Geology and Ground-Water Features of Shasta Valley, Siskiyou County California

By SEYMOUR MACK

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By Seymour Mack

ABSTRACT

Shasta Valley is in the central part of Siskiyou County, Calif., and about 12 miles south of the Oregon border. It lies between the Klamath Mountains on the west and the Cascade Range on the east. The valley has an area of about 250 square miles; the north-south length is about 30 miles and the maximum width is about 15 miles. The average precipitation from July 1 to June 30 at Yreka and Montague is about 17 and 12 inches, respectively, and the average annual temperature at Yreka is 51.5°F. The area has a population of about 12,000, most of whom are employed in farming, cattle raising, and lumbering. The farm income is derived chiefly from livestock, principally beef cattle, hogs, and sheep. Alfalfa, wheat, barley, oats, and rye are the main crops grown in the valley.

The Klamath Mountains are underlain by metamorphic and sedimentary rocks of Paleozoic age and by intrusive rocks of Mesozoic age that form the basement complex. Near Yreka the Chico formation of Late Cretaceous age, which is composed of shale, sandstone, and some conglomerate, overlies the older rocks with profound unconformity. The Chico formation in turn is overlain disconformably by the Umpqua formation of Eocene age, which consists mainly of black shale. These rocks are covered by a thin veneer of older alluvium which floors much of the northern part of the valley.

Volcanic rocks make up much of the valley floor from Montague southward to Edgewood. The southeastern, flatter part of the valley is occupied by the Plutos Cave basalt, which is a relatively large single flow erupted from the northeast flank of Mount Shasta within the last few thousand years. The western half of the valley floor is occupied largely by the older volcanic rocks of the western Cascades, which range in age from Eocene to Miocene and which have been eroded into hillocks that range in height from a few feet to as much as 300 feet. Between these hillocks lie many small ponds and marshes and the alluvial flats formed by slow, winding streams.

The valley is drained principally by the Shasta River and Parks Creek, which rise in the Klamath Mountains, and the Little Shasta River, which rises in the high Cascades. The volcanic rocks of the high Cascades were built by eruptions that commenced at the close of the Miocene epoch and continued intermittently to Recent time. Mount Shasta was built mainly during the Pleistocene epoch.

Morainal and fluvioglacial deposits, which are concentrated at the south end of the valley, were formed mainly during Pleistocene time by glaciers that descended the northwest flanks of Mount Shasta. Glaciers still remain

on Mount Shasta and have supplied fluvioglacial debris to the valley during Recent time.

The Plutos Cave basalt constitutes the principal aquifer in the valley, yielding abundant water for irrigation, stock, and domestic wells in the vicinity of Big Springs. Yields of irrigation wells in the basalt average about 1,300 gpm (gallons per minute). The andesitic lavas of the western Cascades supply sufficient water for domestic and stock uses. Yields of wells tapping the andesites vary greatly because of rapid changes in lateral and vertical permeability. Abundant water for irrigation is yielded from fractures in the volcanic rocks of the western Cascades in the Gazelle-Grenada area.

The basement complex and the Chico and Umpqua formations are tapped by relatively few wells in the area, although locally these wells seem to yield sufficient water for domestic and stock uses. The basement complex yields water from joints, faults, shear zones, and openings along foliation planes.

The morainal and fluvioglacial deposits generally yield sufficient water for domestic and stock uses. Several irrigation wells tapping glacial materials east of Edgewood yield 600 to 1,500 gpm. The younger and older alluviums of Recent and Pleistocene age yield water sufficient for domestic and stock uses. Along the west side of the valley the younger alluvium yields sufficient water for irrigation and supplies Yreka with abundant water for municipal uses.

Ground water moves generally northward in the southern part of Shasta Valley and troughward from the east and west, converging toward the Shasta River along the valley axis. At the north end of the valley an eastward-trending divide separates the ground water that moves north to Willow Creek from ground water that moves south to the Shasta River.

Recharge to ground water is effected by deep infiltration of precipitation that falls on the tributary drainage area, principally the western slopes of Mount Shasta, and by seepage from streams. The mean annual precipitation on the valley floor of 12–15 inches probably is not sufficient to contribute much recharge to ground water, but during years of above-average precipitation some deep penetration probably occurs. Recharge from irrigation water in 1953 was about 15,000 acre-feet from a total surface-water diversion of 58,000 acre-feet, and recharge from ground water pumped for irrigation was about 2,000 acre-feet.

Ground-water discharge in Shasta Valley occurs principally by seepage into streams, which is estimated crudely to have been 70,000 acre-feet in 1953. Big Springs has an annual discharge of about 30,000 acre-feet. Evapotranspiration from subirrigated crops is estimated to have been 28,000 acre-feet in 1953. Pumpage for all uses in 1953 was approximately 6,000 acre-feet, and net draft was about 4,000 acre-feet. Ground-water discharge in 1953 by all these principal means was about 130,000 acre-feet. In addition, there was minor discharge from flowing wells, unestimated discharge from small springs on the valley floor, and evapotranspiration losses from relatively small areas of phreatophytes.

Because of the relatively small pumpage in the valley, water levels in wells show declines of only 5–10 feet during the summer and autumn. So far as is known, the levels each winter and spring recover nearly completely, and as of 1953 there had been no indication of a long-term decline of water levels in the valley.

Surface water and ground water are generally low in dissolved mineral content and with few exceptions meet minimum standards for irrigation and domestic use. A close correlation exists between the composition of the various rock types in the area and the mineralization of surface and ground waters in areas adjacent to each rock type.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

In June 1953 the United States Geological Survey undertook a reconnaissance investigation of the geology and ground water of Shasta Valley, Siskiyou County, Calif., as part of a cooperative program with the California Division of Water Resources (now California Department of Water Resources). The investigation and report were to include the following elements: The extent and thickness of the water-bearing rocks, the physical character and hydrologic properties of the rocks, the occurrence and movement of ground water, the chemical character of ground water and its relation to occurrence, movement, and use, and an estimate of the ground-water storage capacity of the rocks insofar as practicable. The last element—estimating the ground-water storage capacity—was abandoned, finally, because of the difficulty in assigning rational values to the specific yield of the volcanic rocks that underlie much of Shasta Valley. All the other elements of the investigation are discussed in the present report. In addition the report contains records of water wells, chemical analyses, water-level fluctuations, and drillers' logs of wells.

This study was started under the general supervision of J. F. Poland and was completed under the supervision of his successor, G. F. Worts, Jr., district geologist of the Ground Water Branch of the Geological Survey in charge of ground-water investigations in California; and under the direct supervision of A. R. Leonard, geologist. P. R. Wood, geologist, inventoried the springs and made periodic water-level measurements in wells in Shasta Valley.

LOCATION OF THE AREA

Shasta Valley, which is in the central part of Siskiyou County, lies between the Klamath Mountains on the west and the Cascade Range on the east. The valley area investigated has a north-south length of about 30 miles, a maximum width of about 15 miles, and an area of about 250 square miles. The area mapped lies between long 122°15′ and 122°40′ W., and lat 41°25′ and 41°55′ N. and is included within the Yreka, Macdoel, Etna, and Dunsmuir topographic quadrangle maps of the Geological Survey (scale 1:125,000). Figure 1 shows the location of Shasta Valley and other areas in the upper Klamath River basin of California for which reconnaissance ground-water investigations have been made by the Geological Survey. Plate 1 shows the geology of Shasta Valley and the location of wells and springs.

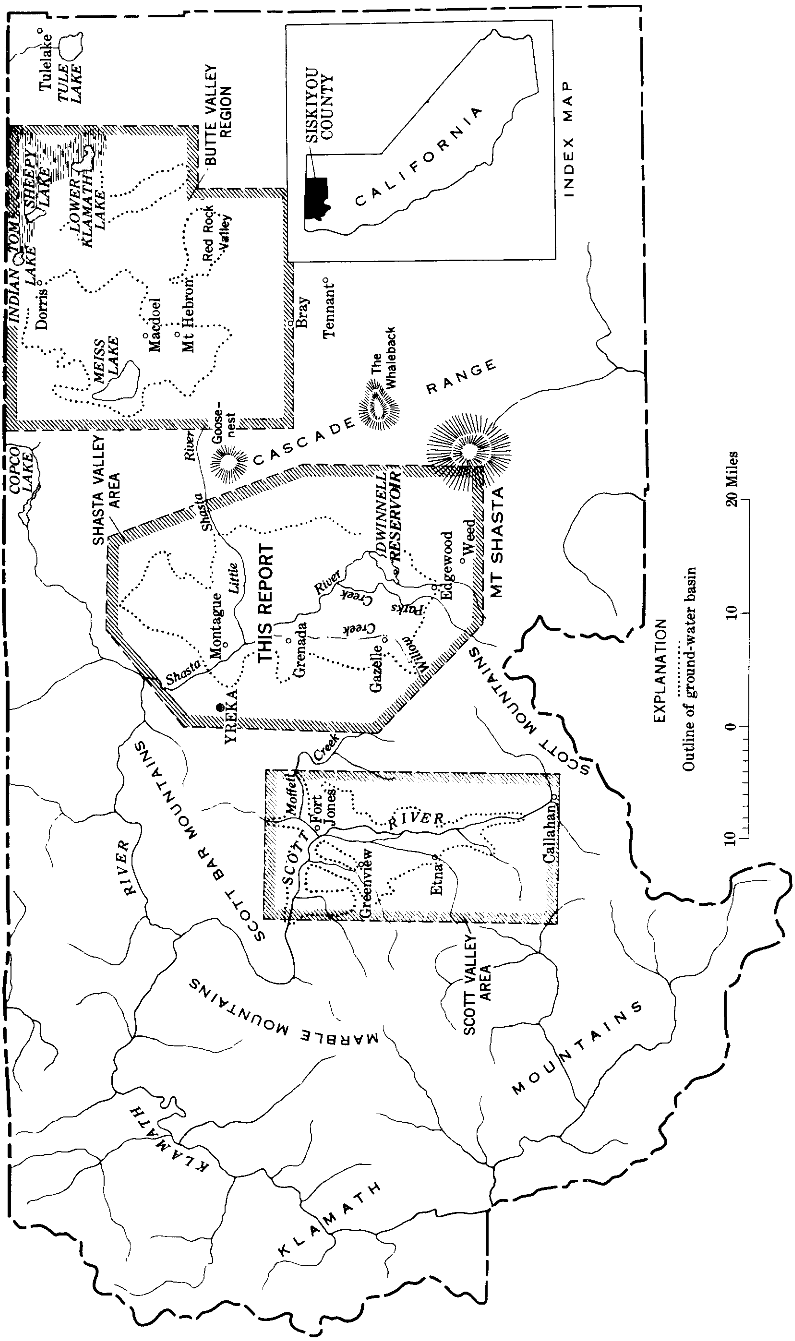

FIGURE 1.—Map of Siskiyou County, Calif., showing location of valleys investigated for Upper Klamath project.

METHODS OF INVESTIGATION

During the summer and autumn of 1954, the writer spent about 3 months in the field inventorying wells, mapping the geology, and studying the ground-water hydrology of Shasta Valley. Water-level measurements were made in the spring and autumn of 1953 and the spring of 1954 by the Geological Survey and the California Division of Water Resources. The land-surface altitude at each well was determined by interpolation between 5-foot contours on topographic maps of Shasta Valley, scale 1:24,000, prepared in 1922 by the Geological Survey in cooperation with the U.S. Bureau of Reclamation and the State of California. General information regarding the character and thickness of the water-bearing materials and yields of wells was obtained from drillers' logs and from the well owners in the area.

Geologic boundaries were mapped on aerial photographs at a scale of 1:47,000, and later were transferred to the base map at a scale of 1:62,500, which had the Yreka, Macdoel, Etna, and Dunsmuir quadrangles. Wells were located by measuring distances with an odometer from section corners, section lines, and roads.

Howel Williams (1949) mapped the geology of the eastern part of the valley which composes approximately 65 percent of the area shown on plate 1. The writer mapped the remainder of the valley for the present report, namely the area west of Montague and south of Gazelle.

PREVIOUS INVESTIGATIONS

In an early report, Waring (1915) described several springs along the east side of Shasta Valley, and in 1923 Watson, Wank, and Smith mapped the soils in the valley. Averill (1931, 1935) and O'Brien (1947) described the mineral resources of the area. Averill's 1931 report was accompanied by a geologic map (scale 1:250,000) of the Shasta quadrangle, prepared by the Geological Department of the Southern Pacific Company. The geology of the valley floor was not mapped, and only the broader geologic features along the west side of Shasta Valley are shown on the map.

Hinds (1931, 1932, 1933) described the stratigraphy of the southern Klamath Mountains, much of which is especially pertinent to the pre-Cretaceous rocks along the west side of the valley. Heyl and Walker (1949) described the geology of a limestone deposit near Gazelle. Callaghan (1933) and Callaghan and Buddington (1938) described the volcanic sequence in the Cascade Range in Oregon, which is similar to that found in the Shasta Valley area.

In a report on the Macdoel quadrangle, Williams (1949) described the geology of the eastern part of Shasta Valley and the surrounding high Cascades volcanoes. Williams mapped and established many of the geologic units discussed in the present report, and a large part of the geologic map (pl. 1) is based on Williams' map. Circular soil structures in the fluvioglacial deposits at the south end of the valley were described by Masson (1949).

ACKNOWLEDGMENTS

Acknowledgment is made to the residents of Shasta Valley who assisted in the collection of field data used in this report and supplied hydrologic data concerning their wells. Messrs. R. B. Bond, S. T. Pyle, B. H. Hoffmaster, B. T. Bower, R. E. Franson, and H. J. Peters of the California Division of Water Resources supplied various hydrologic data used by the writer and canvassed about 80 percent of the wells shown in table 19. Messrs. Don Enloe and E. C. Maples, well drillers, furnished logs and hydrologic data on wells drilled in Shasta Valley. Mr. John M. Nichols of the Montague Soil Conservation District and Mr. C. B. Kay of Montague furnished valuable information concerning the local geology and hydrology.

WELL-NUMBERING SYSTEM

The well-numbering system used by the Geological Survey in California since 1940 shows the location of wells and springs according to the rectangular system for the subdivision of public land. For well 45/7–35B1, the part of the number preceding the hyphen indicates the township and range (T. 45 N., R. 7 W.); the digits between the hyphen and the letter indicate the section (sec. 35), and the letter indicates the 40-acre subdivision of the section as shown in the accompanying diagram.

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

Within each 40-acre tract the wells and springs are numbered serially, as indicated by the final digit of the number, thus, well 45/7-36D2 is the second well to be listed in the NW¼NW¼ sec. 36. Because all the area in Shasta Valley is north and west of the Mount Diablo baseline and meridian, the foregoing abbreviations of the township and range are sufficient.

Incomplete numbers which lack the final digit, such as 45/6-4P, indicate locations of sampling points or rock outcrops described in the text that are approximate to the 40-acre tract indicated by the letters.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

Shasta Valley is a nearly oval intermontane basin. The valley floor lies between altitudes of 2,400 and 2,800 feet and slopes generally northward. West of the valley the Klamath Mountains are underlain, in the area studied, by metamorphic and sedimentary rocks of Paleozoic age and intrusive rocks of Mesozoic age. Many of the higher peaks are snow covered in early summer. The highest peak, Mount Eddy (not shown on fig. 1), about 9 miles southwest of Weed, attains an altitude of 9,038 feet.

The western part of Shasta Valley is underlain (pl. 1) chiefly by Quaternary alluvium deposited by the Shasta River and its tributaries, and by volcanic rocks of Eocene, Oligocene, and Miocene age characteristic of the western Cascades (Callaghan and Buddington, 1938, p. 6). Williams (1949, p. 11) described the topography developed on the volcanic rocks as follows:

> The western half [of the valley] consists of older volcanic rocks eroded into a myriad of hillocks that range from a few feet to 200 and rarely to 300 feet in height. Most of these hillocks are domical, some are conical, others are mesas, and a few are long, hogback ridges. Together they form a strange landscape, deceptively like the products of recent volcanic activity.

The eastern half of the valley, which is much flatter than the western part, is occupied largely by an extensive flow of basaltic lava relatively recently erupted from the flanks of Mount Shasta. This flow, named by Williams (1949) the Plutos Cave basalt, covers more than 50 square miles and is featured topographically by caves or lava tubes, schollendomes (oval mounds formed by hydrostatic pressure of liquid lava under the congealed crust), pressure ridges along the margins, and collapse depressions in the lower part of the flow. Despite these irregularities, the surface of the Plutos Cave basalt is fairly uniform when viewed from a distance. The slope of the surface of the flow is about 5° near the area of eruption on the flanks of Mount Shasta and to nearly horizontal in the heart of Shasta Valley.

On the east, Shasta Valley is bounded by the Cascade Range, a broad northward-trending series of giant volcanoes ranging in age from Pliocene to Recent. The volcanoes of Pliocene age are deeply eroded, whereas the more youthful volcanoes, which were formed by effusions during Pleistocene and Recent time, have been only slightly dissected. The most prominent volcano of the high Cascades (Callaghan and Buddington, 1938, p. 6) is Mount Shasta, which rises to an altitude of 14,162 feet at the south end of the valley. Its peak, snow-covered the year round, is the most conspicuous feature of the landscape and can be seen from all parts of the valley. Several glaciers lie on its upper slopes. On its north slope Whitney, Bolam, and Hotlum Glaciers descend to altitudes of about 10,000 feet. On the south slope the Konwakiton Glacier descends to an altitude of 12,000 feet, and the Clear Creek and Winton Glaciers to about 11,000 feet.

During the Pleistocene epoch, glaciers that descended the northwest slopes of Mount Shasta spread into Shasta Valley to an altitude of about 2,800 feet. The record of this glaciation is preserved in the southern part of the valley in the form of morainal hills and ridges, remarkably similar in appearance to the erosional remnants of the volcanic rocks of the western Cascades and in bouldery outwash deposits that extend from the shores of Dwinnel Reservoir southward to Weed. Fluvioglacial materials derived from the Whitney, Bolam, and Hotlum Glaciers are still being deposited on the lower northwest flank of Mount Shasta as broad fans which are spreading over the edges of the Plutos Cave basalt.

The northern part of Shasta Valley is underlain by a wide belt of older alluvium deposited for the most part as fans upon the eroded surface of sandstone of Late Cretaceous age (Chico formation), sandstone and shale of Eocene age (Umpqua formation), and the volcanic rocks of the western Cascades. The landscape in this part of the valley is gently rolling, particularly in the area west of Montague where only a thin veneer of alluvium rests on the Chico formation.

The drainage basin of the Shasta River and its tributary streams has an area of about 800 square miles. The floor of Shasta Valley occupies about 250 square miles of this area and contributes little runoff in years of average or below-average precipitation. Local runoff in the valley may flow into depressions and then percolate into the ground without reaching the main surface streams, but the volume probably is small. Most of the runoff occurs along that part of the west side of the valley adjacent to the Klamath Mountains. By contrast, most of the east-side streams that cross the lava flows of the high Cascades normally do not maintain a flow as far west as Shasta Valley, owing to the porous nature of the lava. The major streams that drain the area are the Shasta River, Parks Creek, and the Little Shasta River. The Shasta River and Parks Creek rise in the mountains southwest of Shasta Valley in an area that has an annual precipitation of 40–50 inches. Because of the heavy precipitation, the steep mountainous slopes, and the relatively impermeable nature of the serpentine bedrock in its drainage system, the Shasta River has the highest runoff rate of any stream entering the valley. Discharges of 58,400 acre-feet in 1952–53 and 53,100 acre-feet in 1953–54 were recorded at the gaging station near Edgewood.

About 4 miles downstream from Edgewood, the Shasta River enters Dwinnel Reservoir, and then flows through the hillocks and knolls of lava of the western Cascades for several miles to its junction with Parks Creek about 2 miles southwest of Big Springs. From this point the Shasta River is a sluggish stream trending northwestward through the Grenada and Montague areas until it leaves the valley about 5 miles northwest of the town of Montague. At the valley outlet the river becomes a vigorous downcutting stream and tumbles through a narrow, rocky gorge carved in resistant, strongly jointed greenstone through which it descends to join the Klamath River at a point immediately northwest of the area shown on plate 1. The Little Shasta River, which rises in the high Cascades between Goosenest and Willow Creek Mountain (east of the area shown on pl. 1), flows sluggishly westward across the north-central part of Shasta Valley for approximately 9 miles to join the Shasta River about 2 miles south of Montague. Table 1 lists the measured discharge for the water years 1953 and 1954 of the Shasta and Little Shasta Rivers and Parks Creek near the entrance to Shasta Valley at gaging stations maintained by the California Division of Water Resources. The water year covers the period October 1 to September 30, and each year is designated by only one calendar year; thus, 1953 is used rather 1952–53.

The Geological Survey has maintained a gaging station on the Shasta River downstream from the valley outlet about 6 miles north of Yreka, the station being designated in published reports as Shasta River near Yreka. Records are available for the years 1932–33 to 1940–41 and 1945–46 to 1952–53. The average annual discharge for the 17 years was 167 cfs (cubic feet per second), or

TABLE 1.—*Measured discharge in acre-feet, of Shasta and Little Shasta Rivers and Parks Creek at gaging stations near the entrance to Shasta Valley*

[Data from California Division of Water Resources]

Water year	October	November	December	January	February	March	April	May	June	July	August	September	Total
Shasta River at Edgewood													
1952–53	841	1, 644	6, 121	13, 400	4, 854	5, 127	6, 853	8, 555	6, 889	3, 041	495	571	58, 391
1953–54	1, 242	6, 914	4, 338	6, 869	8, 075	6, 807	7, 363	7, 222	2, 251	344	728	910	53, 063
Parks Creek west of Yreka Ditch													
1952–53	-------	[1] 380	600	4, 056	1, 751	1, 386	2, 993	3, 933	4, 832	1, 674	413	207	22, 025±
1953–54	408	1, 500	1, 031	1, 069	1, 853	2, 370	4, 887	4, 596	1, 392	365	212	[1] 200	19, 883±
Little Shasta River near Table Rock													
1952–53	[1] 400	280	419	2, 225	1, 543	2, 517	2, 719	4, 961	4, 179	1, 349	659	539	21, 790±
1953–54	455	963	1, 308	804	1, 775	2, 261	3, 299	2, 394	1, 047	507	401	337	15, 551

[1] Estimated monthly runoff based on incomplete data.

about 120,900 acre-feet (Wells and others, 1956, p. 543). Figure 2 shows the annual discharge reported by the Geological Survey and the annual precipitation recorded by the U.S. Weather Bureau at Yreka. The plotted discharge figures are for the water year October 1 to September 30; the precipitation figures are for the climatological year July 1 to June 30. In general the two graphs show a rather close correlation. However, the ratio of stream discharge to precipitation does vary, as may be seen by comparing the records for the years 1937–38 and 1940–41. In 1937–38, precipitation of 26.5 inches resulted in runoff of 208,500 acre-feet; in 1940–41, precipitation was 6.22 inches less than the 1937–38 total, yet runoff was 210,600 acre-feet. Deviations such as these are caused mainly by variations in the storm-frequency pattern of rainfall, and partly by regulation of the flow of the Shasta River at Dwinnel Reservoir at the south end of Shasta Valley. The flow of the stream is affected also by the many irrigation diversions upstream from the gaging station.

CLIMATE

The climate of Shasta Valley is of the Mediterranean type and is well suited to stock raising and grain growing, the principal agricultural pursuits in the area. The growing season, from the last killing frost in the spring to the first killing frost in the autumn, averages about 130 days.

The annual rainfall cycle is common to most of the Pacific Northwest—summer and autumn are dry, and precipitation occurs mainly during the winter and early spring. The wet season lasts from October to April, when temperatures are moderate to low. In Shasta Valley the temperature at times drops to zero, and some snow falls nearly every winter. During the summer, temperatures higher than 100°F are often recorded, but such hot periods generally are short. The mean annual temperature at Yreka is 51.5°F. During the wet season it averages about 41°F and during the dry season, approximately 62°F. July, the hottest month, has an average temperature of 71.5°F, and January, the coldest month, 33.6°F.

In general the amount of precipitation at any place and the proportion of precipitation that falls as snow are related directly to the altitude. The upland regions of the Klamath Mountains and Cascade Range, which receive the heaviest snowfall and greatest total precipitation in the area, are covered by thick stands of ponderosa pine, Douglas fir, white fir, incense-cedar, and tamarack pine and scattered groves of aspen, maple, and oak. The eastern part of the Klamath Mountains receives 20–50 inches of precipita-

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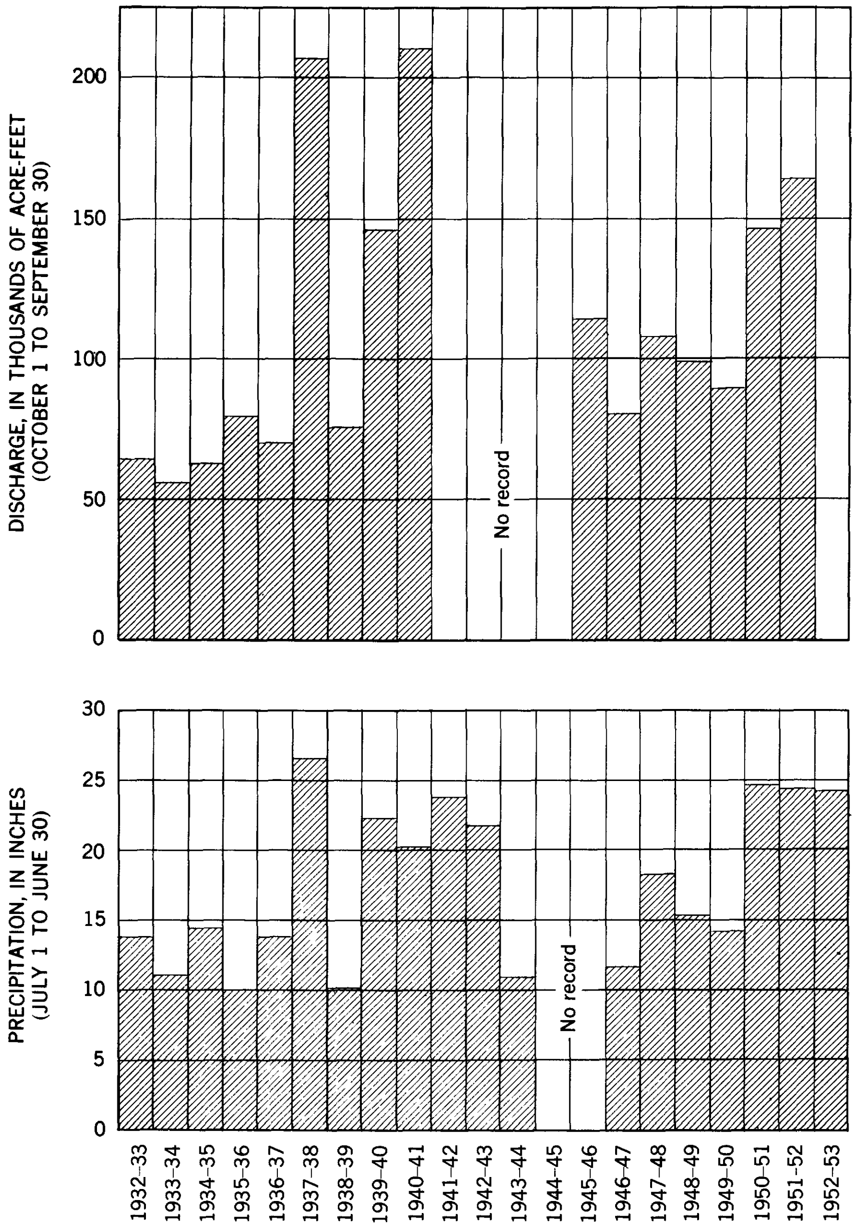

FIGURE 2.—Annual discharge of Shasta River near Yreka and precipitation at Yreka.

tion annually, and the Cascade Range receives 30–70 inches (California State Water Resources Board, 1951, pl. 3). Precipitation on the valley floor is much less than in the surrounding mountains. At Yreka, which is separated from Shasta Valley by the northeastward-trending ridge known locally as Butcher Hill, the mean annual (July 1 to June 30) precipitation for the 73 years, 1872–1907, 1916–44, and 1947–54 was 17.49 inches. The extremes of annual precipitation for the period of record are a low of 7.89 inches in 1923–24 and a high of 31.29 inches in 1903–04. At Montague, about 6 miles east of Yreka, the annual precipitation for the period 1889–1952 averaged 12.20 inches. Precipitation extremes there were 4.14 inches in 1897–98 and 24.19 inches in 1889–90. Near the south end of the valley at Edgewood the annual precipitation for the period 1888–89 to 1914–15 averaged 20.42 inches, and the extremes were 9.42 inches in 1898–99 and 36.34 inches in 1889–90.

U.S. Weather Bureau records of annual precipitation at Yreka, Montague, and Edgewood are summarized in table 2. Average monthly precipitation and temperature data for the station at Yreka are summarized in tables 3 and 4, respectively.

TABLE 2.—*Annual precipitation, in inches, at Yreka, Montague, and Edgewood, Calif.*

[Data from publications of the U.S. Weather Bureau]

Year ending June 30	Yreka	Montague	Edgewood
1871–72	14.25		
1872–73	12.04		
1873–74	12.77		
1874–75	10.20		
1875–76	22.04		
1876–77	14.02		
1877–78	18.73		
1878–79	13.32		
1879–80	17.57		
1880–81	20.48		
1881–82	13.08		
1882–83	12.16		
1883–84	16.20		
1884–85	19.68		
1885–86	18.95		
1886–87	19.03		
1887–88	15.70		
1888–89	10.42	7.37	15.90
1889–90	30.42	24.19	36.34
1890–91	12.92	9.87	13.35
1891–92	14.12	5.63	11.11
1892–93	16.53	9.26	24.46
1893–94	30.50	17.27	18.32
1894–95	19.75	7.05	21.84
1895–96	23.28	11.04	19.89
1896–97	20.84	11.42	19.18
1897–98	13.05	4.14	16.76
1898–99	12.41	6.31	9.42
1899–1900	18.11	11.42	19.10
1900–01	23.55		16.36

TABLE 2.—*Annual precipitation, in inches, at Yreka, Montague, and Edgewood, Calif.*—Continued

[Data from publications of the U.S. Weather Bureau]

Year ending June 30	Yreka	Montague	Edgewood
1901–02	19. 34		22. 06
1902–03	16. 12		
1903–04	31. 29	21. 71	
1904–05	20. 28	12. 68	
1905–06	22. 10	13. 17	
1906–07	25. 54	15. 60	26. 71
1907–08		12. 05	20. 72
1908–09		14. 37	25. 42
1909–10		10. 11	16. 46
1910–11		13. 89	23. 91
1911–12		14. 97	15. 45
1912–13		13. 69	14. 80
1913–14		19. 04	33. 58
1914–15		12. 99	28. 71
1915–16	17. 29	11. 03	
1916–17	12. 67	11. 07	
1917–18	11. 08	7. 93	
1918–19	19. 63	14. 12	
1919–20	9. 25	6. 84	
1920–21	21. 96	16. 16	
1921–22	14. 61	9. 76	
1922–23	13. 80	11. 96	
1923–24	7. 89	6. 74	
1924–25	26. 25	14. 15	
1925–26	11. 83	9. 80	
1926–27	27. 38	20. 51	
1927–28	15. 39	12. 52	
1928–29	11. 33	8. 91	
1929–30	14. 88	12. 16	
1930–31	13. 46	7. 78	
1931–32	15. 32	11. 04	
1932–33	13. 75	7. 81	
1933–34	11. 07	8. 22	
1934–35	14. 44	10. 74	
1935–36	19. 81	12. 90	
1936–37	13. 85	10. 96	
1937–38	26. 50	18. 20	
1938–39	10. 16	6. 35	
1939–40	22. 29	17. 99	
1940–41	20. 28	16. 24	
1941–42	23. 63	17. 13	
1942–43	21. 85	15. 51	
1943–44	10. 89	10. 55	
1944–45		14. 58	
1945–46		11. 35	
1946–47	11. 61	8. 86	
1947–48	18. 31	13. 43	
1948–49	15. 30	12. 16	
1949–50	14. 21	9. 25	
1950–51	24. 60	14. 12	
1951–52	24. 42	16. 36	
1952–53	24. 23		
1953–54	20. 50		
Average	17. 49	12. 20	20. 42

TABLE 3.—*Average monthly precipitation at Yreka, Calif., 1872–1954*

[Data from publications of the U.S. Weather Bureau]

Month	Precipitation (inches)	Month	Precipitation (inches)
January	3. 06	July	6. 35
February	2. 33	August	. 28
March	1. 65	September	. 47
April	1. 03	October	1. 23
May	. 99	November	2. 38
June	. 67	December	3. 04
		Average annual total	17. 49

TABLE 4.—*Average monthly temperature at Yreka, Calif., 1903–55*

[Data from publications of the U.S. Weather Bureau]

Month	Temperature (°F)	Month	Temperature (°F)
January	33. 6	July	71. 5
February	38. 4	August	70. 5
March	43. 7	September	62. 5
April	49. 2	October	52. 4
May	56. 2	November	41. 6
June	63. 6	December	35. 0
		Average annual total	51. 5

TRANSPORTATION

U.S. Highways 97 and 99 connect the Shasta Valley area with nearby cities in Oregon and northern California. Highway 97, linking Weed, Calif., with Klamath Falls, Oreg., crosses the valley on the east side, following the main line of the Southern Pacific Railroad; Highway 99, along the west side of the valley, links Weed with Yreka and with Medford, Oreg. A system of State and county roads branches from Highways 97 and 99 and provides access to points within the flat farming country of the valley. The Siskiyou County Airport at Montague provides air transportation via Southwest Airlines to many communities in Oregon and northern California.

POPULATION

According to the 1950 census, Yreka, the county seat of Siskiyou County, had a population of 3,139, and Montague, a dairying and stockraising center east of Yreka, a population of 571. Weed, a large unincorporated town at the south end of Shasta Valley, is a logging and lumbering center whose estimated population is 4,000.

Edgewood, Gazelle, and Grenada are small unincorporated towns in the valley having a total population of about 400. The total urban and farm population in the Shasta Valley area in 1953 was estimated by the California Division of Water Resources (Horn and others, 1954, p. 28) to be about 12,000.

AGRICULTURE

Most of the farm income in Shasta Valley is derived from the sale of livestock, principally beef cattle, hogs, and sheep. Cattle are herded over large areas of mountainous rangeland in the summer, and many more are pastured on the poorer lands on the valley floor. Cattle that summer in the mountains usually are driven down into the valley in November and fed on alfalfa hay for about 3 months before marketing. Most of the cattle shipped from the valley are marketed in central California. The ranges and pasturelands unsuited to cattle are profitably devoted to sheep grazing. The dairy industry is developed around the towns of Montague, Grenada, and Edgewood.

Alfalfa, wheat, barley, oats, and rye are the most important crops grown in the valley. Small areas of wild grasses, timothy, and clover occupy the poorly drained parts of the valley in which the soils are underlain by hardpan and are not suited to growing alfalfa. Alfalfa is grown on the best soils of the valley where abundant water is available. Most of the alfalfa is used for livestock feed in the valley; only the surplus is baled and shipped. Onions, lettuce, radishes, squash, and melons are grown for local use.

MINERAL RESOURCES

Coal.—Thin beds of lignite and subbituminous coal, which dip to the northeast at angles of 15° to 20°, are found in the Umpqua formation at several localities along the west side of the valley (Williams, 1949, p. 57). The principal workings are about 5 miles south of Ager and a few hundred feet west of the Ager-Montague road. The main coal seam averages about 2 feet in thickness and reaches a maximum thickness of 6 feet. The deposits were not being mined in 1954.

Copper and molybdenum.—Small amounts of copper and molybdenum have been obtained from the Yellow Butte mine in the W½ sec. 25, T. 43 N., R. 4 W., on the northeast slope of Yellow Butte. Production came from highly fractured and mineralized shear zones in a body of coarse-grained hornblende-biotite quartz monzonite near the contact with siliceous schist and quartzite of the Abrams mica schist. The incline shaft is caved and the old workings are inaccessible, but the dump shows specimens of white quartz containing pyrite, chalcopyrite, and some molybdenite.

Construction materials.—Most of the different types of rocks in the area are used locally for building stone, concrete aggregate, or road metal. Sandstone of Cretaceous age has been quarried for building stone from an outlier about 2 miles northeast of Yreka. The strongly jointed Plutos Cave basalt, owing to the ease with which it breaks into cuboidal blocks, is used extensively by ranchers in the construction of stone fences. Platy-jointed andesite from the western Cascade lavas is quarried on a large scale from a hillock in sec. 25, T. 45 N., R. 6 W., for use in road surfacing. Several other quarries in the andesite have been worked for road metal, but on a much smaller scale. Rhyolitic lava from Owls Head in sec. 16, T. 44 N., R. 5 W., and near Little Shasta River in sec. 36, T. 45 N., R. 5 W., also has been used for road surfacing. Basaltic cinders are quarried for road metal from a cinder cone in sec. 26, 27, T. 43 N., R. 4 W., near Yellow Butte.

Sand and gravel of the Recent alluvium in Yreka Creek, north of the Yreka city limits, have been found well suited for concrete aggregate, road material, and general construction in the area. Near U.S. Highway 97 fluvioglacial deposits from a large fan built up by Whitney Creek have been worked on a small scale for local use on roads.

Gold.—The original settlement of the area by white men dates from the discovery of gold in Trinity County in 1848. Many placer deposits were worked along the west side of Shasta Valley in those days, but in the 1850's, as ever increasing numbers of miners came into the area and as the available gold became scarce, some of the settlers turned to agriculture and started raising such staple commodities as corn, wheat, and beef for the growing population. In recent years, in addition to small-scale placer operations, gold has been recovered from quartz veins generally occurring in greenstone, and by dredging operations along Yreka Creek and other west-side streams. Gold mining came virtually to a halt with the advent of World War II and has not recovered since the end of the war, owing to the fixed price of gold and the rising cost of labor.

GEOLOGY

GENERAL CHARACTER AND AGE OF THE ROCKS

The rocks of the Shasta Valley area range in age from early Paleozoic to Recent. The oldest rocks are the Abrams mica schist of early Paleozoic age and the Chanchelulla formation of Hinds (1931), which underlie the Klamath Mountains from the vicinity of Gazelle northward to Yreka. The Abrams mica schist makes up most of Yellow Butte, an elongate fault block at the foot of Mount Shasta. Meta-andesite, correlative with either the Copley greenstone of pre-Middle Devonian age or the Applegate group of Triassic(?) age, underlies the rugged hills known as Paradise Crags or Paradise Craggy in the area north of Yreka. The older rocks are intruded by serpentinized ultrabasic rocks and by granitic rocks of Late Jurassic or Early Cretaceous age. These rocks of pre-Late Cretaceous age were not differentiated on the geologic map (pl. 1) and are mapped together as "basement complex."

Near Yreka, at the western margin of Shasta Valley, marine sandstone and conglomerate of Late Cretaceous age, the Chico formation, overlie the older rocks with profound unconformity. The Chico in turn is overlain disconformably by the Umpqua formation of Eocene age, which consists mainly of shale, sandstone, and conglomerate, among which are a few thin beds of coal. Volcanic rocks make up much of the valley floor. The western half is underlain largely by volcanic rocks of the western Cascades which consist principally of lava and pyroclastic beds ranging in age from Eocene to Miocene. The high Cascades, which border Shasta Valley on the east, were built by volcanic eruptions that commenced at the close of the Miocene epoch and continued intermittently to Recent time. Mount Shasta was built mainly during the Pleistocene epoch. The Plutos Cave basalt, which covers an extensive area in the southeastern part of the Valley, was erupted during Recent time, probably no more than a few thousand years ago.

Morainal and fluvioglacial (outwash) deposits at the south end of the valley were laid down during the later part of the Pleistocene epoch by glaciers that descended the northwest flank of Mount Shasta. Alluvial fans of outwash, supplied by melt waters from the Whitney Glacier, are still accumulating. Older alluvium mantles much of the northern part of Shasta Valley in the vicinity of Montague, and although the deposits are now being dissected they are probably at least in part of Recent age. At the present time the Shasta River and its tributaries are alluviating their courses.

The various stratigraphic (geologic) units that were distinguished in this study, their general character, and their water-bearing properties are summarized as follows, and their areal distribution is shown on plate 1. Stratigraphic relations and structure are shown by the cross sections on figures 3 and 8.

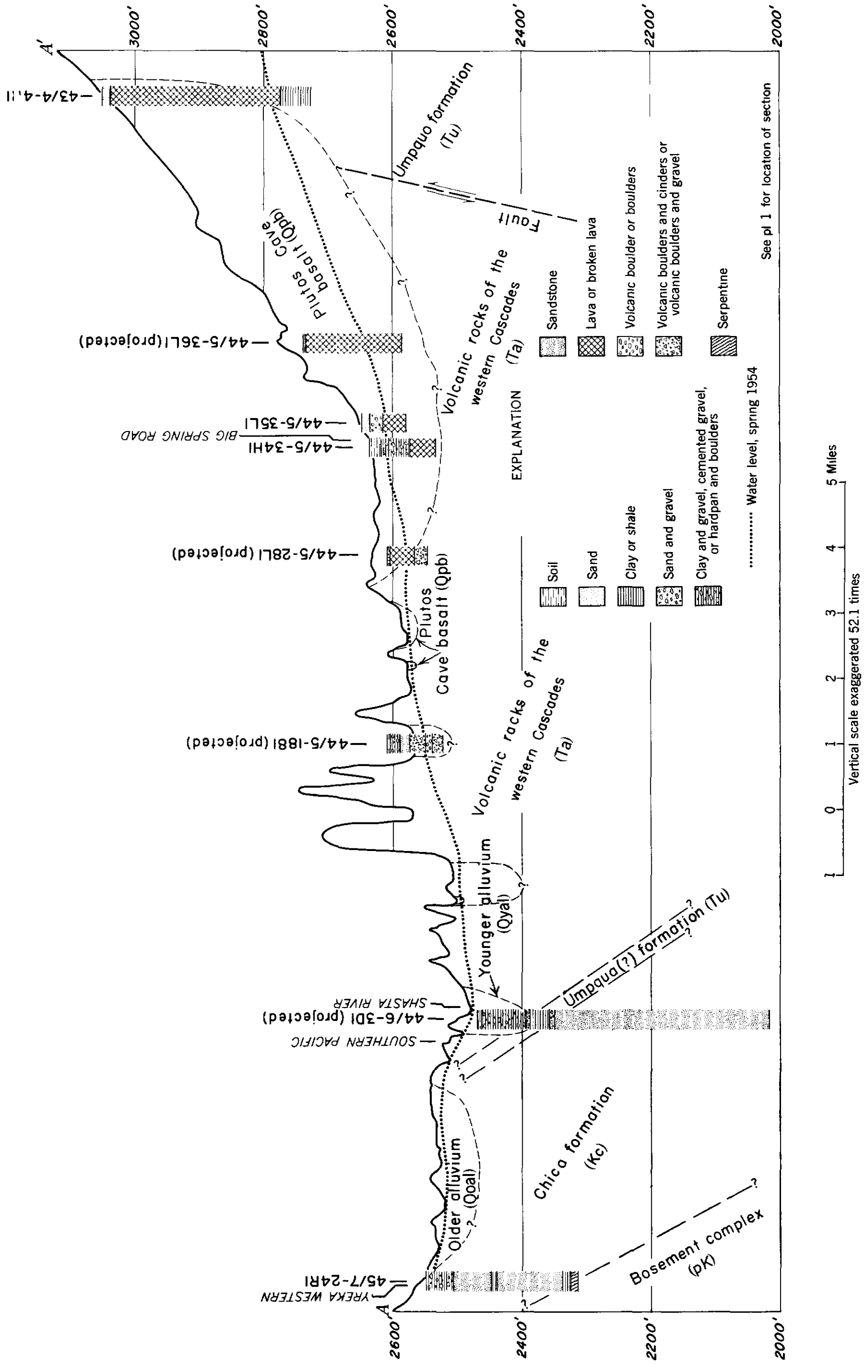

FIGURE 3.—Geologic section *A–A'* across Shasta Valley.

Geologic units of Shasta Valley, California

	Age	Geologic unit on pl. 1	Thickness (feet)	General character	Water-bearing properties
Quaternary	Recent	Younger alluvium	0–140±	Unconsolidated stream-channel, flood-plain, and alluvial-fan deposits consisting of lenses of sand, gravel, and some clay.	Fairly permeable. Yield sufficient water for domestic and stock uses and locally along the west side of the valley for irrigation use. Gravelly deposits near Yreka Creek yield abundant water for municipal use to Yreka.
		Plutos Cave basalt	0–400±	Black vesicular olivine-rich augite basalt.	Constitutes the principal aquifer in Shasta Valley, yielding abundant water to irrigation, stock, and domestic wells in the vicinity of Big Springs. The amounts from irrigation wells vary considerably but average about 1,300 gpm.
	Recent to Pleistocene	Older alluvium	0–90±	Unconsolidated deposits consisting of poorly sorted boulders, gravel, sand, and clay. Contains a persistent layer of hardpan about 1 foot thick which commonly is found 10–16 inches below land surface. Underlies much of the northern part of the valley in the vicinity of Montague.	Generally less permeable than the younger alluvium. Yields are small, but generally are sufficient for domestic and stock uses.
		Fluvioglacial and morainal deposits	0–300±	Unconsolidated materials ranging in size from clay to boulders, highly variable in permeability from place to place according to the proportion of fine materials to coarse.	Wide differences in permeability exist within relatively short distances. Irrigation wells tapping glacial deposits east of Edgewood yield 600–1,500 gpm.

Quaternary	Pleistocene	Terrace deposits	0–50 ±	Unconsolidated; gravel and sandy clay along west side of valley.	Unimportant hydrologically because of rather limited extent and position generally above the water table.
	Recent to Pliocene	Volcanic rocks of the high Cascades		Lava flows, consisting mainly of olivine basalt and basaltic andesite.	Very permeable; important as a storage reservoir for much of the ground water that eventually finds its way into Shasta Valley. Springs issue near contact with underlying volcanic rocks of the western Cascades.
Tertiary	Miocene to Eocene	Volcanic rocks of the western Cascades	15, 000 ±	Composed chiefly of andesitic lavas and pyroclastic ejecta and subordinate flows of basalt and dacite, beds of rhyolite tuff, and a few rhyolite domes.	Yields of wells vary greatly because of rapid changes in permeability both laterally and vertically. Supply sufficient water for domestic and stock uses. Yield abundant water for irrigation in Gazelle-Grenada area.
	Eocene	Umpqua formation	800–2, 000	Sedimentary beds of fresh-water origin, consisting mainly of thin-bedded black shale and silty shale, although sandstone and conglomerate are present.	Yield is generally small. Locally yield sufficient water for domestic and stock uses.
Cretaceous	Late Cretaceous	Chico formation		Dominantly well bedded yellow to greenish-gray arkosic sandstone and graywacke. In the uppermost part of the formation, beds of black shale alternate with layers of sandstone.	Tapped by only a few wells in the area. Yields are generally small. Locally yields sufficient water for domestic and stock uses.

Geologic units of Shasta Valley, California—Continued

	Age	Geologic unit on pl. 1	Thickness (feet)	General character	Water-bearing properties
Cretaceous and older	Pre-Late Cretaceous	Basement complex (includes Abrams mica schist, Chanchelulla formation of Hinds (1931) and other rocks, undifferentiated)		Composes the bedrock along the western part of Shasta Valley. Consists of quartzitic schist; slightly metamorphosed sandstone, shale, and limestone; metavolcanic greenstone; and intrusive ultramafic and granitic rocks.	Tapped by only a few wells in the area. Yields are generally small, but structural openings such as joints, faults, shear zones, and openings along foliation planes locally transmit sufficient water for domestic and stock uses.

HYDROLOGIC PROPERTIES OF AQUIFERS

The permeability of any rock is a measure of its capacity to transmit water. Nearly all the rocks that immediately underlie the surface of the earth contain open spaces or interstices which range in size from the minute pores in clay to large lava tunnels such as those found in the Plutos Cave basalt, or great caverns in limestone such as Carlsbad Caverns. The porosity, or percentage of the total volume of the rock occupied by openings, is not necessarily a measure of the ease with which fluids may be transmitted through the rock. If the pore spaces or fractures are not interconnected or if the openings are very small, the rock may have a very low permeability even though the porosity is high. A formation sufficiently permeable to transmit water readily is termed an aquifer.

The permeability of an aquifer can be determined in the field by test pumping. When water is pumped from a well, the water table or piezometric surface develops a depression which has virtually the form of an inverted cone. The apex of the cone is at the water level in the pumped well, and the base is at the original water surface. The height of the cone is equal to the drawdown in the pumped well. The area affected by a pumped well (area of influence) is the land area that has the same horizontal extent as the part of the water surface that is lowered; it is controlled by several factors, one of which is the rate of pumping. The height and slope of the cone in a specific aquifer vary directly with the pumping rate of a well in that aquifer. A well in an aquifer of low permeability will have a larger drawdown than a well in a more permeable aquifer, if both wells are pumped at equal rates.

Specific capacity, a term used to indicate the productivity of a well, is defined as the amount of water in gpm (gallons per minute) that is yielded for each foot of drawdown in the pumped well. It generally is determined after the well has been pumped long enough to stabilize the drawdown. Specific capacities of different wells tapping the same deposit, however, are not necessarily comparable, largely because of differences in depth and in the methods of construction and development of the 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. As originally defined (Poland and others, 1945, p. 57), the yield factor is the specific capacity of the well divided by the thickness in feet of the aquifers yielding or assumed to yield water to the well, multiplied by 100. For the purposes of this report the yield factor is defined as the specific capacity divided by a figure taken to represent the total thickness of saturated material tapped by the well (total depth of well minus the depth to water), multiplied by 100. For a well in which the casing is perforated throughout its length the yield factor, as determined here, affords an approximate measure of the average permeability of the saturated material penetrated by the well. For wells perforated only at selected intervals the yield factor is likely to be a conservative measure of the permeability of the water-producing beds.

In practice it has been found that a crude estimate of the permeability of the deposits can be obtained by multiplying the yield factor by 15 (water-table conditions) or 20 (confined conditions). In several areas of California (Thomasson and others, 1959, p. 220–223) it has been found that under semiconfined conditions, multiplying the yield factor by 17 has given permeability estimates which compare reasonably well with aquifer-test results.

GEOLOGIC UNITS AND THEIR WATER-BEARING PROPERTIES

ROCKS OF PRE-LATE CRETACEOUS AGE

Exposures of the basement complex (pl. 1) are limited to the Klamath Mountains, which border the west side of Shasta Valley, and to Yellow Butte, a narrow northward-trending horst at the northern base of Mount Shasta. No attempt was made to differentiate the various formations of pre-Late Cretaceous age on the geologic map (pl. 1), because the aim of the study was concentrated upon those formations considered to be possible present or future sources of water supply. The basement rocks, however, were mapped and described in the Scott Valley area (Mack, 1955) and include, from oldest to youngest the Abrams mica schist, the Chanchelulla formation of Hinds (1931), greenstone, serpentine, and granitic rocks.

The Abrams mica schist underlies much of the Klamath Mountains from Grenada northward to the vicinity of Paradise Craggy. Except for beds of quartz-epidote-albite schist, which probably are metamorphosed basic tuff, the Abrams mica schist in the Shasta Valley area represents the accumulation of several thousand feet of argillaceous, arenaceous, and calcareous sediments that have undergone considerable recrystallization. Siliceous metasediments appear to compose most of the section throughout the area. Yellow Butte consists mainly of nearly vertical beds of dense bluish-white quartzite and metachert which strike dominantly north.

The Chanchelulla formation of Hinds (1931) forms the bedrock in the Klamath Mountains from the vicinity of Grenada south to Willow Creek. Near Grenada the rocks of the Chanchelulla formation are dominantly beds of gray quartzose sandstone which have been cut by closely spaced quartz veinlets. Original thin argillaceous interbeds have been converted to slate and phyllite. Beds of blue-gray limestone are prominent in the formation east of Gazelle along Willow Creek.

Strongly jointed volcanic rocks, altered to greenstone and to a lesser extent greenstone schist, compose much of the bedrock along the northwestern part of Shasta Valley in the area immediately north of Yreka. The greenstone, which forms a belt more than 3 miles wide, underlies most of the rugged hills known as Paradise Craggy and is incised deeply by the precipitous gorge of the Shasta River where it crosses the mountains.

Serpentine, presumably of Jurassic age and presumably derived from the autometamorphism of peridotite, intrudes the older formations of the Klamath Mountains in the Willow Creek area and in the vicinity of Yreka. The southern mass extends from Willow Creek southward more than 30 miles and underlies much of the mountainous area between the Sacramento and Trinity Rivers. The northern body of serpentine is a tabular sill-like sheet several miles in width that extends from Yreka southwestward into Scott Valley. Smaller bodies of serpentine crop out along the edges of the alluvium in Shasta Valley from Yreka to the vicinity of Paradise Craggy and may be apophyses from the main serpentine body.

Silicic intrusive rocks of Late Jurassic or Early Cretaceous age crop out at several isolated places in the Shasta Valley area. Along the east flank of Yellow Butte the siliceous beds of the Abrams mica schist are intruded by coarse-grained hornblende-biotite quartz monzonite and thin dikes of aplite. West of Gazelle along Willow Creek, Heyl and Walker (1949, p. 517) report small bodies of diorite and quartz diorite which intrude the folded beds of the Chanchelulla formation of Hinds (1931).

Water-bearing properties.—The Upper-Cretaceous rocks are for the most part dense and crystalline and ordinarily would not be expected to yield water in amounts sufficient for irrigation in the Shasta Valley area. However, in almost all these rocks there are joints, faults, shear zones, and foliation openings which are capable of transmitting sufficient water for domestic and stock uses. In the Klamath Mountains such fractures feed the springs that supply water to streams entering Shasta Valley from the west.

Domestic well 45/6–3Q1, 120 feet deep and completed in the Abrams mica schist along the northwestern part of the valley, penetrated approximately 5 feet of sandstone of Late Cretaceous age and 115 feet of the Abrams mica schist. Approximately 20 gpm of water was obtained, mostly from the bottom 20 feet, which suggests that a zone of water-bearing fractures was found.

E. C. Maples, a well driller in Montague, reports that a well drilled near the west edge of Yreka penetrated 195 feet of serpentine and, when tested, yielded only 8 gallons per hour. This very small yield, however, is an isolated case and may not be representative of the serpentine where it is strongly sheared.

CONSOLIDATED SEDIMENTARY ROCKS OF CRETACEOUS AND EOCENE AGE

CHICO FORMATION (UPPER CRETACEOUS)

General character.—The basement complex is overlain with strong unconformity by marine Upper Cretaceous sedimentary rocks which form an arcuate, discontinuous series of outcrops along the western margin of Shasta Valley from 5 miles southeast of Yreka to the vicinity of Black Mountain in the northern part of the valley. The Cretaceous rocks extend eastward at depth beneath the younger sedimentary and volcanic rocks in Shasta Valley and perhaps beneath the Cascade Range.

The Upper Cretaceous rocks in Shasta Valley were correlated by Williams (1949, p. 16) with the Chico group of formation, one of the most extensive subdivisions of the Cretaceous of the Pacific Coast. The formation consists dominantly of well-bedded yellow to greenish-gray arkosic sandstone and graywacke firmly cemented with calcite and limonite. The weathered sandstone and the soil derived from it are characteristically deep brownish red. The basal part of the formation consists of conglomerate, containing poorly sorted, well-rounded pebbles. Higher in the formation, arkose and graywacke predominate, although beds of coarse conglomerate are common. In the uppermost part, beds of black shale alternate with sandstone. The basal conglomerate and the overlying sandstone reflect the mineralogy of the Jurassic and older bedrock in the area. Williams (1949, p. 16) states that north of Shasta Valley, where the basal conglomerate is crossed by the Klamath River, it is crowded with pebbles and cobbles of greenstone. In Shasta Valley the conglomerate contains abundant pebbles of milky quartz, quartzite, and chert derived from the siliceous beds of the Abrams mica schist.

Anderson noted two distinctive fossil horizons in the Upper Cretaceous rocks in the area (Averill, 1931, p. 10-14). From the lower zone below the middle of the sandstone, near U.S. Highway 99 west of Hornbrook, he reported numerous species of marine bivalves and gastropods, such as *Trigonia evansana* Meek, *Chione varians* Gabb, *Glycymeris veatchi* Gabb, and *Cucullaea decurtata* Gabb. From the upper zone, at the contact of the uppermost sandstone beds and the overlying shales, he collected a variety of cephalopods including *Pachydiscus henleyensis* Anderson, *Barroisiceras knighteni*

Anderson, *Placenticeras pacificum* Smith, and *Placenticeras californicum* Anderson.

The Chico formation was deposited in a shallow sea that occupied the present sites of the southern part of the Cascade Range and the flanks of the Klamath Mountains. The coarse clastic sediments, the large shallow-water fossils, and the rapid variation in lithology of beds in the Chico formation are indicative of nearshore marine deposition adjacent to a land mass of fairly rugged relief.

The beds of the Chico formation generally dip to the east and northeast at relatively flat angles. Dips are rarely more than 20°. However, Williams reports that on the flanks of Black Mountain the beds dip as much as 25° NE. Locally south of Delphic School in sec. 6, T. 44 N., R. 6 W., the beds dip 14° NW., 9° NE., and 4° SE., possibly reflecting the surface irregularity of the metachert on which they were deposited. Where the Chico formation occupies the higher lands adjacent to Shasta Valley, it holds little or no soil cover and hence is easily recognizable from a distance. On the valley floor the Chico formation is covered by a thin veneer of soil and crops out as ridges and mounts of very low relief which slope gently valleyward from their more conspicuous position at the valley margins.

On the flanks of Black Mountain the Chico formation is about 1,000 feet thick and is overlain disconformably by the Umpqua formation of Eocene age. At the valley margin west of Montague only several hundred feet of the lower part of the formation is exposed. In the Medford quadrangle, Wells and others (1939) reports a maximum thickness of 600 feet for the two formations.

Water-bearing properties.—The beds of the Chico formation are in most places firmly cemented and crop out within a rather restricted area of the valley. Hence, they are unfavorable in both character and position for recharge and are of minor importance as an aquifer in Shasta Valley. A few deep wells have been drilled into the formation, and the yields, although generally small, are sufficient for domestic uses.

Well 45/7–36D2, at the valley margin about 4 miles west of Montague, penetrated 307 feet of conglomerate and sandstone in the Chico formation and yielded 50 gallons per hour. Well 45/7–36D1, only a few hundred feet to the northwest, penetrated 290 feet of blue and yellow sandstone of the Chico and 105 feet of the Abrams mica schist and yielded no water. Approximately half a mile to the west, a domestic well in the Chico (45/7–35B1), 38 feet deep, yields about 10 gpm. The following log of unused well 45/7–24R1 is indicative

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of the lithology of the basal part of the Chico formation in the area west of Montague.

Drillers' log of well 45/7–24R1 [1]

	Thickness (feet)	Depth (feet)
Older alluvium of Recent and Pleistocene age:		
Yellow clay and gravel	40	40
Chico formation of Late Cretaceous age:		
White sandstone	40	80
Hard boulder	5	85
Gray sandstone	15	100
Black clay	7	107
Gray sandstone	105	212
Black mud	10	222
Basement complex of pre-Late Cretaceous age:		
Serpentine	13	235

[1] Stratigraphy interpreted by Seymour Mack.

Salt water, probably of connate origin, accompanied by considerable gas is yielded by artesian well 44/6–3D1, which taps the Chico formation about 2 miles south of Montague. The well was drilled near the Shasta River during the latter part of the 19th century for F. J. King. The owner extracted salt from the water for table, stock, and dairy uses. An account of observations made during construction of the well is given by Wells (1881, p. 193–194). The well was drilled to a depth of 450 feet and flowed about 100 gpm, the water rising in pipes to 30 feet above the surface. Artesian water was found at 4 horizons, at a depth of 107 feet from an 11-foot bed of quicksand and gravel and at depths of 357, 384, and 409 feet in sandstone of the Chico formation. Fossil shells of marine animals were found in the sandstone at depths of 285 and 317 feet. The log of the well follows:

Drillers' log of well 44/6–3D1 [1]

	Thickness (feet)	Depth (feet)
Younger alluvium (Recent):		
Soil with alkali	6	6
Clay and fine gravel, somewhat cemented	63	69
Boulders, hard and difficult to drill through	7	76
Umpqua(?) formation (Eocene):		
Hard cemented clay	31	107
Quicksand and gravel	11	118
Chico formation (Upper Cretaceous):		
Sand rock, marine fossils at 285 and 317 feet	332	450

[1] Stratigraphy interpreted by Seymour Mack.

UMPQUA FORMATION (EOCENE)

General character.—Sedimentary rocks of fresh-water origin disconformably overlie the Chico formation in Shasta Valley and are probably correlative with the Umpqua formation, which underlies broad areas west of the Cascade Range from the vicinity of Roseburg, Oreg., to northern California. Fossil flora in coal beds in the Umpqua formation near Ashland, Oreg., are reported to be Eocene in age (Diller, 1907, p. 405). Williams (1949, p. 19) believed that there is little doubt that fossil leaves in the Umpqua in Shasta Valley also are of Eocene age.

The Umpqua formation crops out in two widely separated areas in Shasta Valley. Along the northern part of the valley it forms a belt that ranges in width from half a mile on the west flank of Black Mountain to 3 miles in the vicinity of Willow School. Along the east edge of the valley near Pluto Cave, the Umpqua formation constitutes the bedrock in an area of about 1.5 square miles. Interpretation of drillers' logs of wells suggests that the Umpqua formation underlies older alluvium at shallow depth throughout much of the area from Montague northeast to Snowdon School.

Thin-bedded black shale and silty shale make up most of the formation, although beds of sandstone and conglomerate also are present. The sandstone is medium to coarse and rather weakly cemented with calcite and clay. Along the Ager-Montague Road are many outcrops of massive sandstone which can be dug easily by hand. The sandstone ranges from white to light brown, but yellow brown is dominant. Soils overlying the sandstone are characteristically yellow brown, in contrast to the soils developed on the Chico formation which generally are brownish red. Mineralogically, the sandstone of the Umpqua formation differs from that of the Chico formation in that it contains less feldspar and ferromagnesian minerals, such as hornblende and chlorite.

A few hundred feet west of the Ager-Montague Road, near Snowdon School, a bed of subbituminous coal, having a maximum thickness of 6 feet, lies about 300 feet stratigraphically above the base of the Umpqua formation. Above this the Umpqua formation consists of alternating sandstone, sandy shale, and shale. The following log of unused well 46/5–18L1 illustrates the lithology of the Umpqua in the upper part of the formation.

Drillers' log of unused well, 46/5–18L1 [1]

	Thickness (feet)	Depth (feet)
Umpqua formation (Eocene):		
Soil	2	2
Sand	23	25
Shale	15	40
Sand	5	45
Shale	5	50
White sand	10	60
Shale	10	70
Brown sand	10	80
Sandy shale	45	125
Hard sand	25	150
Black shale	30	180
Black sandy shale	10	190
Black sand	10	200
Brown sand	20	220
Black shale	17	237

[1] Stratigraphy interpreted by Seymour Mack.

The Umpqua formation in Shasta Valley has a maximum thickness of about 2,000 feet and generally dips 15°–20° NE. It can be traced from the flanks of Black Mountain northward across the Klamath River to the Oregon-California border. Williams (1949, p. 19) reported that banded shale and silty shale predominate but that layers of tuffaceous material increase in number and thickness toward the Oregon-California boundary, particularly in the upper part of the formation. Near Hilt (north of area shown on pl. 1) a few lava flows appear in the uppermost part of the formation. The sandstone in the area shows strong crossbedding, and channel deposits of conglomerate as much as 15 feet in thickness occur within the sandstone beds.

In Shasta Valley the Umpqua formation appears to be wholly of fresh-water origin. Concerning its origin, Williams states (1949, p. 20):

> * * * the shales and silty shales composing the major part of the formation presumably represent deposits laid down on wide alluvial flats bordering sluggish streams that drained a country of low relief to the west * * *.

Water-bearing properties.—The water supply of wells drilled in the Umpqua formation is generally small but appears to be sufficient locally for domestic uses. Drillers' logs indicate that in the lower part of the formation the ratio of sandstone to shale, silty shale, and "hard" sandstone is approximately 1:3. In the Ager area the alternation of eastward-dipping beds of sandstone and impermeable shale and silty shale sets up favorable conditions for the confinement of water under artesian pressure. Well 46/6–24L1, which is unused, has a small artesian flow for most of the year. During the late summer and early autumn, when ground-water replenishment in the area is at a minimum, the flow of the well ceases and the water level drops 2–3 feet below the top of the casing. Well 46/6–24E1, a quarter of a mile to the north, yields 75 gpm with 70 feet of drawdown, thus having a specific capacity of about 1 gpm per foot of drawdown.

East of the Ager-Montague Road and stratigraphically higher in the formation, the percentage of shale gradually increases. Hence, it would appear that the shale should yield less water in this direction. However, irrigation well 46/6–24E1, nearly 1 mile east of the road, yields 400 gpm with a drawdown of 65 feet. The specific capacity, therefore, is 6 gpm per foot of drawdown. An extensive fracture system associated with a major fault less than 1 mile east (pl. 1) of the well may account for the relatively large supply of water.

Drillers' logs indicate that in the vicinity of Montague the Umpqua formation is relatively shallow. The log of well 45/6–23E1, which is about half a mile northeast of Montague, records black shale from 30 to 120 feet below the land surface. Well 45/6–14P1, about half a mile farther north, penetrates sticky black clay from a depth of 34 feet to the bottom of the well at 40 feet. According to local residents, the old Montague city wells, which were drilled to depths of 900–1,000 feet, penetrated mostly blue mud. Some water was obtained from a depth of 600 feet but was insufficient for municipal supply. In a later attempt to obtain water a tunnel was driven at shallow depth to connect the wells with Oregon Slough, but the supply developed by this project also was inadequate. Present municipal supplies are obtained by ditch from Dwinnel Reservoir in summer and from the Little Shasta River in winter.

VOLCANIC ROCKS OF TERTIARY AND QUATERNARY AGE

VOLCANIC ROCKS OF THE WESTERN CASCADES (EOCENE TO MIOCENE)

General character.—From Mount Hood in northern Oregon to Mount Shasta the Cascade Range has been divided longitudinally into two physiographic subprovinces—the high Cascades and the western Cascades (Callaghan and Buddington, 1938, p. 6). The western Cascades are underlain by a belt of Tertiary lava and pyroclastic rocks which border the western flank of the towering, youthful volcanic cones of the high Cascades. The lava of the western Cascades probably issued from a north-south series of cones and fissures close to or coincident with the present position of the volcanoes of the high Cascades. In Jackson County, Oreg., flora ranging in age from late Eocene to middle Miocene were identified from the rocks of the western Cascades (Callaghan and Buddington, 1938, p. 8). In the northern part of Shasta Valley the volcanic rocks of the western Cascades overlie unconformably the Umpqua formation of Eocene age, and along the eastern margin of the valley they are in turn overlain unconformably by the Pliocene and younger lava of the high Cascades.

The rocks of the western Cascades are chiefly andesitic lavas and pyroclastic ejecta and subordinate flows of basalt and dacite, beds of rhyolite tuff, and a few rhyolite domes. They underlie much of the western part of Shasta Valley from the vicinity of Edgewood to Montague. From Montague northward they constitute the bedrock along the eastern margin of the valley. The lava and fragmental ejecta dip about 15° E. and northeast. The maximum exposed thickness in Shasta Valley is about 15,000 feet, although nowhere are the beds exposed to their full thickness because of overlap by the younger lava of the high Cascades.

The topography developed on the belt of rocks of the western Cascades in Shasta Valley is entirely erosional, consisting of a myriad of hillocks that range in height from a few feet to as much as 300 feet. Most of the hillocks are symmetrical, but some are quite irregular. They form a strange landscape which at first glance suggests that very recent volcanism has taken place from hundreds of scattered centers of eruption. Their origin has been ascribed to such activity in previous reports. Diller and others (1915, p. 61) mentioned the valley briefly and said:

> Scattered over Shasta Valley are many small knolls of lava and tuff, which appear to be, in part at least, the products of minor and local eruptions that broke through the Cretaceous beds, each vent contributing its little pile of material. Such feeble and diffuse volcanic activity is in marked contrast with the vigorous outbursts that built up the great cone of Shasta.

Fenner (1923, p. 49), upon fleeting observation of Shasta Valley, believed that the hillocks might have originated in much the same manner as the great tuff deposit in the Valley of the Ten Thousand Smokes in Alaska, which may have been formed by the intrusion at shallow depth of a sill composed of highly gaseous acid magma. The strata overlying the sill, being extremely thin, were fractured extensively by the force of the intrusion, thus allowing the magma to reach the surface from many centers of eruption. Fenner (1923, p. 49) made the following comparison between the two areas:

> The form of intrusion suggested here (Valley of the Ten Thousand Smokes) is one that would occur only under special conditions, and its surface expression would not survive for a long period, but I have seen one region where the same sort of process is indicated. This is in Shasta Valley, California, and does not seem to have been studied in detail. * * * The fact that

the extruded lava built up cones here (Shasta Valley), while in the Katmai region it formed a great sandflow, would appear to be due to the basic composition and relatively gas-free condition of one and the siliceous composition and highly gas-charged condition of the other * * *.

There can be little doubt, however, that the exceptional topography developed on the rocks of the western Cascades is of erosional origin as described by Williams (1949, p. 11) and not due to the processes suggested by Diller and Fenner. This conclusion is supported by the consistent eastward dip of the lava in the hillocks by the paucity of volcanic necks in the area, and by what appears to have been a singular absence of fumarolic or solfataric activity in the vicinity of the hillocks.

Hypersthene-augite andesite makes up the greatest proportion of the lava flows in the rocks of the western Cascades in Shasta Valley. Several flows of hydrothermally altered dacite occur near the base of the unit in the hills south of Ager. Basalt flows are found north of Shasta Valley in the vicinity of Willow Creek. Williams (1949, p. 21) distinguished two types of andesite, one a pale-gray pilotaxitic variety rich in large phenocrysts of basic plagioclase and pyroxene, the other a much finer grained dark-gray to black variety having fewer phenocrysts in a glassy matrix. In Oregon, Callaghan and Buddington (1938, p. 9) also reported the occurrence of two varieties of andesite in the rocks of the western Cascades and noted that in the vicinity of the Rogue River the gray andesitic lava appears to interfinger with the black, but farther north the gray appears to be stratigraphically higher than the black. In Shasta Valley the black lava is localized in a narrow belt along the western part of the valley, and because of the prevailing eastward dip of the beds, it probably occupies a lower stratigraphic position than the gray lava.

The andesite generally is only slightly vesicular and is cut either by widely spaced joints (blocky jointing) or by closely spaced joints (platy jointing). Blocky jointing is more common in the black andesite, platy jointing in the gray andesite. A notable occurrence of the platy jointing is in a quarry south of Montague at locality 44/6–33H. The andesite is gray and contains abundant phenocrysts of calcic plagioclase, hypersthene, and augite averaging about 3 millimeters in length. Hypersthene and augite phenocrysts are much less abundant than the plagioclase, making up only about 5 percent of the total phenocrysts. The lava is highly fractured, the fracture planes being spaced about half an inch apart. Near the base of the quarry the joints are nearly vertical, but they curve gently and near the top of the quarry wall dip about 70° NE. Similar platy cleavage in the gray andesite was observed in a quarry at locality 45/6–25D near the Montague–Little Shasta road. The andesite, by virtue of its closely spaced joints, has been found particularly useful for crushed rock and has proved satisfactory for surfacing the Siskiyou County Airport. Williams (1949, p. 21) ascribed the origin of much of the platy jointing in the lava of the western Cascades to shearing of the flows during the final stages of advance.

The proportion of tuffaceous beds in the volcanic rocks of the western Cascades increases toward the top of the unit. North of the valley dense rhyolite tuffs are found near the top of Bogus Mountain. Sheep Rock, which lies about 2 miles northeast of Yellow Butte, is composed of a large amount of andesitic tuff-breccia of probable mudflow origin. The breccia is characterized by a chaotic assemblage of large angular and subangular blocks set in a tuffaceous matrix (fig. 4). Where U.S. Highway 97 cuts through the tuff-breccia of

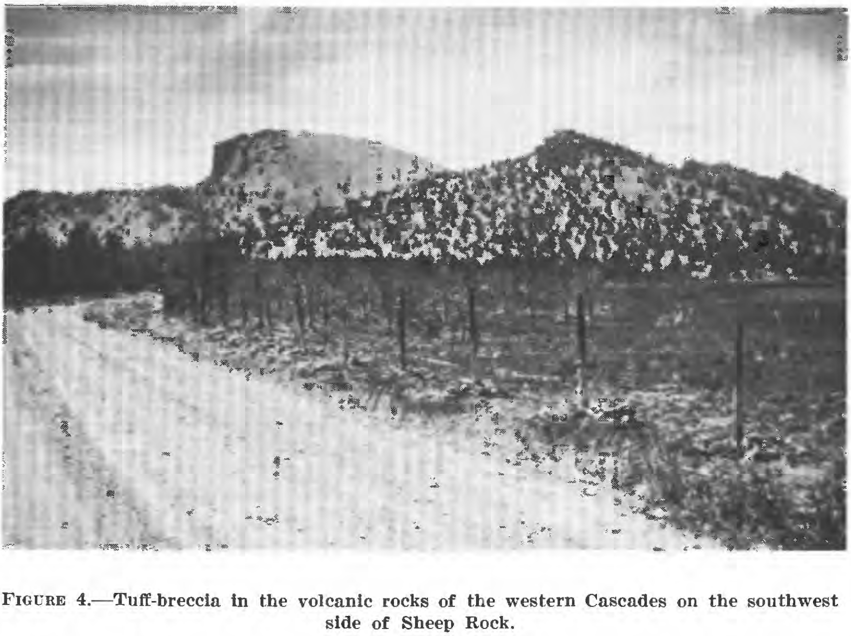

FIGURE 4.—Tuff-breccia in the volcanic rocks of the western Cascades on the southwest side of Sheep Rock.

Sheep Rock, many fracture planes in the rock are coated with small thin crystalline plates of hematite, probably formed as a sublimation product of volcanic emanations. What is apparently a mudflow deposit, consisting of large boulders of andesite, rhyolite, and quartzite set in a matrix of red tuffaceous clay, is exposed in a quarry at locality 45/5–7Q about 2 miles south of Snowdon.

There are few volcanic necks in Shasta Valley. The largest forms Gregory Mountain, which is about 1 mile southeast of Montague and consists of nearly vertically jointed dusky-yellow fine-grained hornblende andesite. The small peak at locality 46/5–19, about 2 miles north of Snowdon, is a neck of fine-grained black basalt. Viscous protrusions of rhyolitic lava form a northeastward-trending series of domes extending from Owls Head (fig. 5) in sec. 16, T. 44 N.,

FIGURE 5.—Owls Head, a jointed rhyolitic lava dome in the volcanic rocks of the western Cascades.

R. 5 W., to the vicinity of Table Rock. The rhyolite in a quarry adjacent to the cemetery in Little Shasta is a white fine-grained rock almost indistinguishable from quartzite. A similar sample was obtained from the east flank of Owls Head where the rhyolite is a pale-cream fine-grained rock containing scattered minute crystals of biotite and feldspar which are barely visible with a hand lens.

Water-bearing character.—Because of rapid changes in water-bearing character of the rocks, both laterally and vertically, yields of wells that tap the rocks of the western Cascades vary greatly, not only in different parts of the valley but also locally. Wells that obtain water from these rocks are either in areas where they penetrate alluvium at the surface and bottom in the volcanics, or are located along the flanks of hillocks of lava that jut out of the alluvium. Water-yielding zones in the rocks of the western Cascades may occur in jointed lavas, buried veneers of talus surrounding the hillocks, reworked volcanic sand and gravel, or clinkery contacts between the flows. Outcrops of the rocks lack vesicles and cavities caused by the expansion of gases during the cooling of the lava, and such openings are presumed to have virtually no effect on the ability of the lava to yield water. Table 5 lists the yield characteristics of wells tapping the volcanic rocks of the western Cascades in various parts of the valley.

TABLE 5.—*Summary of yield characteristics of wells tapping the volcanic rocks of the western Cascades in Shasta Valley*

[Discharge and drawdown data obtained from drillers' logs]

Well	Discharge (gpm)	Drawdown (feet)	Specific capacity [1]	Saturated thickness (feet)	Yield factor [2]
43/6-10K1	840	30	28	95	30
10Q1	120	59	2.0	[3] 100	2.0
21J2	800	40	20	218	9.2
22A1	1,400	5	280	95	300
23N1	800	60	13	93	14
44/4-5 F1	300	74	4.0	[3] 130	3.1
5K1	400	58	6.9	[3] 330	2.1
44/5-1J1	250	47	5.3	160	3.3
1J2	125	38	3.3	56	5.9
1J3	100	60	2.0	127	1.6
18B1	600	15	40	67	60
45/5-18D1	13	10	1.3	[3] 140	.9
45/6-28A1	5	7	.7	30	2.3

[1] Gallons per minute per foot of drawdown.
[2] Gallons per minute per foot of drawdown per foot of saturated thickness penetrated by the well, times 100.
[3] Based on estimated depth to water.

The most productive wells that obtain water from the rocks of the western Cascades are in the southwestern part of Shasta Valley between Gazelle and Grenada. Yields of irrigation wells in that area ranged from 120 gpm reported for well 43/6-10Q1 to 1,400 gpm for well 43/6-22A1 (table 5). The specific capacity of 280 gpm per foot of drawdown for the latter well is the highest value obtained for any well tapping these rocks. Striking differences in water-bearing properties of the rocks are shown by the yield characteristics of wells 43/6-10K1 and 43/6-10Q1, which are about 2,000 feet apart. The two wells are of about equal depth and both are on the flanks of isolated hillocks of lava standing above the alluvium deposited by Willow Creek. Well 43/6-10K1 had a specific capacity of 28, based on a discharge of 840 gpm and a drawdown of 30 feet, whereas well

43/6-10Q1, which evidently penetrates rocks considerably less productive of water had a specific capacity of 2.0, based on a discharge of 120 gpm and a drawdown of 59 feet.

Well 43/6-21J2 yielded 800 gpm with 40 feet of drawdown, whereas well 43/6-21J1, about 300 feet away, yielded about 200 gpm but briefly was pumped dry within a few minutes after the pump was started. The drillers' logs do not suggest marked lateral differences in water-yielding properties in either the alluvium and or the volcanic rocks across the 300-foot distance separating the wells. Well 43/6-21J2 is 47 feet deeper than 43/6-21J1 and probably penetrates a productive zone of lava not tapped by the other well. Moreover, the logs indicate that well 43/6-21J2 penetrated about 19 feet more of alluvium before entering the rocks of the western Cascades than did well 43/6-21J1. The drillers' logs of the two wells follow:

Log of well 43/6-21J1[1]

	Thickness (feet)	Depth (feet)
Alluvium (Recent and Pleistocene?):		
Clay	17	17
Gravel	1½	18½
Clay	23½	42
Gravel	1	43
Clay	43	86
Boulders, sand and gravel	10	96
Coarse gravel	9	105
Clay	29	134
Volcanic rocks of the western Cascades:		
Lava	42	176
Clay and gravel	22	198
Boulders	5	203

Log of well 43/6-21J2[1]

	Thickness (feet)	Depth (feet)
Alluvium (Recent and Pleistocene?):		
Clay with occasional thin gravel seams	60	60
Gravel and clay	55	115
Volcanic rocks of the western Cascades:		
Cinders, boulders, and clay	135	250

[1] Stratigraphy interpreted by Seymour Mack.

Many of the drillers' logs report beds of red cinders in the rocks of the western Cascades from which copious supplies of water are obtained. Cinder beds are not known to crop out in Shasta Valley, however, and the materials logged as cinders may represent the tops of individual flows that have been oxidized by weathering and by the baking effect of overlying flows. For example, in well 44/5–18B1, which yielded 600 gpm, the driller logged the materials from the major water-bearing horizon as red cinders and gravel. Samples of this material were examined by the author and were found to consist of angular fragments of nonvesicular reddish andesite and well-rounded pebbles of dark-gray andesite, probably derived from stream action over the weathered top of a flow. The log of well 44/5–18B1 is as follows:

Log of well 44/5–18B1

	Thickness (feet)	Depth (feet)
Volcanic rocks of the western Cascades (Eocene to Miocene):		
Top soil, hardpan, and boulders	18	18
Boulders and sand, water-bearing	17	35
Boulders and cemented red cinders	22	57
Boulders	10	67
Red cinders and gravel, water-bearing	18	85

Although generally sufficient for domestic and stock use and locally for irrigation, yields of wells tapping the volcanic rocks of the western Cascades in other parts of Shasta Valley are considerably smaller than those obtained in the Gazelle-Grenada area. At some places the smaller yields undoubtedly are due to the poor water-yielding character of the lava and pyroclastic rocks. In the vicinity of Montague, however, the older alluvium receives only slight influent seepage from streams entering the valley, and mean annual precipitation on the valley floor (12–15 inches) is probably too small to contribute much recharge to the ground-water body.

Along the east side of the valley near Little Shasta, 5 irrigation wells had an average yield of 235 gpm and a drawdown of 55 feet, for an average specific capacity of about 4 gpm per foot of drawdown. Domestic wells in this area yield 10–15 gpm. Mudflow deposits and fine-grained pyroclastic rocks which underlie much of the cultivated lands bordering Little Shasta Valley on the north, are generally poor aquifers. Domestic well 45/5–7Q1, several hundred feet south of a quarry in mudflow deposits, found mostly clay and boulders to a depth of 125 feet. The well produced about 10 gpm and became dry during the late summer after periods of extensive pumping.

VOLCANIC ROCKS OF THE HIGH CASCADES (PLIOCENE TO RECENT)

East of the hummocky valley land of the western Cascades, the more youthful high Cascades form a broad northward-trending chain of large volcanic peaks extending from the north end of the Sierra Nevada virtually to the Canadian border. The older peaks of the high Cascades that bound Shasta Valley are a series of basaltic shield volcanos built up by quiet effusions of highly fluid lava during Pliocene and Pleistocene time. These include Miller Mountain, Eagle Rock, and the partly buried shields under Goosenest and Willow Creek Mountain (outside area shown on pl. 1). Miller Mountain, the western part of which occupies the area shown on the geologic map in T. 44 N., R. 4 W., is the most deeply eroded of the shields and may have been the first to become extinct, possibly during late Pliocene or early Pleistocene time. Its flanks have been eroded by the sapping action of springs and streams that have cut readily into the less resistant underlying volcanic rocks of the western Cascades. To the north, the flanks of Eagle Rock volcano, whose summit (altitude 6,970 feet) is approximately 8 miles east of Bogus Mountain, have been only slightly modified by erosion, suggesting that eruptions continued after the Miller Mountain volcano became extinct. The presence of the old shields under the more youthful volcanic rocks of Goosenest and Willow Creek Mountain is indicated by the distribution and altitudes of older basaltic lavas around the bases of the younger flows. Outliers of basalt related to the shield volcano beneath Willow Creek Mountain form Solomons Temple, Temple Rock, and Table Rock.

The present Willow Creek Mountain and Goosenest are steep-sided volcanoes built up by flows of hypersthene-rich andesite. Willow Creek Mountain is not shown on the geologic map but lies 6 miles north of Goosenest and 7 miles east of Foothill School. The top of Goosenest is about 3 miles east of the area shown on plate 1, but the flanks occupy the area between Little Shasta River and Walbridge Gulch. The southeast side of Goosenest has a slope of 8°, whereas the other flanks have slopes of 14°–18°, flattening gradually toward the base. The andesitic cone of Willow Creek Mountain has slopes of 10°–13°. The larger of the two cinder cones atop Goosenest is between 600 and 700 feet high and has a well-preserved crater in the top. Flows from Goosenest occupy most of the area mapped (pl. 1) as volcanic rocks of the high Cascades between Davis Gulch and Little Shasta River. Williams (1949, p. 48) stated that the remarkably fresh appearance of the latest flows from Goosenest indicates that they were extruded probably less than a thousand years ago.

Mount Shasta, one of the highest and most spectacular of the volcanoes of the high Cascades (fig. 6), lies at the southeastern margin of the valley and its peak is about 10 miles east of Weed.

FIGURE 6.—Mount Shasta, looking southeast from vicinity of Montague; low hillock in foreground underlain by volcanic rocks of western Cascades; and older alluvium in middle distance.

The principal activity that built Mount Shasta took place during Pleistocene time, at first almost wholly by effusions of andesitic lava but in the final stages by eruptions of dacite and basalt as well (Williams, 1949, p. 14). The latest flows from Mount Shasta, one of which presents a steep blocky front along Highway 97 between Weed and Yellow Butte, are probably not more than a few centuries old, as is indicated by their perfectly preserved steep fronts and the paucity of vegetation on the tops of the flows.

Water-bearing properties.—The volcanic rocks of the high Cascades that are adjacent to Shasta Valley serve chiefly as a large intake area and storage reservoir for ground water much of which eventually finds its way into the valley. Most of the steep, mountainous area of the high Cascades is mantled with thin rocky soils that overlie highly fractured volcanic rocks, and hence can readily absorb large quantities of water derived from rain and snow. That part of the precipitation that passes beyond the reach of native plants passes through the many fractures and crevices within and between the interbedded lava flows. With the exception of Whitney Creek, which obtains its flow from melt water of the Whitney Glacier atop Mount Shasta, Little Shasta River and other streams along the east side of Shasta Valley derive most of their flow from springs and seeps issuing from the volcanic rocks of the high Cascades.

PLUTOS CAVE BASALT (RECENT)

General character.—An extensive basalt flow occupying an area of more than 50 square miles in the southeastern part of the valley and exceeding 20 miles in length was named the Plutos Cave basalt by Williams (1949, p. 42). The name is adopted in this report. Although the Plutos Cave basalt is a product of Recent volcanic activity in the area and hence could be considered a part of the volcanic rocks of the high Cascades, it is here discussed separately because it was mapped separately by Williams and because of its hydrologic importance in Shasta Valley.

The Plutos Cave basalt appears to have issued from fissures close to the northeastern base of Mount Shasta, probably no more than several thousand years ago, and may attain a thickness of 400 feet (fig. 3) near its south end (Williams, 1949, p. 43). The flow is composed of black vesicular olivine-rich augite basalt. The name is derived from a large lava tube near its south end at the locality named Pluto Cave on the geologic map (pl. 1). The lava tube, one of several in the Plutos Cave basalt, was formed as the roof and sides of the flow solidified leaving a cavity through which molten lava continued to stream. The lava then escaped through fractures in the sides or at the front of the flow, leaving the underground passageway. Sections of the roof have fallen along the length of the tube, forming long, narrow trenches and many short caves filled with broken rock (fig. 7). The author walked through one section of the cave for several hundred feet before being stopped by huge blocks of basalt, which had fallen from the ceiling.

FIGURE 7.—Collapsed lava tube in Plutos Cave basalt near Pluto Cave.

Water-bearing character.—The Plutos Cave basalt constitutes the most prolific aquifer in Shasta Valley, yielding abundant water to wells and springs for irrigation and domestic uses. Yields of irrigation wells range from small to large but average about 1,300 gpm. Well 44/5–34H1 has a specific capacity of 120 gpm per foot of drawdown, yielding 4,000 gpm with 34 feet of drawdown. Nearby well 44/5–34G1 has a specific capacity of only 11 gpm per foot of drawdown, based on a yield of 900 gpm with 80 feet of drawdown. Large well yields are obtained from the Plutos Cave basalt in two areas—one in the vicinity of Big Springs and the other at the northern terminus of the basalt near Little Shasta. The area near Big Springs is the major ground-water-producing area in the valley. Table 6 lists the yield characteristics of wells tapping the Plutos Cave basalt.

TABLE 6.—*Summary of yield characteristics of wells tapping the Plutos Cave basalt in Shasta Valley*

[Discharge and drawdown data obtained from drillers' logs]

Well	Discharge (gpm)	Drawdown (feet)	Specific capacity [1]	Saturated thickness (feet)	Yield factor [2]
44/5– 2K1	1, 000	32	31	60	52
12L1	900	15	60	80	75
21H1	120	12	10	255	3. 9
34G1	900	80	11	115	9. 6
34H1	4, 000	34	120	76	160
34J1	900	41	22	76	29
34Q1	1, 250	9	140	39	360
35L1	1, 300	20	65	29	220

[1] Gallons per minute per foot of drawdown.
[2] Gallons per minute per foot of drawdown per foot of saturated thickness penetrated by the well, times 100.

Fractures and other permeable zones through which water moves in the basalt are related intimately to the fluidity and history of cooling of the flow. The basalt in surface exposures contains many lava tunnels. Below the water table, such tunnels undoubtedly are present and act as huge channels for the conveyance of subsurface water from the recharge area at the southeastern part of the valley to the Big Springs area. No drillers' logs specifically indicate that lava tunnels have thus far been penetrated, but many of the zones described as bouldery may possibly be caves filled with debris fallen from the sides and ceiling of the tunnels.

Shrinkage fractures formed during cooling of the basalt provides routes for the transmission of water through the flow, and are the means by which excess irrigation water and precipitation percolate downward to become ground water. The rapidity with which the basalt receives and transmits water is illustrated by the Big Springs (pl. 1), which supply copious amounts of water to the Big Springs

Irrigation District. Excess irrigation water, derived from applications in the area above the springs from May to August, seeps downward through the strongly jointed basalt and results in an increased flow of 6 to 8 cfs at the springs during the irrigation season.

The surface of the basalt contains numerous pressure domes (schollendomes) which are believed to have originated by buckling of the flow crust caused by the pressure of the underlying fluid lava. In general the domes are elliptical in plan, with a principal axis not more than 30 feet in length, and are not more than 15 feet high. An open crack extends along the summit paralleling the long axis of the dome. In places, additional cracks are disposed radially from the summit. Fractures such as these undoubtedly provide access for the infiltration and vertical transmission of water.

Contacts between individual flow units may be among the most productive water-yielding zones in the basalt. As described by Nichols (1936, p. 617), flow units are tongue-shaped structures within a flow formed by lava which flows in a series of spurts rather than at a constant velocity. At the front of the flow and also on its margins, tongues a few hundred feet wide break out and flow for considerable distances. A number of tongues form, crusts appear on them, and these tongues are buried by later tongues. This process may be repeated several times, and what is to all intents and purposes a single eruption is actually composed of several flow units. Three, and in places four, superimposed flow units with clinkery tops and bottoms can be seen on the walls of Pluto Cave. The contacts between these flow units are characterized by marked vesicularity and by many openings, some of which are quite extensive and appear to be capable of transmitting large quantities of water. These openings were formed when succeeding gushes of lava failed to fill completely the irregularities developed on the rough, broken upper crust of preceding flow units.

UNCONSOLIDATED DEPOSITS OF QUATERNARY AGE

TERRACE DEPOSITS (PLEISTOCENE)

Two terrace deposits of probable Pleistocene age are found along the west side of Shasta Valley. About 3 miles south of Grenada a dissected terrace deposit, which mantles sandstone of the Chanchelulla formation, has a maximum thickness of about 50 feet. The deposit consists of very well rounded cobbles of lava of the western Cascades and of granitic rocks in a matrix of brown sandy clay. Southwest of Gazelle, a terrace underlain by tuffaceous clay and gravel lies about 20 feet above the Recent alluvium deposited by Willow Creek.

No wells tap the terrace deposits, perhaps because they are of rather small extent and are generally above the water table.

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MORAINAL AND FLUVIOGLACIAL DEPOSITS (PLEISTOCENE AND RECENT)

Morainal and fluvioglacial deposits have been distinguished on the geologic map (pl. 1). However, because the two units are genetically closely related and because they are restricted to about 35 square miles in the southeastern part of Shasta Valley, they are discussed together in this section of the report.

General character.—At the close of the Wisconsin stage of the Pleistocene epoch, glaciers which had descended the northwestern slopes of Mount Shasta and which had spread into Shasta Valley retreated leaving terminal moraines along the shores of the present Dwinnell Reservoir and recessional moraines as far south as Weed. Wide sheets of bouldery fluvioglacial deposits containing abundant sand, silt, and clay were laid down beyond the ends of the glaciers. At the surface, the fluvioglacial deposits appear to be poorly stratified, but their surficial jumbled nature may result at least in part from frost action, and at depth they may be well stratified. Along the northwest shore of Dwinnell Reservoir abutting against the volcanic rocks of the western Cascades, are well-bedded sand and gravel cut by small faults, probably of slump origin. This sand and gravel, some of which was used in the construction of the earth-fill dam for the reservoir, represents deposits of stratified drift which were probably laid down in contact with the wasting glacial ice. Alluvial fans composed of sandy and gravelly outwash also spread down the northwest flank of Mount Shasta during the retreat of the glaciers. These outwash deposits are still accumulating debris provided by the existing glaciers on Mount Shasta.

The long bouldery ridge of outwash material that extends from the recessional moraines west of Weed northward to Cedar Park School (pl. 1) has been cut to a depth of about 50 feet by Parks Creek and Shasta River and forms a terracelike surface above the Recent alluvium of the stream. A similar surface is also formed by Pleistocene outwash a short distance eastward, at locality 42/5–21. Both these areas of outwash have on their surface many closely spaced bare mounds encircled by rings of loose stones, a phenomenon once thought by local residents to have been the work of early Indians. Masson (1949, p. 61–71) examined the stone circles at these and other localities in Siskiyou County, and explained their origin as follows: alternate freezing and thawing caused the concentration of clay into local centers; the upfreezing of stones to the surface; and radial or centrifugal movement of the stones away from the clay centers. Near the south end of Butte Valley, similar stone rings have also developed on an outwash deposit that surficially consists of a poorly stratified mass of boulders in an unconsolidated matrix of sand, silt, and clay.

Water-bearing character.—Except for scattered lenses of well-bedded sand and gravel in the vicinity of Dwinnell Reservoir, the morainal and fluvioglacial deposits consist of coarse, poorly sorted bouldery deposits. Hydrologic data from the few wells that tap the glacial deposits suggest that the rocks have a wide range in permeability within relatively short distances. No known wells tap the outwash deposits in the vicinity of Edgewood, on which "stone circles" have developed (Masson, 1949). It is possible that the clay mounds that occur within the circles implies higher proportions of clay than underlie areas on which no mounds are present. If this supposition is correct, outwash deposits near Edgewood are probably less permeable than are outwash deposits that occur farther east.

Hydrologic data are available from four irrigation wells tapping glacial deposits in the area east of Edgewood. Wells 42/5–23J1 and 42/5–26R1 are drilled into the morainal deposits and wells 42/5–12C1 and 42/5–26A1 into fluvioglacial deposits. The log (table 21) of each well shows high proportions of boulders and clay and angular gravel. Table 7 lists the yield characteristics of these wells. Although the well records are few, the table suggests that wells drilled in the morainal deposits are the more prolific, having much higher specific capacities and yield factors than wells drilled in the fluvioglacial deposits. It is possible, however, that at depth the wells tapping morainal deposits have encountered permeable volcanic rocks of the western Cascades.

TABLE 7.—*Summary of yield characteristics of wells tapping morainal and fluvioglacial deposits in Shasta Valley*

[Discharge and drawdown data obtained from drillers' logs]

Well	Deposit tapped	Discharge (gpm)	Drawdown (feet)	Specific capacity [1]	Saturated thickness (feet)	Yield factor [2]
42/5–12C1	Fluvioglacial	800	170	4. 7	210	2. 2
23J1	Morainal	1, 000	40	25	75	33
26A1	Fluvioglacial	600	40	15	115	13
26R1	Morainal	1, 500	25	60	65	92

[1] Gallons per minute per foot of drawdown.
[2] Gallons per minute per foot of drawdown per foot of saturated thickness penetrated by the well, times 100.

OLDER ALLUVIUM (PLEISTOCENE AND RECENT)

General character.—Older alluvium underlies much of the northern part of the valley in the vicinity of Montague. It appears to have been derived from the surrounding mountains and deposited as a series of broad coalescing fans which merged with contemporaneous flood-plain deposits of the Shasta River. Near Montague the present flood plain of the Shasta River has a maximum width of half a mile and is entrenched about 15 feet below the surface of the older flood-plain and alluvial-fan deposits.

Thin remnant patches of material interpreted (pl. 1) as older alluvium occur along the valley margins west of Montague. In this alluvium are boulders identified as of the Plutos Cave basalt. If the identification is correct, and if Williams' assumption (1949, p. 5) that the basalt was extruded only a few thousand years ago is correct the material mapped as older alluvium must be of Recent age at least in part. However, the generally advanced stage of dissection of the older alluvium and the almost universal presence of a well-cemented hardpan suggest that the greater part of the older alluvium is of Pleistocene age.

The soil formed on the older alluvium is a brown sandy loam containing abundant gravel derived mostly from metamorphic rocks of the Klamath Mountains and from quartzose conglomerate of the Chico formation. The topography is characterized by gently sloping to undulating treeless plains, in places marked by low mounds. The mounds are 8–15 feet in diameter and 1–2 feet in height. They are especially prominent in the area west of Montague where they are underlain at shallow depth by sandstone of the Chico formation.

In the older alluvium a persistent hardpan layer about a foot thick commonly is found 10–16 inches below the land surface. The hardpan is brown to yellowish brown and cemented principally with iron minerals, although seams and incrustations of calcareous material also occur.

Between the valley margins and the vicinity of Montague, the thickness of the older alluvium ranges from 0 to 100 feet. Well 45/6–27A1 is 116 feet deep and penetrates older alluvium from the land surface to 90 feet. The interval between 90 and 116 feet probably is the Umpqua formation of Eocene age, although it might be older alluvium. The log of the well follows:

Log of well 45/6–27A1

	Thickness (feet)	Depth (feet)
Older alluvium (Recent and Pleistocene): [1]		
Soil	10	10
Boulders—water	25	35
Clay	5	40
Cement gravel	50	90
Umpqua(?) formation (Eocene):		
Black clay	2	92
Black sand—water	24	116

[1] Stratigraphy interpreted by Seymour Mack.

Water-bearing properties.—Most of the wells that tap the older alluvium are shallow dug wells several feet in diameter, walled with bricks, rocks, or boards. Yields are small but generally are sufficient for domestic and stock uses. It is highly doubtful whether water in volumes adequate for irrigation could be obtained from the older alluvium. Well 45/6–28B1, about 1 mile west of Montague, penetrates 20 feet of older alluvium and yields slightly more than 1 gpm. The log is as follows:

Log of well 45/6–28B1

	Thickness (feet)	Depth (feet)
Older alluvium (Recent and Pleistocene): [1]		
Soil	6	6
Hardpan	4	10
Adobe and angular fragments	10	20

[1] Stratigraphy interpreted by Seymour Mack.

Wells 45/6–17F1 and 45/6–17F2 are flowing wells, 63 and 75 feet deep, respectively, located about 3 miles northwest of Montague. When measured on September 22, 1954, well 45/6–17F1 flowed approximately 1 gpm and well 45/6–17 F2, 2 gpm. The wells are near the outer edge of an old alluvial fan built out from the mountains to the north. The flow probably results from the occurrence of local lenses of permeable material in the older alluvium confined by layers of less permeability. Chemical analyses (table 22) of the water show a fairly high magnesium content which may be related to sills of serpentine in the nearby mountains.

YOUNGER ALLUVIUM (RECENT)

General character.—The younger alluvium underlies the present stream channels and the gently sloping alluvial fans built by streams issuing from the western mountains, the broad alluvial flats of Little Shasta Valley, and the large part of western Shasta Valley that is drained by Parks and Willow Creeks and the Shasta River (fig. 1). So far as is known, the maximum thickness of younger alluvium in the area is 140 feet, which was logged by the driller as clay in well 44/7–3Q2, about 3 miles south of Yreka. In general, the younger alluvium throughout the valley consists of beds of silt and clay with intercalated lenses of sand and gravel. The logs of two wells that tap younger alluvium on the flood plain of Yreka Creek follow:

Drillers' log of well 45/7–27R2

	Thickness (feet)	Depth (feet)
Younger alluvium (Recent): [1]		
Soil, gravelly	2	2
Gravel	7	9
Clay, gravelly	5	14
Gravel	4	18
Clay, gravelly	21	39
Gravel, dirty	7	46
Clay, gravelly	50	96
Basement complex of pre-Late Cretaceous age:		
Shale	5	101

Drillers' log of well 45/7–34K1

	Thickness (feet)	Depth (feet)
Younger alluvium (Recent): [1]		
Soil and gravel	4	4
Dirty gravel	4	8
Yellow clay and gravel	12	20
Loose gravel	4	24
Reddish clay, some gravel	25	49
Reddish clay, some sand and gravel	28	77
Clay and gravel	38	115
Gravel, some clay	12	127
Basement complex of pre-Late Cretaceous age:		
Hard broken gray rock	3	130
Broken rock and clay	5	135
Hard gray rock, clay seams	5	140

[1] Stratigraphy interpreted by Seymour Mack.

The younger alluvium in Little Shasta Valley was derived mainly from basic volcanic rocks of high calcium content. As a result, considerable calcium carbonate has been concentrated in the subsoil, cementing the subsoil into a hardpan. The alluvial strip from Gazelle northward to Grenada, however, contains no hardpan and forms the main body of valuable agricultural land in Shasta Valley.

Water-bearing character.—Most of the wells tapping younger alluvium are shallow dug wells used for domestic and stock uses. Some irrigation wells obtain water from the younger alluvial deposits, but most of those are along the western margin of the valley. Important exceptions are well 45/5–34C1 in Little Shasta Valley and well 42/5–8P1 on the flood plain of Parks Creek. Yreka obtains its municipal supply from an infiltration gallery (45/7–14N1) about 8 feet in diameter which induces flow from nearby Yreka Creek. The gallery has a yield of 1,200 gpm and a drawdown of 5 feet, and hence a specific capacity of 240 gpm per foot of drawdown. A supplemental supply for Yreka is obtained from well 45/7–34B1, near Greenhorn Creek, which yields approximately 300 gpm. Table 8 lists the yield characteristics of wells drawing water from the younger alluvium.

TABLE 8.—*Summary of yield characteristics of wells tapping the younger alluvium in Shasta Valley*

[Discharge and drawdown data obtained from drillers' logs]

Well	Discharge (gpm)	Drawdown (feet)	Specific capacity [1]	Saturated thickness (feet)	Yield factor [2]
42/5– 8P1	1, 000	15	67	65	100
42/6– 9F1	400	8	50	122	41
43/6–33J1	150	10	15	46	33
45/5–34C1	250	70	3. 6	100	3. 6
45/7–34K1	128	110	1. 2	132	. 9

[1] Gallons per minute per foot of drawdown.
[2] Gallons per minute per foot of drawdown per foot of saturated thickness penetrated by the well, times 100.

STRUCTURE

The sedimentary and metamorphic rocks of pre-Late Cretaceous age along the western side of Shasta Valley generally strike northeast and either stand vertically or dip at high angles. In the vicinity of Yreka these rocks generally are intruded conformably by sill-like bodies of serpentine ranging in width from several tens of feet to several thousand feet. At Yellow Butte the metamorphic rocks strike dominantly north, and the bedding in few places dips at less than 80°.

The beds in the Chico and Umpqua formations generally strike northwest and dip 15°–20° NE. At some localities, such as that about a mile southwest of Delphic School in 44/6–6, the Chico formation locally dips westward, possibly reflecting the surface irregularity of the Abrams mica schist on which it was deposited. Near the western part of the valley the strikes and dips of the volcanic rocks of the western Cascades are similar to those of the Chico and Umpqua formations, but farther east along the margin of the high Cascades the dips flatten to approximately 5°. The eastward dips of all these formations are probably the result of subsidence of the valley under the rapid accumulation of 10,000–15,000 feet of rocks of the western Cascades. Subsidence may have resulted in part also from the transfer of rock materials to the surface from an underlying magmatic reservoir and the subsequent subsidence of the roof of the magma chamber.

The major structural elements in Shasta Valley are two narrow northwestward-trending fault blocks, one in the northern part of the valley, and the other at its eastern margin (pl. 1). North of Snowdon an upthrown block contained between two faults is traceable for about 5 miles. To the south it is concealed beneath alluvium, and to the north it disappears near the Klamath River. Williams (1949, p. 52) reported that the downthrow on the east side of the horst diminished northward from a maximum of about 400 feet; the downthrow on the west side diminished northward from a maximum of 200 feet.

The horst at Yellow Butte, which bounds the valley on the east in the Pluto Cave area, is traceable for about 8 miles northwest and is the more prominent of the two structures. Near the south end of this horst at Yellow Butte, faulting has brought to the land surface metasedimentary rocks of Paleozoic age and quartz monzonite of probable Jurassic age. Three miles to the north the Umpqua formation has been brought into fault contact with rocks of the western Cascades. The observed dips and stratigraphic relations of the two rock units suggest that the eastern fault may have a displacement of about 1,000 feet. The contact locally is marked by springs, and artesian wells are obtained east of the fault. A short distance north of Yellow Butte a scarplet about 15 feet high in the Plutos Cave basalt indicates movement of the eastern fault within the last few thousand years.

The western fault of the Yellow Butte horst is concealed by the Plutos Cave basalt throughout its extent. The position of the Umpqua formation in the horst and the dip of the Umpqua formation beneath the rocks of the western Cascades west of the fault, shown diagrammatically on figure 3, imply that the displacement of the fault is at least 2,000 feet.

Geologic structure sections across Shasta Valley are shown on figure 8. Section *B–B′* extends east-northeastward from the vicinity of Paradise Craggy to Bogus Mountain and crosses the horst some 3.5 miles north of Snowdon. Section *C–C′* trends east-southeastward from the vicinity of Yreka to the Goosenest volcano. That part of the cross section (fig. 8) east of the point *C′* is after Williams (1949).

GEOLOGIC HISTORY

The oldest formation in the area is the Abrams mica schist of the basement complex, a series of highly siliceous beds probably of early Paleozoic (pre-Silurian) age, which show evidence not only of extensive sedimentation but also of an epoch of metamorphism and erosion which antedates the deposition of the sediments of the

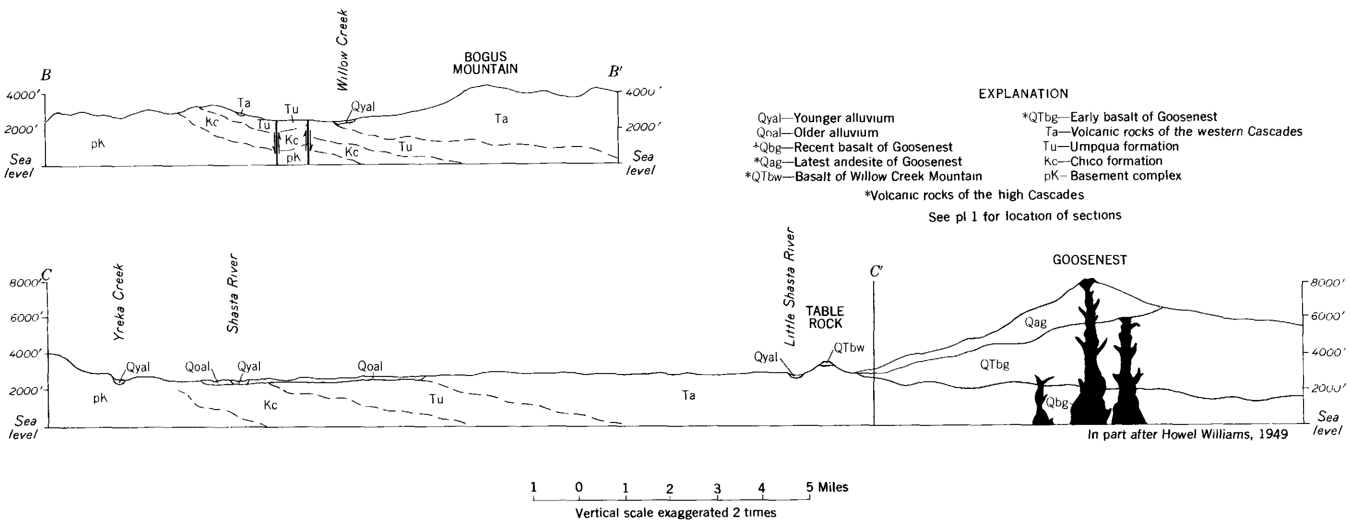

Figure 8.—Diagrammatic sections B–B′ and C–C′ across Shasta Valley illustrating geologic structure.

Chanchelulla formation of Hinds (1931). During Silurian and early Devonian time deep seas covered a great part if not all of the region occupied by the Klamath Mountains. The beds of the Chanchelulla formation that record the Silurian phase of deposition in the Shasta Valley area are chiefly sandstone and shale and scattered lenses of limestone in which corals and other forms of marine life were abundantly preserved. The next event recorded by the rocks in the area is a period of vigorous volcanic activity when a great mass of andesitic lava, now converted to greenstone and greenstone schist, was extruded. The age of the greenstone is problematical; it may be correlative with the Copley greenstone of pre-middle Devonian age or with the Applegate group of Triassic(?) age in southern Oregon. It seems probable that, as has occurred elsewhere in the southern Klamath Mountains area, during the latter part of the Paleozoic and continuing into the Mesozoic era a great thickness of sedimentary and volcanic rocks was deposited and subsequently eroded from the Shasta Valley area. The close of the Jurassic period and possibly the Early Cretaceous were marked by the Nevadan orogeny, one of the great mountain-building epochs of the Pacific coast of the United States. The rocks were strongly folded, faulted, uplifted, and intruded by igneous rocks that ranged in composition from peridotite to granodiorite.

With the termination of the Nevadan orogeny the land began to subside more or less continuously, the sea advanced upon the land, and the Chico formation was deposited. Near the close of Cretaceous time the Shasta Valley area probably was covered completely by water, but at the close of the Cretaceous period the Klamath Mountains again were uplifted. During Eocene time the Umpqua formation, which is of fresh-water origin and which is composed of shale, sandstone, conglomerate, and a few thin beds of coal, was deposited on the eroded Cretaceous and older rocks at the present sites of the east flank of the Klamath Mountains and Shasta Valley. Northward in the vicinity of Roseburg, Oreg., the Umpqua formation is marine and includes abundant flows of pillow basalt.

Late Eocene time ushered in a period of extensive volcanic activity which continued through the Miocene epoch. Most of the volcanoes lay to the east of Shasta Valley and possibly now are covered by the lavas of the younger volcanoes of the high Cascades. Williams (1949, p. 33) states that the volcanoes of the western Cascades never could have been very high, because fossil redwood forests, which presumably required abundant moisture as do modern redwoods, have been found east of the Cascade Range in upper Miocene beds. Their occurrence is taken by Williams to indicate that the volcanoes were not high enough to check moisture-laden ocean winds and therefore did not reduce the rainfall on the lee side by more than a few inches. Because the volcanic rocks of the western Cascades accumulated to thicknesses greater than 10,000 feet, the area must have subsided many thousands of feet as the eruptions continued if the land surface remained relatively low as postulated.

At the close of the Miocene epoch the entire Cascade belt was upheaved on a broad scale. This upheaval was accompanied by the formation of north-northwestward-trending faults along the bases of the volcanic cones and by the opening of fissures along the crest of the range, from which poured the Pliocene and younger lavas that built the giant cones of the high Cascades (Williams, 1949, p. 35). During Pliocene and early Pleistocene time a northward-trending chain of shield volcanoes was built up by quiet effusions of fluid olivine basalt and basaltic andesite. At the same time andesite flows were discharged by other volcanoes along the crest of the range. Mount Shasta was built mainly during the Pleistocene epoch, at first principally by andesitic flows but in the final stages by eruptions of dacite and basalt as well.

The glacial history of Mount Shasta is not well enough known to determine whether there were several stages such as those recorded in the Cascade Range of Oregon and in the Sierra Nevada of California. At their maximum extent, which may have occurred during the late Pleistocene at the climax of the Tioga stage of Blackwelder (1931), the glaciers that descended the northwest slopes of Mount Shasta spread into Shasta Valley to an altitude of about 2,800 feet. The maximum advance is well marked by the position of the terminal moraines.

After the close of the Pleistocene epoch, while the glaciers of Mount Shasta were retreating to their present position, many new volcanoes were formed in the Cascade Range. Some of the flows and associated cones are hardly modified by erosion and must have been formed within the last few thousand years. Products of the most recent volcanism in the area include the last flows of Mount Shasta and Goosenest and the Plutos Cave basalt.

The ancestral Shasta Valley probably was formed at the close of the Miocene epoch prior to the growth of the Pliocene shield volcanoes. Drainage then was different from that of today, as the Shasta River formerly ran close to the edge of the high Cascades. Today the Shasta River makes a sharp westward bend on leaving the Dwinnell Reservoir site and flows parallel to the margin of the Plutos Cave basalt for about 10 miles. This course was established only a few thousand years ago when the former channel was occupied by the flow.

GROUND WATER

OCCURRENCE AND MOVEMENT

In the unconsolidated sediments of Shasta Valley, such as the younger and older alluviums and the glacial deposits near the south end of the valley, ground water occupies the openings between the constituent grains which make up the sediments. In consolidated sedimentary rocks, such as the sandstone beds of the Chico and Umpqua formations, the size and number of these openings have been reduced by compaction and by the deposition of cementing material between the mineral grains. Additional interstices, however, are present in the rocks of the Chico and Umpqua formations in the form of openings along bedding and joint planes. The rocks of the basement complex of the Klamath Mountains along the west side of the valley also contain fracture openings such as those along bedding planes, joints, faults, sheer zones, and foliation planes. Openings in the volcanic rocks of the western Cascades and the Plutos Cave basalt are found mainly in the form of joints and the clinkery contacts between flows. Buried lava tubes are numerous in the Plutos Cave basalt and are thought to be especially important for the transmittal of water through the basalt.

The ground-water body in Shasta Valley appears to be hydrologically continuous within all the geologic units in the valley, although the irregular topography and the distribution of the geologic units suggests that the valley might be divided into several distinct hydrologic units. That illusion is fostered by the northward-trending central belt of rocks of the western Cascades (pl. 1) which extends the length of the valley on the surface. The rocks rise to heights of several hundred feet above contiguous parts of the valley area and appear to form imposing hydrologic barriers between lithologic units that crop out on the east and west flanks of the valley. On the north they separate older alluvium in the Montague area from the younger alluvium of Little Shasta Valley, and on the south they separate the Plutos Cave basalt and glacial deposits from the younger alluvium in the Gazelle-Grenada area. However, geologic and hydrologic evidence indicates that the rocks of the western Cascades do not form barriers to ground-water movement, except perhaps locally. They are highly permeable in some areas of the valley, as is indicated by high yields of irrigation wells that tap them in the Gazelle-Grenada area. Reported high seepage losses through the rocks of the western Cascades which form the western wall of Dwinnell Reservoir also attest to their permeability.

Plate 2 shows contours representing the surface of the ground-water body in Shasta Valley. The altitudes of the water levels in wells were determined from measurements made during April 1954. The direction of ground-water movement is at right angles to the contours in a downslope direction from the areas of recharge to the areas of discharge. The water-level contours on plate 2 show that ground water moves generally northward in the southern part of Shasta Valley and troughward toward the Shasta River in the eastern and western parts. From about Weed northward the contours intersect the channels of the major streams, indicating that ground-water discharge supplements the surface-water flow in the Shasta River system. At the north end of the valley, an eastward-trending ground-water divide occurs about at Snowdon—to the north ground water moves out of the valley between Bogus and Black Mountains and to the south ground water moves toward the Shasta River.

The hydraulic gradient varies considerably in the different types of material underlying the valley. In the vicinity of Big Springs the water surface in the Plutos Cave basalt slopes to the west at about 25 feet per mile. The water table in the glacial material between Mount Shasta and Dwinnell Reservoir slopes northwestward at about 150 feet to the mile, reflecting the steep terrain at the foot of the mountain or low permeability, or both. Hydraulic gradients in the volcanic rocks of the western Cascades average about 30 feet per mile throughout most of the valley. Immediately west of Dwinnell Reservoir, however, the gradient in these rocks steepens, sloping to the northwest at about 100 feet per mile. This steepening may reflect sizable recharge to the volcanic rocks from Dwinnell Reservoir. Hydraulic gradients in the Gazelle-Grenada alluvial belt and in Little Shasta Valley average about 30 feet per mile.

The depth to the water table varies greatly throughout Shasta Valley. The depths are greatest at the south end of the valley near its eastern and western margins. The depths are least near the valley trough. Near Pluto Cave the water table lies at a depth of about 300 feet. Northward and westward the land surface declines rapidly and many large springs issue from the basaltic lava. In Little Shasta Valley the water table locally intersects the land surface and ponds and meadows occupy the depressions. The maximum depth to water along the western margin of the valley was that in well 43/6–29Q1, near the head of an alluvial fan built out from the Klamath Mountains about 2½ miles northwest of Gazelle. The measurement at this location in the spring of 1954 indicated the water level to be 82.4 feet below the land surface.

So far as is known, water-table conditions exist throughout most of the valley, but artesian conditions exist locally. For example, at the north end of the valley, well 46/6–24L1, which penetrates 200 feet of sandstone and shale of the Umpqua formation, overflows during the winter and spring. Ground water in the fairly permeable sandstone beds in the Umpqua formation is confined between beds of impermeable shale. Near Gazelle, well 43/6–21J2, which pumps about 800 gpm, shows rapid and nearly complete recovery of water level, amounting to about 40 feet, within 10 minutes after pumping ceases. This rapid recovery may reflect artesian conditions; however, it might reflect instead a high entrance loss. The well is drilled through alluvium but penetrates volcanic rocks of the western Cascades. Well logs in this area suggest that water is confined in a permeable zone of rocks of western Cascades, possibly a contact zone between flows, between overlying, and underlying impermeable lava. Big Springs yield considerable water under pressure from the Plutos Cave basalt. The water may originate in snowmelt from Mount Shasta and flow through a lava tube which nears the surface at Big Springs.

The Plutos Cave basalt is the most important aquifer in Shasta Valley, yielding abundant water to wells and springs in the vicinity of Big Springs. The north slopes of Mount Shasta, which comprise an area of almost 170 square miles, receive as much as 70 inches of precipitation annually, mostly as snow, and supply abundant recharge to the Plutos Cave basalt. Yields of irrigation wells that tap the basalt range from 120 to 4,000 gpm and average about 1,300 gpm.

Wells that tap the volcanic rocks of the western Cascades vary greatly in yield, as the permeability of the lavas depends upon the somewhat random distribution of joints or clinkery contacts, or both. However, in most parts of the valley the rocks of the western Cascades generally supply sufficient water for domestic and stock uses. In the Gazelle-Grenada area, irrigation wells in these rocks yield 120–1,400 gpm and average 800 gpm. North of the Little Shasta River they contain a high percentage of tuffaceous beds and mudflow deposits which appear to be less permeable, and hence less suited to development, than the areas underlain by the andesitic lava of the western Cascades exposed elsewhere in the valley. The rhyolite lava domes and andesite volcanic necks also are presumed to be of lower permeability than the main body of andesitic lava, chiefly because they lack the openings provided by the clinkery contacts between the individual flows.

The basement complex and the Chico and Umpqua formations are tapped by relatively few wells in the area. Locally these rocks, where strongly jointed, are capable of yielding sufficient water for domestic and stock uses.

Morainal and fluvioglacial deposits generally yield sufficient water for domestic and stock supplies. Irrigation wells that tap the bouldery glacial deposits east of Edgewood have yields ranging from 600 to 1,500 gpm. The elongate outwash deposit immediately west of Edgewood is not tapped by wells but probably is only poorly permeable because of the high clay content suggested by the formation of the ubiquitous clay-centered stone rings exposed on the surface.

The younger and older alluviums generally yield water sufficient for domestic and stock uses. Locally along the west side of the valley in the vicinity of Gazelle, well that tap the younger alluvium obtain sufficient water for irrigation. Yreka obtains its municipal supply of about 1,200 gpm from an infiltration gallery constructed in the younger alluvium. The older alluvium commonly is poorly sorted and probably not capable of yielding water in amounts adequate for irrigation.

SPRINGS

Springs and seeps occur in some exposures of all the formations in the Shasta Valley area, particularly near the borders of the valley and along the courses of the major streams. In the Klamath Mountains, springs issuing from fractures in the basement complex supply water to many streams entering Shasta Valley from the west. Fractures in the Chico and Umpqua formations supply small springs in the northern part of the valley. In the high Cascades, springs issue from the porous top and bottom parts of lava flows and from joints in the lava; other springs issue from the rims of depressions between adjacent shields; still others occur in fault zones cutting the lavas; and some springs issue from tubes in basaltic flows. The following discussion relates primarily to the occurrence of springs in the volcanic rocks along the east side of Shasta Valley, because these springs are of far greater quantitative importance than those found elsewhere in the valley.

Numerous springs and seeps occur in the valley of Parks Creek along the western base of the long northeastward-trending ridge of andesite that forms the western wall of Dwinnell Reservoir. There, water flows from closely spaced fractures in the andesite and from the foot of talus slopes. One of these springs, at location 42/5–4B1, was flowing 2.7 cfs (cubic feet per second) on September 24, 1954. According to residents of the area, seep areas always have been present in this vicinity, but the springs did not attain their present high rate of flow until after the construction of Dwinnell Reservoir.

About 2 miles to the north, at location 43/5–28B1, a flow of approximately 6 cfs was recorded on September 24, 1954, from two vents in fractured lava at the base of a hill.

Several springs, including spring 44/4–28H1 which supplies the major flow of Spring Creek, are oriented along the fault that marks the east side of Yellow Butte. At spring 44/4–28H1 water gushes from several slits in the lava of the high Cascades and flows down a steep slope to join Spring Creek. On October 15, 1954, the flow in Spring Creek below the main spring was about 1 cfs. Above the junction with the main spring the flow was only about 0.2 cfs.

Along the east edge of Shasta Valley, springs are common close to the contact between the volcanic rocks of the western Cascades and the overlying flows of the high Cascades. Cold Spring (also called Cleland Spring), 45/4–17Q1, gushes from numerous vents for a distance of about 200 feet along the toe of a Recent lava flow from Goosenest. At one place water jets from fractured basalt as though forced from a pipe. At the most southerly vent, water flows quietly from clinkers and talus blocks lying beneath massive black finely vesicular basalt. Water from the spring area is collected in a channel and is used for irrigation in Little Shasta Valley. Table 9 shows the variation in flow at Cold Spring from January to May 1954.

TABLE 9.—*Flow at Cold Spring from January to May 1954* [1]

Date	Flow (cfs)
1954	
Jan. 22	12.7
Feb. 11	13.5
Mar. 25	13.8
Apr. 14	10.8
May 11	11.2

[1] Data from unpublished records in the files of the California Division of Water Resources.

Numerous springs issue from the Plutos Cave basalt. The best known of these is the Big Springs, from which about 30,000 acre-feet of water is discharged yearly. Water from Big Springs flows westward and is impounded in an artificial lake and thence diverted to ditches for use by the Big Springs Irrigation District. Big Springs Creek flows from beyond the lake to the Shasta River—a distance of about a mile. Water rises in many places in the creek bed, and evidence of spring sapping in the banks is widespread. Measurements made in 1918 (Watson and others, 1923, p. 149) summarize spring discharge in the immediate area: flow of Big Springs at outlet, 32 cfs; Little Springs (located 1 mile southwest of Big Springs) near outlet, 6 cfs; Big Springs Creek at junction with Shasta River, 103 cfs. The results of these measurements show an increase of about 65 cfs derived mainly from springs in the bed of the stream downstream from Big Springs between the outlet of the two springs and the Shasta River.

Two clusters of highly saline carbonated springs are in Shasta Valley and vicinity—one near Table Rock, and the other near Bogus School about 6 miles northeast of Ager (north of area shown on pl. 1). The temperature of Bogus Springs ranges from 73°F to 81°F. A qualitative analysis made in 1947 showed the presence of sodium chloride, magnesium and calcium carbonate, sodium phosphate, silica, iron, and traces of lithium and hydrogen sulfide (Williams, 1949, p. 56). The different outlets of Table Rock Springs yield water ranging in temperature from 57°F to 65°F. The waters have a high content of calcium and sodium bicarbonate and sodium chloride. Water from one of the Table Rock springs, a few hundred yards north of Little Shasta River near the northern base of Table Rock, formerly was bottled as a carbonated mineral water.

The Bogus Springs issue from low mounds of dazzling white calcareous tufa, in an area about 400 feet across, at the base of a hillside near the county road between Ager and the Copco Reservoir north of the mapped area. Gas bubbles from all the springs. Volcanic rocks of the western Cascades, probably andesite or basaltic andesite, cover the slopes in the immediate vicinity of the springs. North and east of the springs are a series of flat-topped hills capped by flow remnants of Pliocene(?) olivine basalt derived from the Eagle Rock volcano. The main tufa mound, which contains 4 vents, measures about 20 feet in height and 30 yards in diameter. The largest vent on this mound forms an oval pool, 5 by 3 feet, in which a temperature of 81°F was measured. Although the water bubbled vigorously, no flow occurred over the sides of the vent. Southeast of this deposit are 10 smaller mounds of tufa. Six of these did not flow water but the water was seen to bubble feebly in the summer of 1954.

Along the east side of Shasta Valley, at the spring near the base of Table Rock (45/4–20D1) on the Terwilliger Ranch, an estimated flow of 2 to 3 gpm of carbonated water issues from the top of a low mound of calcareous tufa about 100 yards in diameter. Two miles downstream from that spring, at location 45/5–25B1, strongly carbonated water rises from the lava-rock gravel at the south edge of the Little Shasta River. The spring there discharges about 1 gpm at a temperature of 57°F. The rocks in the vicinity of the spring are strongly iron-stained and cemented by calcareous tuffa. Cemented gravel is exposed in the stream bed several hundred feet upstream from the present spring, suggesting that carbonated water formerly issued from vents at that place. The third of the carbonated springs

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in the Table Rock area (45/4–29M1) is near the southern base of Table Rock on the Martin Ranch. About 1 gpm issues from a vent some 75 yards west of a tufa mound, 10 feet high, which formerly was the principal outlet.

FLUCTUATIONS OF WATER LEVELS

The rise and decline of water levels in wells in Shasta Valley is related to the amount of recharge to the ground-water reservoir and the amount of discharge from the reservoir. When recharge exceeds discharge the water levels rise, and conversely, when the draft exceeds the inflow the water levels decline. The principal factors that influence the rise and fall of water levels are infiltration of rainfall into permeable rocks within the tributary drainage area, ground-water discharge into streams, evapotranspiration, pumping from wells, and recharge from excess application of irrigation water.

Figure 9 shows hydrographs of wells 44/5–34C1, 45/5–28D1, and

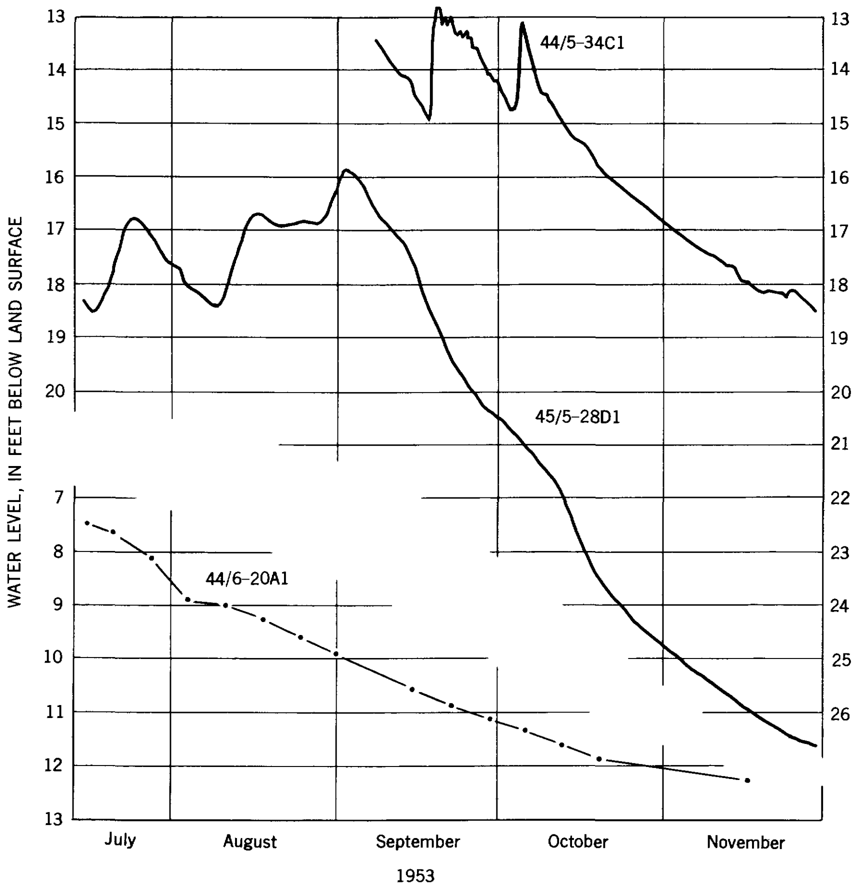

FIGURE 9.—Hydrographs of wells 44/5–34C1, 45/5–28D1, and 44/6–20A1.

44/6–20A1 for the period July to November 1953. Automatic water-stage recorders were installed on wells 44/5–34C1 and 45/5–28D1, and weekly measurements were made in the third well. The hydrograph for well 44/6–20A1 illustrates the normal seasonal downward trend of the water table during the summer and fall. The hydrographs for wells 44/5–34C1 and 45/5–28D1 probably would have maintained almost the same seasonal slope as well 44/6–20A1, had it not been for several peaks caused by the infiltration of excess irrigation water to the water table. The graphs show that the net declines ranged from about 5 feet in wells 44/5–34C1 and 44/6–20A1 to nearly 11 feet in well 45/5–28D1.

Figure 10 shows hydrographs of wells 43/6–21J1 and 43/6–21J2 in which weekly water-level measurements were made from July to November 1953. The wells are about 300 feet apart and are near the west edge of an alluvial fan extending valleyward from the Klamath Mountains about 2 miles north of Gazelle. The nonpumping water levels in both wells are almost the same, and, instead of

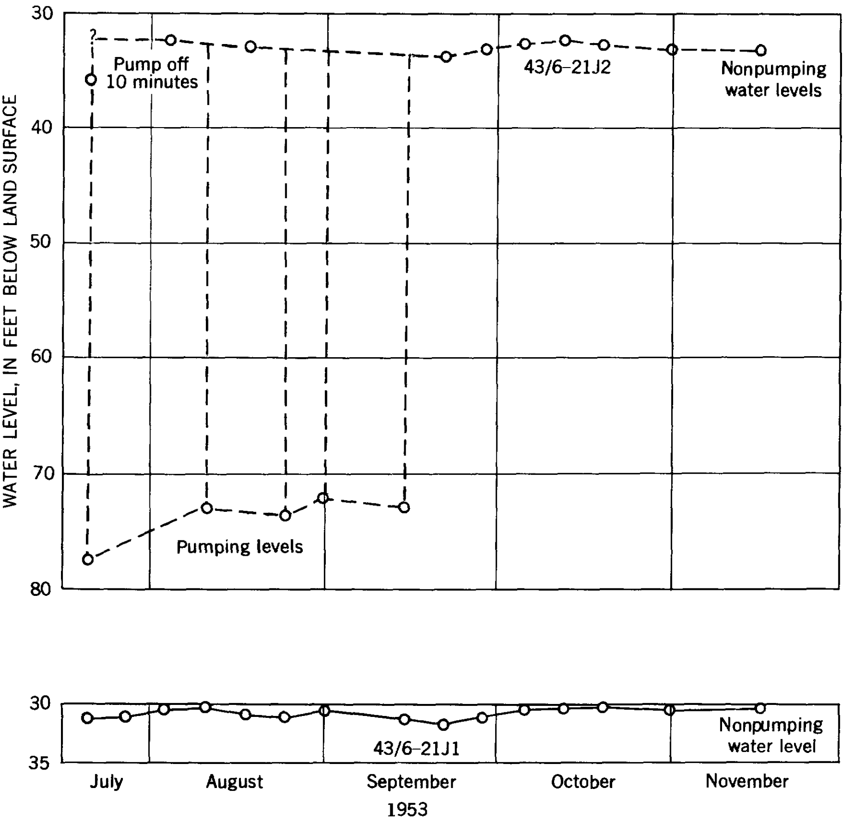

FIGURE 10.—Hydrographs of wells 43/6–21J1 and 43/6–21J2.

reflecting the normal seasonal decline, change remarkably little. Apparently the addition of recharge from an excess of water applied for irrigation in the area virtually balanced the seasonal decline, thus maintaining a nearly static level. Well 43/6–21J2 has a drawdown when pumping of about 40 feet. Despite the short distance between the wells, pumping in well 43/6–21J2 had no apparent effect on the water level in 43/6–21J1. This may be due to the difference in depth of wells 43/6–21J1 and 43/6–21J2, which are 203 and 250 feet deep, respectively. Drillers' logs suggest that the pumped well penetrates a permeable zone of rocks of the western Cascades that is not reached by well 43/6–21J1. This and the rapid rise in water level suggest the possibility of artesian conditions. Water-level measurements taken on July 20, 1953, showed a pumping level of 77.8 feet below the land-surface datum (table 20). After the pump had been shut down for 10 minutes, the water rose about 40 feet or to within 36 feet of the land-surface datum.

Water-level measurements made in Shasta Valley during the spring of 1953 and 1954 indicate that only a slight net change in water levels, and hence in ground-water storage, occurred in that period. In the vicinity of Big Springs, there was a net rise averaging approximately 1 foot. Near Ager the change was so small as to be nearly unmeasurable. In the Edgewood area, the net rise was about 1.5 feet, and in the Gazelle-Grenada and Little Shasta areas the net rise averaged 0.5 foot. The Montague area showed the only net decline in water levels during the year, about 1.5 feet.

RECHARGE

Most of the recharge to the ground-water body in Shasta Valley is effected by infiltration (deep percolation) of precipitation that falls on the tributary drainage area. From this area water moves into the valley in part underground and in part as spring discharge. Recharge is effected also by seepage from streams draining the upland areas, and by influent seepage of surface water used for irrigation. Probably a small proportion of the total recharge comes from precipitation that falls directly on the valley floor.

The water-level contour map (pl. 2) shows that ground water moves troughward towards the Shasta River from areas of recharge along the eastern and western margins of the valley. From the east the high Cascades contribute abundant recharge because of the high precipitation in the area and the extremely porous and permeable nature of the soil and the underlying volcanic rocks. The northern slopes of Mount Shasta, which comprise about 170 square miles, or approximately 20 percent of the total drainage area, probably contribute more recharge to the ground-water reservoir in Shasta Valley than does any other part of the basin. The sedimentary and crystalline rocks of the Klamath Mountains on the west are not nearly as porous or permeable as the volcanic rocks of the high Cascades. Direct runoff from the Klamath Mountains is considerably higher than that from the Cascade Range, and some recharge in the fanhead areas is effected by seepage loss from streams issuing from the Klamath Mountains.

Recharge resulting from irrigation with surface water constitutes an important source of ground water in the area. In 1953 about 25,000 acres was irrigated with about 60,000 acre-feet of water. Of this total, about 58,000 acre-feet was surface water diverted from streams and from Dwinnell Reservoir and the remainder was ground water. The average irrigation efficiency (percentage of water applied that is used by the crops) throughout Shasta Valley was estimated at about 75 percent by the California Division of Water Resources (Horn and others, 1954). Applying this estimate, recharge from surface-water irrigation in 1953 was about 15,000 acre-feet.

It is doubtful whether any significant amount of precipitation falling on the vally floor percolates below the root zone in Shasta Valley in years of average or below-average rainfall. The mean annual precipitation on the valley floor, which is only about 12–15 inches, probably is not sufficient to contribute much recharge to the ground-water body, but it appears sufficient to supply the soil-moisture requirements for all the valley's vegetation, except that along watercourses which in part may be phreatophytic. However, in years of above-average rainfall the precipitation probably supplies some recharge to ground water.

DISCHARGE

Ground water in Shasta Valley is discharged by both natural and artificial means. Natural discharge occurs by seepage into streams and by evapotranspiration (evaporation directly from the soil, and plant transpiration). Little ground water moves out of the valley as underflow through the thin alluvial deposits of the Shasta River and through the underlying bedrocks. Artificial discharge results from the pumping and flow of water from wells. The discharge from flowing wells is small.

In 1953 about 6,000 acre-feet of water was pumped from the ground-water reservoir in Shasta Valley. This figure includes 3,500 acre-feet withdrawn for use in urban miscellaneous water-service areas and 2,500 acre-feet for irrigation. These figures, however, represent the pumpage; the net draft, or water permanently removed from the reservoir, probably was about 4,000 acre-feet. The difference represents return irrigation water.

Natural discharge from the area far exceeds artificial discharge. In 1953 natural subirrigation was received by about 13,000 acres of pastureland and grainland, for the most part in areas of the younger alluvium bordering the major streams in the valley. It was estimated by the California Division of Water Resources (Horn and others, 1954) that about 28,000 acre-feet of water was lost to the atmosphere by evapotranspiration from these subirrigated areas.

The water-level contours on plate 2 indicate that the Shasta River is a gaining stream throughout most of its course through the valley as a result of movement of ground water troughward from the valley margins. A crude estimate of the ground-water discharge to the Shasta River and its tributaries in Shasta Valley can be made by subtracting the total gaged and estimated surface-water inflow, less the net surface-water diversions for irrigation, from the total gaged outflow of the Shasta River near Yreka. This estimate is derived below.

The Geological Survey and the California Division of Water Resources have gaged the principal streams in the area, the Shasta and Little Shasta Rivers and Parks Creek. The discharge of Big Springs is included as an element of surface-water inflow only because it is a gaged quantity that flows into the Shasta River and therefore is distinguished from rising ground water along the stream courses. Estimates of the discharge of minor streams that flow into the Shasta River are based on drainage area and precipitation data and have been obtained from unpublished records in the files of the California Division of Water Resources. Table 10 shows the gaged and estimated surface-water inflow to Shasta Valley for the water year ending September 1953:

TABLE 10.—*Gaged and estimated surface-water inflow to Shasta Valley in the year ending September 30, 1953*

Stream	Discharge [1] (acre-feet)
Shasta River at Edgewood	58, 000
Parks Creek near west edge of valley	23, 000
Little Shasta River near east edge of valley	22, 000
Big Springs	[2] 30, 000
All streams along western part of valley from north of Parks Creek to the mouth of the Shasta River	[3] 35, 000
Other minor streams	[4] 5, 000
Total about	170, 000

[1] All figures are rounded to the nearest thousand acre-feet.
[2] Discharge of Big Spring is gaged and is a known contribution to streamflow.
[3] Estimated by the California Division of Water Resources.
[4] Estimated by the Geological Survey.

The table shows that the total surface-water inflow to Shasta Valley in the water year 1952–53 was about 170,000 acre-feet, including the discharge of 30,000 acre-feet from Big Springs. Of this total, a part is diverted for irrigation and a part is evaporated from Dwinnell Reservoir and from the surfaces of the streams and detention reservoirs. The California Division of Water Resources has estimated the annual evaporation from Dwinnell Reservoir to be about 5,000 acre-feet from a water-surface area of about 1,300 acres. Evaporation from the approximately 500 acres of stream surface and detention reservoirs is estimated to be 2,000 acre-feet.

The estimated surface-water diversion for irrigation in 1953 was 58,000 acre-feet. Of this total a small part was diverted upstream from the stream gages, and must be deducted from the estimated diversion because it was not included in the estimate of total surface-water inflow. In addition, a small part of the diverted water applied to field crops near river banks returned to the streams as tail waste. Accordingly, the net water diverted was somewhat less than 58,000 acre-feet.

The net water diverted plus the surface water lost by evaporation in 1953 probably was about 60,000 acre-feet. This total subtracted from the estimated total surface-water inflow of 170,000 acre-feet leaves a residual of 110,000 acre-feet, which, if the above estimates are reasonable, would have been the total surface-water outflow at th valley outlet north of Yreka had there been no added increment due to ground-water discharge into the streams. However, the flow of Shasta River near Yreka in the 1953 water year was 181,400 acre-feet (Wells and others, 1955, p. 545). The gaged outflow less the residual of 110,000 acre-feet is 70,000 acre-feet, which is a crude measure of the ground-water discharge into the Shasta River and its tributaries in the 1953 water year.

In the preceding paragraphs of this section the principal elements of ground-water discharge from Shasta Valley have been estimated for the 1953 water year. These rough estimates include the following: Discharge into the river, 70,000 acre-feet; net pumpage, about 4,000 acre-feet; evapotranspiration from subirrigated lands, about 28,000 acre-feet; and gaged discharge from Big Springs, 30,000 acre-feet, most of which is discharged from the valley as streamflow, or a total of about 130,000 acre-feet. This total constituted the bulk of the ground-water discharge from Shasta Valley in the 1953 water year. Unestimated elements are minor and include the uncontrolled flow from a few wells, the discharge of small springs on the valley floor, and evapotranspiration losses in small areas of phreatophytes.

WATER UTILIZATION

Most of the wells in Shasta Valley are dug wells about 20 feet deep which supply water for domestic and stock uses. Most of the irrigation wells are in the Gazelle-Grenada and the Big Springs areas. Municipal supplies are obtained from wells. Yreka has a municipally owned water system, whereas the smaller towns in the valley are served by either private water companies or individually owned wells.

The California Division of Water Resources' interim report on the Klamath River basin (Horn and others, 1954) contains figures on water utilization and the present land-use pattern in relation to water requirements in Shasta Valley. Three categories of land-use pattern are listed:

1. An irrigated land group which includes all agricultural lands dependent upon surface application of water, as well as those agricultural lands utilizing water from a shallow-water table (subirrigation) or from winter flooding.
2. Urban lands which include the developed area of towns within the valley.
3. Miscellaneous water-service areas which include farmsteads, parks, golf courses, cemeteries, airports, and industrial sites, which are not within urban boundaries.

Total water applied for all uses in Shasta Valley in 1953 was about 64,000 acre-feet. Urban use was about 2,500 acre-feet, based on an estimated daily per capita consumption of 200 gallons. Miscellaneous water-service areas used about 1,000 acre-feet, most of the supply coming from wells. By far the greatest part of the water used in Shasta Valley was applied for irrigation. A total of about 25,000 acres was irrigated with about 2,500 acre-feet of ground water and 58,000 acre-feet of surface water (California Division of Water Resources, written communication).

Four organized irrigation districts provide water for approximately 10,000 acres of irrigated land in Shasta Valley (table 11).

TABLE 11.—*Principal water-service agencies in Shasta Valley in 1953*

[Based on Horn and others (1954, table 3)]

Agency	Source of water supply	Approximate area irrigated (acres)
Montague Water Conservation District	Shasta River	5, 000
Grenada Irrigation District	do	1, 000
Shasta River Water Users Association	do	2, 500
Big Springs Irrigation District	Big Springs	1, 500

The Montague Water Conservation District, containing a gross area of about 21,000 acres, is the largest. Others are the Grenada Irrigation District, containing about 2,000 acres, the Big Springs Irrigation District, containing 3,700 acres, and the Shasta River Water Users Association, covering about 5,100 acres.

The Montague District has maintained Dwinnell Reservoir for regulation of the Shasta River and as a facility for diversion of water into the district's distribution system. The dam was designed originally to impound 70,000 acre-feet of water, but because of excessive leakage through the sides of the reservoir the water stage is maintained at or below an elevation of 2,796 feet, providing an effective storage capacity of about 34,000 acre-feet. During the 1953 irrigation season, 13,900 acre-feet of water was diverted into the district's main canal from the reservoir. Inflow to the reservoir is supplemented by a diversion from Parks Creek, a tributary of the Shasta River.

The Big Springs Irrigation District obtains its water by pumping from a pond fed by copious flows from the Big Springs. The Shasta River Water Users Association and Grenada Irrigation District both pump directly from the Shasta River. The Shasta River and its major tributaries constitute an adjudicated stream system, from which lands outside organized districts are served by individual diversions from the stream system.

QUALITY OF WATER

Minerals in the earth's crust are attacked and dissolved by water at the land surface and water percolating through the rocks above and within the zone of saturation. The solvent action of water is greatly increased by the presence in solution of carbon dioxide, derived from the atmosphere and the soil, and by organic substances leached from the soil. The character of the dissolved mineral matter in natural waters is thus intimately related to the composition of the soils and rocks in a particular area. The concentration of mineral constituents is controlled partly by rainfall. Where rainfall is abundant, concentrations tend to be low because the volumes of water are relatively large and rates of movement relatively fast. The converse is true in arid regions; where water stays for a long time in contact with the rocks, the concentrations of dissolved minerals in natural waters tend to be high.

In natural waters most of the mineral constituents occur in ionic form, but some occur as colloidal suspensions. The common ionized constituents generally reported in water analyses are the cations (basic or positive ions) calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) and the anions (acid or negative ions) carbonate (CO_3), bicarbonate (HCO_3), sulfate (SO_4), and chloride (Cl). The constituents that may occur in colloidal form include silica (SiO_2) and iron and aluminum oxides and usually are reported as total quantities present of silica, iron, and aluminum. In addition, in many analyses other constituents such as boron (B), fluoride (F), and nitrate (NO_3), which in part affect the quality of water with respect to its use for agricultural or domestic uses, are reported. The chemical analyses of water were made by the U. S. Geological Survey, Quality of Water Branch.

Chemical analyses of water are commonly expressed in terms of ppm (parts per million) or of equivalents per million or both. Parts per million expresses the concentration of an ion (such as calcium or chloride) by weight when compared to the weight of a million parts of water, the unit of measurement being the same. Equivalents per million expresses the concentration of the chemical constituents dissolved in the water in terms of their chemical combining weights; in this form or expression one equivalent per million of any ion present is chemically equal to one equivalent per million of any other ion in solution.

In the following discussions of water chemistry another term, percentage reacting value (or percentage equivalents per million) is also employed. Percentage reacting value is defined as the proportion of one cation (in equivalents per million) to the sum of all the cations (in equivalents per million) expressed as a percentage, or the proportion of one anion (in equivalents per million) to the sum of all the anions (in equivalents per million).

RELATION TO USE

In the spring and autumn of 1953 the California Division of Water Resources collected 109 samples of ground water and 27 samples of surface water in Shasta Valley for analysis at the U.S. Geological Survey Quality of Water Laboratory at Sacramento, Calif. The results of these analyses are assembled in tables 22 and 23 and show that the Shasta Valley waters are virtually of the calcium magnesium bicarbonate type and are generally satisfactory, except for hardness, for domestic uses, and excellent for irrigation.

The physical, chemical, and bacteriological quality of drinking water in the United States may be judged by the U.S. Public Health Service Drinking Water Standards (1946, p. 13). Although these standards apply officially only to drinking water and water-supply systems used by interstate carriers subject to Federal Quarantine Regulations, they have been accepted voluntarily by the departments of public health of most States as criteria for the evaluation of public water supplies. The recommended maximum concentration for the more common mineral constitutents follows:

Maximum concentration for mineral constituents

Constituents	Maximum concentration (ppm)
Fluoride	1.5
Iron and manganese together	0.3
Magnesium	125
Chloride	250
Sulfate	250
Dissolved solids	[1] 500

[1] Dissolved solids of 1,000 ppm permitted if water of better quality is not available.

The waters in Shasta Valley generally conform to the listed standards for drinking water. Several ground-water samples, however, contained concentrations of chloride higher than those suggested in the standards, and rather high concentrations of nitrate as well, probably owing to local contamination by livestock and human wastes. For the most part the contaminated waters are restricted to the older alluvium in the northern part of the valley, where water is obtained mainly from dug wells that average only 20 feet in depth. Water from two springs in the vicinity of Table Rock had a very high chloride content, but the chloride is probably of deep-seated origin. Water from these springs has a mineral concentration in excess of 4,000 ppm and formerly was bottled for sale as carbonated mineral water. The water of East and West Lakes, which are about 3 miles east of Grenada, contains about 1,100 ppm of dissolved solids as a result of evaporation of the water and concentration of the dissolved mineral matter.

Hardness is caused mainly by salts of calcium and magnesium and when using soap with this water it is difficult to obtain a lather. It is expressed as an equivalent amount of calcium carbonate ($CaCO_3$). According to Bateman (1950, p. 866), soft waters range in hardness from 0 to 55 ppm, slightly hard waters from 56 to 100 ppm, moderately hard waters from 101 to 200 ppm, and hard waters from 200 ppm. In general, Shasta Valley waters are hard, the hardness ranging from 30 to 582 ppm, and averaging about 250 ppm throughout the valley. The hardest waters, averaging 314 ppm in hardness, are from wells tapping the older alluvium. The softest waters are from two wells tapping the Umpqua formation at the north end of the valley. There the hardness of waters from wells 46/5–18L1 and 45/5–6E1 was 30 and 44 ppm, respectively.

The most important factors that affect the quality of water for irrigation are the total amount of dissolved salts, the bicarbonate content, the boron content, and the relative proportion of sodium. These factors may vary independently, so that water adequate in several respects may be rendered unsuitable because of a high concentration of one constituent.

Water having a high sodium ratio (percent sodium) adversely affects the soil texture by the chemical process of cation exchange, in which sodium replaces calcium and magnesium in the soil complex and the soil particles then have a tendency to become disaggregated or dispersed. Studies have shown that the dispersion of soil particles may occur when the percent sodium in irrigation water exceeds 50. Dispersion may cause the soil to become relatively impermeable to the downward movement of water (puddled) and thereby may accentuate drainage problems and bring about alkali conditions and crop damage.

Wilcox (1948, p. 27) presents a table (see following table) based on field observations that classifies water for irrigation on the basis of total concentration as indicated by the electrical conductivity (see table 22) and percent sodium.

Classification of water for irrigation

Classes of water		Specific conductance (micromhos at 25° C.)	Percent sodium
Rating	Grade		
1	Excellent	Less than 250	Less than 20.
2	Good	250–750	20–40.
3	Permissible	750–2,000	40–60.
4	Doubtful	2,000–3,000	60–80.
5	Unsuitable	More than 3,000	More than 80.

Boron is an essential element for normal plant growth, but at concentrations only slightly above optimum it is exceedingly toxic to many plants. Natural waters containing more than 2 ppm of boron are likely to cause injury to many plants.

If water having a high concentration of bicarbonate is used for irrigation there is a tendency for calcium and magnesium to precipitate as carbonates as the soil solution becomes more concentrated and carbon dioxide is lost from solution. As the concentrations of calcium and magnesium are thereby reduced, the relative proportion of sodium is increased. If the amount of carbonate and bicarbonate equals or exceeds the amount of calcium and magnesium, all expressed in equivalents per million, nearly all the calcium and magnesium may be precipitated and the percent sodium may rise to nearly 100, the sodium being present largely as residual sodium carbonate. The pH of the water increases, and the alkaline water may dissolve organic matter from the soil, producing the condition often referred to as black alkali.

Water in the Shasta Valley area is generally of excellent quality for irrigation. A few sources, however, yielded waters that contained undesirably large amounts of boron or high percent sodium, or both. Such waters are known from only the springs near Table Rock and the deeper wells tapping the Umpqua formation in the vicinity of the fault block near Snowdon.

RELATION TO GEOLOGY

A correlation has been recognized between the composition of the bedrock in different parts of the area and the chemical character of water from wells and streams deriving water from the several bedrock terranes. This statement applies particularly to areas underlain by limestone ($CaCO_3$) and serpentine ($Mg_3 Si_2 O_5 (OH)_4$) which readily give up the calcium and magnesium ions, respectively, to natural waters that contain dissolved carbon dioxide.

Near the southwestern margin of Shasta Valley, from Willow Creek south to Weed, ground water percolates through masses of serpentine which underlie much of the mountainous area between the Sacramento and Trinity Rivers. The average percentage of magnesium in the waters of 5 wells tapping alluvium in this area is 86 percent of total cations. The concentration of silica also is high in the waters, averaging 16 percent of the dissolved solids. Table 12 lists significant chemical features of ground water from wells considered to derive water from serpentine. The Shasta River heads in the area west of these wells, and in the upper reaches the quality of the river water also shows the influence of the serpentine.

TABLE 12.—*Chemical features of water draining the serpentine*

Well	Parts per million			Cations, in percent		
	Silica	Dissolved solids	Hardness	Ca	Mg	Na+K
41/5–4N1	53	350	321	7	87	6
4D1	29	236	217	12	80	8
9F3	32	183	167	6	90	4
42/5–33M1	55	295	247	9	83	8
42/6–10J1	50	320	296	8	89	3
Average	44	277	250	8	86	6

Figure 11 shows cation relationship of Shasta River water at several localities in the valley. Close to the mountains at sampling locality 41/5–9P, magnesium in the river water made up 91 percent of the total cations. About 4 miles downstream at locality 42/5–20J, the magnesium percentage dropped to 56, because of mixing with ground water from glacial deposits near Edgewood. At locality 44/6–23H, near Grenada, the magnesium content decreased further to 45 percent. Near the mouth of the river, at locality 46/7–24H, the magnesium percentage rose to 53, presumably indicating the presence of several small sill-like bodies of serpentine that are intruded into the Siskiyou Range north of Yreka.

Samples from Parks and Willow Creeks also indicate the presence of the large serpentine mass at the south end of the valley. A sample from Yreka Creek at location 45/7–34L near the county fairgrounds shows a magnesium content of 74 percent. There, drainage is over

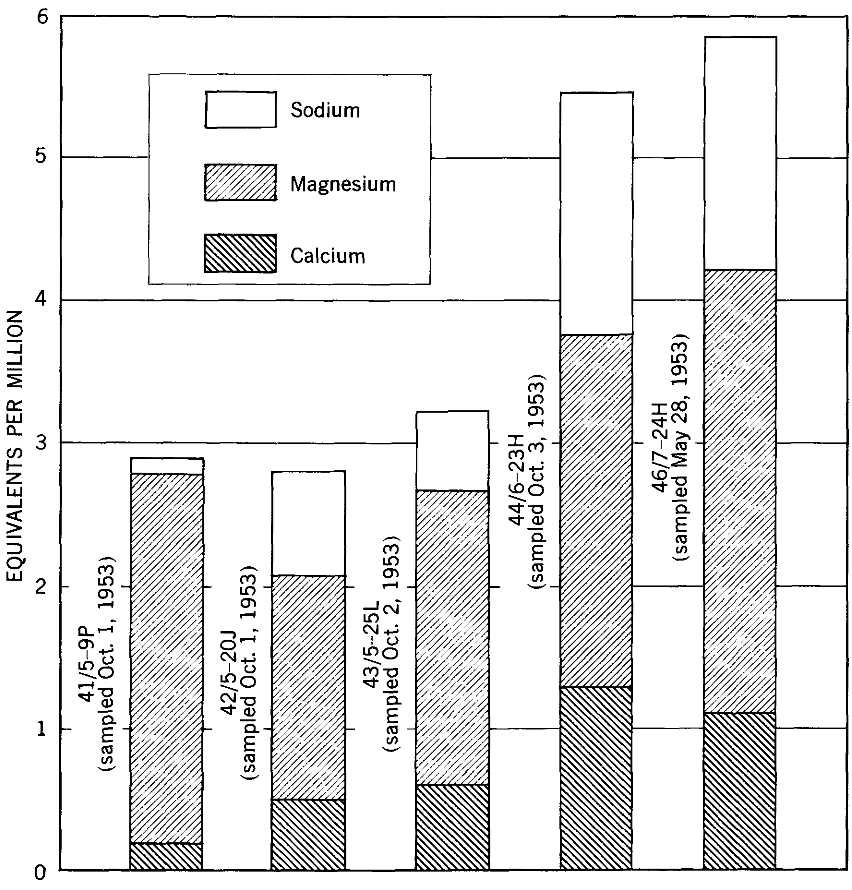

FIGURE 11.—Cation relationships of Shasta River water at five sampling localities in Shasta Valley.

a southeastward-dipping sill-like body of sepentine which extends from Yreka 15 miles south-southwest into Scott Valley.

Like serpentine, limestone has influenced the chemical quality of ground water in localized areas in Shasta Valley. Beds of limestone included within the Abrams mica schist and the Chanchelulla formation of Hinds (1931), are found in the mountains bordering the valley on the west. Along Willow Creek, in the Chanchelulla formation, a resistant blue-gray limestone bed that averages about 200 feet in thickness forms prominent scarps and high cliffs. Smaller lenses of limestone are included in a zone extending from 35 to 325 feet below the main limestone. Analyses of water from wells 42/6-3L1 and 42/6-8H1 show calcium percentages of 54 and 60, respectively. Similarly, about 5 miles northwest of Grenada, beds of dark-gray limestone in the Abrams mica schist have imparted a high calcium concentration to the ground water. There, water from wells 44/7-13C2 and 44/7-13J1 shows a calcium percentage of 75. Table 13 shows the chemical features of analyses of well water from known limestone areas in Shasta Valley.

TABLE 13.—*Chemical features of water draining known limestone beds*

Well	Parts per million			Cations, in percent		
	Silica	Dissolved solids	Hardness	Ca	Mg	Na+K
42/6- 3L1	25	301	259	54	38	8
8H1	19	315	278	60	33	6
44/6-18M4	25	266	209	70	16	14
44/7-13C2	28	217	165	75	15	10
13J1	17	203	172	75	18	7
Average	23	260	217	67	24	9

Excluding those areas containing known limestone beds, surface waters draining over the Abrams mica schist and the Chanchelulla formation of Hinds (1931) are of the calcium magnesium bicarbonate type and show average calcium and magnesium percentages of 51 and 35 percent, respectively. The average dissolved solids and hardness are 299 and 234 ppm, respectively.

The predominant anion in Shasta Valley waters is bicarbonate, which generally constitutes 80–90 percent of the total anions. However, water draining the Chico formation west of Montague has an average sulfate content of 35 percent, possibly due to the oxidation of pyrite which is present in beds of black shale in the uppermost part of the formation. Three wells, each exceeding 200 feet in depth, tap the Chico formation in the vicinity of Montague. Those are the salt-water artesian well 44/6-3D1, well 45/7-24R1, and well

45/6–19E1. Water from the latter 2 wells has an average percent sodium of 44, (table 14) which is considerably higher than the average for water obtained from rocks of the Chico formation at shallow depth and may indicate a base-exchange reaction.

TABLE 14.—*Chemical features of water draining the Chico formation*

Well	Depth of well (feet)	Parts per million			Cations, in percent		
		Silica	Dissolved solids	Hardness	Ca	Mg	Na+K
45/6–19E1	425	23	252	114	32	24	44
45/7–24R1	235	20	307	142	27	27	46
45/6–30D1	Shallow	40	332	203	36	37	27
45/7–25N2	Shallow	16	482	303	33	42	25
Average		25	343	190	32	32	36

No analysis was made of the artesian salt water from well 44/6–3D1, which taps the Chico formation, but the water is probably of connate origin. The percentage of sodium chloride in the water is undoubtedly very high, because in the latter part of the 19th century, the owner was known to have extracted common salt from the water. (See discussion of Chico formation.)

Water from the springs near Table Rock is virtually a sodium bicarbonate water (percent sodium 85), the chloride making up about 26 percent of the total anions. In addition to high concentrations of sodium and chloride, these waters have an average of about 4,700 ppm of dissolved solids, and high concentrations of boron (14 ppm). Water from the cluster of carbonated springs near Bogus School also is highly mineralized and similar in composition to the water from the Table Rock Springs. It is possible that the sodium chloride in both these spring areas originates from the Chico formation at great depth. However, the high sodium chloride content might reflect instead the recent volcanic activity in the region, particularly because a high boron content is characteristic of springs in volcanic areas. According to Williams (1949, p. 56), no major faults are known to be present in either of these areas, but probably the springs lie on fractures of small displacement.

In the northern part of the valley, well 46/5–8P2, which is 200 feet deep, penetrates volcanic rocks of the western Cascades at land surface, but it probably enters the Umpqua formation at shallow depth. Water from the well contains more than 800 ppm dissolved solids and has a relatively high content of sodium, chloride, and boron. The percentages of these constituents are similar to percentages for the spring water in the vicinity of Table Rock, about 10 miles to the southeast. Table 15 shows this comparison.

TABLE 15.—*Chemical features of water from springs near Table Rock and well 46/5–8P2*

Location	Percent		Parts per million		Ratio of boron to dissolved solids
	Sodium	Chloride	Boron	Dissolved solids	
45/5–25B	88	28	14	4, 870	1/348
45/4–20D	84	24	-------	4, 540	----------
46/5–8P2	75	34	2. 8	828	1/296

Table 15 shows that although the absolute amount of boron in parts per million in the spring water at location 45/5–25B differs considerably from that in the well water at 46/5–8P2, the ratio of boron (ppm) to dissolved solids (ppm) in both samples is remarkably similar. It seems possible, therefore, that these waters have circulated through similar rocks. Boron, probably related to the recent volcanic activity in the area, occurs in fairly large amounts not only in the high-chloride waters discussed above but also in low-chloride waters from wells tapping the Umpqua formation in the vicinity of the fault block near Snowdon. Table 16 shows these relationships.

TABLE 16.—*Chemical features of water from the Umpqua formation*

Location	Percent		Parts per million		Ratio of boron to dissolved solids
	Sodium	Chloride	Boron	Dissolved solids	
45/5– 6E1	92	8	5. 5	614	1/112
7P1	21	5	. 66	532	1/806
18L1	95	1	1. 2	736	1/613
46/6–24E1	24	5	1. 3	515	1/396

The low-chloride content of these waters probably eliminates the possibility that they are of connate origin, and hence the high percent sodium in water from wells 45/5–6E1 and 46/5–18L1 may result from base exchange. The most noteworthy feature of these waters is their divergence from one another.

Analyses of water from wells tapping the Plutos Cave basalt are presented in table 17 and show very consistent chemical characteristics, possibly because most of the samples were obtained from a rather restricted area in the vicinity of Big Springs. The basalt, however, was extruded as a single flow; hence, it might be expected to be of uniform mineral composition and to yield waters of uniform character. The analyses of waters from the volcanic rocks of the western Cascades are shown in table 18. The waters are not as uniform in composition as the waters from the Plutos Cave basalt, perhaps because samples were collected from a larger area throughout the valley but more probably because the rocks of the western Cascades lack the homogeneity of composition of the Plutos Cave basalt. Ground-water samples from the Plutos Cave basalt have an average concentration of silica of 63 ppm (highest in the valley) compared to 45 ppm for waters draining the dominantly andesitic rocks of the western Cascades.

The high silica content of water from wells tapping the Plutos Cave basalt probably is not derived entirely from the basalt. It may be derived in large part from the pyroclastic debris and glacial outwash deposits which mantle a large part of the recharge area on the north slopes of Mount Shasta. Because of the large surface area they present in relation to their volume, finely comminuted particles of glacial flour and volcanic ash would be likely to impart a high silica content to natural waters. This supposition is supported by analyses of water from Garrick Creek (42/5–22P), which flows through an extensive area of fluvioglacial material near the south end of the valley. The sample from Garrick Creek, collected April 27, 1953, contained 75 ppm of silica and the sample collected October 1, 1953, contained 60 ppm of silica. By contrast, the average silica content of other surface waters in Shasta Valley is only about 30 ppm.

TABLE 17.—*Chemical features of water from wells tapping the Plutos Cave basalt*

Well	Parts per million			Cations in percent		
	Silica	Dissolved solids	Hardness	Ca	Mg	Na+K
43/5- 3R1	63	246	120	23	42	33.5
9C1	67	482	279	21	45	34
23A1	75	388	226	24	46	30
23M1	74	340	188	22	47	31
44/5- 2R1	51	301	169	38	30	32
34G1	61	385	257	31	45	24
34H1	66	408	240	31	40	30
34J1	60	453	246	26	36.5	37.5
34N1	58	324	148	23	36	41
34Q1	58	363	204	28	39	34
35L1	63	449	250	26	38	35
Average	63	376	194	27	40	33

TABLE 18.—*Chemical features of water from wells tapping the volcanic rocks of the western Cascades*

Well	Parts per million			Cations in percent		
	Silica	Dissolved solids	Hardness	Ca	Mg	Na+K
44/5- 1J2	47	416	274	46	29	25
45/5- 4N1	35	317	208	51	28	20
19P1	61	262	168	39	46	15
21P1	46	308	208	41	37	21
24R1	49	327	239	38	46	16
27A1	49	456	368	39	47	14
28D1	33	224	128	44	24	31
28M2	41	543	382	37	45	18
29B1	50	335	214	37	37	26
29B2	51	328	214	42	33	24
46/5-21J1	28	309	201	43	22	34
Average	45	348	237	42	36	22

In summary, ground and surface waters draining the different formations in the Shasta Valley area generally can be distinguished by their chemical character. The predominant anion in all the waters is bicarbonate (fig. 12), which usually averages between 80 and 90 percent of the total anion content. Along the west side of the valley the waters draining areas of serpentine have a very high percentage of magnesium (86 percent), and waters draining limestone beds have a high percentage of calcium (67 percent). Waters from the near-surface Chico formation west of Montague have nearly equal percentages of calcium, magnesium, and sodium plus potassium. Saline water is found principally at the Table Rock Springs, the cluster of carbonated springs near Bogus School, and the salt-water artesian well at locality 44/6–3D1. The salt water in well 44/6–3D1 is probably of connate origin, whereas the waters of Table Rock Springs and the springs near Bogus School may receive substantial mineralization from a volcanic source. The most diagnostic chemical features of these spring waters are the high salinity, high sodium, and high boron content (as high as 14 ppm). The chloride content averages about 30 percent of total anions. Two wells tapping the Umpqua formation at the north end of the valley show a percent sodium as high as 90, which is possibly due to base exchange. The boron content of 4 samples from this source averaged about 2.3 ppm, and may have been derived from the low-grade coal beds near the base of the Umpqua formation. Water from the Plutos Cave basalt has an unusually large amount of silica, which averages about 63 ppm. Silica averages about 45 ppm in water from the volcanic rocks of the western Cascades.

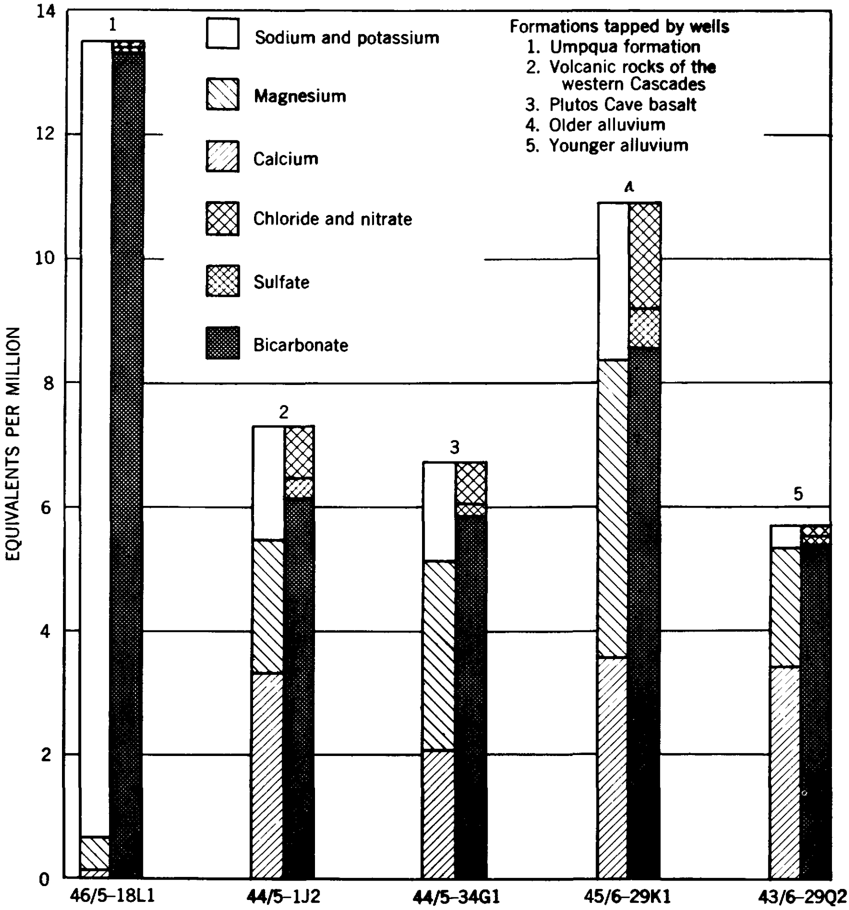

FIGURE 12.—Graphical presentation of analyses of selected samples of ground water in Shasta Valley.

TABLE 19.—*Description of water wells in the Shasta Valley area, California*

Altitude of land-surface datum: Altitude interpolated to the nearest foot from topographic maps of Shasta Valley prepared in 1922 by the Geological Survey in cooperation with the Bureau of Reclamation.
Depth: Reported by the owner or was obtained from the driller's log.
Type of well: Du, dug; P, drilled with percussion or cable-tool equipment; R, drilled with rotary tools.
Discharge and drawdown: The discharge, in gallons per minute, and the drawdown, in feet, are listed as reported by the owner or well driller.
Use of water: D, domestic; G, garden; I, irrigation; M, municipal; S, stock; U, unused well.
Other data available: Additional basic data available in the files of the Geological Survey: C, chemical analysis; L, driller's log.

Well	Owner or tenant	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well	Diameter of well casing (inches)	Water level		Discharge (gpm)	Drawdown (feet)	Use of water	Other data available
							Date measured	Distance above (+) or below land-surface datum (feet)				
41/5- 4D1	John Mazzini		3,086		Du		4- 2-53	2.5			D	C
							10-25-53	2.5				
							5- 4-54	1.9				
4N1	Dwight Hammond		3,161	20	Du	24	4- 2-53	4.0			D	C
							10-25-53	3.3				
							5- 4-54	3.3				
9F3	John Bussi		3,207		P	6	4- 2-53	7.8			D	C
							10-25-53	8.2				
							5- 4-54	4.1				
42/5- 8E1	Hay and Grisson		2,712				5-20-54	5.7			D	
8P1	do	1950	2,708	68	P	16	5-20-54	3.3	1,000	15	I	
12C1	Lee Bryan	1952	2,933	315	P	20			800	170	I	L
20J1	Ernest Spada	1952	2,882	40	P	8	4- 2-53	6.2			D	C
							10-25-53	6.4				
							5- 4-54	3.8				
23J1	A. B. Hoy & Son	1953	3,225	205	P	16	6-15-54	130	1,000	44	I	L
26A1	do		3,218	205	P	16	6-15-54	90	600	40	I	L
26R1	Don Enloe	1953	3,345	160	P	20	6-15-54	96	1,500	25		L
28D1	J. W. King	1946	2,930	32	P	6					D	C
33M1	W. H. King	1950	3,041	148	P	10					D	C
33M2	do	1941	3,041	28	Du	48	4- 2-53	6.75			U	
							10-25-53	6.10				
							5- 4-54	6.60				
42/6- 3L1	M. L. Bridwell	Old	2,796		Du		4- 6-53	7.80			D	C
							10-19-53	25.0				
							5- 3-54	9.30				
8H1	Darrel Etchison	Old	2,981		Du		10-31-53	9.10			D	C
9F1	D. C. Shelley	1950	2,956	147	P	10	12-11-52	24.9	400+	8	I	
							4- 6-53	25.9				
							10-31-53	26.0				
							5- 3-54	27.5				

TABLE 19.—*Description of water wells in the Shasta Valley area, California*—Continued

Well	Owner or tenant	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well	Diameter of well casing (inches)	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Discharge (gpm)	Drawdown (feet)	Use of water	Other data available
42/6- 9N2	Paul Clark		2,958	12	Du		4- 6-53	6.0			D	
							10-31-53	6.2				
							5- 3-54	4.7				
10J1	G. G. Maxwell	1946	2,841	110	P	6	4- 6-53	6.2			D	C
							10-31-53	9.3				
							5- 3-54	2.9				
43/4- 2E1	Bob Martin	1950	3,325	175	P	16			400		I	
3A1	do	Old	3,380	119	P	10	9- 3-54	Flowing	Flowing 13		I	
3A2	Bob Martin	1953	3,380	105	P	16	7- 5-54	3.45	200		U	L
4J1	Jess Martin	1954	3,075	203	P	16					U	L
4R1	do	1954	3,050	300	P	10					U	L
10A1	do		3,215	285	P						S	L
10E1	H. J. Hight	1954	3,100	335	P	10					U	L
43/5- 3C1	Don Taylor	Old	2,616				4- 2-53	11.6			U	
							10-25-53	9.9				
							5- 4-54	10.5				
4G1	Ellis Louie	Old	2,592		P	10	4- 2-53	6.8			U	
							10-25-53	6.7				
							5- 4-54	6.5				
8R1	Frank Costello		2,600		P	6	5-14-54	4.9			D	
9C1	Ellis Louie	Old	2,601	16	Du		4- 2-53	12.95			D	C
							5- 4-54	9.6				
19F1	Unknown		2,638		P	6	5-14-54	12.00			U	
19L1	Unknown		2,628	10	Du	360	5-14-54	.4				
23A1	Howard J. Hawkins	Old	2,687	100±	P	8	4- 2-53	32.9			D	C
							10-25-53	34.7				
23M1	K. Waters	1949	2,668	44	P	8					D	C
43/6- 3D1	Riemo Capafello	1954	2,610	64	P	10			10		D	L
3L1	Henry Burbank	1953	2,588	27			4- 6-53	2.5			D	C
							5- 3-54	2.5				
10K1	C. S. Timmons	1952	2,638	105	P	16	4- 6-53	9.75	840	30	I, S	L
							5- 3-54	10.50				
10Q1	do	1952	2,635	92	P	14			120	59	I, S	L, C
15F2	do	1952	2,663	94	P	14					I	L, C
21E1	Molly Coonrod	Very old	2,758	125±			4- 6-53	51.7			D	C
							10-31-53	46.4				
							5- 3-54	46.4				

21J1	Dougherty & Son	1951	2,729	203	P	16	7-20-53	33.4	200		U	L
							11-16-53	32.35				
21J2	do	1952	2,733	250	P	16	11-16-53	33.15	800	76	I	L, C
22A1	R. E. Richman	1952	2,665	100	P	16	12-11-52	4.8	1,400	5	I	L
							4- 6-53	4.8				
							10-31-53	5.1				
							5- 3-54	3.1				
22P1	California Highway Dept		2,712				4- 6-53	10.8			U	C
22P2	McDonald		2,715	36	P	6	5-11-53	7.3			D	C
23N1	Dick Richman	1952	2,672	100	P	14	12-11-52	7.3	800	60	I	L
							10-31-53	7.9				
							5- 3-54	7.3				
23N2	do	1922	2,676	50	P	14	12-11-52	3.2	2,000		I	C
							10-31-53	2.9				
							5- 3-54	2.7				
29Q1	Gus Nelson	1930	2,883	440	P	10	12-11-52	77.1			U	
							4- 6-53	80.1				
							10-31-53	80.8				
							5- 3-54	82.4				
29Q2	do	1936	2,883	150	P	8	4- 6-53	80.1	100		I	C
30R1	—Ledwig	1950	2,960	157							S	L
33J1	— Cleland	1927	2,752	60	P	10	12-11-52	13.5	150	10	I	C
							10-31-53	12.4				
44/4- 5F1	O. E. Davis	1938	3,050	150	P	8			300	74	I	
5K1	do	1937	3,040	335	P	8			400	58	I	
8P1	Larry Walters		3,025	275	R	6	7- 7-54	9.5	50	20	U	L
8R1	do	1951	3,175	275					60		S	L
17P1	do	1949	2,900	850	P	12					U	L
18F1	do		2,780	126	R	6					U	L
18Q1	do	1942	2,825	246	P	8			Dry hole		U	L
44/5- 1J1	Jess Martin	1950	2,774	165	P	18	12-10-52	4.7	250	47	I	
							4- 8-53	4.8				
							5- 6-54	2.3				
1J2	do	1951	2,771	59	P	16	12-10-52	1.3	125	38	I	C
							4- 8-53	2.8				
							5- 6-54	1.7				
1J3	do	1951	2,762	135	P	18	12-10-52	12.4	100	60		
							4- 8-53	8.8				
							5- 6-54	10.0				
1R1	do	1950	2,765		P	18			100	55	I	
2K1	R. E. Hart	Very old	2,698	62	P	16	4- 8-53	2.2	1,000	32	I	
							5-14-54	1.9				
2Q1	do	1927	2,699	80±	P	10	4- 8-53	1.3			U	
							5-14-54	1.2				
2R1	do	Old	2,720	80±							D	C
4C1	do		2,660		Du	60	5-12-54	10.7			U	
11M1	do	Old	2,670		Du	48	4- 8-53	5.8			U	
							5-14-54	6.5				
12L1	do	1952	2,742	120		16	4- 8-53	40.3	900	15	I	
							5-14-54	41.7				

TABLE 19.—*Description of water wells in the Shasta Valley area, California*—Continued

Well	Owner or tenant	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well	Diameter of well casing (inches)	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Discharge (gpm)	Drawdown (feet)	Use of water	Other data available
44/5-12Q1	E. H. Williams	1954	2,748	105	P	14	6-20-54	68	1,000		I	L
14M1			2,670		P	8	5-12-54	51.5			U	
18B1	Frank Brahs	1954	2,610	85	P	16	5-17-54	18	600	15	U	
21H1	W. Sterchi	1953	2,675	335			5-12-54	80.5	120	12	U	L
22P1	Lloyde Fleisch		2,662	80	P	12	5-12-54	59.2			S	
24R1	Dr. Nunes	1954	2,793	700±	P	14	5-12-54	129.7			I	
28K1	Louis Silva	1950	2,632	200	P	16	5- 5-54	34.7	150	12	I	L
28L1	do		2,610	64	P	6			10		D	L
32C2	do	1952	2,583	80	P	14	5-13-54	38.0			D	L
33J1	E. Louie	1951	2,611	150			4- 2-53	9.6			U	
							5- 4-54	10.5				
34C1	Tony Pimental		2,632	137	P	20	5- 5-54	20.4			U	
34G1	do	1952	2,628	132	P	16	4- 2-53	16.65	900	108	I	C
							10-25-53	11.5				
							5- 5-54	14.1				
34H1	Henry Silva	1952	2,637	96	P	16	11- 2-52	28.4	4,000	34	I	L, C
							4- 2-53	19.8				
							5- 5-54	28.6				
34J1	John Perino	1952	2,640	104	P	16	12-11-52	27.4	900	41	I	L, C
							4- 2-53	28.3				
							10-25-53	26.6				
							5- 5-54	27.5				
34N1	Don Taylor	Old	2,606				4- 2-53	8.7			U	C
							10-25-53	7.4				
							5- 4-55	9.9				
34Q1	A. J. Quadros	1951	2,625	55		16	4- 2-53	16.5	1,250	9	I	L, C
35C1	Don Taylor	Old	2,627		P	16	4- 2-53	30.15			I	
							10-25-53	45.4				
35F1	A. S. Quadros	1954	2,657	131	P	16	5-14-54	60.9	1,500	44	I	
35L1	John Deas	1953	2,648	65	P	16			1,300	20	I	L, C
35L2	—Zediker	1953	2,669	76	P	16			1,750		I	
36L1	R. E. Hogan	1949	2,735	149	P	12			1,100	31	I	L
44/6-3D1	George Fiock	Prior to 1881	2,470	450			5-14-54	Flowing				L
3M1	Shasta River Water Assoc.	1953	2,525	40	P	6					D	L
10F1	—Mazzuchi	1952	2,537	113	P	8	4- 6-53	26.3			D, S	C
							10-31-53	23.7				
							5- 3-54	26.1				

10F3	Raymond Sears	1951	2,523	28	P	6			20		D	
10R1	A [illegible]eka Kennels)	Old	2,533		P	6	4- 6-53	7.9	50	7	D	C
							10-31-53	9.8				
							5- 3-54	11.5				
14H1	May Crutchfield	Old	2,512	300	P	8	4- 6-53	7.70			D	C
15H1	Fred Burbank	Old	2,533	12	Du	48	4- 6-53	5.10			S	C
							10-31-53	4.40				
							5- 3-54	4.90				
18M4	J. P. Heft		2,792	230	P	8	4- 6-53	38.55			D	C
							5- 3-54	38.7				
20A1	Dr. Charles Orr	Old	2,684	25	Du	48	4- 6-53	6.85			U	C
							10-19-53	11.89				
							5- 3-54	6.4				
21K1	Brahs Bros. Inc	Old	2,622	45			4- 6-53	20.7			D	
							10-30-53	21.1				
							5- 3-54	18.8				
22K1	Clay Stone		2,560	49	P	6			25		D	L
22M1	Felix Arami	Old	2,590	29	P	8	10-31-53	13.7			I, D, S	C
22M2	Billie Arami		2,600	135	P	12	5-12-53	8.00			U	C
							5- 7-54	3.4				
22Q1	Andrea Zanotta	1954	2,560	41	P	6					D	L
27D1	— Sousa	1954	2,582	40	P	6			10		D	L
27Q1	Howard Hogle	Old	2,558		Du	48	4- 6-53	4.7			I	C
							10-31-53	2.7				
							5- 3-54	2.1				
29D1	Joe Arnold	Old	2,798		Du	48	4- 6-53	8.8			U	C
							5- 3-54	9.1				
34K1	Ernest Bhend	Old	2,574	15	Du	48	4- 6-53	5.10			U	
34K2	do		2,574	80							D	C
44/7- 3Q1	John F. Denz	1954	2,780	57	P	6			10		D	L
3Q2	— Silva	1953	2,760	140	P	6			15	90	D	L
12P1	— Brazie	1947	2,880	175	P	12			225		I	L
13C2	Fred Sellstrom	1946	2,753	95	P	6	4- 6-53	17.7			D	C
							10-31-53	19.5				
							5- 3-54	16.0				
13J1	Raymond Black		2,824	46			4- 6-53	24.8			D	C
							10-19-53	27.4				
							5- 3-54	24.2				
45/5- 4N1	G. Yonce	1880	2,770	22	Du	48	4- 7-53	Flowing			S, I, D	L, C
6E1	Siskiyou County Airport		2,635		P	6					U	C
45/5- 7H1	W. G. Halter	1949	2,655	56	P	6			10	9	D	L
7N1	H. I. McGraw		2,618	21	Du	24	4- 7-53	8.9			D	C
7Q1	James Elsea	1950	2,673	125	P	8			10		D, I	L
18D1	Tom Williams	1925	2,645	168	P	6			13	10	D	
19P1	R. D. Dudley		2,584		Du	30	4- 8-53	5.2			D, S	C
21P1	S. O'Connor	Old	2,694	31	Du	48	4- 8-53	24.5			D	C
22P1	E. F. Dreyer	1870	2,710		Du	48	4- 8-53	19.2			D	
23R1	Ray Soule		2,798	20	Du	48	5- 6-54	11.8			D	
24R1	Unknown	1900	2,865	42	Du	48	5- 7-53	26.5			D, S	C
							5- 5-54	31.1				
26Q1	Schlichter	Old	2,712	50	Du	48					D	C

TABLE 19.—*Description of water wells in the Shasta Valley area, California*—Continued

Well	Owner or tenant	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well	Diameter of well casing (inches)	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Dis-charge (gpm)	Draw-down (feet)	Use of water	Other data available
45/5-27A1	Ross-Shelley		2,723	30	Du	48	4- 8-53	21.90			D	C
							10-19-53	18.55				
							5- 5-54	18.10				
28D1	Bruce M. Long		2,662	183+	P	16	5- 5-54	24.3				C
28M2	Brice Long		2,618	14	Du	60	4- 8-53	8.6			S	C
							5- 6-54	7.8				
29B1	Paul Karney	1945	2,635	25	Du		4- 8-53	21.3			D, S	C
							10-19-53	17.65				
							5- 5-54	22.0				
29B2	Stanley Wendt	Old	2,935	20	Du						D	C
33B1	L. P. Dunlap	1852	2,622	16	Du	60	4- 8-53	8.40			D	C
34C1	LeRoy Miller	1947	2,658	100	P	16	12-10-52	.60	250	70	I	
							4- 8-53	.50				
							5- 6-54	.30				
35N1	R. E. Hart		2,700				4- 8-53	2.30			U	
							10-12-53	4.19				
							5-14-54	3.30				
36D1	Little Shasta Cemetery		2,745	80	P	8	6-30-54	18.46	15		D	L
36E1	Oliver Lane	1954	2,745	85	P	6	6- 3-54	20.00	20		D	L
36N1	Dan Haight		2,721	35			4- 8-53	11.40			D	
							5- 6-54	10.80				
45/6- 1H1	Smith and Droz		2,620	176	P	10	7-20-53	.75			U	
							11- 3-53	2.50				
2Q1	George Walker		2,631	8	Du		4- 7-53	14.40			D	C
							10-24-53	15.00				
							5- 6-54	16.40				
3Q1	Paul Richman	1954		120	P	6			20		D	L
10A1	— Haley		2,645				4- 7-53	3.50			D, G	C
							5- 6-54	7.40				
10G1	J. Maddox		2,662		Du		4- 7-53	16.60			D	C
							10-24-53	18.90				
							5- 6-54	19.30				
14P1	Vernon Schwanke	1954	2,575	70	P	8			60			L
15F1	— Crowell	1948	2,585	37	Du		4- 7-53	21.70			D, S	C
							10-24-53	19.50				
							5- 6-54	22.0				

17F1	Henry Fiock		2,475	63	P	8	4- 7-53	Flowing	1		I, S	
							10-24-53	Flowing				
							5- 7-54	Flowing				
17F2	do		2,475	75	P	8	5- 7-53	Flowing	2		I, S	
18K1	Araujo Bros		2,442	75	Du		4- 7-53	15.50			U	C
							10-24-53	15.50				
							5- 6-54	16.40				
19E1	George Weldon		2,538	425	P	16	4- 7-53	17.60			D	C
							10-24-53	20.70				
							5- 6-54	20.40				
19H1	C. S. Hammond		2,490		Du		4- 7-53	5.60			U	C
20L1	Norman Fiock		2,453		Du		4- 7-53	14.40			D	C
							5- 7-54	13.60				
20P1	Ralph E. Cope		2,486	78	Du		5- 6-54	1.90			D	
22C1	F. R. Parker		2,543	28	Du		4- 7-53	4.60			D	C
							10-24-53	4.70				
							5- 6-54	4.60				
23E1	Bub Bandy		2,565	150	P	8			5		D	L
26C1	Jack Peebles		2,640	110	P	6			1			L
26D1	E. J. Carlson	1951	2,615	160	P	6					D	L
26D2	do	1951	2,615	40	P	6					D	L
27A1	Mrs. Rodgers		2,560	116	P	8					D	L
27E1	Jack Churchill	1950	2,529	42	P	8	7-14-53	7.50			U	L
28A1	K. R. Caine	1954	2,523	51	P	6	6-15-54	21.53	5	7		L
28B1	— Lane		2,518	20	P	6	6-15-54	20.0			S	L
29K1	Ray Nylund		2,498	12	Du	48	4- 7-53	4.5			D	C
							10-24-53	5.4				
							5- 6-54	6.0				
30D1	— Lorenzini		2,550		Du	48	4- 7-53	7.2			D	C
							5- 6-54	7.6				
32K1	Louie Bacciarini	Old	2,572	30	Du	48	4- 7-53	18.6			D, S	C
							5- 6-54	24.7				
33E1	John Rizzardo		2,535		Du	48	4- 7-53	6.4			D	C
							10-24-53	6.4				
							5- 6-54	5.9				
45/7-14N1	City of Yreka	1948	2,565	26	Du	96			1,200	5	M	
24R1	Doug Eastlick	1942	2,549	235	P	16	4- 7-53	6.5			U	L, C
							10-24-53	8.7				
							5- 6-54	6.8				
25N2	John D. Saunders		2,643				4- 7-53	1.05			I	C
							5- 7-54	3.5				
26P1	— Crawford		2,690	57	P	6	6-15-54	6.00	½		U	L
27R1	Fruit Growers Supply Co.	1945	2,655	159	P	12	8-15-54	8.8				L
27R2	do	1945	2,655	101	P	12						L
33A1	City of Yreka	1947	2,740	26	Du	72			300		M	
34K1	10th Dist. Agricultural Assoc.	1953	2,701	140	P	10			128	110	I, D	L
35B1	C. E. Reeves		2,765	38	P	6	6-15-54	3.9	10	3	D	
36D1	Ree Bowen	1951	2,685	400	P	12					U	L
36D2	Wayman Core	1954	2,685	307	P	12			1		D	L
36L1	Charles Dunlap	1917	2,672	16	Du	48	4- 7-53	7.9			U	C
							5- 6-54	4.6				

TABLE 19.—*Description of water wells in the Shasta Valley area, California*—Continued

Well	Owner or tenant	Year completed	Altitude of land-surface datum (feet)	Depth (feet)	Type of well	Diameter of well casing (inches)	Water level: Date measured	Water level: Distance above (+) or below land-surface datum (feet)	Discharge (gpm)	Drawdown (feet)	Use of water	Other data available
46/5-7G1	Allen Williams	Old	2,382	22	Du		5-6-53	10.2			D	C
7K1	Willow Creek School		2,415		P	8	5-6-53	17.4			D	
7P1	Lela Meek		2,437	200	P	6	4-9-53	3.5			D	
							10-24-53	3.8				
							5-7-54	4.2				
8P2	K. Severns	1940	2,425	200	P	6	4-9-53	18.0			S	
							10-24-53	26.7				
							5-7-54	16.7				
18L1	Stan Cooley	1950	2,550	237	P	16	4-9-53	16.8			U	L, C
							10-24-53	19.0				
							5-7-54	17.6				
21J1	Hermen & George Enslin		2,568	9	Du		4-9-53	4.7				C
							10-24-53	4.8				
							5-7-54	5.6				
30P1	Vic Stewart	1953	2,675	150	P	10	10-4-54	6.9			S	L
31F1	V. C. Stuart		2,655	75	P	6	5-7-53	15.0				C
46/6-24E1	Fred Betts		2,600	100	P	8	5-6-53	26.4	75		D, I	C
24L1	do		2,600	220	P	10	4-9-53	Flowing			U	L
25B1	Stan Cooley, Jr.		2,625		P	8	5-7-53	8.0			D	C
25D1	do	1951	2,700	90	P	6					D	
25H1	do		2,660	235	P	12	5-7-53	7.9	400	65	I	

TABLE 20.—*Weekly water-level measurements in wells, in feet below land-surface datum, in the Shasta Valley, Calif.*

[Symbols preceeding water-level measurements refer to pumping operations. a, pumping; b, well nearby pumping; c, recently pumped]

42/6-3L1

[M. L. Bridwell. Measuring point, top of well, 1 ft above land-surface datum which is 2,796 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 16	7.28	Sept. 14	23.00
July 20	a 9.70	Sept. 21	23.85
July 27	7.90	Sept. 28	24.56
Aug. 3	6.66	Oct. 5	25.10
Aug. 10	7.59	Oct. 12	25.42
Aug. 17	13.80	Oct. 19	24.00
Aug. 24	17.64	Nov. 16	23.30
Aug. 31	20.15		

42/6-9F1

[D. C. Shelley. Measuring point, top of casing northwest side, at land-surface datum which is 2,956 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 16	20.67	Sept. 14	23.72
July 20	21.16	Sept. 21	24.15
July 27	20.94	Sept. 28	24.56
Aug. 3	20.20	Oct. 5	24.82
Aug. 10	21.70	Oct. 12	25.20
Aug. 17	21.98	Oct. 19	25.60
Aug. 24	22.37	Oct. 31	26.00
Aug. 31	22.85	Nov. 16	26.10

42/6-10J1

[G. G. Maxwell. Measuring point, top of casing, at land-surface datum which is 2,841 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 16	3.05	Sept. 14	7.70
July 20	3.72	Sept. 21	8.30
July 27	5.28	Sept. 28	9.00
Aug. 3	5.75	Oct. 5	14.20
Aug. 10	a 11.45	Oct. 12	9.80
Aug. 17	5.60	Oct. 19	9.60
Aug. 24	5.94	Oct. 31	9.30
Aug. 31	6.70		

43/6-21J1

[Dougherty & Son. Measuring point, top of casing, 1.9 ft above land-surface datum which is 2,729 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 20	b 31.50	Sept. 21	31.85
July 27	b 31.26	Sept. 28	31.10
Aug. 3	30.50	Oct. 5	30.53
Aug. 10	b 30.30	Oct. 12	30.40
Aug. 17	30.90	Oct. 19	30.45
Aug. 24	b 31.20	Oct. 31	30.60
Aug. 31	b 30.64	Nov. 16	30.45
Sept. 14	b 31.47		

TABLE 20.—*Weekly water-level measurements in wells, in feet below land-surface datum, in the Shasta Valley, Calif.*—Continued

43/6-21J2

[Dougherty & Son. Measuring point, access hole in concrete block, at land-surface datum which is 2,733 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 20	c 35.90	Sept. 21	33.75
Aug. 3	32.40	Sept. 28	33.20
Aug. 10	a 73.10	Oct. 5	32.50
Aug. 17	32.80	Oct. 12	32.20
Aug. 24	a 73.70	Oct. 19	32.80
Aug. 31	a 72.20	Oct. 31	33.20
Sept. 14	a 73.00	Nov. 16	33.15

43/6-22P1

[California Highway Dept. Measuring point, top of casing, 3 ft below land-surface datum which is 2,712 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 20	11.80	Sept. 14	13.70
July 27	12.00	Sept. 21	14.02
Aug. 3	12.27	Sept. 28	14.25
Aug. 10	13.02	Oct. 5	14.40
Aug. 17	12.86	Oct. 12	14.50
Aug. 24	13.22	Oct. 19	14.00
Aug. 31	13.50	Nov. 16	14.00

44/5-28K1

[Louis Silva. Measuring point, concrete base at top of casing, at land-surface datum which is 2,632 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 15	34.16	Aug. 31	32.50
July 20	33.71	Sept. 21	32.80
July 27	34.76	Sept. 28	32.33
Aug. 3	33.15	Oct. 5	33.00
Aug. 10	42.63	Oct. 12	32.40
Aug. 17	32.89	Oct. 19	32.60
Aug. 24	34.85	Nov. 16	33.34

44/5-28R1

[Unknown. Measuring point, access hole on pump base on northeast side, at land-surface datum which is 2,635 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 15	27.61	Sept. 14	26.47
July 20	27.62	Sept. 21	26.45
July 27	27.57	Sept. 28	26.28
Aug. 3	27.10	Oct. 5	26.90
Aug. 10	27.13	Oct. 12	26.29
Aug. 17	27.70	Oct. 19	26.62
Aug. 24	26.54	Nov. 16	27.20
Aug. 31	25.94		

TABLE 20.—*Weekly water-level measurements in wells, in feet below land-surface datum, in the Shasta Valley, Calif.*—Continued

44/5-34C1

[Tony Pimental. Measuring point, top of casing, 1 ft above land-surface datum which is 2,631 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 15	17.48	Sept. 14	14.30
July 20	13.74	Sept. 24	13.18
July 27	15.70	Sept. 28	14.02
Aug. 3	15.64	Oct. 5	13.05
Aug. 10	14.08	Oct. 12	14.82
Aug. 17	12.75	Oct. 19	15.84
Aug. 24	14.05	Oct. 26	16.47
Aug. 31	12.90	Nov. 3	17.10
Sept. 7	13.37	Nov. 16	17.98

44/5-34H1

[Henry Silva. Measuring point, pump base north side, at land-surface datum which is 2,637 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 16	29.02	Sept. 14	26.00
July 20	27.37	Sept. 21	25.80
July 27	26.98	Sept. 28	26.40
Aug. 3	a 33.88	Oct. 5	26.70
Aug. 10	26.40	Oct. 12	26.90
Aug. 17	a 33.55	Oct. 19	27.42
Aug. 24	a 33.64	Nov. 16	28.30
Aug. 31	25.40		

44/6-18M4

[J. P. Heft. Measuring point, top of casing, 1 ft above land-surface datum is 2,792 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 15	39.46	Aug. 10	42.06
July 20	a 41.78	Aug. 17	38.70
July 27	39.18	Nov. 16	39.90
Aug. 3	41.60		

44/6-20A1

[Dr. Charles Orr. Measuring point, top of wooden cover south side, at land-surface datum which is 2,683 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 15	7.49	Sept. 14	10.60
July 20	7.65	Sept. 21	10.88
July 27	8.14	Sept. 28	11.12
Aug. 3	8.90	Oct. 5	11.38
Aug. 10	9.00	Oct. 12	11.65
Aug. 17	9.25	Oct. 19	11.89
Aug. 24	9.60	Nov. 16	12.30
Aug. 31	9.90		

TABLE 20.—*Weekly water-level measurements in wells, in feet below land-surface datum, in the Shasta Valley, Calif.*—Continued

44/6-21K1

[Brahs Bros. Inc. Measuring point, wooden base of pump west side, at land-surface datum which is 2,622 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 15	14.63	Sept. 14	8.95
July 20	17.56	Sept. 21	11.70
July 27	10.07	Sept. 28	13.42
Aug. 3	11.66	Oct. 5	15.30
Aug. 10	13.98	Oct. 12	17.15
Aug. 17	16.66	Oct. 19	18.50
Aug. 24	9.10	Oct. 31	21.10
Aug. 31	13.22	Nov. 16	23.15

44/6-22M2

[Billie Arami. Measuring point, top of casing concrete base, at land-surface datum which is 2,600 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 15	4.74	Sept. 28	3.60
July 20	5.52	Oct. 5	5.05
July 23	1.28	Oct. 12	6.36
Aug. 3	2.72	Oct. 19	7.50
Aug. 10	4.12	Nov. 16	10.20
Aug. 17	5.38		
Aug. 24	1.20	*1954*	
Aug. 31	2.24		
Sept. 14	.95	May 7	3.40
Sept. 21	2.00		

44/7-13J1

[Raymond Black. Measuring point, wooden floor below pump, at land-surface datum which is 2,824 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 15	25.69	Sept. 14	26.77
July 20	25.75	Sept. 21	27.00
July 27	25.90	Sept. 28	26.99
Aug. 3	26.00	Oct. 5	27.15
Aug. 10	26.12	Oct. 12	27.40
Aug. 17	26.30	Oct. 19	27.42
Aug. 24	26.38	Nov. 16	27.70
Aug. 31	26.53		

45/5-19P1

[R. D. Dudley. Measuring point, at base of pumphouse north side, 0.7 ft above land-surface datum which is 2,584 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 14	4.68	Sept. 14	4.00
July 20	a 5.26	Sept. 21	4.43
July 27	3.25	Sept. 28	4.40
Aug. 3	4.34	Oct. 5	4.47
Aug. 10	3.77	Oct. 12	4.42
Aug. 17	4.25	Oct. 19	4.48
Aug. 24	3.28	Nov. 16	4.37
Aug. 31	3.50		

TABLE 20.—*Weekly water-level measurements in wells, in feet below land-surface datum, in the Shasta Valley, Calif.*—Continued

Date	Water level	Date	Water level
45/5-21P1			
[S. O'Connor. Measuring point, top of brick casing, 5 feet above land-surface datum which is 2,694 ft above sea level]			
1953		*1953*	
July 14	13.93	Sept. 14	15.00
July 20	13.19	Sept. 21	15.82
July 27	13.05	Sept. 28	16.48
Aug. 3	13.74	Oct. 5	16.95
Aug. 10	13.27	Oct. 12	17.85
Aug. 17	14.00	Oct. 19	18.60
Aug. 24	14.00	Nov. 16	21.10
Aug. 31	13.30		
45/5-23R1			
[Ray Soule. Measuring point, floor of pumphouse, 1 ft above land-surface datum which is 2,798 ft above sea level]			
1953		*1953*	
July 14	9.92	Sept. 14	9.77
July 20	9.72	Sept. 21	11.02
July 27	10.56	Sept. 28	12.50
Aug. 3	9.68	Oct. 5	12.82
Aug. 10	9.65	Oct. 12	12.08
Aug. 17	a 10.42	Oct. 19	12.68
Aug. 24	9.84	Nov. 16	15.70
Aug. 31	10.65		
45/5-24R1			
[Unknown. Measuring point, hole in floor or cover of well, at land-surface datum which is 2,865 ft above sea level]			
1953		*1953*	
July 14	23.74	Sept. 14	25.32
July 20	23.35	Sept. 21	25.98
July 27	23.06	Sept. 28	25.66
Aug. 3	23.38	Oct. 5	26.03
Aug. 10	23.70	Oct. 12	26.22
Aug. 17	23.85	Oct. 19	26.88
Aug. 24	24.45	Nov. 16	27.60
Aug. 31	24.33		
45/5-27A1			
[Ross-Shelley. Measuring point, top of well, 2.5 ft above land-surface datum which is 2,723 ft above sea level]			
1953		*1953*	
July 14	14.30	Sept. 14	14.70
July 20	13.55	Sept. 21	14.60
July 27	13.40	Sept. 28	15.04
Aug. 3	14.59	Oct. 5	15.15
Aug. 10	14.20	Oct. 12	15.72
Aug. 17	15.20	Oct. 19	16.05
Aug. 24	14.10	Nov. 16	16.72
Aug. 31	14.15		

506344 O—60——7

TABLE 20.—*Weekly water-level measurements in wells, in feet below land-surface datum, in the Shasta Valley, Calif.*—Continued

45/5-28D1

[Bruce M. Long. Measuring point, top of casing, 1 ft above land-surface datum which is 2,662 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 14	18. 29	Sept. 14	17. 46
July 20	17. 88	Sept. 21	19. 22
July 27	17. 16	Sept. 28	20. 32
Aug. 3	18. 01	Oct. 5	21. 07
Aug. 10	18. 44	Oct. 12	21. 94
Aug. 17	16. 76	Oct. 19	23. 65
Aug. 24	16. 98	Oct. 26	24. 35
Aug. 31	16. 27	Nov. 3	25. 10
Sept. 7	16. 55	Nov. 16	26. 02

45/5-29B1

[Paul Karney. Measuring point, wooden platform below pump, at land-surface datum which is 2,635 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 14	a 19. 00	Sept. 14	17. 60
July 20	18. 42	Sept. 21	17. 60
July 27	17. 97	Sept. 28	17. 60
Aug. 3	18. 04	Oct. 5	17. 70
Aug. 10	19. 06	Oct. 12	17. 25
Aug. 17	a 20. 15	Oct. 19	17. 65
Aug. 24	18. 33	Nov. 16	a 18. 15
Aug. 31	17. 26		

45/5-35N1

[R. E. Hart. Measuring point, top of casing, 2.03 ft above land-surface datum which is 2,700 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 10	1. 94	Aug. 31	3. 35
July 20	2. 41	Sept. 7	3. 27
July 27	2. 69	Sept. 14	3. 22
Aug. 3	2. 76	Sept. 21	3. 25
Aug. 10	2. 85	Sept. 28	2. 77
Aug. 17	3. 09	Oct. 5	2. 48
Aug. 24	3. 29	Oct. 12	2. 16

45/6-1H1

[Smith and Droz. Measuring point, top of casing, 1.96 ft above land-surface datum which is 2,620 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 10	1. 41	Sept. 14	1. 40
July 20	0. 80	Sept. 21	1. 34
July 27	. 88	Sept. 28	1. 24
Aug. 3	1. 07	Oct. 5	1. 06
Aug. 10	1. 30	Oct. 12	0. 93
Aug. 17	1. 44	Oct. 19	. 85
Aug. 24	1. 45	Oct. 26	. 71
Aug. 31	1. 28	Nov. 3	. 54
Sept. 9	1. 44		

TABLE 20.—*Weekly water-level measurements in wells, in feet below land-surface datum, in the Shasta Valley, Calif.*—Continued

45/6-19E1

[George Weldon. Measuring point, top of casing, 1 ft above land-surface datum which is 2,538 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 13	18.66	Sept. 14	20.55
July 20	a 21.90	Sept. 21	22.50
July 27	19.70	Sept. 28	22.94
Aug. 3	20.72	Oct. 5	22.62
Aug. 10	18.79	Oct. 12	20.17
Aug. 17	21.80	Oct. 19	19.70
Aug. 24	22.19	Nov. 16	21.39
Aug. 31	21.70		

45/6-20P1

[Ralph E. Cope. Measuring point, wooden floor of pumphouse, 1 ft above land-surface datum which is 2,486 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 13	2.50	Sept. 14	6.92
July 20	c 9.82	Sept. 21	6.12
July 27	6.98	Sept. 28	8.02
Aug. 3	12.71	Oct. 5	2.42
Aug. 10	3.05	Oct. 12	1.67
Aug. 17	5.14	Oct. 19	1.57
Aug. 24	5.57	Nov. 16	1.65
Aug. 31	4.04		

45/6-20Q1

[E. B. Fiock. Measuring point, concrete platform top of well, 1 ft above land-surface datum which is 2,449 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 13	4.04	Sept. 14	3.00
July 20	2.46	Sept. 21	2.50
July 27	2.80	Sept. 28	2.17
Aug. 3	1.56	Oct. 5	3.60
Aug. 10	3.15	Oct. 12	3.00
Aug. 17	3.15	Oct. 19	3.40
Aug. 24	a 4.40	Nov. 16	4.70
Aug. 31	3.72		

45/6-24N1

[R. D. Hoopes. Measuring point, top of wooden cover of well, at land-surface datum which is 2,638 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 14	8.00	Sept. 14	a 11.22
July 20	7.89	Sept. 21	9.29
July 27	7.98	Sept. 28	9.46
Aug. 3	8.34	Oct. 5	9.68
Aug. 10	7.28	Oct. 12	10.60
Aug. 17	8.15	Oct. 19	10.18
Aug. 24	8.90	Nov. 16	11.26
Aug. 31	7.66		

TABLE 20.—*Weekly water-level measurements in wells, in feet below land-surface datum, in the Shasta Valley, Calif.*—Continued

45/6-27A1

[Mrs. Rodgers. Measuring point, top of wooden planking over well opening, at land-surface datum which is 2,560 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 13	11.74	Sept. 14	12.80
July 20	12.10	Sept. 21	12.84
July 27	a 12.37	Sept. 28	12.97
Aug. 3	12 45	Oct. 5	12.94
Aug. 10	12.36	Oct. 12	12.98
Aug. 17	12.48	Oct. 19	13.00
Aug. 24	12.54	Nov. 16	13.22
Aug. 31	12.60		

45/6-27E1

[Jack Churchill. Measuring point, top of casing, 3.5 ft above land-surface datum which is 2,529 ft above sea level]

Date	Water level	Date	Water level
1953		*1953*	
July 14	4.00	Aug. 31	4.00
July 20	3.78	Sept. 14	4.20
July 27	4.38	Sept. 21	4.15
Aug. 3	3.93	Sept. 28	1.90
Aug. 10	4.00	Oct. 5	4.23
Aug. 17	4.08	Oct. 12	4.22
Aug. 24	4.12		

TABLE 21.—*Selected drillers' logs of wells in the Shasta Valley, Calif.*

[Correlations by U.S. Geological Survey]

42/5-12C1

[Lee Bryan. Drilled by Don Enloe Co. Altitude 2,933 ft]

	Thickness (feet)	Depth (feet)
Fluvioglacial deposits:		
Sand rock	122	122
Water sand	38	160
Sand rock	114	274
Brown sand	30	304

42/5-23J1

[A. B. Hoy and son. Drilled by Don Enloe Co. Altitude 3,225 ft]

	Thickness (feet)	Depth (feet)
Morainal deposits:		
Boulders and clay	128	128
Angular gravel	77	205

TABLE 21.—*Selected drillers' logs of wells in the Shasta Valley, Calif.*—Continued

	Thickness (feet)	Depth (feet)
42/5-26A1		
[A. B. Hoy and son. Drilled by Don Enloe Co. Altitude 3,218 ft]		
Fluvioglacial deposits:		
Clay	100	100
Large boulder	10	110
Sand rock	90	200
Clay and sand	5	205
43/4-4J1		
[Jess Martin. Drilled by Clyde Enloe Co. Altitude 3,075 ft]		
Plutos Cave basalt:		
Soil	4	4
Lava	51	55
Very hard gray rock	5	60
Lava	88	148
Lava, broken	28	176
Umpqua(?) formation:		
Clay	27	203
43/4-4R1		
[Jess Martin. Drilled by Clyde Enloe Co. Altitude 3,050 ft]		
Plutos Cave basalt:		
Sand	12	12
Lava, badly broken	88	100
Hard gray lava	6	106
Lava, broken	24	130
Hard gray lava	16	146
Lava, broken	127	273
Umpqua(?) formation:		
Clay with layer of sand and gravel on top of clay	27	300
43/6-3D1		
[Riemo Capafello. Drilled by Clyde Enloe Co. Altitude 2,610 ft]		
Basement complex:		
Soil	4	4
Shale—fine soft rock	8	12
Gray hard rock	[illegible] or 74?	76 or 86?
43/6-10K1		
[C. S. Timmons. Drilled by Don Enloe Co. Altitude 2,638 ft]		
Volcanic rocks of the western Cascades:		
Dirt and boulders	12	12
Red sand and cinders	26	38
Cement gravel	34	72
Hardpan	22	94
Boulders	6	100
Yellow muck	5	105

TABLE 21.—*Selected drillers' logs of wells in the Shasta Valley, Calif.*—Continued

	Thickness (feet)	Depth (feet)
44/4-18F1		
[Larry Waters. Altitude 2,780 ft]		
Plutos Cave basalt:		
Lava	108	108
Cinders with water	7	115
Lava	11	126
44/5-18B1		
[Frank Brahs. Drilled by Don Enloe Co. Altitude 2,610 ft]		
Volcanic rocks of the western Cascades:		
Hardpan and boulders	18	18
Boulders and sand, water-bearing	17	35
Boulders and cemented red cinders	22	57
Boulders	10	67
Red cinders and gravel, water-bearing	18	85
44/5-28L1		
[Louis Silva. Drilled by—Kilgore. Altitude 2,610 ft]		
Plutos Cave basalt:		
Soil	2	2
Boulders	4	6
Lava rock	34	40
Older alluvium(?):		
Chalk, pale-yellow	1	41
Boulders and gravel	23	64
44/5-34J1		
[John Perino. Drilled by C. Widmore. Altitude 2,640 ft]		
Plutos Cave basalt:		
Soil	3	3
Lava ash	25	28
Black lava	76	104
44/5-34Q1		
[A. J. Quadros. Drilled by Don Enloe Co. Altitude 2,625 ft]		
Plutos Cave basalt:		
Soil	3	3
Pea size gravel	15	18
Lava, water	37	55

TABLE 21.—*Selected drillers' logs of wells in the Shasta Valley, Calif.*—Continued

	Thickness (feet)	Depth (feet)
44/7-12P1		
[—Brazie. Drilled by Buckner. Altitude 2,880 ft]		
Younger alluvium:		
Soil, gravelly	8	8
Clay, some water at 60 feet	52	60
Clay	35	95
Basement complex:		
Shale	15	110
Clay	4	114
Quartz ledge	61	175
45/5-7Q1		
[James Elsea. Drilled by—Kilgore. Altitude 2,673 ft]		
Volcanic rocks of the western Cascades:		
Soil	10	10
Cement gravel	15	25
Hard yellow clay	20	45
Cement gravel	10	55
Brown clay	10	65
Gravel	15	80
Hard rock	4	84
Black formation	16	100
Gray hard rock	25	125
45/6-26D1		
[E. J. Carlson. Drilled by—Kilgore. Altitude 2,615 ft]		
Volcanic rocks of the western Cascades:		
Soil	5	5
Yellow clay	30	35
Gumbo	10	45
Rock, gravel with water	20	65
Gray rock	95	160
45/6-27A1		
[Kilgore. Drilled by—Kilgore. Altitude 2,545 ft]		
Older alluvium:		
Soil	10	10
Boulders, water	25	35
Clay	5	40
Cement gravel	50	90
Umpqua(?) formation:		
Black clay	2	92
Black sand, water	24	116

TABLE 21.—*Selected drillers' logs of wells in the Shasta Valley, Calif.*—Continued

	Thickness (feet)	Depth (feet)
45/7-24R1		
[Doug Eastlick. Drilled by H. Palmer. Altitude 2,549 ft]		
Older alluvium:		
Yellow clay and gravel	40	40
Chico formation:		
White sandstone	40	80
Hard boulder	5	85
Gray sandstone	15	100
Black clay	7	107
Gray sandstone	105	212
Black mud	10	222
Basement complex:		
Serpentine	13	235
45/7-27R1		
[Fruit Growers Supply Co. Drilled by N. R. Jessee. Altitude 2,655 ft]		
Younger alluvium:		
Soil	2	2
Gravel	12	14
Clay, gravelly	6	20
Gravel	2	22
Clay, gravelly	45	67
Clay	9	76
Clay, gravelly	14	90
Gravel, loose	4	94
Black clay	12	106
Basement complex:		
Shale and quartz bedrock	53	159
45/7-34K1		
[10th Dist. Agricultural Assoc. Drilled by N. R. Jessee. Altitude 2,701 ft]		
Younger alluvium:		
Soil and gravel	4	4
Dirty gravel	4	8
Yellow clay and gravel	12	20
Loose gravel	4	24
Reddish clay, some gravel	53	77
Clay and gravel	38	115
Gravel, some clay	12	127
Basement complex:		
Hard broken gray rock	3	130
Broken rock and clay	5	135
Hard gray rock, quartz seams	5	140

TABLE 21.—*Selected drillers' logs of wells in the Shasta Valley, Calif.*—Continued

	Thickness (feet)	Depth (feet)
45/7-36D1		
[Ree Bowen. Drilled by—Kilgore. Altitude 2,685 ft]		
Chico formation:		
Soil	2	2
Blue sandstone	138	140
Yellow sandstone	150	290
Basement complex:		
Blue quartz	5	295
Schist containing pyrite	105	400
46/5-18L1		
[Stan Cooley. Altitude 2,550 ft]		
Umpqua formation:		
Soil	2	2
Sand	23	25
Shale	15	40
Sand	5	45
Shale	5	50
White sand	10	60
Slate	10	70
Brown sand	10	80
Sandy shale	45	125
Sand, hard	25	150
Black shale	30	180
Sandy black shale	10	190
Black sand	10	200
Brown rock	20	220
Black shale	17	237

TABLE 22.—*Chemical analyses of ground water in the Shasta Valley, Calif.*

Upper number, parts per million; Lower number, equivalents per million

Well	Date sampled	pH	Specific conductance (micromhos at 25° C)	Dissolved solids (sum)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Hardness as $CaCO_3$	Percent sodium
41/5- 4D1	5-11-53	7.9	395	236	29	0.6	11	46	6.3	3.8	0	272	2.3	2.5	0.5	0.0	0.11	217	6
							0.549	3.783	0.274	0.097	0	4.458	0.048	0.071	0.008	0			
4N1	10- 1-53	8.0	559	338	54	-----	8.6	72	6.3	.8	0	376	4.0	6.5	.4	.0	.14	318	4
							.43	5.92	.27	.02	0	6.16	.08	.18	.01	0.00			
	5-11-53	7.8	586	350	53	.0	10	72	82	2.0	0	397	3.7	4.8	1.1	.0	.12	321	5
							.50	5.92	.36	.05	0	6.51	.08	.14	.02	0			
9F3	5-11-53	8.2	300	183	32	.0	4.2	38	2.4	1.1	0	198	2.8	2.5	2.7	.0	.04	167	3
							.210	3.125	.104	.028	0	3.245	.058	.071	.044	0			
42/5-20J1	5-11-53	7.6	372	249	46	1.1	15	30	25	2.1	0	236	5.4	9.0	.3	.2	.09	161	25
							.749	2.467	1.087	.054	0	3.868	.112	.254	.005	.011			
28D1	5-11-53	8.0	307	238	59	.0	16	11	22	19	0	146	8.5	8.2	22	.4	.06	85	30
							.798	.905	.957	.486	0	2.393	.177	.231	.355	.021			
	10- 1-53	7.2	285	211	56	-----	13	11	21	18	0	152	7.2	7.0	2.3	.3	.07	78	31
							.649	.905	.913	.460	0	2.491	.150	.197	.037	.016			
33M1	5-11-53	7.6	463	295	55	.0	10	54	8.7	1.5	0	284	7.4	7.8	11	.0	.00	247	7
							.50	4.44	.38	.04	0	4.65	.15	.22	.18	0			
42/6- 3L1	5-11-53	8.0	486	301	25	.0	61	26	8.7	2.4	0	297	19	2.5	10	.0	.03	259	7
							3.04	2.14	.38	.06	0	4.87	.40	.07	.16	0			
	10- 5-53	7.9	468	286	27	-----	60	23	8.7	2.1	0	284	15	3.5	6.8	.1	.08	244	7
							2.99	1.89	.38	.05	0	4.65	.31	.10	.11	.01			
8H1	5-11-53	8.3	512	315	19	.8	72	24	8.2	.6	12	297	20	2.0	11	.0	.04	278	6
							3.59	1.97	.36	.02	0.40	4.87	.42	.06	.18	0			
10J1	5-11-53	8.4	508	320	50	.0	10	66	4.1	.3	10	324	4.1	4.5	12	.0	.00	296	3
							.50	5.43	.18	.01	.33	5.31	.09	.13	.19	0			
43/5- 3R1	5- 8-53	7.0	347	246	63	.0	17	19	29	2.6	0	193	4.3	16	.1	.2	.29	120	34
							.848	1.562	1.261	.067	0	3.163	.090	.451	.002	.011			

9 C1	10- 1-53	7.7	765	482	67	------	36 1.80	46 3.78	64 2.78	4.5 .12	0 0	416 6.82	9.2 .19	48 1.35	1.8 .03	.5 .03	.64	279	33
23A1	5- 8-53	7.5	578	388	75	.0	31 1.55	36 2.96	43 1.87	2.5 .06	0 0	349 5.72	6.7 .14	21 .59	.4 .02	.4 .01	.28	226	29
23M1	5- 8-53	7.3	489	340	74	.0	24 1.20	31 2.55	38 1.65	2.1 .05	0 0	286 4.69	10 .21	18 .51	1.3 .02	.3 .02	.28	188	30
	10- 1-53	7.5	486	333	72	------	25 1.25	31 2.55	36 1.57	2.2 .06	0 0	282 4.62	9.9 .21	16 .45	1.4 .02	.3 .02	.26	190	29
43/6- 3L1	5-12-53	8.2	769	490	55	.3	46 2.30	43 3.54	63 2.74	3.0 .08	0 0	404 6.62	23 .48	48 1.35	10 .16	.3 .02	.25	292	32
10Q1	5-12-53	8.0	408	263	40	.0	41 2.046	25 2.056	12 .522	1.7 .043	0 0	252 4.130	7.7 .160	6.2 .175	5.4 .087	.1 .005	.02	205	11
15F2	5-12-53	7.9	429	270	37	.0	41 2.046	25 2.056	14 .609	1.6 .041	0 0	274 4.490	5.5 .115	2.2 .062	9.1 .147	.1 .005	.04	205	13
21E1	5-11-53	8.3	457	285	26	.3	52 2.59	29 2.38	10 .43	.8 .02	0 0	304 4.98	5.8 .12	4.0 .11	7.8 .13	.0 0	.02	248	8
21J2	5-11-53	8.1	457	286	30	.0	57 2.84	25 2.06	9.2 .40	1.1 .03	0 0	302 4.95	8.1 .17	2.0 .06	4.8 .08	.0 0	.05	245	8
22P1	5-11-53	8.4	535	347	35	.0	58 2.89	32 2.63	19 .83	1.4 .04	18 .60	320 5.24	10 .21	9.0 .25	6.8 .11	.0 0	.05	276	13
22P2	5-11-53	8.3	515	327	32	.2	56 2.79	31 2.55	16 .70	1.1 .03	6 .20	308 5.05	13 .27	5.0 .14	15 .24	.0 0	.03	267	12
	10- 5-53	7.7	529	321	31	------	58 2.89	30 2.47	14 .61	.9 .02	0 0	332 5.44	12 .25	3.5 .10	8.1 .13	.0 0	.04	268	10
23N2	5-11-53	8.1	519	328	39	.0	49 2.45	32 2.63	18 .78	1.5 .04	0 0	328 5.38	13 .27	9.0 .25	4.6 .07	.0 0	.07	254	13
29Q2	5-11-53	8.4	484	299	21	.0	69 3.44	23 1.89	8.0 .35	.8 .02	10 .33	308 5.05	7.7 .16	1.5 .04	6.0 .10	.0 0	.00	266	6
33J1	5-11-53	8.1	383	255	42	.0	49 2.445	18 1.480	9.0 .391	1.0 .026	0 0	244 3.999	8.1 .169	4.0 .113	3.6 .011	.2 .011	.02	196	9
44/5- 1J2	5- 7-53	7.6	658	416	47	.0	67 3.34	26 2.14	41 1.78	2.0 .05	0 .0	375 6.15	17 .35	26 .73	5.4 .09	.1 .01	.81	274	24
2R1	5- 7-53	7.4	454	301	51	.0	38 1.896	18 1.480	35 1.522	2.9 .074	0 .0	259 4.245	9.4 .196	15 .423	4.4 .071	.1 .005	.32	169	31
	10- 5-53	7.4	505	332	54	------	43 2.15	21 1.73	38 1.65	3.0 .08	0 0	282 4.62	12 .25	15 .42	6.7 .11	.1 .01	.44	194	29

TABLE 22.—*Chemical analyses of ground water in the Shasta Valley, Calif.*—Continued

Upper number, parts per million; Lower number, equivalents per million

Well	Date sampled	pH	Specific conductance (micromhos at 25° C)	Dissolved solids (sum)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Hardness as $CaCO_3$	Percent sodium
44/5-34G1	5- 8-53	7.5	586	385	61	.0	42 2.10	37 3.04	34 1.48	4.9 .13	0 .0	356 5.83	6.9 .14	18 .51	5.2 .08	.2 .01	.23	257	22
34H1	5- 8-53	7.3	634	408	66	.0	42 2.10	33 2.71	44 1.91	5.2 .13	0 0	368 6.03	7.6 .16	21 .59	8.0 .13	.1 .01	.26	240	28
34J1	5- 8-53	7.5	690	453	60	.0	41 2.05	35 2.88	65 2.83	5.1 .13	0 0	390 6.39	13 .27	27 .76	15 .24	.2 .01	.27	246	36
34N1	5- 8-53	8.1	472	324	58	.2	23 1.148	22 1.809	34 1.478	23 .588	0 .0	236 3.868	8.1 .169	22 .620	17 .274	.5 .026	.35	148	29
34Q1	5- 8-53	7.9	549	363	58	.0	34 1.70	29 2.38	45 1.96	4.6 .12	0 .0	311 5.10	10 .21	22 .62	7.1 .11	.2 .01	.24	204	32
35L1	5- 8-53	8.6	659	449	63	.0	41 2.05	36 2.96	60 2.61	4.9 .13	20 .67	358 5.87	11 .23	25 .71	12 .19	.2 .01	.26	250	34
44/6-10F1	5-12-53	8.3	654	412	50	.0	60 2.99	45 3.70	17 .74	1.8 .05	6 .20	367 6.01	17 .35	26 .73	8.5 .14	.2 .01	.03	334	10
10R1	5-12-53	8.0	747	469	36	.0	77 3.84	26 2.14	58 2.52	1.6 .04	0 .0	428 7.01	12 .25	31 .87	17 .27	.0 .0	.39	299	30
14H1	5-12-53	8.0	586	351	32	7.5	59 2.94	27 2.22	29 1.26	3.2 .08	0 0	351 5.75	7.2 .15	20 .56	1.0 .02	.1 .01	.18	258	19
	10- 5-53	7.8	621	367	33	------	55 2.74	34 2.80	30 1.30	3.1 .08	0 0	367 6.01	6.9 .14	24 .68	.3 .00	.2 .01	.19	277	19
15H1	5-12-53	8.2	575	362	34	.1	66 3.29	18 1.48	37 1.61	1.1 .03	0 .00	333 5.46	9.9 .21	22 .62	9.8 .16	.1 .01	.26	238	25
18M4	5-12-53	7.9	409	266	25	1.8	68 3.393	9.6 .789	15 .652	.9 .023	0 .000	292 4.785	2.1 .044	1.0 .028	.9 .015	.0 .000	.01	209	13
	10- 5-53	7.8	428	259	25	------	66 3.293	9.0 .740	15 .652	.7 .018	0 0	282 4.622	2.2 .046	2.0 .056	.2 .003	.0 .000	.01	202	14

20A1	5-12-53	7.5	307	190	22	.0	39 1.946	13 1.069	7.8 .339	1.5 .038	0 .00	178 2.917	7.7 .160	.5 .014	11 .177	.0 .00	.00	151	10
22M1	5-12-53	8.2	500	310	35	.0	62 3.09	21 1.73	15 .65	1.6 .04	0 .00	284 4.65	5.4 .11	21 .59	8.7 .14	.1 .01	.05	241	12
	10- 5-53	7.8	500	299	33	------	59 2.94	22 1.81	15 .65	1.5 .04	0 .00	276 4.52	5.3 .11	19 .54	7.9 .13	.1 .01	.08	238	12
22M2	5-12-53	7.9	667	667	35	.4	76 3.79	25 2.06	38 1.65	1.8 .05	0 0	368 6.03	12 .25	29 .82	17 .27	.0 .00	.20	292	22
27Q1	5-12-53	8.5	634	388	31	.0	33 1.65	45 3.70	43 1.87	2.4 .06	16 .53	332 5.44	13 .27	30 .85	11 .18	.0 .00	.35	268	26
29D1	5-12-53	7.5	245	160	25	.0	28 1.397	11 .905	7.2 .313	1.1 .028	0 .000	136 2.229	6.1 .127	3.5 .099	11 .177	.0 .000	.01	115	12
34K2	5-12-53	8.5	736	476	52	.0	60 2.99	44 3.62	46 2.00	3.1 .08	25 .83	408 6.69	9.4 .20	27 .76	9.3 .15	.1 .01	.37	330	23
44/7-13C2	5-12-53	8.1	336	217	28	.0	55 2.745	6.7 .551	8.0 .348	.5 .013	0 .000	194 3.179	7.9 .164	4.0 .113	11 .177	.1 .005	.00	165	10
13J1	5-12-53	7.3	337	203	17	.0	55 2.745	8.4 .691	5.4 .235	.4 .010	0 .000	208 3.409	6.0 .125	1.8 .051	6.4 .103	.1 .005	.04	172	6
45/4-20D1	----------	------	--------	4,545	45	.3	138 6.90	21 1.75	1,133 49	--------	0 .000	2,714 44.5	2.9 .06	489 13.8	--------	--------	--------	------	84
45/5-4N1	5- 8-53	7.6	482	317	35	.0	54 2.69	18 1.48	24 1.04	.2 .01	0 0	226 3.70	14 .29	12 .34	48 .77	.1 .01	.00	208	20
	10- 4-53	7.8	4.45	290	36	------	51 2.545	16 1.316	21 .913	.3 .008	0 .000	220 3.605	14 .291	9.0 .254	34 .548	.3 .016	.00	193	19
6E1	5- 8-53	8.4	961	614	17	.1	7.5 .37	6.1 .50	242 10.52	1.5 .04	14 .47	580 9.51	.4 .01	32 .90	.1 .00	2.4 .13	5.5	44	92
	10- 4-53	8.0	997	615	13	------	5.5 .27	4.0 .33	243 10.57	2.0 .05	0 .00	616 10.10	2.1 .04	32 .90	.1 .00	2.2 .12	7.8	30	94
7N1	5- 8-53	7.7	449	280	32	.0	29 1.447	9.8 .806	52 2.261	1.0 .026	0 .000	184 3.016	24 .500	26 .733	15 .242	.4 .021	.08	113	50
19P1	5- 7-53	8.1	365	262	61	.0	31 1.547	22 1.809	13 .565	.8 .020	0 .000	190 3.114	16 .333	3.8 .107	21 .339	.2 .011	.03	168	14
21P1	5- 7-53	8.4	455	308	46	.2	44 2.20	24 1.97	26 1.13	.5 .01	18 .60	238 3.90	14 .29	7.2 .20	11 .18	.3 .02	.12	208	21

TABLE 22.—*Chemical analyses of ground water in the Shasta Valley, Calif.*—Continued

Well	Date sampled	pH	Specific conductance (micromhos at 25° C)	Dissolved solids (sum)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Hardness as $CaCO_3$	Percent sodium
				Upper number, parts per million Lower number, equivalents per million															
45/5-24R1	5- 7-53	7.6	498	327	49	.0	43 2.15	32 2.63	20 .87	2.7 .07	0 .00	302 4.95	10 .21	6.0 .17	15 .24	.1 .01	.06	239	15
	10- 5-53	7.7	370	265	57	------	32 1.597	22 1.809	13 .565	.8 .020	0 .000	188 3.081	15 .312	5.0 .141	27 .435	.2 .011	.03	170	14
25B1	10- 5-53	7.4	7,400	4,870	86	7.4	133 6.64	53 4.36	1,740 75.66	80 2.05	0 .00	3,810 62.44	11 .23	860 24.25	12 .19	.4 .02	14.00	550	85
26Q1	5- 7-53	7.8	657	404	41	.0	34 1.70	16 1.32	89 3.87	2.5 .06	0 .00	312 5.11	6.0 .12	57 1.61	4.6 .07	.1 .01	.66	151	56
27A1	5- 7-53	7.9	718	456	49	.0	67 3.34	49 4.03	28 1.22	.6 .02	0 .00	488 8.00	8.7 .18	6.0 .17	7.0 .11	.2 .01	.13	368	14
	10- 5-53	7.8	786	492	52	------	73 3.64	53 4.36	29 1.26	.7 .02	0 .00	509 8.34	9.7 .20	8.0 .23	16 .26	.3 .02	.20	400	14
28D1	5- 7-53	7.9	339	224	33	.6	33 1.647	11 .905	24 1.044	4.5 .115	0 .000	178 2.917	17 .354	10 .282	3.0 .048	.5 .026	.17	128	28
28M2	5- 7-53	8.2	829	543	41	.0	69 3.44	51 4.19	35 1.52	4.2 .11	0 .00	392 6.42	42 .87	27 .76	81 1.31	.0 .00	.23	382	16
	10- 5-53	7.8	858	559	48	------	92 4.59	40 3.29	34 1.48	5.0 .13	0 .00	392 6.42	38 .79	29 .82	80 1.29	.2 .01	.33	394	16
29B1	5- 7-53	8.3	505	335	50	.0	43 2.15	26 2.14	34 1.48	.9 .02	8 ------	300 4.92	7.5 .16	12 .34	6.1 .10	.1 .01	.11	214	26
29B2	5-14-53	7.5	496	328	51	.0	48 2.40	23 1.89	31 1.35	.9 .02	0 .00	308 5.05	6.1 .13	12 .34	3.6 .06	.2 .01	.13	214	24
33B1	5- 7-53	7.8	1,130	739	49	.0	50 2.50	40 3.29	158 6.87	1.1 .03	0 .00	516 8.46	41 .85	72 2.03	73 1.18	.3 .02	.89	290	54
	10- 5-53	8.0	1,090	691	53	------	50 2.50	38 3.12	156 6.78	1.0 .03	0 .00	600 9.83	32 .67	47 1.33	17 .27	.5 .03	1.00	281	55

45/6- 2Q1	5- 8-53	7.3	306	210	40	.0	35 1.747	15 1.234	8.2 .357	1.4 .036	0 .000	165 2.704	12 .250	3.0 .085	14 .226	.2 .011	.05	149	11
10A1	5- 8-53	8.3	325	208	32	3.8	32 1.597	20 1.645	7.6 .330	.3 .008	0 .000	188 3.081	11 .229	3.2 .090	9.6 .155	.2 .011	.00	162	9
10G1	5- 8-53	7.4	308	220	49	.0	21 1.048	24 1.974	7.4 .322	1.6 .041	0 .000	149 2.442	11 .229	7.8 .220	25 .403	.1 .005	.00	151	10
15F1	5- 8-53	8.1	408	280	57	1.8	27 1.347	33 2.714	12 .522	.5 .013	0 .000	236 3.868	7.8 .162	2.0 .056	24 .387	.1 .005	.00	203	11
	10- 4-53	7.7	417	285	58	------	28 1.397	32 2.632	13 .565	.5 .013	0 .000	232 3.802	9.5 .198	4.0 .113	26 .419	.1 .005	.01	201	12
17F1	5- 8-53	7.4	302	210	45	.0	17 .848	25 2.056	11 .478	1.5 .038	0 .000	110 2.802	3.2 .208	.1 .090	.03 .210	13 .005	--------	145	14
18K1	5- 8-53	7.8	773	498	22	.0	68 3.39	41 3.37	47 2.04	2.9 .07	0 .00	356 5.83	96 2.00	14 .39	32 .52	.2 .01	.05	338	23
19E1	5- 8-53	8.2	388	252	23	.0	26 1.297	12 .987	41 1.783	1.2 .031	0 .000	188 3.081	51 1.062	4.5 .127	.1 .002	.3 .016	.18	114	44
19H1	5-11-53	8.4	786	514	61	.0	72 3.59	36 2.96	57 2.48	.4 .01	28 .93	382 6.26	23 .48	38 1.07	11 .18	.3 .02	.34	328	27
20L1	5-11-53	8.6	1,100	710	59	.0	69 3.44	76 6.25	85 3.70	2.6 .07	55 1.83	504 8.26	30 .62	78 2.20	7.1 .11	.1 .01	.43	484	27
	10- 4-53	7.7	1,140	692	58	------	65 3.24	78 6.41	79 3.44	1.8 .05	0 .00	634 10.39	28 .58	68 1.92	2.3 .04	.1 .01	.68	482	26
22C1	5- 8-53	7.9	1,480	981	68	.2	62 3.09	77 6.33	85 3.70	150 3.84	0 .00	796 13.05	72 1.50	50 1.41	25 .40	--------	.49	471	22
	10- 4-53	7.8	772	474	50	------	61 3.04	65 5.35	17 .74	.8 .02	0 .00	513 8.41	8.5 .18	7.5 .21	11 .18	.2 .01	.19	420	8
29K1	5-11-53	8.2	938	594	58	.0	72 3.59	58 4.77	56 2.44	2.5 .06	0 .00	522 8.55	30 .62	58 1.64	2.2 .04	.3 .02	.36	418	22
30D1	5- 8-53	7.2	505	332	40	.0	40 2.00	25 2.06	34 1.48	.4 .01	0 .00	225 3.69	60 1.25	10 .28	12 .19	.3 .02	.05	203	27
32K1	5-11-53	8.1	1,230	694	29	.3	116 5.79	71 5.84	28 1.22	1.6 .04	0 .00	364 5.97	42 .87	180 5.08	47 .76	.3 .02	.01	582	9
	10- 4-53	7.6	1,160	655	34	------	119 5.94	65 5.35	25 1.09	1.2 .03	0 .00	414 6.78	35 .73	150 4.23	22 .35	.3 .02	.03	226	9
33E1	5-11-53	8.2	1,020	642	54	.0	105 5.24	45 3.70	60 2.61	2.7 .07	0 .00	484 7.93	51 1.06	74 2.09	12 .19	.2 .01	.38	447	22

TABLE 22.—*Chemical analyses of ground water in the Shasta Valley, Calif.*—Continued

Upper number, parts per million; Lower number, equivalents per million

Well	Date sampled	pH	Specific conductance (micromhos at 25° C)	Dissolved solids (sum)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Hardness as $CaCO_3$	Percent sodium
45/7-24R1	5- 8-53	7.9	471	307	20	3.0	29 1.45	17 1.40	55 2.39	1.1 .03	0 .00	194 3.18	86 1.79	2.2 .06	1.0 .02	.4 .02	.08	142	45
25N2	5- 8-53	7.3	724	482	16	.0	54 2.69	41 3.37	46 2.00	1.2 .03	0 .00	204 3.34	213 4.43	2.0 .06	7.7 .12	.3 .02	.05	303	25
36L1	5- 8-53	7.8	455	275	21	.0	53 2.64	23 1.89	10 .43	4.8 .12	0 .00	254 4.16	29 .60	6.5 .18	2.5 .04	.0 .00	.00	226	8
46/5- 7G1	5- 6-53	8.4	702	451	21	.0	83 4.14	31 2.55	26 1.13	.9 .02	10 .33	300 4.92	26 .54	20 .56	85 1.37	.1 .01	.09	334	14
	10- 3-53	7.5	591	365	21	------	70 3.49	23 1.89	26 1.13	.6 .02	0 .00	294 4.82	41 .85	8.5 .24	30 .48	.1 .01	.19	269	17
7K1	5- 6-53	8.0	558	356	19	.0	68 3.39	21 1.73	18 .78	.6 .02	0 .00	226 3.70	35 .73	18 .51	65 1.05	.2 .01	.09	256	13
7P1	5- 6-53	8.5	810	532	20	.0	80 3.99	44 3.62	46 2.00	.5 .01	22 .73	368 6.03	98 2.04	16 .45	24 .39	.2 .01	.66	380	21
8P2	5- 6-53	8.6	1,390	828	18	.0	33 1.65	26 2.14	265 11.52	2.5 .06	24 .80	524 8.59	19 .40	179 5.05	.5 .01	.3 .02	2.8	190	75
	10- 3-53	7.7	1,480	853	19	------	58 2.89	22 1.81	247 10.74	3.0 .08	0 .00	603 9.88	16 .33	188 5.30	.4 .01	.3 .02	2.5	235	69
18L1	5- 7-53	8.2	1,190	736	15	.1	3.0 .15	5.5 .45	292 12.70	1.6 .04	0 .00	832 13.64	3.2 .07	3.0 .08	.3 .00	1.2 .06	1.2	30	95
21J1	5- 7-53	7.9	309	201	28	.3	29 1.447	9.1 .748	26 1.131	.7 .018	0 .000	176 2.884	12 .250	6.0 .169	3.4 .055	.3 .016	.10	110	34
31F1	5- 7-53	8.4	403	263	28	.0	28 1.397	18 1.480	36 1.565	.6 .015	0 .000	234 3.835	18 .375	9.2 .259	10 .161	.3 .016	.28	144	35

46/6-24E1	5- 6-53	8.0	773	515	21	1.2	91 4.54	26 2.14	47 2.04	1.6 .04	0 .00	284 4.65	171 3.56	15 .42	.5 .01	.5 .03	1.3	334	23
	10- 3-53	7.7	779	504	23	------	93 4.64	23 1.89	52 2.26	1.7 .04	0 .00	354 5.80	120 2.50	16 .45	.2 .00	.5 .03	.56	326	26
25B1	5- 7-53	7.5	629	393	22	.0	71 3.54	27 2.22	27 1.17	1.6 .04	0 .00	321 5.26	60 1.25	6.0 .17	20 .32	.3 .02	.10	288	17
25D1	5- 6-53	8.4	609	398	29	.1	75 3.74	33 2.71	31 .57	.8 .02	22 .73	257 4.21	74 1.54	5.5 .16	19 .31	.2 .01	.07	322	8
25H1	5- 7-53	7.0	593	350	32	23	47 2.35	28 2.30	16 .70	2.6 .07	0 .00	388 6.36	1.2 .02	5.0 .14	3.5 .06	.5 .03	.10	232	11

TABLE 23.—*Chemical analyses of surface water in Shasta Valley, Calif.*

Upper number, parts per million; lower number, equivalents per million

Name of stream	Location number	Date sampled	pH	Conductance (K×10⁶ at 25° C)	Dissolved solids	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Hardness as $CaCO_3$	Percent sodium
Shasta River	41/5- 9P	10- 1-53	8.2	259	155	28	3.5 0.175	32 2.632	1.8 0.078	0.3 0.008	0 0.000	172 2.819	2.3 0.048	1.8 0.051	0.2 0.003	0.0 0.000	0.10	140	3
Parks Creek	41/6- 1A	3-18-53	8.0	278	159	21	7.6 .379	31 2.549	4.1 .178	.1 .003	0 .000	176 2.884	2.1 .044	6.5 .183	.0 .000	.0 .000	.12	146	6
		4-22-53	7.8	162	101	19	4.2 .210	18 1.480	2.0 .087	.4 .010	0 .000	107 1.754	2.4 .050	1.5 .042	.3 .005	.1 .005	.01	84	5
		5-27-53	8.3	217	138	28	6.7 .334	25 2.056	3.1	.3	0	143 2.344	2.0 .042	2.2 .062	.2 .003	.1 .005	.02	120	5
		10- 1-53	8.0	334	199	31	11 .549	35 2.878	7.4 .322	.4 .010	0 .000	208 3.409	3.9 .081	7.5 .212	.3 .005	.0 .000	.27	171	9
Shasta River	42/5-20J	3-18-53	7.4	194	134	36	6.3 .314	18 1.480	7.4 .322	1.4 .036	0 .000	120 1.967	2.9 .060	2.0 .056	.9 .015	.1 .005	.07	90	15
		4-22-53	7.9	186	119	26	4.0 .200	21 1.727	3.2 .139	.7 .018	0 .000	122 1.999	2.8 .058	1.0 .028	.2 .003	.1 .005	.04	96	7
		5-27-53	8.0	209	140	34	5.8 .289	22 1.809	5.2 .226	.7 .018	0 .000	134 2.196	2.9 .060	2.5 .071	.5 .008	.1 .005	.04	105	10
		10- 1-53	7.6	252	178	46	10 .499	19 1.562	16 .696	2.0 .051	0 .000	152 2.491	3.6 .075	6.0 .169	.4 .006	.2 .011	.09	103	25
Garrick Creek	22P	5-27-53	8.3	514	366	75	33 1.65	30 2.47	39 1.70	3.7 .09	0 .00	297 4.87	21 .44	17 .48	.5 .01	.5 .03	.15	206	29
		10- 1-53	8.0	711	457	60	42 2.15	43 3.45	56 2.44	4.6 .12	0 .00	408 6.69	26 .54	24 .68	.5 .01	.3 .02	.40	280	30
Shasta River	28M	4-15-53	7.7	322	190	28	8.0 .399	39 3.207	3.8 .165	.4 .010	0 .000	216 3.540	1.9 .040	2.0 .056	.4 .006	.1 .005	.07	180	4
Willow Creek (west).	42/6-19A1	3-20-53	8.3	461	284	32	34 1.70	43 3.54	3.8 .17	.5 .01	0	288 4.72	26 .54	1.0 .03	1.3 .02	.0 .00	.02	262	3
		10- 2-53	7.9	528	318	37	40 2.00	47 3.87	6.0 .26	1.2 .03	0 .00	334 5.47	19 .40	2.0 .06	1.7 .03	.1 .01	.08	294	4
Shasta Reservoir	43/5-25E1	5-27-53	8.2	265	170	32	11 .549	22 1.809	12 .522	1.6 .041	0	163 2.671	6.7 .139	4.2 .118	.6 .010	.1 .005	.04	118	18

Do	25L1	10- 2-53	7.7	293	180	29	12 .599	25 2.056	12 .522	1.6 .041	0 .000	178 2.917	5.4 .112	5.8 .164	.8 .013	.2 .011	.10	133	16
West Lake	44/5-29C1	5-27-53	9.5	1,770	1,100	13	15 .75	86 7.07	300 13.05	11 .28	205 6.83	394 6.46	11 .23	255 7.19	.8 .01	.3 .02	4.0	391	62
East Lake	29G1	5-27-53	9.3	1,750	1,190	.9	13 .65	199 16.37	184 8.00	23 .59	260 8.67	834 13.67	3.6 .07	88 2.48	1.4 .02	.2 .01	3.6	851	31
Shasta River	44/6-23H1	10- 3-53	7.9	496	321	56	26 1.30	30 2.47	37 1.61	3.2 .08	0 .00	276 4.52	8.1 .17	23 .65	1.1 .02	.2 .01	.39	188	29
Little Shasta River.	45/4-15C1	3-24-53	6.9	69.7	62	26	6.5 .324	2.6 .214	4.0 .174	.9 .023	0 .000	42 .688	.9 .019	.0 .000	.9 .015	.0 .000	.08	27	24
		5-27-53	7.3	76.0	71	29	7.5 .374	2.7 .222	4.3 .187	.9 .023	0 .000	46 .754	3.2 .067	.0 .000	.5 .008	.1 .005	.04	30	23
Cleland Springs	20B1	3-24-53	7.4	89.0	95	47	7.2 .359	3.2 .263	6.9 .300	1.3 .033	0 .000	58 .951	.6 .012	.5 .014	.0 .000	.0 .000	.05	31	31
Greenhorn Creek	45/7-34E1	5-28-53	8.1	356	210	17	37 1.85	23 1.89	4.5 .20	1.1 .03	0 .00	211 3.46	22 .46	1.2 .03	.2 .00	.0 .00	.00	187	5
Yreka Creek	34L1	3-27-53	8.0	531	306	29	30 1.50	57 4.69	2.6 .11	.4 .01	.0 .00	366 6.00	4.0 .08	.5 .01	2.5 .04	.0 .00	.03	310	2
		5-28-53	8.2	525	309	28	35 1.75	52 4.28	4.1 .18	.7 .02	0 .00	364 5.97	6.5 .14	1.2 .03	2.4 .04	.0 .00	.02	302	3
Willow Creek (north).	46/5-6J1	5-27-53	8.0	296	190	27	32 1.597	9.7 .798	18 .783	1.4 .036	0 .000	167 2.737	15 .312	2.2 .062	2.5 .040	.3 .016	.04	120	24
Shasta River	46/7-24H1	5-28-53	8.2	515	320	40	22 1.10	38 3.12	36 1.57	3.0 .08	0	312 5.11	10 .21	16 .45	1.2 .02	.3 .02	.19	211	27

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