr.

[Drilled by W. A. Duer. Altitude, 280 feet. On gently sloping hillside]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Soil	4	4	Sand, soft, blue	41	96
Clay and sand, dry	26	30	Sandstone, hard, blue	24	120
Sand, soft, yellow	25	55			

Well 7/9-5N1. Petri Wine Co.

[Drilled by W. A. Duer. Altitude, 170 feet. On hillside. Yield, 77 gpm. Cased between surface and depth of 75 feet (open end). One ring of perforations at depth of 58 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Soil	3	3	Clay, blue, and sandstone	30	250
Sand, hard yellow	65	68	Sandstone, blue	10	260
Clay, blue, and sandstone	82	150	Clay, blue, and sandstone	22	282
Sandstone, blue	20	170	Clamshells in sandstone	5	287
Clay, blue, and sandstone	35	205	Franciscan group:		
Sandstone, blue	15	220	Bedrock	5	292

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/9-14K1. G. Leurs

[Drilled by Davis and Alcorn Drilling Co. Altitude, 80 feet. On rolling plain. Gravel packed. Pumping test: static level, 22 feet; pumping level, 75 feet after 30½ hours pumping at 750 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Merced formation:		
Topsoil	2	2	Sand, blue	70	208
Clay and sand	14	16	Sand, blue and some gravel	49	257
Sand	4	20	Sand and gravel, small	39	296
Clay, hard	3	23	Gravel, small	62	358
Sand	12	35	Shells and gravel mix	202	560
Gravel, very small; water	5	40	Gravel, fine	10	570
Clay, sticky blue	22	62	Sand and shells	14	584
Clay, small gravel, and sand	24	86	Shale	52	636
Clay and gravel mix	20	106			
Clay and sand mix	32	138			

Well 7/9-21G1. F. Schell

[Drilled by N. F. Keyt. Altitude, 240 feet. On upland at base of isolated hill. Cased between surface and depth of 515 feet. Open end, no perforations]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Soil, sandy	2	2	Sand, blue, and clam shells	46	316
Clay, yellow, sandy	54	56	Sand, blue	147	463
Sand, yellow	117	173	Sand, blue, and clam shells	8	471
Clay, yellow, sandy	12	185	Sandstone, blue	25	496
Clay, blue, sandy	1	186	Sand, yellow	3	499
Sand, blue	19	205	Sandstone, blue	5	504
Sand, blue, and clam shells	39	244	Sand, yellow	10	514
Sand, blue	26	270	Clay, blue, sandy	16	530

Well 7/9-24J1. L. Ramondo (Ramondo core hole 1)

[Drilled by E. W. Lenhart (operator). Altitude, 90 feet. On slightly dissected plain. Unproductive oil-test hole]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Merced formation:		
Brown, sandy clay	38	38	Shale and limestone streaks, shells	94	920
Brown sand	7	45	Black gravel and sand	50	970
Blue sand and clay	37	82	Shale and limestone streaks	220	1,190
Black clay	4	86	Very hard shale and limestone	30	1,220
Blue sand and clay	44	130	Sand, shale, and boulders	45	1,265
Gray sand and gravel	5	135	Small black boulders, sand	15	1,280
Gray sand and clay	25	160	Sand and shale with lime streaks	188	1,468
Brown and blue clay	11	171	Sandy shale and wood	7	1,475
Sand and gravel	24	195	Hard black shale and sand	45	1,520
Merced formation:			Very hard shale	35	1,555
Blue clay and blue sand	60	255	Blue sand and brown shale	19	1,574
Hard sand and clay	24	279	Clay and limestone streaks	92	1,666
Coarse gravel	6	285	Blue sand and shale	20	1,686
Blue clay and blue sand	85	370	Shale and limestone shelves	193	1,879
Blue clay and shale	173	543	Blue shale and hard black shale	26	1,905
Blue sand and shale	22	565	Blue shale and limestone	50	1,955
Brown shale	10	575	Blue sandy shale, limestone, shells	98	2,053
Blue shale and sand	40	615	Interbedded sand and limestone in wafer-like sections, ½–1 inch thick	22	2,075
Glen Ellen formation (?):					
Shale and boulders	80	695			
Shale and showing of wood	10	705			
Hard shale	35	740			
Shale with brown sandy streaks	20	760			
Black coarse gravel	40	800			
Shale and boulders	26	826			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 7/9-29J2. A. Hellwig.

[Drilled by Weeks Hardware Co. Altitude, 120 feet. At edge of alluvial plain. Cased between surface and depth of 45 feet. No perforations]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Merced formation—Continued		
Topsoil; sandy loam	23	23	Blue clay	20	519
Blue clay	23	46	Hard sand rock	13	532
Merced formation:			Sandy blue clay	16	548
Blue sandstone with occasional hard streaks of hard gray sandstone	453	499	Blue sand with shells	32	580
			Blue sandstone	77	657

Well 7/9-35R1. The Barlow Co.

[Drilled by W. A. Duer. Altitude, 60 feet. On hillside. Cased between surface and depth of 76 feet. Perforated between depths of 42 and 61 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Sand, red, and gravel	3	55
Soil	4	4	Gravel and some sand	6	61
Sand, blue, and gravel	24	28	Gravel	2	63
Sand, gray, and gravel	9	37	Sand, clay, and gravel	7	70
Sand, yellow, dry, and clay	5	42	Clay, hard, and white sand	20	90
Sand and gravel	10	52			

Well 7/9-36F1. W. L. Hepworth

[Drilled by Davis and Alcorn Drilling Co. Altitude, 85 feet. On rolling plain. Gravel packed. Pumping test: drawdown, 26 feet after 8 hours pumping at 550 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Gumbo	30	30	Dirt, black	22	155
Clay and mixed gravel	10	40	Mud	5	160
Gravel, pea; some water	5	45	Merced formation:		
Clay	15	60	Sand, river; water	28	188
Gravel, fine	10	70	Clay and mixed sand	12	200
Gravel, large; water	20	90	Sand, quick; water	28	228
Shale and small boulders	32	122	Gravel, fine; water	23	251
Pack sand, solid	11	133	Gravel, coarse; water	19	270

Well 7/9-36H1. J. Egitkhanoff

[Drilled by N. F. Keyt. Altitude, 85 feet. On plain. Casing perforated between depths of 61 and 92 and 412 and 572 feet. Gravel packed. Bailer test: static level, 15 feet; bailing level, 55 feet at 100 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Merced formation:		
Top soil	2	2	Hard sandstone	70	350
Yellow clay	28	30	Sandstone	135	485
Blue clay	40	70	Blue sand	18	503
Gravel	32	102	Sandstone	7	510
Blue clay	178	280	Gravel and sand	50	560
			Blue clay	8	568

Well 7/9-36M1. Sebastopol Meat Co.

[Drilled by N. F. Keyt. Altitude, 70 feet. On low slope above alluvial flat. Bailer test: static level, 11 feet; bailing level, 45 feet at 2,000 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Adobe	4	4	Sand, blue, and some gravel; water	14	86
Sandstone, yellow	4	8	Merced formation:		
Clay, blue	30	38	Sandstone, blue	2	88
Sandstone and gravel	8	46			
Clay, blue	26	72			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 8/8-17L1. G. Blasi

[Drilled by N. F. Keyt. Altitude, 185 feet. At edge of alluvial plain. Bailer test: static level, 103 feet; bailing level, 235 feet at 10 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Clay, sandy, and gravel	30	30	Clay, sandy gray, and gravel	52	222
Clay, yellow, and gravel	32	62	Clay, brown, and gravel	26	248
Clay, brown	12	74	Clay, blue	9	257
Clay, yellow, and gravel; water at 103 feet	82	156	Gravel; top 3 feet good gravel, then clay, then fair gravel	17	274
Clay, blue	14	170	Clay, yellow, and gravel	4	278

Well 8/8-19M1. Industrial Manufacturing Co.

[Drilled by H. Nutting. Altitude, 105 feet. On hummocky area at edge of alluvial plain. Casing perforated between depths of 35 and 50 and 100 and 260 feet. Gravel packed. Pumping test: static level, 10 feet; pumping level 80 feet after 3 days pumping 280 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Fine soil	2	2	Small boulders	15	130
Yellow sandy clay	25	27	Yellow clay and fine gravel	30	160
Yellow sand and fine gravel	10	37	Fine gravel and brown sand	25	185
Coarse packed gravel	8	45	Small gravelly brown clay	20	205
Yellow sandy clay	20	65	Coarse packed brown gravel	30	235
Coarse gravelly clay	25	90	Medium brown gravel	20	255
Medium packed brown clay	25	115	Large packed gravel	5	260

Well 8/8-20Q1. H. Faught

[Drilled by N. F. Keyt. Altitude, 145 feet. On alluvial plain. Casing perforated between depths of 56 and 66, 94 and 115, 133 and 182, 210 and 233, and 252 and 310 feet. Gravel packed. Pumping test: static level, 20 feet; pumping level, 30 feet at 300 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Glen Ellen formation—Continued		
Top soil	10	10	Gravel and sand	115	237
Glen Ellen formation:			Gravel	58	295
Yellow clay	10	20	Yellow clay	13	308
Gravel and some clay	102	122	Boulders and clay	4	312

Well 8/8-29C1. Mr. Waggoner

[Drilled by Crislip Drilling Co. Altitude, 135 feet. On alluvial plain. Casing perforated between depths of 44 and 68 feet. Bailer test: static level, 30 feet; bailing level, 40 feet at 20 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Soil	2	2	Yellow clay	35	60
Yellow clay	18	20	Gravel	8	68
Blue clay	5	25			

Well 8/8-29D1. C. B. Hurst

[Drilled by Crislip Drilling Co. Altitude, 125 feet. On alluvial plain. Casing perforated between depths of 45 and 57 feet. Bailer test: static level, 8 feet; bailing level, 24 feet at 30 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Sandy blue clay	24	24	Red sand	6	56
Sandy red clay	26	50	Blue clay	1	57

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 8/8-30G1. C. Wulf

[Drilled by Crislip Drilling Co. Altitude, 115 feet. At edge of alluvial plain. Casing perforated between depths of 40 and 60 and 80 and 120 feet. Pumping test: static level, 15 feet; pumping level, 80 feet after 4 hours pumping at 40 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Old well	84	84	Yellow gravel	5	115
Yellow gravel	8	92	Gray clay	7	122
Yellow clay	18	110	Yellow sand and gravel	18	140

Well 8/8-30L1. Sonoma County Airport

[Drilled by N. F. Keyt. Altitude, 120 feet. On rolling plain. Casing perforated between depths of 90 and 112, 117 and 145, 160 and 188, 204 and 245, 260 and 280, 300 and 320, 350 and 370, 410 and 436, and 442 and 462 feet. Yield, 500 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Soil	3	3	Clay, blue	16	204
Hardpan	14	17	Clay, yellow, and gravel	41	245
Clay, sandy, blue	26	43	Clay, sandy, yellow, and gravel	23	268
Clay, yellow	47	90	Clay, sandy, blue	17	285
Clay, yellow, and gravel	17	107	Clay, blue, and gravel	40	325
Gravel	17	124	Clay, sandy, blue	15	340
Clay, blue, and gravel	11	135	Clay, blue, and gravel	5	345
Gravel, coarse, blue, and some clay	10	145	Clay, sandy, blue	30	375
Gravel and clay	43	188	Clay, sandy, blue, and gravel	88	463

Well 8/8-30N1. L. Nagy

[Drilled by N. F. Keyt. Altitude, 120 feet. On rolling plain. Casing perforated between depths of 60 and 98, 119 and 223, 231 and 239, and 253 and 350 feet. Gravel packed cable tool. Yield, 480 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Soil	2	2	Gravel and clay, yellow	38	223
Hardpan	17	19	Clay, blue	8	231
Clay, yellow	2	21	Gravel, cemented	8	239
Clay, yellow, and gravel	19	40	Clay, blue	14	253
Clay, yellow	20	60	Gravel and clay, blue	77	330
Clay, yellow, and gravel	35	95	Clay, sandy, and gravel	20	350
Clay, blue, and gravel	3	98	Clay, blue	55	405
Clay, blue	17	115	Clay, saudy, blue, and gravel	5	410
Clay, yellow, and gravel	4	119	Clay and gravel	40	450
Gravel	6	125	Clay, blue	5	455
Gravel and clay	60	185			

Well 8/8-30N2. L. Nagy

[Drilled by N. F. Keyt. Altitude, 120 feet. On rolling plain. Casing perforated between depths of 60 and 65, 80 and 85, 100 and 105, 130 and 135, 150 and 155, 175 and 190, 330 and 350, and 375 and 390 feet. Gravel packed (cable tool)]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Soil	4	4	Clay, blue, and coarse gravel	8	348
Clay, yellow, and gravel	51	55	Clay, blue, and gravel	27	375
Clay, sandy, yellow	7	62	Clay, yellow, and gravel	15	390
Clay and gravel	113	175	Clay, blue	35	425
Clay, blue	2	177	Clay, blue, and gravel	5	430
Gravel	6	183	Clay, sandy, blue	6	436
Clay, blue	7	190	Clay, blue	144	580
Clay, blue and gravel	70	260	Clay, blue, and some gravel	5	585
Clay, sandy, blue and gravel	13	283	Clay, blue	15	600
Clay, blue, and gravel	57	340			

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 8/9-1M1. S. R. Demagio

[Drilled by Crislip Drilling Co. Altitude, 185 feet. At edge of alluvial plain. Casing perforated between depths of 222 and 315 feet. Bailer test: static level, 80 feet; bailing level, 108 feet at 12 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Surface soil	6	6	Sand and gravel	1	262
Yellow clay	84	90	Blue clay	19	281
Gravel, first water	5	95	Sand and gravel	1	282
Yellow clay	67	162	Blue clay	16	298
Blue clay	88	250	Sand and gravel	2	300
Sand and gravel	2	252	Blue clay	15	315
Blue clay	9	261			

Well 8/9-3P1. R. Remolif

[Drilled by Crislip Drilling Co. Altitude, 75 feet. At edge of flood plain. Casing perforated between depths of 30 and 42 and 60 and 98 feet. Pumping test: static level, 1 foot; pumping level, 64 feet at 90 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Glen Ellen formation—Continued		
Black soil	10	10		12	52
Glen Ellen formation:			Blue sandy clay	22	74
Hardpan, yellow	10	20	Gravel and clay	11	85
Yellow clay	15	35	Blue sand	13	90
Yellow sand and gravel	5	40	Blue clay	12	118
Yellow gravel	12	52			

Well 8/9-9H1. R. Remolif

[Drilled by Crislip Drilling Co. Altitude, 70 feet. On flood plain. Casing perforated between depths of 30 and 40 feet. Pumping test: static level, 13 feet; pumping level, 16 feet at 350 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Older alluvium or Glen Ellen formation:		
Surface soil	2	2	Hard yellow cemented gravel	2	40
Loose yellow sand and gravel	36	38			

Well 8/9-11P1. V. Rafanelli

[Drilled by Hammond Bros. Altitude 120 feet. Near base of low hill. Bailed at rate of 120 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Glen Ellen formation—Continued		
Top soil	4	4	Blue clay	28	40
Gravel	8	12	Gravel	110	150

Well 8/9-13C1. Windsor School District

[Drilled by N. F. Keyt. Altitude 105 feet. On alluvial plain. Casing cemented between surface and depth of 24 feet, and perforated between depths of 96 and 116, 136 and 156, and 180 and 200 feet. Gravel packed. Pumping test: static level, 12 feet; pumping level, 100 feet at 100 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen formation:			Younger alluvium and Glen Ellen formation—Continued		
Yellow clay	15	15	Yellow clay and gravel	105	170
Gravel	6	21	Gravel	27	197
Yellow clay	44	65	Yellow clay	5	202

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 89-/13N1. A. Botto

[Drilled by H. E. Crabtree. Altitude, 90 feet. At edge of alluvial plain. Cased between surface and depth of 188 feet and perforated between depths of 14 and 40, and 70 and 184 feet]

	Thickness (feet)	Depth (feet)
Glen Ellen formation:		
Soil	6	6
Hardpan	8	14
Gravel, water	7	21
Gravel	19	40
Clay, sandy	30	70
Gravel, water	4	74
Clay, blue	8	82
Gravel, water	4	86
Clay	12	98
Glen Ellen formation—Continued		
Sand and gravel, water	12	110
Clay	20	130
Sand, clay, and gravel; water	6	136
Clay	16	152
Gravel, water	16	168
Clay, blue	4	172
Gravel, water	12	184
Shale, blue	24	208

Well 8/9-15D1. C. D. Thompson

[Drilled by F. B. Dykes. Altitude, 65 feet. On alluvial plain. Casing perforated between depths of 37 and 47 and 63 and 133 feet. Gravel packed]

	Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen(?) formation:		
Topsoil	12	12
Sand, fine	9	21
Gravel and sand	8	29
Gravel, coarse	8	37
Clay	11	48
Sticky clay, blue	15	63
Younger alluvium and Glen Ellen(?) formation—Continued		
Pea gravel	3	66
Pure blue gumbo, tight	21	87
Quicksand, tight, packed	33	120
Clay	6	126
Sand and gravel	7	133
Hard clay	1	134

Well 8/9-23L1. C. Wright

[Drilled by Davis and Alcorn Drilling Co. Altitude, 75 feet. At edge of alluvial plain. Cased between surface and depth of 410 feet. Gravel packed. Pumping test: static level, 36 feet; pumping level, 69 feet after 4 hours pumping at 750 gpm]

	Thickness (feet)	Depth (feet)
Glen Ellen formation:		
Topsoil	4	4
Soil and white clay	8	12
Sand and clay	3	15
Sand, blue	10	25
Coarse gravel	26	51
Blue clay	5	56
Coarse gravel	14	70
Blue clay	4	74
Coarse gravel	11	85
Blue clay, mixed gravel	22	107
Glen Ellen formation—Continued		
Soft blue clay	64	171
Hard blue shale	53	224
Soft blue sandy shale	82	306
Gravel	45	351
Blue clay	3	354
Blue shale	10	364
Sandy blue clay	12	376
Coarse sand and washed shale	27	403
Soft blue clay	3	406
Blue clay	23	429

Well 8/9-27K1. H. A. Faught

[Drilled by McCollum. Altitude, 60 feet. On flood plain of Windsor Creek. Reported yield, 800 gpm at pumping level of 60 feet]

	Thickness (feet)	Depth (feet)
Younger alluvium:		
Soil	6	6
Glen Ellen and Merced formations:		
Clay hard, yellow	44	50
Sand and gravel, water	2	52
Glen Ellen and Merced formations—Continued		
Blue clay	251	303
Gravel and clam shells, water	30	333

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 8/9-33J1. A. Emert

[Drilled by N. F. Keyt. Altitude, 45 feet. At edge of flood plain]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Merced formation—Continued		
Adobe	7	7	Blue clay and gravel	21	150
Merced formation:			Decomposed brown rock	6	156
Hardpan	13	20	Decomposed rock	34	190
Clay, sandy water	35	55	Yellow clay	5	195
Blue clay	7	62	Blue clay and gravel	25	220
Gravel, water	9	71	Cemented gravel	48	268
Blue clay and gravel, hard	30	101	Cemented gravel, hard	17	285
Blue clay and gravel	5	106	Franciscan group:		
Yellow clay and gravel	23	129	Hard rock and shale	40	325

Well 8/9-34R1. Ben L. Steele

[Drilled by Bente. Altitude, 65 feet. On flood plain of Mark West Creek. Yield, 900 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen(?) formation:			Merced formation:		
Clay, blue and yellow; contains gravel	260	260	Clean sand and gravel, clam and snail shells	60	320
			Fine sand; includes shells	37	357
			Clay	3	360

Well 8/9-34R2. Ben L. Steele

[Drilled by Davis and Alcorn Drilling Co. Altitude, 65 feet. On flood plain of Mark West Creek. Casing perforated between depths of 291 and 491 feet. Gravel packed]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium and Glen Ellen(?) formation:			Merced formation—Continued		
Top soil	20	20	Sand, fine	20	210
Sand	16	36	Sand and tules	20	230
Pea gravel	44	70	Gravel, small	30	260
Clay, blue, sandy	38	108	Gravel, pea	20	280
Clay, yellow	10	118	Gravel, small, and tules	20	300
Gravel, small	10	128	Shells and gravel	40	340
Mixed clay and small gravel	27	155	Shells	10	350
Gravel, small, and tules	4	159	Clay, sand, and shells	60	410
Merced formation:			Sand, small gravel, and shells	75	485
Clay, sandy	31	190	Clay, hard, blue	6	491

Well 8/9-35K1. E. Slusser

[Drilled by N. F. Keyt. Altitude, 80 feet. At edge of flood plain of Mark West Creek. Casing perforated between depths of 50 and 72, 198 and 208, 270 and 280, 398 and 410, and 473 and 498 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Ellen formation:			Merced formation—Continued		
Clay, yellow	28	28	Sandstone	2	270
Clay, blue	5	33	Clay, blue, and gravel	10	280
Sand, blue, and gravel	4	37	Sandstone	40	320
Clay, blue	13	50	Clay, blue, tough	32	352
Gravel, cement; water and gas	22	72	Clay, blue, soft	8	360
Clay, sandy, blue	32	104	Gravel, cement	2	362
Gravel, cement	2	106	Clay, blue, soft	16	378
Clay, blue	22	128	Sandstone	11	389
Clay, sandy, blue	12	140	Clay, soft, blue	9	398
Clay, tough, blue	20	160	Gravel, cement	12	410
Clay, sandy, blue	38	198	Sandstone	15	425
Gravel, cement	10	208	Clay, blue	9	434
Clay, blue	3	211	Clay, soft, blue	8	442
Clay, sandy, blue	19	230	Sandstone	20	462
Gravel, cement	2	232	Clay, soft, blue	3	465
Merced formation:			Sandstone, hard	8	473
Clay, blue	4	236	Gravel, cement	17	490
Clay, sandy, blue	4	240	Sand and gravel	6	496
Clay, blue	28	268	Clay, blue	2	498

TABLE 22.—*Drillers' logs of wells in the Santa Rosa Valley area, California*—Con.

Well 8/9-36L1. Mrs. M. Talmadge

[Drilled by Bente. Altitude, 95 feet. On flood plain of Mark West Creek. Yield, 450-500 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Glen Ellen formation—Continued		
Blue clay	27	27	Gravel	10	455
Gravel	6	33	Blue clay	65	520
Glen Ellen formation:			Gravel	15	535
Blue clay	397	430	Blue clay	30	565
Sand	15	445			

Well 8/9-36P1. P. W. Bussman

[Drilled by N. F. Keyt. Altitude, 90 feet. On flood plain of Mark West Creek]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Merced formation:		
Soil	9	9	Clay, blue	35	765
Clay, blue	41	50	Sand, gray	39	804
Yellow	7	57	Clay, blue	4	808
Gravel	5	62	Clay, sandy	27	835
Glen Ellen formation:			Clay, blue	15	850
Clay, yellow	18	80	Sand, gray; sand running bad	30	880
Clay, blue	61	141	Clay, blue	30	910
Pea gravel	6	147	Glen Ellen formation:		
Clay, blue	63	210	Gravel	84	994
Clay, yellow	7	217	Merced formation:		
Clay, blue	238	455	Sand	11	1,005
Clay, blue, sandy	8	463	Sand and clam shells	5	1,010
Clay, blue	168	631	Clay, blue	10	1,020
Clay, blue, sandy	19	650	Basalt(?) (probably dark massive well-cemented fine-grained sandstone)	5	1,025
Clay, sandy	28	678	Fossil formation	23	1,048
Clay, blue	33	711			
Sand, coarse, and pea gravel	19	730			

TABLE 23.—*Description of water wells in the Petaluma Valley area, California*

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F.)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 3 N., R. 5 W.																		
3/5- 5D1	Matthews	1950	5	200	D				QTm (?).								[1]	
6C1	C. Silva		9	50	D 8				do	2-17-50 4- 6-51	33.21 23.06		J 2				S	Cp.
6C2	do	1947	9	165	D 8				do	2-17-50 4- 6-51	60.08 17.67		L				D, S	
7A1	R. Dickson		2±	435	D 8								L, Wind					Cp.
T. 3 N., R. 6 W.																		
3/6- 1L1	Mrs. H. Clokie		3±	30	Dv 3				Qyal				L, Wind				S	
1L2	do		3±	15.5	Dv 3				do	2-22-50 4- 6-51	0.54 2.09						U	
1Q1	do		2±	225	D 7					1-25-50	+.39		L				D, S	Cp, W
1R1	C. Silva		0±		D 3½					2-22-50 4- 6-51	+.82 +.50		L, Wind				S	
3C1	O. White		5		Dug 36				Qyal				L, Wind				D	Cp.
4B1	Radio Station KSFO.	1949	0	91	Dv				do								[2]	L.
4B2	do	1949	0	94	Dv				do								[2]	L.
4C1	Radio Station KCBS.	1951	0	164	D 8	160	4	"Water sand"	QTm (?).	4- 5-51	2.17		J 1				San	Cp, L.
4D1	W. Q. Wright	1950	−4	120	D 8	80	6	Gravel	Qyal	6-14-50	2.45		C				U	W.
4F1	Radio Station KSFO.	1949	0	105	Dv				do								[2]	L.
4F2	do	1949	0	90	Dv				do								[2]	L.
5A1	W. Q. Wright	1949	−.80	83	Jt 4	77	6	Gravel	do	12-15-49	[3]	64	C, Gas	[4] 37			Irr, S	Cp, L, W.

11B1	S. K. Herzog and Co.	1924	2	250	D 7					1-25-50 4- 6-51	2.41 [5] 5.46		J ½	15			D, S	Cp.
12E1	Mrs. H. Clokie		0±	200+	D 2½					2-22-50 4- 6-51	(3)	63		[6] ⅛			S	Cp.
18F1	North Marin County Water District.		15	38	D 8				do		[7] 18			42	6+		PS	L.
18N1-6.	do		20	45	D				do		[7] 15				6+	23	PS	L.
29C1			30	167	D 8				KJu	1-25-50	[8] 20+			½			U	
29C2			30	135	D 8				do	1-25-50	21.29		L	11			D	

T. 3 N., R. 7 W.

3/7-11L1			75	46	D 12				Qyal	10-11-49	[5] 21.25		J 3				D	
11L2			75	30	D 8				do	10-11-49	20.85						U	
13D1	North Marin County Water District.	1949	40		D 10				do	10-11-49	7.44				25	23	PS	L.
13D2	do		40		D 10				do	10-11-49	7.00				25	23	PS	L.
13D3	do	1949	40		D 10				do	10-11-49	6.97				25	23	PS	L.
13D4	do	1949	40	43	D 10				do	11-22-49	4.12				25	23	PS	L.
13D5	J. H. Rose	1949	35	55	D 8	49	4	Gravel	do	1-25-50	9.15		J ½		7	13	D	L.
13D6	A. Balz	1949	40	48	D 10	42	5	do	do	1-25-50	5.52		P	10	10	10	D	L.
14H1	Miss Pino		50	28	D 6				do				J ¾				D	

T. 4 N., R. 6 W.

4/6-7H1	Lopes		10	35	D 8				do	10-13-49 4- 6-51	[9] 23.46 5.02		J 1				D,S,Dy	
7H2	do		5	13.5	Dug 60				do	10-13-49 4- 6-51	9.72 2.01		P				S	
8C1	Roche brothers		40	55	D 12				QTm (?)	10-13-49 4- 6-51	[9] 24.73 12.78		J ½				D	
8L1	J. Gilardi	1950	25	49	D 8	19	10	Hardpan and gravel.	Qoal (?)	4- 6-51	9.27		L 1				D, PS	L.
8P1	Gilardi	1949	20	200	D, G									8			(10)	
17C1	do	1910	15	24	Dug 60				Qyal	10-13-49 4- 6-51	13.41 5.97		L ½				D, S	
17R1	Q. V. Silacci	1917	30	21	Dug 48	21		Sandstone	QTm	4- 6-51	16.90		L 1½	5			D,S,Dy	
21J1	L. A. Bourke	1948	80	184	D 8	162	7	Gravel	do	10-12-49	63.06				11	136		W.
21Q1	do	1949	55	464	D 10				do	10-12-49 4- 5-51	59 ± 72.40		L 3	30			D, S	Cp, E.
21Q2	do	1939	75	318	D				do	10- ?-39	[11] 118				8	22	A	L.
22N1	F. F. Locchini		50	21	Dug 60	15		Sand	do	10-12-49 4- 5-51	17.00 13.85		L				D	

See footnotes at end of table.

TABLE 23.—*Description of water wells in the Petaluma Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Water-yielding zone: Thickness (feet)	Water-yielding zone: Character	Water-yielding zone: Geologic formation	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Temperature (° F.)	Pump: Type and horsepower	Pump: Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Results of tests: Drawdown (feet)	Use	Other data available
T. 4 N., R. 6 W.—Continued																		
26P1	S. K. Herzog and Co.		70	325	D 10				QTm	2-17-50	73.05		L	4			D	
26P2	do	1940	50	[12] 325	D 6				do	7- ?-40 4- 6-51	[11] 67 66.76		J 1		16	73	S	L.
27L1	do		5	500	D 10-8	98 485	4 15	Gravel do	Qoal QTm	2-22-50 4- 5-51	.13 ±.09			10	16		U	L.
27M1	do		5		D 6					2-22-50 4- 5-51	6.72 3.13						U	(13)
27N1	L. A. Bourke		0	222	D 12-8	145	71	Gravel; clay and gravel; sand and gravel; sandy clay; cemented gravel.	QTm (?)	5-24-41	[11] 6		J 2		50	39	S	Cp, L.
27R1	S. K. Herzog and Co.	1934	34	736	D 12-8				QTm	2-17-50 4- 6-51	28.23 17.65		L	5			S, Dy	Cp, L.
28B1	L. A. Bourke	1939	25	390	D					10- ?-39	[11] 215						A	L.
33K1	O. White		0	35	Dv 1½				Qyal	10-12-49	(3)			[6] 2			U	
33R1	do	1948	0	175+	D 6				Qyal (?).								irr	Cp.
34C1	L. A. Bourke		5	92	D 2				do	10-12-49	4.06						U	W.
34H1	S. K. Herzog and Co.	1930±	10	[14] 250	D 12					4- 6-51	4.46		L 2				S	
35J1	C. Silva	1947	25	165	D 8				Qyal, QTm (?).	2-22-50 4- 6-51	9.15 [9] 7.78		L				S	Cp.
35J2	do		25	12	Dug 240				Qyal	2-22-50 4- 6-51	8.85 3.6						S	
36P1	do	1940±	8	12	Dug 96				do	4- 6-51	.20		L, Wind				S	

T. 4 N., R. 7 W.																		
4/7- 2D1 4D1	Union Oil Co. S. Gibson	1938 1939	0 55	62 20 70	D 6 Dug 32 D 8				do Tsv	 6- ?-39 2- 7-50 4- 6-51	 [11] 15 20.42 15.80		J 1 J		 8	 3	Ind D	Cp, L. Cp, L.
4D2	E. A. Potter	1935	55	64	D 8				do	3- ?-35 2- 7-50 4- 6-51	[11] 12 28.22 23.98				7	6	U	L.
4F1	Mrs. F. Stege- man.	1934	65	184	D 8				KJu	6- ?-34 2- 7-50 4- 6-51	[11] 22 30.29 20.09		L ¾		9	35	irr	L.
13D1	Tunzi		20	10	Dug 60				Qyal	11-21-49 4- 6-51	7.62 5.02		L, Gas				D	Cp.
14R1			5	13	Dug 168				do	11-21-49 4- 6-51	11.62 2.48		O				S	
T. 4 N., R. 8 W.																		
4/8- 1K1	G. Kilpatrick	1948±	450	150	D	10	140	Sandstone	QTm						13		D	L.
T. 5 N., R. 6 W.																		
5/6-30A1	Ducker	1923	200	[15] 1,311	D 12½- 10.				Tp	4- 5-51	([16])		L, Wind				S	L.
30D1	G. Myles	1949	120	155	D 8				do	11- ?-49 4- 5-51	[5] 114.60 73.27		L 1½	10	19	78	D, S	Cp, L.
T. 5 N., R. 7 W.																		
5/7- 5K1	J. D. Mackey	1947	160	339	D 8				QTm (?).	4- ?-47 4- 4-51	[11] 128 148.56		L 3	17	17	51	D	L.
5M1	S. Fishman	1935	150	127	D 8	80	47	Cemented gravel	do	5- ?-35 12-19-49 4- 4-51	[11] 57 81.0 71.6		L	17	15	19	D	L.
5M2	do		120	300±	D 8				do	12-19-49 4- 4-51	[8] 75+ [8] 75+						U	
5M3	S. Goertzel	1942	115	98	D 8	84	14	Sandstone and "oyster shells"; sandstone; gravel.	QTm	4- ?-42	[11] 64		½		8	10	D	L.
6J1	D. King	1937	125	325	D 8				do	8-?-37	[11] 80		T 5		17	60	D, S	L.

See footnotes at end of table.

TABLE 23.—*Description of water wells in the Petaluma Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well				Water level		Temperature (° F.)	Pump		Results of tests		Use	Other data available
						Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Date measured	Distance above (+) or below land-surface datum (feet)		Type and horsepower	Discharge (gpm)	Bailing or pumping rate (gpm)	Drawdown (feet)		
								T. 5 N., R. 7 W.—Continued										
5/7-6K1	A. Matson	1948	125	104	D 8				QTm	6- ?-48	[11] 23		L 3		27	22	Irr, S	L.
										12- 8-49	31.85							
										4- 4-51	26.76							
6P1	I. Beloff	1945	115	122	D 8				do	7- ?-45	[11] 38		J		30	20	D	L.
6P2	M. Gutter	1938	115	114	D 8	98	16	Cemented gravel.	do	4- 6-51	30.70		L 2		25	[17] 72	D	Cp, L.
6R1	E. James	1947	100	97	D 8				do	1947	[11] 57		L ½		17	6	D	L.
7E1	Wesgaard	1941	245	232	D 8	204	25	Cemented gravel; clay and gravel.	QTm (?).	10- ?-41	[11] 93		L		10	77	D, S	L.
										12- 8-49	93.97							
7E2	A. W. Hillen-dahl.	1948	275	442	D 8	162	96	Clay and gravel	do	7- ?-48	[11] 118							
						367	17	Gravel; clay and gravel; sand.	do	12- 8-49	118.83		L 1	13	16	50	D	L.
7G1	J. W. Holt	1938	150	134	D 8-6				QTm	7- ?-38	[11] 64		L	17	8		D, S	L.
7J1	M. Seppa	1937	100	118	D 10					12- 6-49	25.60						[13] U	L.
										4- 4-51	21.18							
7J2	do	1937	100	249	D 10												[13] A	L.
7J3	G. Bottarini	1950	80	340	D 9	10	70	Blue sand	QTm	6-28-50	[11] 10		T 2		50	60	Ind	L.
										3-28-51	5.55							
7L1	R. C. Cluver	1947	115	347	D 8	314	33	Gravel; cemented gravel.	QTm (?).	3- 1-50	64.65		L 1	6			D, S	L.
										4- 4-51	[5] 123.06							
7M1	V. Terrill	1950	280	290	D, G 8	104	18	Gravel	do	2-27-50	[11] 98							
						194	16	do	do	3-28-51	98.3		L 2		25	49	D, S	L.
						252	28	Clay and gravel	do									
7R1	D. Serio	1947	75	182	D 8				do	9- ?-47	[11] 110		J 2	10	10	72	D	L.
7R2	J. Groom	1948	80	198	D 8				do	3- 2-50	46.60		J 3				D	Cp, L.
										4- 4-51	53.30							
8B1	T. Ramos	1939	100	131	D 8				QTm	12- 6-49	48.92		J 3	20			Irr	L.
										4- 4-51	48.59							
8D1	J. J. Downey		70	100	D 12				do				L 1	16			PS	C.
8D2	do		70	125	D 12				do				L	10			PS	C.
8D3	N. J. Matzen	1945	105	138	D 8				do	3- ?-45	[11] 40		J 1½	8	17	35	D	L.

8F1	Sorenson	1943	75	115	D 8	100	14	Cemented gravel	do				J 1	20			D	L.
9M1	A. Sonnichsen	1947	110	165	D 8	131	24	Pea gravel	Tp	9-30-49	132.22		L 1	13			D, S	L.
										4-5-51	131.64							
10Q1	A. B. Deniz	1949	300	462	D 8	190	10	Sandstone	do	2-15-50	170+							
						435	27	Loose gravel; sandstone.	do	4-4-51	299+		L 3		12		D, S	C, Cp, L.
14L1	J. Ielmorini	1949	240	[15] 1,450	D 12				do	1-31-50	200+		T 15				Irr	E.
15K1	Mrs. J. P. Whitaker.	1939	135	106	D				Tp (?)	11-?-39	[11] 34		J ¼		40	31	D	L.
16J1	E. Bionda	1949	110	185	D 12	66	61	Sand and gravel; sand.	do	5-3-50	22.20				200	[17] 100	Dy, Irr, S	L.
										4-4-51	26.27							
17C1	J. McCarter	1940	115	339	D 8-6	230	99	Cemented gravel; clay and gravel.	QTm(?).	4-6-51	72.27		L 1½	11	20	61	D	L.
17D1	M. Malacredi	1930	45	60	D 7					9-30-49	20.80						U	W.
17D2	do	1948	45	64	D 12	20	40	Volcanic rock (tuff breccia).	Tsv	9-30-49	[5] 25.71		J 2	16	17	[7] 20	D, Dy, S	L.
										12-28-49	20.66							
										2-23-50	17.83							
										4-6-51	14.29							
17E1	J. J. Clough	1945	120	150	D 8	130	15	Sand	QTm(?).	10-?-45	45		L 1½		23		D	L.
17R1	Mrs. J. Hanson	1939	45	240	D 8				QTm	2-14-50	4.55		L		20	108	D	L.
										4-6-51	3.50							
19A1	Oberg Lumber Co.	1948	30	325	D 8	120	149	Sand; gravel	Qoal(?) QTm.	2-15-50	14.02		L 3				D	L.
						316	7	Fine gravel	QTm	4-6-51	6.09							
19G1	A. V. Auguiar	1948	45	207	D 8	0	207	"Quicksand"; "water" sand.	do	2-14-50	11.29		L	12	[11] 17		D	L.
19G2	R. Carlson	1949	85	216	D 8				do	2-15-50	45.60		J 2		13	40	D	L.
19G3	A. V. Auguiar		45	150	D 6					4-6-51	13.62						U	
19H1	W. B. King	1949	95	305	D 8					3-30-51	54.1		L 3				S, Irr	C.
19N1	M. N. Azavedo	1945	45	180	D 8				QTm	3-1-50	4.37		J 1½		18	37	D, S, Dy	L, W.
19P1	D. Walls	1941	45	160	D 8				do	2-9-50	7.78		J 1		30	28	D	L.
										4-6-51	[5] 23.33							
20B1	W. Brody		40	600	D 12				QTm(?).	9-30-49	29.38		T 7½				D, S	C, Cp, W.
20C1	E. Scott	1949	35	688	D, G 12-8.	20	290	Sand and gravel containing streaks of clay; sandy clay containing streaks of sand and gravel; conglomerate; sand and gravel.	Qyal, Qoal.	10-14-49	8.04		T 40		650	140	Irr, S	Cp, L, W.
						322	88	Sandy clay	QTm									
						435	78	Sandy clay, shells.	do									
						548	47	Free gravel; clay and gravel.	do									
						615	73	Gravel; hard gravel; sand and shells.	do									

See footnotes at end of table.

TABLE 23.—*Description of water wells in the Petaluma Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F.)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
T. 5 N., R. 7 W.—Continued																		
5/7-20L1	W. O. Dilling	1950	25	142	D 8	15	56	Sand and gravel; gravel.	QTm	3-30-51	10.12				30	78	Irr	L.
20L2	Drake Equipment Co.	1950	25	62	D 8	46	16	Sandy clay and gravel; gravel, clay and gravel.	do	10-31-50	[11] 21		J 1		12	29	D, Ind	L.
21C1	P. Solari	1948	50	139	D 8								J		17	[17] 90	D	L.
21E1	C. Muelrath	1949	30	392	D 8-6								T 7½	100			Irr	L.
21H1	E. Curtis	1950	65	92	D 8	60 90	2 2	Small gravel Sand	Qoal do	8-29-51	34.38		J ½				D	L.
22Q1	Calif. Water Service Co. (station 2, well 201).		60	92	D 16				do	4-5-51	3.02		T 7½				PS	C, L, W.
22Q2	Calif. Water Service Co. (station 2, well 202).		60	97	D				do	4-5-51	1.27		T 7½				PS	C, L, W.
24B1	R. Gambonini	1948	335	650	D 10				Tp	4-10-51	57.57						U	C.
24F1	Ernest Sartori	1950	270	[15] 1,896	D 10			Perforated from 300 to 360 and 400 to 450 feet.	do	Fall 50 4-10-51	[7] 48 56.21						S	C, E.
24P1	S. Sartori	1949	135	140	D 12	1	38	Gravel and rocks.	Qoal	5-3-50 4-6-51	22.28 21.44		J 2		40	57	D, Dy	L.
25A1	G. Myles	1948	120	265	D 10-6	145	37	Blue sand	Tp	11-?-49 4-5-51	126.18 128.10		L		3	12	D, S	L, Cp.
25A2	do	1944	115	100	D 6				do	4-5-51	23.45		L 1				Dy, S	
25C1	R. Sartori (Calif. Water Service Co.).	1929	125	230	D 8				Qoal, Tp	4-5-51	123.0		T 5				PS	C, L.
26R1	R. Sartori	1949	53.6	428	D, G 28-12	110 300 450	10 15 20	Sand Gravel Fine gravel	Qoal (?) QTm(?) do	2-2-50	32.93				300	[17] 140	U	C, L, W.

26R2	Hartman		47.4	35	D 12			Qyal	2- 7-50	21.49						U	W.
28A1	Calif. Water Service Co. (station 1, well 114).	1946	35	502	D 12-10	166 330	74 Sandy clay; sand. 95 Fine gravel; clay and gravel.	QTm (?) TQm				T 7½				PS	C, L, W.
28A2	Calif. Water Service Co. (station 1, well 106).	1941	35	99	D 16-12			Qyal, Qoal	4- 5-51	16.99		2				PS	C, L, W.
28A3	Calif. Water Service Co. (station 1, well 111).	1931	35	280	D 14	75 220	15 Sandy clay and gravel; sandy clay. 40 Clay and gravel; sandstone; gravel.	do QTm	4- 5-51	15.79		T 7½		44	117	PS	C, L, W.
28A4	Calif. Water Service Co. (station 1, well 104).		35	94	D 16			Qyal, Qoal								PS	C, L, W.
28G1	Calif. Water Service Co. (station 1, well 113).	1944	35	94	D 12	50 69	7 Gravel and clay 13 Sandy clay and gravel.	Qyal do				T 5				PS	C, L, W.
28H1	Calif. Water Service Co. (station 1, well 115).	1947	35	483	D 12-10	154 250	27 Cemented gravel 186 Clay and boulders; clay and gravel.	Qoal QTm	4- 5-51	21.50		T 7½				PS	C, L, W.
28H2	Calif Water Service Co. (station 1, well 102).		35	95	D 12			Qyal, Qoal	4- 5-51	16.57		T 10				PS	C, L, W.
28H3	Calif. Water Service Co. (station 1, well 103).		35	92	D 12			do				T 5				PS	C, L, W.
28H4	Calif. Water Service Co. (station 1, well 107).		35	83	D 16			Qyal, Qoal.				T 7½				PS	C, L, W.
28H5	Calif. Water Service Co. (station 1, well 112).		35	468	D 14	198 265 300 348	27 Sandstone; gravel. 11 Sandstone; clay and gravel. 35 Clay and gravel; sandstone. 50 Clay and gravel; gravel; sandstone.	Qoal, QTm. QTm do do				T 20		132	62	PS	C, L.
28N1	G. E. Park	1949	15	62	D 6			Qyal	3- 2-50 4- 4-51	4.60 4.55		J 1	15			D	L.
29B1	L. J. Petersen	1948	35	95	D 6	80	5 Red rock	Tsv (?)	4- 4-51 4- 6-51	28.22 26.90		L 1				D	L.

See footnotes at end of table.

TABLE 23.—*Description of water wells in the Petaluma Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well				Water level		Temperature (° F.)	Pump		Results of tests		Use	Other data available
						Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Date measured	Distance above (+) or below land-surface datum (feet)		Type and horsepower	Discharge (gpm)	Bailing or pumping rate (gpm)	Drawdown (feet)		
									T. 5 N., R. 7 W.—Continued									
5/7-29L1	A. H. McNeely	------	45	65	D 8	0	65	Sand; sand and gravel.	QTm				T 1½		16		D	Cp, L.
29M1	H. A. Jewett	1949	125	80	D 8				do	2-14-50 4- 4-51	46.98 47.44		J		4	10	D	L.
29N1	Mrs. B. Berger	1947	185	244	D 8				do	2-16-50 4- 4-51	133.62 133.25		L	18	15	15	D	L.
30F1	E. J. Greenhagen.	1948	80	204	D 8				do	4- 4-51	27.82		L	17	25	[7] 40	D	L.
30N1	L. C. Williams	1950	70	180	D 6	15	165	"Tight-packed" sand; sandstone; clam shells and sandstone.	do				L 1				D	L.
30N2	do	------	70	15	Dug 48					3-30-51	3.30						U	
30Q1	A. Nunes	1949	110	118	D 8	0	118	Quicksand; sand gravel, and "oyster shells."	QTm	2- 9-50 4- 4-51	25.91 23.03		J		13		D	Cp, L.
31F1	A. Forno	1949	95	80	D 8	0	58	Sandstone	do	2-16-50 4- 4-51	5.50 7.30		L	20			D	L.
32J1	G. A. Rollin	1939	75	11 43	Dug 48 D 8	21	43	"Broken rock"	Tsv	2- 7-50 4- 4-51	14.30 11.56		J		9	20	Irr	L.
32R1	Petaluma High School.	1949	50	217	D				do	11-22-49 4- 4-51	25.60 26.62		T 15		110	92	PS	L.
32R2	do	------	50	125	D 8				do	11-22-49 4- 4-51	25.59 [5] 30.65		T 5		86	[7] 35	PS	
32R3	Raney	1949	65	95	D 6				QTm (?)	2- 7-50 4- 4-51	[18] 28.07 22.50		J		16	40	D	L.
32R4	Petaluma Coop Creamery.	1949	85	152	D				Tsv (?)	8-10-49	[7] 29		J 5	30			Ind	
33J1	Poultry Producers of Calif.	1937	10	56	D				Qyl								[2]	L.

33M1	Lace House Laundry.	1947	30	132	D 8				QTm (?)	10-25-47	[11,17] 40		J 5		37	[7] 6	U	L.
33N1	R. Schindler	1934	35	300	D 8				JK	6-23-34 4- 4-51	[11] 260 53.68		L		7	10	D	L.
33N2	A. M. Bullard (Calif. Water Service Co.).		40	250-350	D								T 5				PS	C.
33Q1	City of Petaluma (Wickersham Park).	1948	25	205	D 10-8	30 65 175	5 60 10	Sand and gravel Sandstone "Cracked" blue rock.	Qyal QTm JK	3-24-50 4- 4-51	19.37 21.11		T 10		55	[17] 140	Irr	L.
34A1	G. Perry (Calif. Water Service Co.).	1949	25	410	D 10				Qyal, Qoal (?), QTm.					220			PS	C.
34A2	G. Perry	1950	20	520	D, G 10				do	4- 4-51	12.45		T 15		300	185	Irr	C.
34E1	Ben B. Smith	1937	10	464	D 12-10				QTm (?).								A	L.
34E2	Dr. H. E. Clarke.	1948	10	280	D 8				Qyal, QTm.	2-14-50 4- 4-51	9.44 7.24		T 7½		100		D, Irr, S	L.
34G1	G. Perry	1949	12	230	D, G 10				do	11-13-49 4- 4-51	18.07 9.22		T 20	180		[7,17] 100	Irr	C.
35B1	Riscioni		42	28	D 12±				Qyal	2- 7-50 4- 4-51	24.32 16.31		J ½				U	
35G1	R. Sartori	1920	25	90	D 10				do	11-13-49 4- 4-51	24.01 12.49		L 3	40			D	
35H1	Calif. Water Service Co. (station 5, well 501).	1948	29.2	542	D 28-12	180 440 487	30 40 25	Small gravel; fine gravel and sand; coarse and fine sand. Clay and very small gravel. Small gravel	QTm do do	6-30-48 4-30-49 6-30-49	[7] 75 [7] 65 [7] 75		T 50				PS	C, L.
35K1	R. Sartori	1925	18.8	78	D 12				Qyal	11-13-49	26.81		T 7½	200			Irr	C, W.
36B1	O. Patocchi	1948	50	120	D 8				TP (?)					5	8		D, S	L.

T. 5 N., R. 8 W.

5/8-11N1	Rev. H. Gans	1949	230	271	D	0	271	Sand; sand and gravel.	QTm	2-15-50	111.19		L		17		D	Cp, L.
13A1	S. Pozzi	1941	65	92	D 8				do	4- 4-50 4- 6-51	33.60 31.10		J ¾		12	15	D	L.
13B1	do	1940	45	172	D 8	3	169	Sand; sand and gravel.	Qyal, QTm.	8- 7-40 4- 4-50 4- 6-51	[11] 12 1.37 .5		L		25	36	S	L.
13G1	Mrs. Benson	1930±	40	150-250	D				do	4- 4-50 4- 6-51	(3) (3)		T				Irr, U	

See footnotes at end of table.

TABLE 23.—*Description of water wells in the Petaluma Valley area, California*—Continued

Well no.	Owner or user	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well and diameter of casing (inches)	Water-yielding zone or zones open to well: Depth to top (feet)	Thickness (feet)	Character	Geologic formation	Water level: Date measured	Distance above (+) or below land-surface datum (feet)	Temperature (° F.)	Pump: Type and horsepower	Discharge (gpm)	Results of tests: Bailing or pumping rate (gpm)	Drawdown (feet)	Use	Other data available
								T. 5 N., R. 8 W.—Continued										
5/7-13N1	George Peterson	1948	75	200	D 8	49	151	Sandstone	QTm	2-15-50	(3)		J 5	40	30	[17] 48	S, Irr	L.
13N2	do	1921	75	200	D 8	176	24	Gravel	do	4-10-51	6.20						U	L.
14B1	Ghirardelli brothers.	1949	90	64	Dug 72				Qyal, QTm.	4- 6-51	8.21		L 5				Irr	
14B2	do		90		D 12				do	3- 2-50	9.86						U	
14D1	W. A. Goodanetz.	1947	150	127	D 8	56	71	Fine sand and small gravel; fine sand.	QTm	12- ?-47	[11] 46			10	12	37	D	L.
14G1	P. G. Pedersen	1949	100	150	D 8	0	150	Sand; sand and gravel.	do	2- 9-50	23.62		J 2		33		D	L.
										4- 6-51	21.27							
23L1	Two Rock Army Base.	1942	75	197	D				do				T 5	25			PS	
23L2	do	1942	70	278+	D	8	209	Sandstone	do	4- 7-50	69.2		T 7½	35			PS	L.
										4- 6-51	[5] 79.25							
24J1	Frank Ramos	1941	45	98	D 8	70	28	Sand	do	11- ?-41	[11] 4		J		15	94	D	Cp, L.
										2- 9-50	(3)							
24M1	E. Johnson	1949	60	160	D 8				do	9- ?-49	[11] 10		J		16	55	D	L.
24P1	Leo Vannucci	1941	60	188	D 8	0	185	Sand; sand and gravel; sand and shells; sandstone.	do	11- ?-41	[11] 8		J		12	55	D	L.
25E1	A. F. Cerini	1948	75	128	D 8	12	116	Sand; sandstone	do	10- ?-48	[11] 57		L		16	59		Cp, L.

1 Abandoned water-well test hole. Owner reports small amount of fresh water at 33 feet.
2 Foundation test boring.
3 Well flowing; static level above land-surface datum.
4 Measured by the Geological Survey.
5 Pumping recently.
6 Estimated natural flow.
7 Reported by owner.
8 Obstruction at depth indicated.
9 Pumping.
10 Well was never developed because salt water was encountered.
11 Reported by driller.
12 Reportedly silted up to within about 200 feet of surface.
13 Reported to be a dry hole.
14 Reportedly silted up to within 95 feet of surface.
15 Original depth of oil-and-gas test hole developed as a water well. Present effective depth unknown.
16 No access for measurement but water standing above casing. Bubbling gas indicates gas lift.
17 Pumping level.
18 Nearby well pumping.

TABLE 24.—*Periodic water-level measurements in wells in the Petaluma Valley area, California*

Well 3/6-1Q1

Mrs. H. Clokie. About 11.6 miles southeast of Petaluma, 0.33 mile southeast of State Route 37, 450 feet southwest of Reclamation Avenue, 50 feet east of dwelling, 12 feet northwest of tank house. Domestic and stock well; diameter, 7 inches; reported depth, 225 feet. Measuring point: top of casing, north side, 1.0 foot above land-surface datum, which is 2 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Jan. 25, 1950	+0.39	July 13, 1950	[2] 0.62	Apr. 6, 1951	+0.23
Feb. 22	+.37	Aug. 8	[2] .76	Oct. 16	[3] .98
Mar. 28	+.74	Sept. 7	[1] .86	Dec. 6	[2] +.08
May 3	[1] +.29	Oct. 18	[1] 1.84	Apr. 1, 1952	[3] 1.01
June 14	[2] .32	Dec. 29	[2] +.20	May 20, 1955	.07

[1] Near low tide.
[2] Near high tide.
[3] Between tides.

Well 3/6-4D1

W. Q. Wright. About 8.6 miles southeast of Petaluma, 1.57 miles east of the Northwestern Pacific Railroad at Novato Airport, 430 feet east along levee road from well 3/6-5A1, 525 feet north of levee road, 6 feet west of centerline of north-trending drainage ditch, in field. Unused well; diameter, 8 inches; depth, 120 feet. Measuring point: top of casing, west side, 1.2 feet above land-surface datum, which is 4 feet below sea level (altitude determined by hand level from well 3/6-5A1).

Date	Water level	Date	Water level	Date	Water level
June 14, 1950	[1] 2.45	Oct. 18, 1950	[3] 1.67	Oct. 16, 1951	[2] 1.35
July 13	[1] 2.59	Dec. 29	[1] 1.17	Dec. 6	[1] 1.12
Aug. 8	[2] 2.21	Apr. 6, 1951	1.43	Apr. 1, 1952	[3] 0.84
Sept. 7	[3] 1.75				

[1] Near high tide.
[2] Between tides.
[3] Near low tide.

Well 3/6-5A1

W. Q. Wright. About 8.6 miles southeast of Petaluma, 1.5 miles east of Northwestern Pacific Railroad at Novato Airport, 0.32 mile west along levee road from Radio Station KCBS transmitter, 60 feet north of levee road, 3 feet east of fence. Stock well; diameter, 4 inches; depth, 83 feet. Measuring point: top of casing, north side, 1.3 feet above 4- x 4-inch timber casing supports and land-surface datum, which is 0.80 foot below sea level (altitude determined by spirit level).

Date	Water level	Date	Water level	Date	Water level
Dec. 15, 1949	+0.05	Jan. 31, 1950	.026	Sept. 7, 1950	[2] 0.49
21	.03	Feb. 22	[1] .02	Oct. 18	[2] .75
29	.16	Mar. 31	[2] .07	Dec. 29	[4] .23
Jan. 4, 1950	.00	May 3	[3] +.09	Apr. 6, 1951	.43
11	.13	June 14	[4] .33	Oct. 16	[5] .73
18	+.17	July 13	[4] .45	Dec. 6	[4] .46
26	.25	Aug. 8	[5] .66	Apr. 1, 1952	[2] .12
27	.13				

[1] Low incoming tide; well flowing up outside of casing.
[2] Near low tide.
[3] Near low tide; well flowing up outside casing.
[4] Near high tide.
[5] Between tides.

Well 4/6-21J1

L. Bourke. About 7.7 miles east-southeast of Petaluma, 0.16 mile northeast of New Lakeville Road along old Lakeville Road, 100 feet southeast of old Lakeville Road. Unused well; diameter, 8 inches; depth, 284 feet. Measuring point: notch in south side of casing, 1.1 feet above land-surface datum, which is 80 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Oct. 12, 1949	63.06	Apr. 28, 1950	58.89	Dec. 29, 1950	71.21
Nov. 10	61.82	June 14	61.17	Apr. 6, 1951	68.68
Dec. 7	61.41	July 13	63.64	June 7	70.47
28	61.17	Aug. 8	66.04	Oct. 16	74.71
Jan. 31, 1950	60.20	Sept. 7	68.78	Dec. 6	75.29
Feb. 22	59.69	Oct. 18	70.81	Apr. 1, 1952	70.02
Mar. 28	59.17				

TABLE 24.—*Periodic water-level measurements in wells in the Petaluma Valley area, California*—Continued

Well 4/6-34C1

M. S. Herzog. About 8.8 miles southeast of Petaluma, 2.2 miles northwest of State Highway 37, 0.55 mile southwest of new Lakeville Road, 160 feet north-northeast of fourth cattle guard on ranch road leading southwestward from new Lakeville Road, 115 feet northeast along fence from easternmost of row of eucalyptus trees, 132 feet northwest of fence. Unused well; diameter, 2 inches; depth, 92.0 feet. Measuring point: top of casing, west side, 0.6 feet above land-surface datum, which is 5 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Oct. 12, 1949	4.06	Mar. 28, 1950	1.29	Oct. 18, 1950	3.57
Nov. 10	4.12	Apr. 28	1.54	Dec. 29	1.24
Dec. 7	4.08	June 14	2.14	Apr. 6, 1951	0.19
28	4.08	July 13	2.51	June 5	1.68
Jan. 31, 1950	2.97	Aug. 8	2.84	Apr. 1, 1952	0.14
Feb. 22	1.58	Sept. 7	3.19		

Well 5/7-17D1

M. Malacredi. About 1.0 mile south of Penngrove, 0.14 mile southwest of U. S. Highway 101, 260 feet northeast of Ely Road, 175 feet east-southeast of railroad tracks, 8 feet northeast of northerly corner of garage, 10 feet south of well 5/7-17D2. Auxiliary domestic and dairy well; diameter, 7 inches; depth, 60.0 feet. Measuring point: top of extended casing, west side, 1.5 feet above land-surface datum, which is 40 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Sept. 30, 1949	20.80	Feb. 23, 1950	[1] 17.85	Oct. 18, 1950	[1] 21.55
Oct. 21	[1] 20.67	Mar. 28	16.83	Dec. 29	18.43
Nov. 4	[1] 20.79	Apr. 28	[1] 18.96	Apr. 6, 1951	14.99
10	[1] 20.69	June 13	18.14	June 6	16.24
Dec. 1	[1] 20.64	July 13	19.43	Oct. 16	20.08
28	20.27	Aug. 9	19.19	Dec. 7	[1] 20.82
Jan. 31, 1950	17.87	Sept. 15	[1] 21.40	Apr. 1, 1952	12.60

[1] Nearby well being pumped.

Well 5/7-19N1

M. Azavedo, Route 2, Box 147. About 2.7 miles west-northwest of Petaluma, 320 feet east and 40 feet north of the intersection of Thompson and Skillman Lanes, 30 feet south of dwelling. Domestic and stock well; diameter, 8 inches; depth, 180 feet. Measuring point: top of casing, north side, 1.0 foot above land-surface datum, which is 45 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Mar. 1, 1950	4.37	Oct. 18, 1950	10.95	Nov. 20, 1952	13.30
31	3.03	Dec. 29	2.05	Apr. 17, 1953	5.5
May 3	6.15	Apr. 6, 1951	3.23	Nov. 3	18.9
June 14	11.15	June 5	6.94	Apr. 2, 1954	3.48
July 13	9.18	Oct. 16,	17.35	Apr. 1, 1955	11.23
Aug. 8	13.03	Dec. 6	5.38	Apr. 3, 1956	5.61
Sept. 7	10.62	Apr. 1, 1952	2.52	Mar. 15, 1957	46.00

Well 5/7-20B1

California Water Service Co. well no. 3, Pacific Duck Ranch. W. Brody, 226 Corona Road. About 2.4 miles north-northwest of Petaluma, 375 feet northeast of Northwestern Pacific Railroad tracks, 300 feet southeast of Corona Road, 240 feet north-northeast of large, two-story dwelling, in corrugated-metal pump house. Domestic and stock well; diameter, 12 inches; reported depth, 600 feet. Measuring point: bottom-edge of pump base, east side, 1.0 foot above land-surface datum, which is 40 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Sept. 30, 1949	29.38	Dec. 6, 1951	39.78	Apr. 2, 1954	35.32
Dec. 29, 1950	41.12	Apr. 1, 1952	35.14	Apr. 1, 1955	[1] 59+
Apr. 11, 1951	33.82	Nov. 20	37.50	Apr. 3, 1956	37.79
June 5	32.65	Apr. 17, 1953	[1] 43.1	Mar. 15, 1957	46.00
Oct. 16	47.03	Nov. 3	47.5		

[1] Pumping recently.

TABLE 24.—*Periodic water-level measurements in wells in the Petaluma Valley area, California*—Continued

Well 5/7-20C1

E. Scott. About 2.5 miles northwest of Petaluma, 0.24 mile northwest and 0.16 mile southwest of Northwestern Pacific Railroad crossing of Corona Road, 0.2 mile southwest of railroad, 25 feet west of drainage ditch, in frame pump house. Irrigation well; diameter, 12 inches (reduced to 8 inches); depth, 688 feet. Measuring point: top of access hole in east side of pump base, 1.2 feet above land-surface datum, which is 35 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Oct. 14, 1949	8.04	Dec. 1, 1949	8.05	Mar. 28, 1950	5.64
21	8.07	28	7.96	May 3	5.47
Nov. 4	8.04	Jan. 31, 1950	6.92	June 14	[1] 24.90
10	7.99	Feb. 23	5.98	Oct. 18	21.40

[1] Pumping recently.

Well 5/7-26R1

California Water Service Co. station 6. R. Sartori. About 2.6 miles east-northeast of Petaluma, 400 feet northeast and 100 feet southeast of intersection of Ely Road and Casa Grange Avenue, in open field. Unused well; diameter, 12 inches; depth, 428 feet. Measuring point; top of 1½-inch nipple in top of steel casing cover, 0.3 foot above land-surface datum, which is 53.6 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Feb. 2, 1950	33.23	May 3, 1950	29.25	June 7, 1951	24.62
15	31,33	June 14	30.62	Oct. 16	28.86
22	30.64	July 13	31.70	Dec. 6	32.74
Mar. 1	30.20	Aug. 8	32.67	Apr. 1, 1952	21.19
8	30,21	Sept. 15	34.03	Nov. 20	29.45
14	30.25	Oct. 18	34.82	Apr. 17, 1953	22.03
17	30.22	Dec. 29	30.90	Apr. 2, 1954	26.78
28	29.51	Apr. 4, 1951	23.50	Apr. 1, 1955	30.67

Well 5/7-26R2

W. Hartman. About 2.5 miles east-northeast of Petaluma, 200 feet southwest, thence 250 feet southeast of the intersection of Ely Road and Casa Grange Avenue, 1 foot southwest of base of old wooden tank tower. Unused well; diameter, 12 inches; depth, 35.5 feet. Measuring point: top of casing, southwest side, 1.0 foot above land-surface datum, which is 47.4 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Feb. 7, 1950	21.59	June 14, 1950	25.50	Dec. 6, 1951	26.62
15	23.19	July 13	26.28	Apr 1, 1952	13.91
22	24.26	Aug. 8	27.12	Nov. 20	24.07
Mar. 1	24.63	Sept. 15	28.57	Apr. 17, 1953	16.73
8	24.97	Oct. 18	29.80	Apr. 2, 1954	21.51
14	24.97	Dec. 29	24.01	May 20	26.78
17	25.00	Apr. 4, 1951	18.02	Apr. 1, 1955	25.26
31	24.67	June 7	19.53	Apr. 3, 1956	22.10
Apr. 28	24.26	Oct. 16	25.35	Mar. 15, 1957	30.00

Well 5/7-35K1

R. Sartori. About 2.3 miles east of Petaluma, 0.33 mile east of intersection of Lakeville Road and Casa Grange Avenue, thence 250 feet southwestward along Adobe Creek, 15 feet east of creek in frame pump house. Irrigation well; diameter, 12 inches; reported depth, 78 feet. Measuring point: hole in north side of pump base, at land-surface datum, which is 18.8 feet above sea level.

Date	Water level	Date	Water level	Date	Water level
Oct. 13, 1949	26.81	Sept. 15, 1950	[1] 32.43	Nov. 3, 1953	27.31
Jan. 18, 1950	25.10	Oct. 18	28.00	Apr. 2, 1954	17.45
31	22.84	Dec. 29	19.90	Aug. 22	40.05
Feb. 22	16.63	Apr. 4, 1951	17.48	Apr. 1, 1955	22.15
Mar. 28	16.35	Oct. 16	30.63	Apr. 3, 1956	13.64
Apr. 28	22.68	Dec. 6	20.87	Mar. 15, 1957	19.63
June 14	26.06	Apr. 1, 1952	11.73		
July 13	28.18	Nov. 20	25.12		

[1] Probably pumping recently.

TABLE 25.—*Chemical analyses of water from wells in the Petaluma Valley area, California*

[The laboratories which analyzed the samples are indicated by symbols as follows: GS, U. S. Geological Survey, Quality of Water Branch; UC, University of Calif., Division of Plant Nutrition; CWS, Calif. Water Service Co.]

Sum of determined constituents is the arithmetic sum, in parts per million, of all constituents determined, except bicarbonate for which the figure was halved before addition. Boron and phosphate, if determined, are included only when they exceed 1.0 part per million.

The concentration of sodium was computed by difference and includes the concentration of potassium plus any error of analysis.

Well or location no.	Analyzed by—	Date of collection	Depth of well (feet)	Specific conductance (micromhos at 25°C)	pH	Sum of determined constituents (ppm)	Constituents in parts per million												Hardness as calcium carbonate ($CaCO_3$)	Percent sodium	Type of water
							Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Boron (B)			
3/6-1Q1	GS	4-1-52	225	1,270	......	......	......	......	......	35	35	236	......	......	......	147	......	0.23	232	69	
1Q1	GS	5-19-54	225	1,300	8.1	772	40	......	......	32	30	223	0	585	0.1	146	6.1	.07	204	70	
1Q1	GS	8-22-54	......	1,330	7.9	783	39	0.04	0.000	34	34	211	0	579	4.4	160	9.3	.25	224	67	
3C1	GS	5-19-54	......	3,260	7.2	1,700	381	......	......	73	190	284	0	489	2.4	835	20	.23	963	39	
5/7-8D1, 2	CWS	5-26-47	(1)	910	7.9	487	24	.03	.07	34	22	112	......	234	67	112	0.8	......	175	58	Na-HCO_3.
10Q1	UC	8-27-51	462	2,700	8.5	1,470	......	......	......	10	5	600	20	235	10	705	5	......	40	97	Na-Cl.
19H1	UC	12-9-49	305	470	7.8	257	......	......	......	60	10	30	......	185	10	55	......	......	190	24	Ca-HCO_3.
20B1	CWS	5-26-47	600	533	8.7	318	10	.03	.09	12	5.8	101	......	188	22	58	16	......	53	81	Na-HCO_3.
	GS	4-1-52	......	546	......	......	......	......	......	18	8.3	96	......	......	......	58	......	.08	79	73	
22Q1	CWS	7-21-49	92	640	7.6	406	39	.19	.30	58	31	36	.7	284	76	24	.6	......	269	23	Ca,Mg-HCO_3.
22Q2	CWS	8-3-49	97	468	7.7	284	36	.13	.10	40	19	32	.9	249	13	20	0	......	178	28	Do.
24B1	UC	9-29-49	650	7,500	......	4,300	......	......	......	90	70	1,315	......	180	1,680	1,050	......	7.0	510	85	Na-SO_4.
24F1	UC	10-15-50	1,896	1,100	......	635	......	......	......	5	15	210	......	225	150	140	......	3.4	74	84	Na-Cl,HCO_3,SO_4.
25C1	CWS	5-26-47	235	435	9.3	[2] 275	17	.26	.15	9.6	2.4	95	......	259	2	17	2.5	......	34	81	Na-HCO_3.
26R1	CWS	2-9-49	428	547	7.5	346	37	.03	.07	30	10	81	0	279	17	26	6.8	......	115	60	Na-HCO_3.
28A1	CWS	7-21-49	502	616	8.1	360	31	.12	.01	16	13	97	2	224	26	64	1.2	......	93	69	Do.
28A2	CWS	5-25-49	99	370	7.1	255	51	.14	.11	26	13	35	0	183	8	21	11	......	119	39	Na,Ca,Mg-HCO_3.
28A3	CWS	5-25-49	280	550	8.1	333	27	.01	.14	18	9	92	2	240	26	37	3	......	82	71	Na-HCO_3.
28A4	CWS	5-25-49	94	475	7.3	296	47	.01	.10	36	16	39	0	221	11	28	10	......	157	35	Ca,Na,Mg-HCO_3.
28G1	CWS	5-25-49	94	429	7.3	283	52	.01	.13	36	16	30	0	202	12	20	17	......	155	30	Ca,Mg,Na-HCO_3.
28H1	CWS	7-21-49	483	681	7.9	369	31	.24	.04	44	30	47	1	234	11	89	.6	......	230	31	Ca,Mg,Na-HCO_3.
28H2	CWS	5-25-49	95	496	8.4	319	44	.01	.03	41	17	41	4	214	23	32	12	......	171	34	Ca,Na-HCO_3.
28H3	CWS	5-25-49	92	421	7.5	280	51	.00	.14	31	16	35	0	193	16	22	14	......	143	35	Ca,Na,Mg-HCO_3.
28H4	CWS	5-25-49	83	376	8.2	260	51	.01	.06	29	15	31	2	179	8	20	16	......	133	33	Do.
28H5	CWS	5-25-49	468	576	8.4	334	24	.03	.06	16	11	94	4	238	17	50	1	......	87	70	Na-HCO_3.

33N2	CWS	6- 2-47	(3)	666	7.7	380	32	.07	.24	65	28	24	------	249	57	51	0	------	282	16	Ca,Mg-HCO_3.
34A1	CWS	6- 4-49	410	909	7.9	525	39	.10	.11	30	20	136	2	302	20	128	1	------	157	65	Na-HCO_3,Cl.
34A2	CWS	8-21-50	520	1,080	7.4	609	44	.25	.13	31	18	170	0	260	1	216	0	------	150	71	Na-Cl,HCO_3.
	UC	8-27-51	------	1,130	8.5	626	------	------	------	35	20	170	30	210	------	255	------	1.1	170	67	Do.
34G1	UC	8-27-51	230	1,400	8.1	735	------	------	------	60	40	160	25	260	10	310	------	.64	320	52	Do.
34G1	GS	5-19-54	230	1,570	7.6	855	37	----	------	71	44	181	0	276	17	362	1.9	.63	358	52	Na-Cl.
34G1	GS	8-22-54	------	1,770	8.0	943	34	.1	.000	94	52	176	0	287	15	425	20	.66	448	46	Do.
35H1	CWS	7-21-49	542	541	8.4	335	40	.06	.01	29	14	70	4	243	23	34	.6	------	130	54	Na-HCO_3.
35K1	CWS	5-26-47	78	554	7.1	337	44	.31	.09	46	24	32	------	242	14	42	16	------	214	25	Ca,Mg-HCO_3.
	GS	5-20-54	78	664	7.2	423	67	------	------	61	22	39	0	288	22	47	20	----	242	26	Do.
	GS	8-22-54	------	595	7.7	386	58	.02	.000	50	24	42	0	276	20	42	9.9	.09	224	29	Do.
Adobe Creek.[4]	GS	4- 1-52	------	265	------	------	------	------	------	24	9.2	15	------	------	------	13	------	------	98	25	

[1] Sample probably composite of samples from two wells, 100 and 125 feet deep, located 3 feet apart.
[2] Includes 1.4 ppm phosphate (PO_4).
[3] Reported depth 250-350 feet.
[4] Sampling point 15 feet west of well 5/7-35K1.

TABLE 26.—*Partial chemical analyses of water from wells in the Petaluma Valley area, California*

[Analysed by or under the supervision of A. A. Garrett. Dissolved solids may be estimated from specific conductance by use of figure 18]

Well or location no.	Date of collection	Depth (feet)	Specific conductance (micromhos at 25°C)	Parts per million	
				Chloride (Cl)	Hardness as $CaCO_3$
3/5- 6C1	2-17-50	50	1,600	328	395
7A1	1-25-50	435	2,350	364	425
3/6- 1Q1	1-25-50	225	1,290	143	180
3C1	2-17-50	(1)	1,430	255	310
4C1	4- 5-51	164	3,410	912	910
[2] 5A1	12- 1-49	83	9,590	3,560	1,600
[3] 5A1	12- 1-49		9,600	3,390	1,550
11B1	1-25-50	250	2,090	400	280
12E1	4- 6-51	200+	1,210	137	155
4/6-21Q1	2-17-50	464	1,490	259	155
27N1	2-17-50	222	699	101	90
27R1	2-17-50	736	819	91	220
27R1	4-10-51		838	105	205
33R1	2-17-50	175+	5,460	1,590	1,900
35J1	2-17-50	165	1,080	132	350
4/7- 2D1	1-27-50	62	10,800	3,270	1,100
4D1	2- 7-50	70	227	7.8	75
13D1	4- 4-51	(4)	1,470	105	205
5/6-30D1	4- 5-51	155	717	31	10
5/7- 7R2	3- 1-50	198	578	54	15
10Q1	2-15-50	462	2,760	735	45
20C1	8- 9-50	688	988	202	314
25A1	4- 5-51	265	1,250	135	320
29L1	2- 9-50	65	960	100	320
30Q1	2- 9-50	119	554	55	175
5/8-11N1	2-15-50	271	974	130	125
24J1	2- 9-50	98	476	59	140
25E1	2-14-50	128	656	92	185

[1] Shallow dug well.
[2] Sample taken at start of pumping.
[3] Sample taken 10-15 minutes after pumping began.
[4] Drilled well inside dug well. Dug well 10 feet deep; drilled well reported t obe more than 50 feet deep.

TABLE 27.—*Drillers' logs of water wells in the Petaluma Valley area, California*

Well 3/6-4C1. Columbia Broadcasting System, Radio Station KCBS

[Drilled by Petaluma Pump and Well Co. at sea level. On reclaimed tidal marsh. Casing not perforated; open end]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Black loam	3	3	Blue clay	74	160
Blue muck	69	72	Merced formation(?):		
Gravel bar	14	86	Water sand	4	164

Well 3/7-13D5. J. H. Rose

[Drilled by A. Oberto. Altitude, 39 feet. On alluvial plain. Casing perforated between depths of 35 and 55 feet. Bailer test: static level, 17 feet; bailing level, 30 feet at 400 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Younger alluvium—Continued		
Soil	1	1	Clay, yellow	24	49
Clay, brown, and gravel	22	23	Gravel	4	53
Clay, grey, and gravel	2	25	Clay, yellow	2	55

TABLE 27.—*Drillers' logs of water wells in the Petaluma Valley area, California*—Continued

Well 4/6-27L1. S. K. Herzog Company

[Drilled by N. F. Keyt. Altitude, 5 feet. On alluvial plain. Casing perforated between depths of 98 and 102 and 480 and 500 feet. Yield, 1,000 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older(?) alluviums and Merced formation:			Younger and older(?) alluviums and Merced formation—Con.		
Soil, clay, and gravel	15	15	Clay, yellow	42	295
Clay, yellow; and gravel	83	98	Sand, yellow; (dry)	25	320
Gravel	4	102	Clay, yellow	37	357
Clay, yellow; and gravel	56	158	Gravel, pea	2	359
Sand, blue	17	175	Clay, hard, yellow	91	450
Clay, blue	60	235	Clonglomerate	10	460
Clay, yellow	10	245	Clay, yellow	25	485
Clay, blue	8	253	Gravel	15	500

Well 5/7-5K1. J. Mackey

[Drilled by N. F. Keyt. Altitude, 160 feet. At base of hill. Bailer test: static level, 128 feet; bailing level, 179 feet at 1,000 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced and Petaluma formations:			Merced and Petaluma formations—Continued		
Clay, yellow, sandy; water at 70 feet	74	74	Clay, blue; and gravel	12	265
Clay, blue	57	131	Clay, blue	52	317
Clay, brown	16	147	Clay, joint	9	326
Clay, blue	57	204	Gravel	11	337
Clay, yellow	14	218	Clay, blue; and gravel	2	339
Clay, blue	35	253			

Well 5/7-15K1. Mrs. J. P. Whitaker

Drilled by N. F. Keyt. Altitude, 135 feet. Near edge of alluvial plain. Bailer test: static level, 34 feet bailing level, 65 feet at 40 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older(?) alluviums:			Petaluma formation:		
Soil	5	5	Yellow clay	27	42
Boulders	10	15	Clay, blue, no water	18	60
			Yellow sandstone	35	95
			Blue clay and gravel	11	106

Well 5/7-19N1. M. N. Azavedo

[Drilled by N. F. Keyt. Altitude, 45 feet. On nose of low hill between alluvial tongues. Bailer test: static level, 13 feet; bailing level, 50 feet at 1,080 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Merced formation—Continued		
Sand	6	6	Clay, blue	15	90
Clay, sandy, yellow	9	15	Oyster shells and gravel, water	15	105
Sand, yellow; and gravel; water	10	25	Clay, sandy, blue; and sandstone	35	140
Clay, blue	5	30	Clay, sandy, blue; and blue sandstone	40	180
Clay, sandy yellow and gravel	42	72			
Clay, sandy, yellow	3	75			

TABLE 27.—*Drillers' logs of water wells in the Petaluma Valley area, California*—Continued

Well 5/7-20C1. E. Scott

[Drilled by N. F. Keyt. Altitude, 35 feet. On alluvial plain. Gravel-packed well. Pumping test: drawdown, 140 feet after 108 hours pumping at 650 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older(?) alluviums:			Merced formation—Continued		
Clay	20	20	Clay, blue	5	435
Sand and gravel	46	66	Clay, sandy, blue	71	506
Conglomerate	30	96	Shelf	7	513
Sand and gravel with streaks of clay	106	202	Clay, hard; with gravel	35	548
Sandy clay with streaks of sand and gravel	88	290	Clay, blue; and gravel	10	558
Conglomerate	20	310	Free gravel	37	595
Clay	5	315	Clay, soft	20	615
Merced formation:			Shelf (probably cemented sand)	2	617
Rock (probably cemented sand)	7	322	Gravel	37	654
Sandy clay	33	355	Free gravel	4	658
Clay, blue, sandy	55	410	Sand and shelf (probably cemented layers)	8	666
Rock (probably cemented sand)	20	430	Gravel	9	675
			Gravel, hard	13	688

Well 5/7-25A1. George Myles

[Drilled by N. F. Keyt. Altitude, 120 feet. On colluvial slope. Bailer test: static level, 128 feet; bailing level, 140 feet at 200 gallons per hour]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Petaluma formation:			Petaluma formation—Continued		
No data	136	136	Clay, blue	23	205
Clay, blue, sandy	9	145	Clay, green	5	210
Sand, blue	4	149	Clay, blue	31	241
Clay, sandy, blue	33	182	Clay, green	24	265

Well 5/7-25C1. R. Sartori (California Water Service Co., well 2)

[Drilled by H. Nutting. Altitude, 125 feet. At edge of alluvial plain]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Older alluvium:			Petaluma formation:		
Soil	4	4	Blue clay	30	65
Clay, yellow	21	25	Sand	10	75
Boulders with water	10	35	Blue clay	125	200
			Hard sandstone	25	225
			Sand, water	10	235

Well 5/7-26R1. California Water Service Co.

[Drilled by C. H. Chamberlain. Altitude, 53.6 feet. On alluvial plain. Casing perforated between depths of 140 and of 240, 300 and 390, and 440 and 500 feet. Gravel-packed. Cement plug set at 428 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older alluviums:			Merced(?) formation—Con.		
Clay, adobe, yellow	20	20	Clay, gray, sandy	20	300
Sandy, coarse, and gravel	55	75	Gravel	15	315
Clay, gray, sandy	35	110	Clay, gray	125	440
Sand	10	120	Clay, gray, and hard gray rock	10	450
Clay, yellow, sandy; and wood	40	160	Gravel, fine	20	470
Clay, yellow, sandy	20	180	Petaluma(?) formation:		
Clay, gray, sandy	20	200	Shale and rock, gray	20	490
Wood	10	210	Shale, muddy	40	530
Merced(?) formation:			Clay, gray	70	600
Clay, rusty, sandy	10	220	Clay mud, gray	80	680
Clay, gray, sandy	10	230	Shale, gray	120	800
Bentonite	10	240	Franciscan group:		
Shale, gray, sandy	30	270	Franciscan	35	835
Clay, gray	10	280			

TABLE 27.—*Drillers' logs of water wells in the Petaluma Valley area, California*—Continued

Well 5/7W-28A3. California Water Service Co.

[Drilled by Trojan Engineering Corp. Altitude, 35 feet. On alluvial plain. Casing perforated between depths of 78 and 90 and 220 and 260 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older alluviums:			Merced formation—Continued		
Adobe	7	7	Clay, blue, and fine gravel	34	220
Clay, yellow, and gravel	68	75	Sandstone	8	228
Clay, yellow, sandy	5	80	Gravel	3	231
Clay, yellow, sandy, and gravel	10	90	Sandstone	7	238
Clay, blue	35	125	Rock (probably cemented sand)	1	239
Merced formation:			Clay, blue, and gravel	21	260
Sandstone	23	148	Clay, blue	20	280
Clay, blue	38	186			

Well 5/7-28H1. California Water Service Co.

[Drilled by N. F. Keyt. Altitude, 35 feet. On alluvial plain. Casing perforated between depths of 154 and 315 and 323 and 483 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older alluviums:			Merced formation(?):		
Top soil, adobe	7	7	Blue cemented gravel	27	181
Clay, sandy, yellow	38	45	Blue clay	69	250
Yellow clay	21	66	Blue clay and gravel	24	274
Blue clay	9	75	Blue clay and boulders	186	460
Yellow sand and gravel	4	79	Blue clay	23	483
Yellow sandy clay	5	84			
Blue clay	28	112			
Yellow sand and fine gravel	3	115			
Blue clay	39	154			

Well 5/7-28H5. California Water Service Co.

[Drilled by Trojan Engineering Corp. Altitude, 35 feet. On alluvial plain. Casing perforated between depths of 198 and 225, 264 and 286, and 300 and 397 feet]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older alluviums:			Merced formation—Continued		
Adobe, black, and yellow clay	6	6	Clay, blue, and gravel	4	304
Gravel	12	18	Sandstone	13	317
Clay, sandy, yellow	7	25	Clay, blue	2	319
Clay, yellow	50	75	Sandstone	1	320
Clay, sandy, yellow, and gravel	3	78	Clay, blue, and gravel	15	335
Clay, sandy, yellow	17	95	Clay, blue	13	348
Clay, sandy, blue, and gravel	35	130	Sandstone	2	350
Clay, blue	68	198	Clay, sandy, blue	10	360
Sandstone	10	208	Clay, blue, gravel, and redwood	25	385
Gravel	5	213	Clay, blue, and gravel	5	390
Sandstone	4	217	Sandstone, (hard gravel) [Parentheses are driller's. Material is probably conglomerate]	2	392
Gravel	3	220	Gravel	6	398
Merced formation:			Rock	2	400
Sandstone	5	225	Gravel	6	406
Clay, blue	35	260	Rock	2	408
Clay, blue, and shale	5	265	Clay, blue, gravel, and rock	27	435
Sandstone	11	276	Petaluma formation(?):		
Rock	1	277	Clay, gray hard, compact	33	468
Clay, blue	6	283			
Clay, blue, and gravel	3	286			
Clay, blue	14	300			

TABLE 27.—*Drillers' logs of wells in the Petaluma Valley area, California*—Con.

Well 5/7-32R1. Petaluma High School

[Drilled by N. F. Keyt. Altitude, 50 feet. On hillside. Bailer test: static level, 24 feet; bailing level, 116 feet at 110 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sonoma volcanics:			Franciscan group:		
Adobe	2	2	Rock, green	19	130
Rock, decomposed, yellow	78	80	Rock, blue	70	200
Rock, decomposed, blue	27	107	Rock, blue, with soft streaks	17	217
Rock, decomposed, yellow	4	111			

Well 5/7-33M1. Lace House Laundry

[Drilled by A. J. Oberto. Altitude, 30 feet. Near foot of hill. Bailer test: bailing level 40 feet at 25 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Merced formation:			Sonoma volcanics:		
No record	21	21	Rock	42	132
Gravel, water	?	21			
Clay, blue, and gravel	?	50			
Clay, blue	40	90			

Well 5/7-33Q1. City of Petaluma

[Drilled by A. J. Oberto. Altitude, 25 feet. On alluvial plain. Casing perforated between depths of 30 and 40, 70 and 120, 130 and 145, and 160 and 205 feet. Pumping test: pumping level, 140 feet at 55 gpm]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger alluvium:			Franciscan group:		
Sand and clay, yellow	30	30	Rock, blue	10	145
Sand and gravel (water)	5	35	Rock, serpentine	5	150
Clay, blue	30	65	Rock, blue, and clay	5	155
Merced formation:			Gravel, cement; (water)	5	160
Sandstone, blue; water	60	125	Rock, sand, and clay	10	170
Rock, sand	10	135	Clay, blue, and rock	5	175
			Rock, blue, cracked	10	185
			Rock and clay	20	205

Well 5/7-35H1. California Water Service Co.

[Drilled by N. F. Keyt. Altitude, 35 feet. On alluvial plain. Casing perforated betweeu depths of 180 and 290 and 440 and 512 feet. Gravel packed]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Younger and older(?) alluviums:			Merced formation(?):		
Adobe	5	5	Sand, coarse, and fine; some shell fossils	10	190
Sand, coarse, and small gravel; bottomed in yellow clay	10	15	Gravel, small; shell fossils	10	200
Clay, yellow	15	30	Gravel, small, and fine sand; firm, but friable	10	210
Gravel, small andcoarse sand	5	35	Clay, blue; tan spots	80	290
Sand, coarse; bottomed in yellow clay	5	40	Clay, blue	150	440
Clay, yellow	10	50	Clay, blue; some very small gravel	20	460
Gravel streaks in yellow clay	20	70	Clay, blue; some grit	20	480
Sand, coarse streaks in yellow clay	10	80	Clay, blue	7	487
Clay, yellow, changing to blue	10	90	Gravel, small	25	512
Clay, blue	20	110	Petaluma formation:		
Clay, blue changing to yellow clay	10	120	Shell, very hard	17	529
Clay, yellow	40	160	Shale, blue	11	540
Clay, blue	10	170	Shale; blue gravel, small	2	542
Clay, blue, brown spots	10	180			

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