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EFFECTS OF IRRIGATION DEVELOPMENT ON THE WATER SUPPLY OF QUINN RIVER VALLEY AREA, NEVADA AND OREGON, 1950-64

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With sections on

Surface Water
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Subarea (pl. 1)	Total area (acres)	Area of Mountain block (acres)	Area of valley segment (acres)	Extent
Oregon Canyon	223,000	121,000	102,000	From north end of area south to State line
McDermitt	483,000	369,000	114,000	From State line south to Quinn River gage
Orovada	404,000	200,000	204,000	From Quinn River gage south to State Hwy 8A
Silver State	191,000	62,000	129,000	From State Hwy 8A south to south end of area
Total	1,301,000	752,000	549,000	

Climate

The climate of the Quinn River valley area is arid to semiarid. Precipitation rates range from less than 8 inches per year on the valley floor to more than 22 inches on the mountains. Most of the precipitation in the mountains falls as snow during the winter and runs off during the spring thaw. The precipitation and the cumulative departure from average precipitation at Orovada for the period 1914-63 are shown in figure 1.

Average temperatures for the past 41 years at Orovada are shown in table 3. The average growing season in the basin, based on freeze data from the Orovada weather station from 1931 to 1963, is about 112 days and extends from May 30 to September 19.

Prevailing winds traverse the basin from the west and northwest. Storm trajectories are generally northwesterly (Thomas, 1962, p. A10). Annual evaporation rates in the valley are about 4 feet (Kohler and others, 1959, pl. 2).

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ABSTRACT

This is the second appraisal of the water supply of the Quinn River valley area, made 10 years after the first cooperative study, which was a reconnaissance (Visher, 1957). In the first report the natural discharge was estimated to be only 25,000 acre-feet per year, but excluded the discharge in the northern part of the valley in Oregon; the salvable discharge was estimated to be somewhat less than 20,000 acre-feet per year, excluding streamflow and surface-water diversions. This report concludes that the total natural discharge of the entire valley area averages about 100,000 acre-feet per year and that the perennial yield is on the order of 75,000 acre-feet. This study evaluates the hydraulic effects of the 14 years of pumping on the valley-fill reservoir.

Virtually all the ground-water development is concentrated in the Orovada subarea, and gross pumpage in 1964 was about 40,000 acre-feet. During the 15-year period 1950-64, pumpage totaled 230,000 acre-feet. In recent years, pumpage has been increasing at the rate of 3,000 to 4,000 acre-feet per year. Although no local or valley-wide overdraft existed in 1964, a local overdraft may occur in the Orovada subarea by the year 1970.

Water levels have declined an average of about 12 feet in the Orovada subarea; storage depletion from 1950 to 1963 has amounted to at least 135,000 acre-feet which is slightly more than the estimated net pumping draft of 130,000 acre-feet for the same period. Nearly all the pumpage has been supplied from storage; no natural discharge or streamflow has been salvaged.

Storage depletion is expected to continue for many years, and pumping costs, which were about $4 per acre-foot in 1964, will increase as the pumping lifts increase. If the net pumping draft does not exceed the salvable natural supply in Orovada subarea, a new equilibrium condition could be attained when water levels reach a depth roughly 50 feet lower than those in 1964. If levels were held at that depth, little or no transpiration losses would occur. More critical, however, would be the drastic depletion of natural streamflow in the Quinn River. In the Orovada and southern part of the McDermitt subareas most of the surface water now diverted for irrigation would sink into the stream channel to recharge the depleted ground-water reservoir.

The chemical quality of the water generally is satisfactory for irrigation, domestic, and stock use. However, the water is moderately hard for laundry and similar domestic uses.

INTRODUCTION

Purpose and Scope

This is the second report on the hydrology of the Quinn River valley prepared by the U. S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The first report (Visher, 1957) was a reconnaissance and provided preliminary estimates of recharge and discharge in the Nevada segment of the valley.

The need for this study was expressed by the State and some of the local ranchers, who were concerned over the rapid development of ground water for irrigation during the period 1957-64 and its effect on the water supply. Because virtually all the development (about 40,000 acre-feet in 1964) has occurred in the vicinity of the town of Orovada, the question was raised whether a local overdraft existed. Most critical to the supply is that permitted rights to pump 96,000 acre-feet of water have been granted in this part of the valley.

Accordingly, the principal purpose of this report is to reappraise the hydrology of the valley with special reference to the extent of any overdraft in the vicinity of Orovada. An additional related objective is an appraisal of the entire structural basin, which includes both the Nevada and Oregon segments of Quinn River valley and Silver State Valley to the south, to determine the total water supply in this large hydrologic unit.

To fulfill the foregoing objectives, this report briefly describes the geology and water-bearing character of the rocks and deposits; estimates the long-term inflow to and outflow from the area, which has been subdivided into four discrete hydrologic subareas; evaluates the depletion of ground water for the period 1947-64 in the Orovada subarea caused by the concentration of ground-water pumping; describes the potential effect of continued pumping of the streamflow of Quinn River west of Orovada; estimates the yield and the potential overdraft in the Orovada subarea; and briefly describes the chemical quality of water and the potential effect on the quality that might occur as a result of recycling the pumped water.

Because of the continuing decline of water levels in the Orovada subarea and the potential threat to vested rights in the natural flow of the Quinn River, the Nevada State Engineer acted in March 1965 to halt further development of ground water in this part of Quinn River valley.

This study was begun in July 1963, and the field work was concluded in September 1964.

Geography and General Features of the Area

Location and Areal Extent

The area described in this report includes Quinn River valley in Humboldt County, Nevada, and Malheur and Harney Counties, Oregon, and Silver State Valley in Humboldt County, Nevada (pl. 1). In this report the two valleys collectively are called the Quinn River valley area. It lies approximately between 41° and 42°30' N. lat and 117°30' and 118°15' W. long. It ranges in width from 45 miles near the Nevada-Oregon border to about 12 miles in the south, is about 90 miles long, and covers an area of about 2,100 square miles.

The north-trending valley lowland is bordered on the east by the Santa Rosa Range, on the west by the Quinn River Mountains and the Slumbering Hills, on the north by Battle Mountain, and on the south by unnamed hills (pl. 1). The Quinn River is formed near the State line by the confluence of McDermitt Creek, the East Fork of the Quinn River, and Oregon Canyon Creek. It flows southward to the north end of Silver State Valley, then flows westward out of the area through the gap at Sod House between the Slumbering Hills and the Quinn River Mountains.

Access to the valley area is provided by U. S. Highway 95, which extends northward through the valley, by State Highway 8A, and by several gravel roads. Orovada and McDermitt are the only communities in the valley and both lie astride U. S. Highway 95.

Hydrologic Subareas

For simplicity of treatment, the area has been divided into four subareas, each consisting of a segment of the valley and the adjacent mountain blocks. The subareas are shown on plate 1 and listed in table 1.

The boundaries between the subareas are arbitrarily drawn at convenient points and are not based upon any controlling or limiting hydrologic factors. The southern boundary of the Oregon Canyon subarea, for example, is drawn to coincide roughly with the Oregon-Nevada State line. The boundary between the McDermitt and Orovada subareas transects the valley at a surface-water gaging station on the Quinn River, thereby providing a convenient hydrologic control point between the two units. Silver State subarea is separated from the Orovada subarea along a general line at which the ground-water flow from each subarea converges.

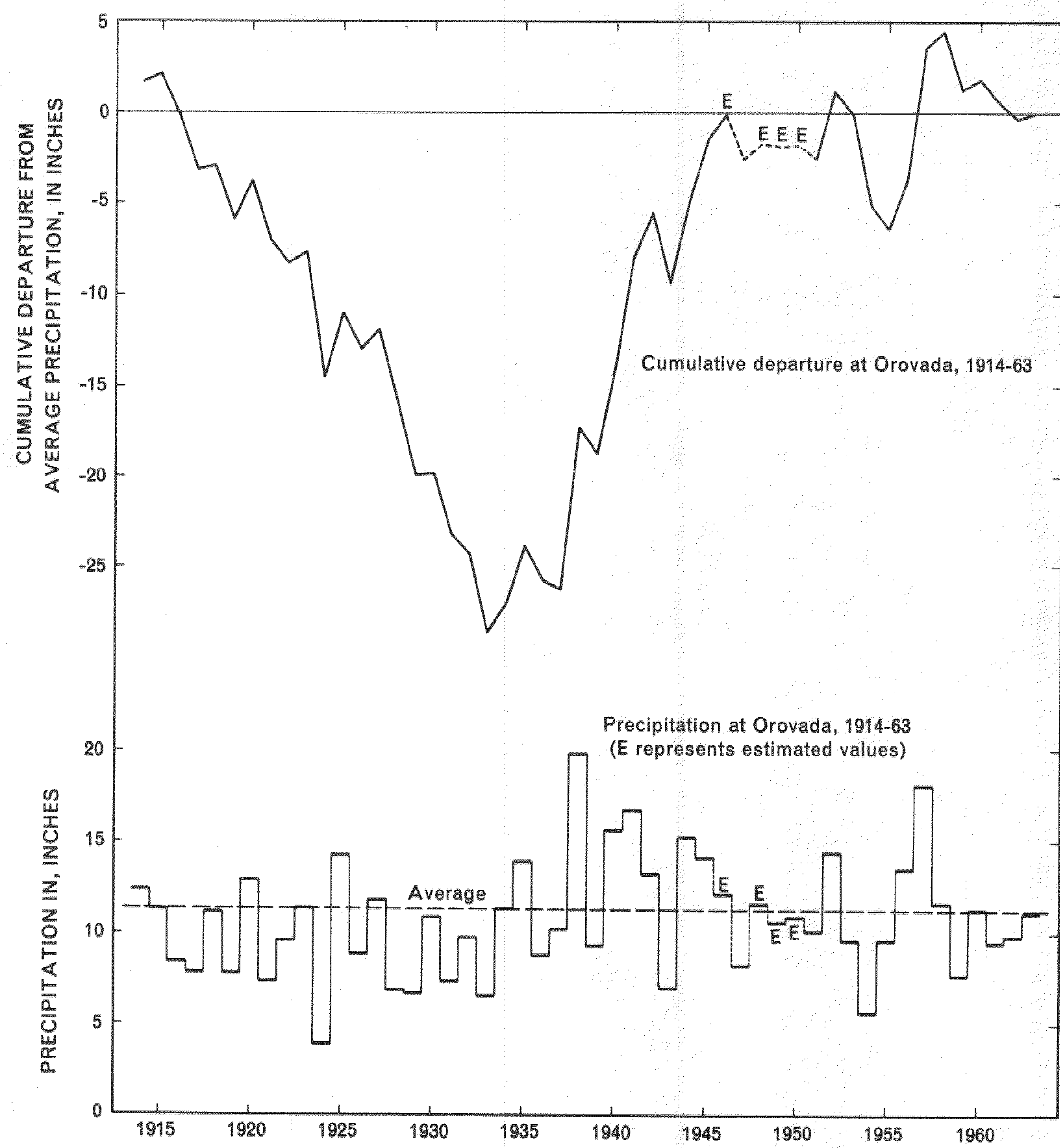

Figure 1.—Precipitation and cumulative departure from average precipitation at Orovada, 1914-63

Table 2. --Average monthly temperature data at Orovada

	Years of records	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average annual temp.
Average monthly temperature	41	28.7	34.7	39.5	44.5	54.9	62.5	72.4	69.7	60.7	50.3	38.7	31.3	49.0
Average maximum temperature	41	53.8	59.2	69.0	78.7	88.2	96.6	101.9	100.2	94.2	83.5	67.6	56.3	79.1
Average minimum temperature	41	−3.3	5.1	11.8	18.2	25.6	32.1	39.7	37.0	26.3	18.9	9.0	0.2	18.4

Culture

The population of the area is estimated to be about 1,500 persons (1960 census). About 1,200 people, including more than 400 Indians on the Fort McDermitt Reservation, live in the northern part of Quinn River Valley in McDermitt Township and are served by the town of McDermitt. This town straddles the Oregon-Nevada border. The remaining 300 people are scattered throughout the valley south of McDermitt. The settlement of Orovada, in the east-central part of the basin, has experienced considerable growth since 1957 as a result of increased farming in the valley.

Ranches were established in the valley by the 1880's, and for many years cattle ranching was the chief agricultural enterprise. Feed for cattle consisted of range forage and native grasses in upland and lowland meadows, which were subirrigated naturally or irrigated by stream diversion. In 1964 about 20,000 head of cattle were raised in the basin.

In the past, attempts were made to practice dry-land farming on homestead plots, but none of these succeeded. With the release of government land under the Desert Land Entry Acts, however, farmers began to establish crops irrigated by ground water from wells. In 1964 more than 13,000 acres of cropland were irrigated from ground water. In addition, a few ranchers have put in wells to provide for supplemental irrigation of native-grass meadows, especially in downstream areas of the Quinn River and its tributaries where streamflow in dry years is deficient.

The principal crops raised in addition to native hay are feed and seed alfalfa. Smaller acreages of small grain and clover are also raised. Table 3 summarizes crop acreages and market values of crops in the valley in 1964. Seed alfalfa has proved to be the most profitable crop, and a seed processing plant has been established at Orovada. However, the high cost of developing land and of power for pumping ground water, and the possibility of late spring or summer freezes make crop farming a precarious undertaking.

The only producing mine in the basin is the Cordero Mine (NE 1/4 sec. 33, T. 47 N., R. 37 E.) west of McDermitt. In 1963 the Cordero Mine produced 4,726 flasks of mercury (Willden, 1964, p. 133). The mine employed about 70 persons in 1964.

Table 3. --Crop acreage, crop yield, and market value, 1964

(Records from U. S. Dept. of Agriculture (1965), Nevada Alfalfa Seed Company, and field observations)

Crop	Total acreage	Total yield	Unit value	Approximate value
Feed alfalfa	5,300	17,900 tons	$22.00/ton	$ 393,000
Cleaned seed alfalfa	5,800	1,800,000 lbs.	.40/lb.	700,000
Small grains	1,975	83,900 bu.	1.85/bu.	155,000
Clover seed (certified and uncertified)	300	122,500 lbs.	.35/lb.	42,900
Subtotal	13,375 1/	--	--	$1,290,900
Native hay	27,000 2/	27,000 tons	$18.00/ton	$ 485,000
Total	40,375	--	--	$1,775,900

1. Irrigated from ground water

2. Used locally in cattle feeding; irrigated largely with surface water

Previous Studies

The earliest geological study which touched on the Quinn River valley area was made by Russell (1885). Subsequent studies by Lindgren (1915), Calkins (1938), and Yates (1941) dealt with ore deposits in the surrounding mountains. The geologic map shown in plate 1 is after Willden (1961, 1964).

The only hydrologic study of the area was made in 1954-55 by Visher (1957). That reconnaissance provided much of the historical data on pumpage and natural discharge used in this report to demonstrate the change in hydrologic conditions that has occurred since large withdrawals began in about 1957.

Well-Numbering System

Numbering of all control points is based on the rectangular system for the subdivision of public lands. Accordingly, the numbers both identify and locate each control point. In Nevada the first unit of each number indicates the township north of the Mount Diablo base line. The second unit, separated from the first by a slant, indicates the range east of the Mount Diablo meridian. In Oregon the first unit indicates the township south of the Willamette base line and the second unit indicates the range east of the Willamette meridian. The third unit, separated from the first two units by a hyphen, lists the section number, followed in turn by two letters that designate the quarter section, and the quarter-quarter section, respectively. The two letters are followed by a number which indicates the chronological order in which the control point was recorded within the 40-acre subdivision. The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarters of each unit. For example, well number 43/37-28ac1 designates the first well recorded in the SW1/4NE1/4 sec. 28, T. 43 N., R. 37 E., Mount Diablo base line and meridian.

GEOLOGIC FEATURES

Physiography

The Quinn River valley area is in the Great Basin Section of the Basin and Range Physiographic Province of Fenneman (1946). The valley area is a north-trending structural trough, bounded on the east and west by uplifted mountain blocks.

The Santa Rosa Range on the east rises to a maximum altitude of 9,770 feet. The Quinn River Mountains (also called Montana, Trout Creek, and Double H Mountains) and Slumbering Hills on the west attain altitudes of 7,096 and 6,060 feet, respectively. Within Nevada, the valley floor ranges in altitude from about 4,110 feet at Sod House, where the Quinn River flows out of the valley, to about 4,400 feet at McDermitt and to about 4,200 feet at the south end of Silver State Valley. The maximum relief within the area is nearly 5,700 feet.

The Quinn River is along the western side of Quinn River valley; its position there has been controlled largely by the alluvial debris deposited by streams from the Santa Rosa Range. The river gradient in the southern part of the valley is less than 5 feet per mile, and the lowland area is subject to flooding in wet years. In Silver State Valley, part of the storm runoff discharges into an unnamed playa, or dry lake, in the northern part of the valley (pl. 1); little discharge reaches the Quinn River.

During the late Pleistocene, Lake Lahontan extended into the valley area (Russell, 1885). The uppermost still stand of the lake was at an altitude of about 4,380 feet. Shoreline features are prominent at and below this altitude.

Geologic Units

The geologic units in the Quinn River valley area, as mapped largely by Willden (1961), have been grouped according to their water-bearing character, as follows: Consolidated rocks, including metamorphic and granite rocks of very low permeability, and the volcanic rocks of low to possibly moderate permeability; and unconsolidated deposits, or valley fill, consisting of older and younger alluvium principally underlying the valley floor and generally having moderate to high permeability. The valley fill was described in moderate detail by Visher (1957, p. 23-25).

Metamorphic and Granitic Rocks

The metamorphic rocks consist of intensely folded phyllite, argillite, and quartzite of Triassic and Jurassic age. They are exposed in the Slumbering Hills and in the Santa Rosa Range, south of Granite Peak. The granitic rocks are principally granodiorite of Cretaceous or early Tertiary age. The granodiorite occurs in several stocks in the central and southern parts of the Santa Rosa Range and in the central part of the Slumbering Hills. The metamorphic and granitic rocks are shown on plate 1.

Volcanic Rocks

The volcanic rocks consist mostly of rhyolite and dacite flows and some basalt and andesite, all largely of Miocene age. They are extensively exposed in the Quinn River Mountains, at the north end of the area, and in the northern part of the Santa Rosa Range (pl. 1).

The lava beds in the Quinn River Mountains are tilted slightly to the northeast. The monoclinal character of these beds has been obscured in the McDermitt Creek basin by faulting of the lava beds (Yates, 1941, p. 323-327).

Older Alluvium

The older alluvium is exposed along the sides of the valley where it underlies the alluvial aprons. It includes the fanglomerate of Visher (1957, p. 21-22). It is moderately dissected and, in the northern part of the valley, is cut by faults of minor displacement. Beneath the valley lowlands it probably underlies the younger alluvium at shallow depth. The older alluvium ranges in age from probably late Pliocene to late Pleistocene. In a map published after this report was submitted for review, Walker and Repenning (1966) show the older alluvium in the Oregon Canyon Creek drainage as Tertiary sedimentary deposits overlain by Pliocene to Pleistocene lag and pediment gravels.

Because of the similarity of the older and younger alluvium,the contact between the two could not be distinguished in well logs. Both deposits are composed of lenses and beds containing varying proportions of gravel, sand, silt, and clay. Color and mineralogical distinctions do not provide a consistent guide as to where the subsurface contact might be.

The thickness of the older alluvium probably is considerably more than the deepest well in the valley, which has a depth of 1, 075 feet (well 43/37-33aa1, table 21).

Younger Alluvium

The younger alluvium is exposed in the valley lowlands and in and adjacent to the active streams in the area (pl. 1). It includes the deposits laid down in Lake Lahontan, the channel deposits of the Quinn River, alluvial-fan deposits, dune sand, and fine-grained deposits in the area adjacent to State Highway 8A where during peiods of flood, the Quinn River spreads out over the broad, nearly flat lowlands. The Lake Lahontan deposits consist principally of coarse gravel beach deposits and extensive fine-grained lake beds. The lake beds underlie more recent alluvial deposits in the topographically low parts of the valley north and south of State Highway 8A. The younger alluvium is largely Recent in age, although the lower part and the Lake Lahontan deposits are late Pleistocene in age.

The thickness of the younger alluvium ranges from a few feet along its contact with older rocks to probably not more than 200 feet near the center of the valley. As previously mentioned, the subsurface contact between the younger and older alluvium could not be determined. Therefore, the maximum thickness of the younger alluvium beneath the valley floor is not known.

VALLEY-FILL RESERVOIR

Extent and Boundaries

The older and younger alluvium form the valley-fill reservoir, which is the principal source of ground water in the Quinn River valley area. The reservoir probably is more than 1,000 feet thick in the deeper parts of the valley. The metamorphic and granitic rocks yield only minor amounts of water to springs and to the valley-fill reservoir by subsurface flow through joints and fractures. The volcanic rocks locally may yield moderate amounts of water to the valley-fill reservoir by subsurface flow through scoriaceous zones and joints. Thus, the hydraulic boundaries of the valley-fill reservoir, based on these qualitative observations, are considered to be slightly leaky along the contact with granitic and metamorphic rocks and moderately leaky along the contact with the volcanic rocks.

A fault cutting the older and younger alluvium near Orovada has been defined as an internal hydraulic boundary and has exerted a pronounced effect on the ground-water flow in this vicinity (pl. 1 and fig. 2). The fault is parallel to and about 1 mile west of U. S. Highway 95 and has a known effective length as a hydraulic boundary of nearly 8 miles.

Recharge boundaries are formed principally by the live-stream segment of the Quinn River and to a lesser extent by the smaller perennial streams where they overlie the valley-fill reservoir. In most years the recharge boundary formed by the Quinn River is effective downstream to a point a few miles south of Orovada. Because the deposits become finer-grained southward, the effectiveness of the recharge boundary also decreases in the same direction.

Coefficients of Transmissibility and Storage

The coefficient of transmissibility is a measure of the resistance to ground-water flow in a reservoir or aquifer system. The coefficient of storage in a heterogeneous valley-fill reservoir is a measure of the amount of water that will drain from the deposits as the water level is drawn down by pumping. When utilized together in certain types of mathematical models or simulated in electrical models, the two coefficients define the hydraulic conductivity of the system, or in simpler terms, can be used to describe the distribution and amount of water-level decline that will result under certain or selected conditions of pumping and boundary conditions.

A total of 18 pumping tests were run in the Orovada subarea to determine principally the coefficient of transmissibility. Most tests were of short duration (60 to 100 minutes), and therefore the coefficient of storage could not be obtained, principally because of the slow vertical drainage of the alluvial deposits. Values of transmissibility obtained from these

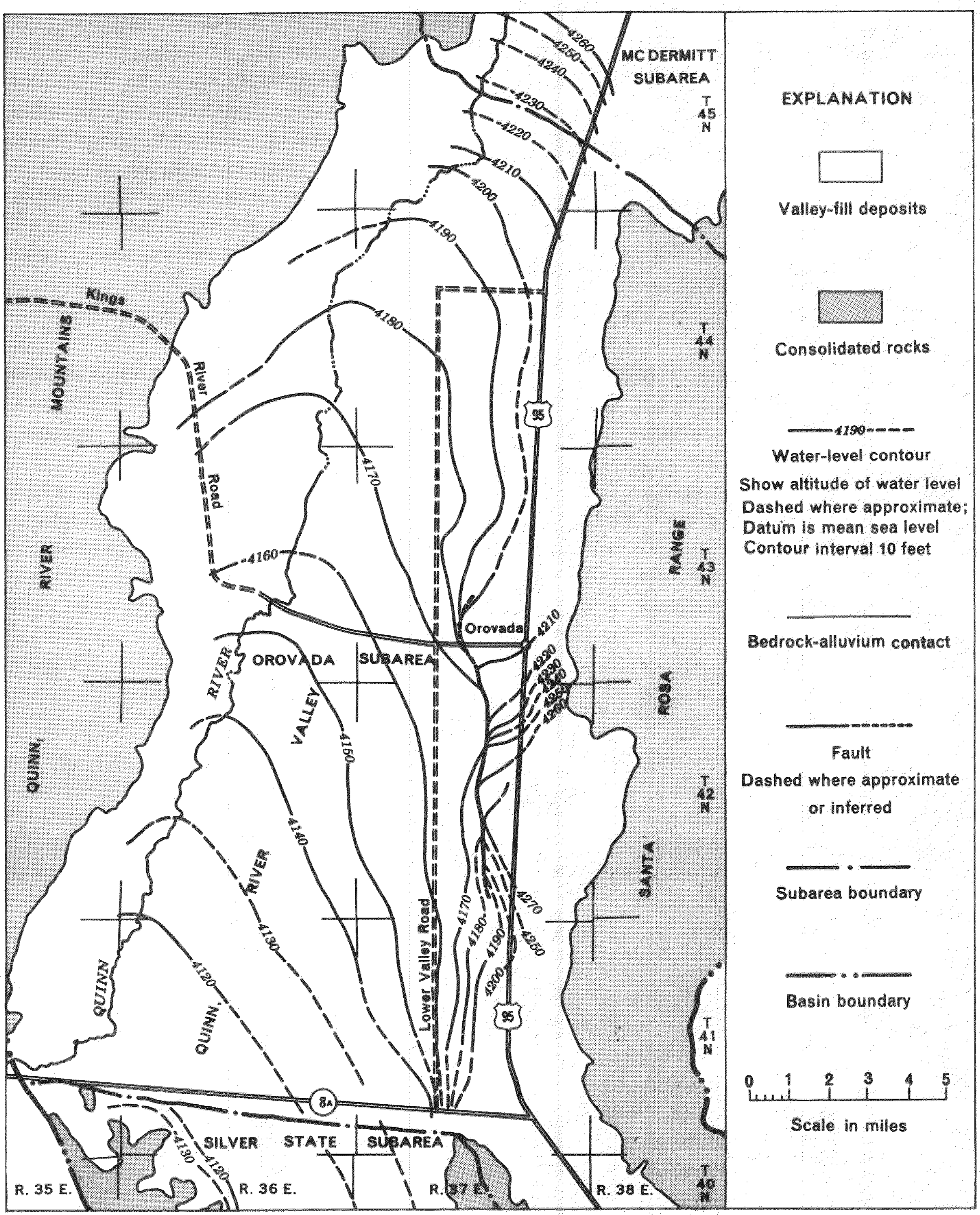

Figure 2.—Water-level contours in the Orovada subarea for February-March 1964

tests ranged from 15,000 to 200,000 gpd (gallons per day) per foot. Figure 3 shows the areal distribution of transmissibility in the Orovada subarea. The boundaries between areas of varying transmissibility are more reliable where most of the tests were run, and decrease away from the areas tested. At best the reliability of the boundaries is no more than 50 percent. The coefficient of storage, which over the long term may be nearly equal to the specific yield of the alluvial deposits, is computed from well logs to be about 0.13 to 0.15, or about equivalent to a specific yield of 13 to 15 percent. (See section on ground water in storage.) Because the deposits become progressively more fine grained southward in Quinn River valley, the flow system for short-term periods responds to stress much like an artesian system. Nevertheless, over the long term all these deposits will drain slowly in response to pumping.

Ground-Water Flow

The direction of ground-water flow in the valley-fill reservoir can be determined from the water-level contours shown in plate 1 and figure 2 by constructing flow lines normal to the contours and pointing down the hydraulic gradient. Plate 1 and figure 2 represent pre-pumping conditions in 1947 and the effect of about 15 years of pumping as of 1964, respectively. Not shown by the contours are the downward component of flow in areas of recharge on the alluvial fans and the upward component of flow in areas of discharge along the river and in areas of evapotranspiration.

The water-level contours are drawn on the heads in wells in the upper part of the valley-fill reservoir. They do not show the flow for the deeper parts of the reservoir. Both sets of contours show that ground water is moving (1) generally southward beneath and toward the river in Quinn River valley, (2) northward toward the river in Silver State Valley, and (3) westward through the valley outlet at Sod House.

Except for the Orovada subarea, the water-level contours for 1947 and 1964 are virtually the same. In the Orovada subarea, pumping has modified the conditions; the gradient toward the river from the east has been reduced substantially. The disparity in water levels in wells 43/37-33da2 and 43/37-34cc1 across the hydraulic barrier west of U.S. Highway 95 has been decreased from about 45 feet in 1947 to 20 feet in 1964.

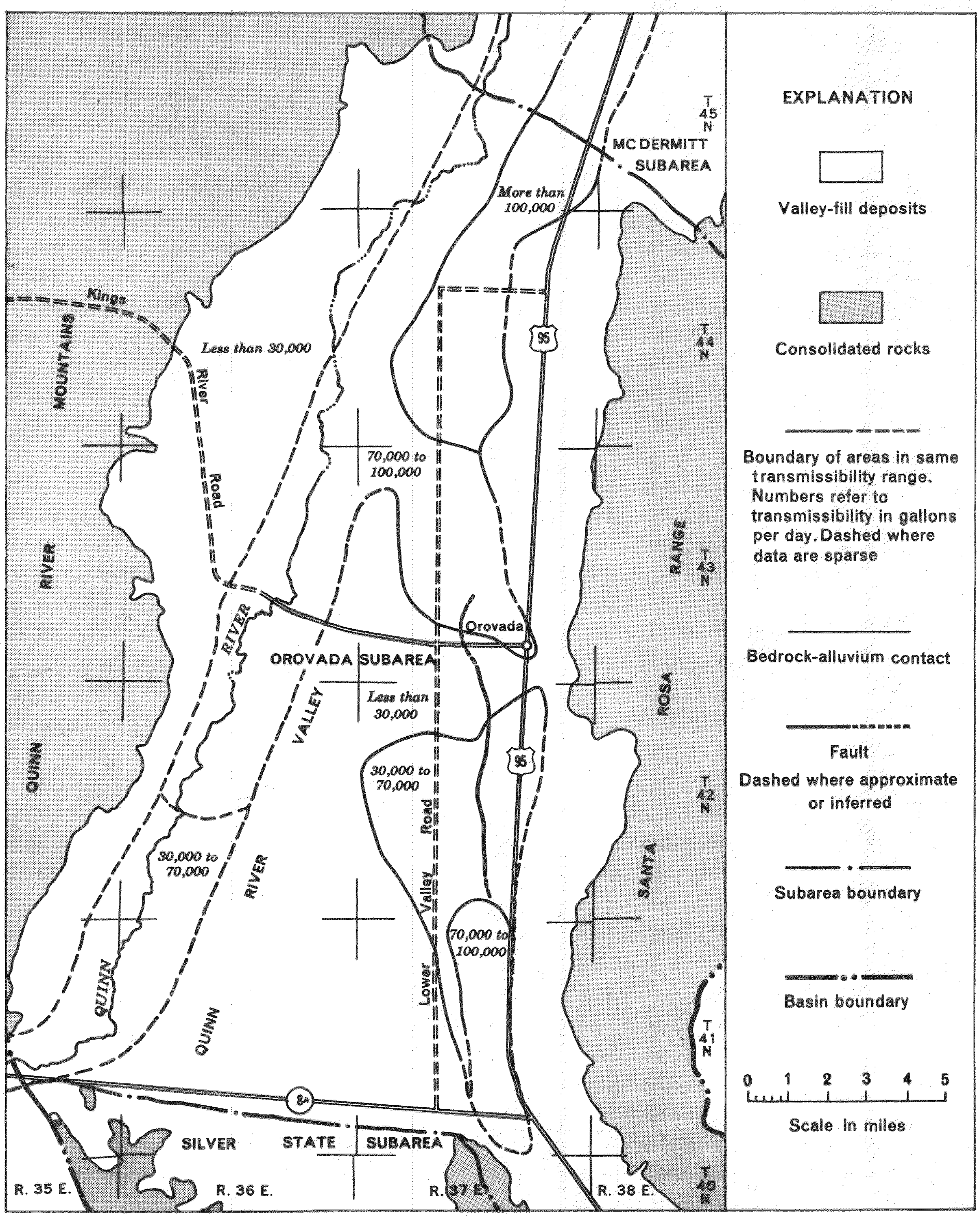

Figure 3.—Transmissibility of the valley-fill in the Orovada subarea

INFLOW TO THE VALLEY-FILL RESERVOIR

Nearly all the development in the Quinn River valley area and from the valley-fill reservoir has occurred in the Orovada subarea (pl. 2). Accordingly, the stress imposed on the flow system by pumping and the accompanying affects are examined in considerable detail. However, to determine whether the estimated values of inflow to and outflow from the entire valley area and in the four subareas are in reasonable agreement, an analysis of the valley-wide quantities is undertaken first.

Precipitation

Distribution and Amount

Precipitation falling as rain or snow is the source of all water entering the hydrologic system of the Quinn River valley area. Hardman (1936) established the gross relation between precipitation rates and altitude in Nevada. Precipitation rates increase with increasing altitude, and mountain peaks may receive three or four times more precipitation than the adjacent valley floors. Precipitation also varies with the orientation of topography to prevailing directions of air movement. The mountains surrounding Quinn River valley are approximately normal to the prevailing westerly to northwesterly winds. As air is forced to ascend the west-facing, or windward, mountain slopes, it is cooled, thereby causing condensation and precipitation. The air is warmed as it descends the east-facing, or leeward, mountain slopes, and thus is able to retain more of its remaining moisture. Accordingly, precipitation on the west-facing mountain slopes of the area is usually greater than that on the east-facing slopes.

Figure 4 shows the locations of weather stations in and near the Quinn River valley area, and table 4 shows the average annual precipitation at these stations. The relation between precipitation and altitude at these several stations is shown on figure 5. Because the one side of the valley generally is wetter than the other side, for the reasons already mentioned, two curves are drawn to reflect these conditions: The curve for the east side of the valley represents the precipitation-altitude relation along eastern sides of the Oregon Canyon, McDermitt, and Orovada subareas; the curve for the west side of the valley represents this relation along the western sides of Oregon Canyon, McDermitt, and Orovada subareas and all of Silver State subarea. Based on these two curves and the areas covered, the estimated average annual precipitation on the Quinn River valley area is roughly 1,200,000 acre-feet.

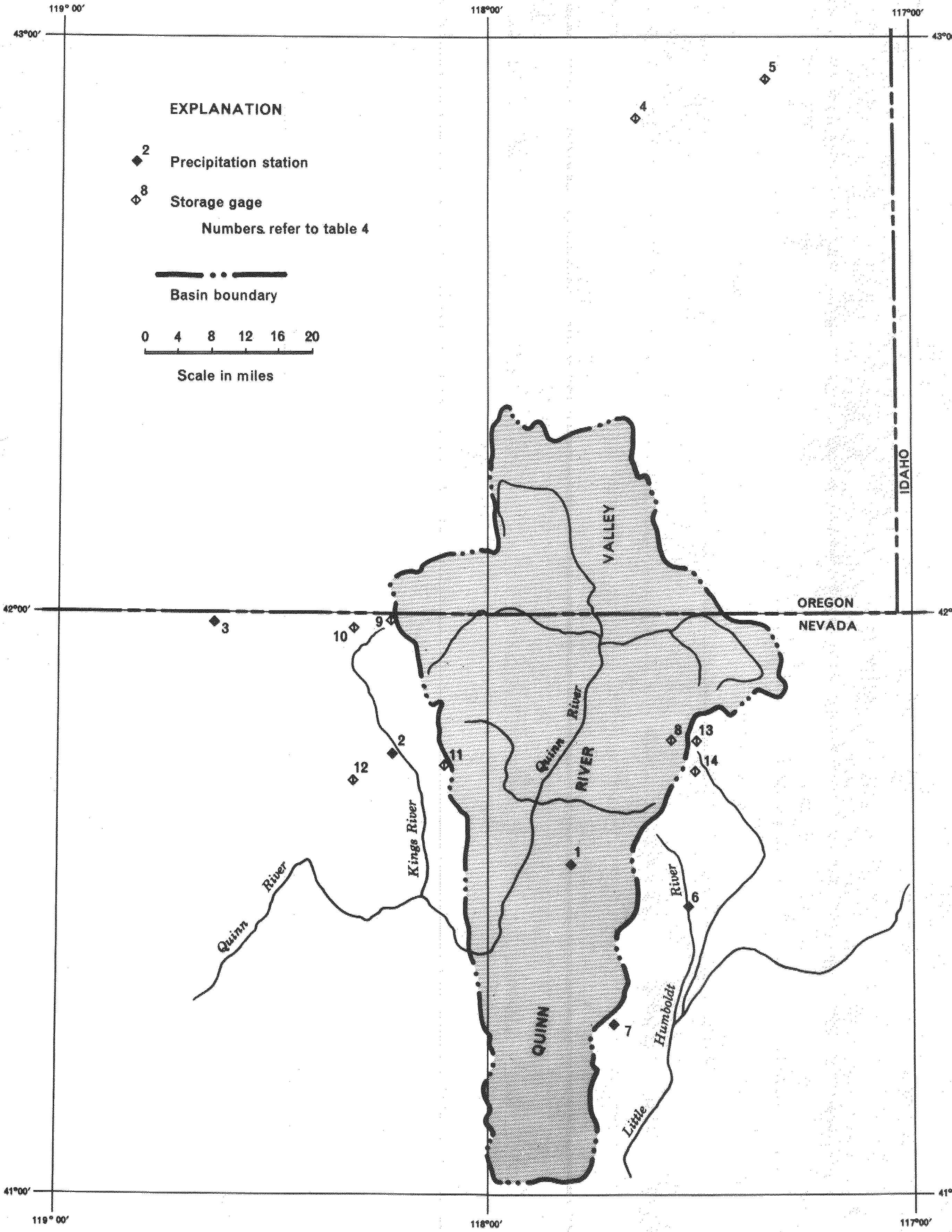

Figure 4.—Locations of weather stations in and near the report area

Table 4. --Average annual precipitation in and near Quinn River valley

(Data from U. S. Weather Bureau annual summaries and from records of the Nevada Department of Conservation and Natural Resources)

No.	Station	Altitude (feet)	Years of record	Period of record used	Average annual precipitation (inches)
	Precipitation				
1	Orovada	4,300	30	1931-60	11.40
2	Kings River Valley	4,240	7	1957-63	9.11
3	Denio	4,200	12	1952-63	8.42
4	Rome, Ore.	3,400	7	1957-63	8.62
5	Danner, Ore.	4,400	30	1931-60	11.07
6	Paradise Valley	4,700	9	1955-63	8.66
7	Paradise Hill	4,500	3	1961-63	8.10
	Precipitation storage				
8	Canyon Creek	7,000	2	1962-64	17.81
9	Disaster Peak	6,800	4	1960-64	17.40
10	Kings River Canyon	5,500	4	Do.	12.84
11	Thacker Pass	5,000	2	1962-64	11.53
12	9-mile Pass	5,500	4	1960-64	10.14
13	Buckskin	7,800	15	1947-61	24.50
14	Cabin Creek	6,500	4	1959-60, 1961-64	12.30

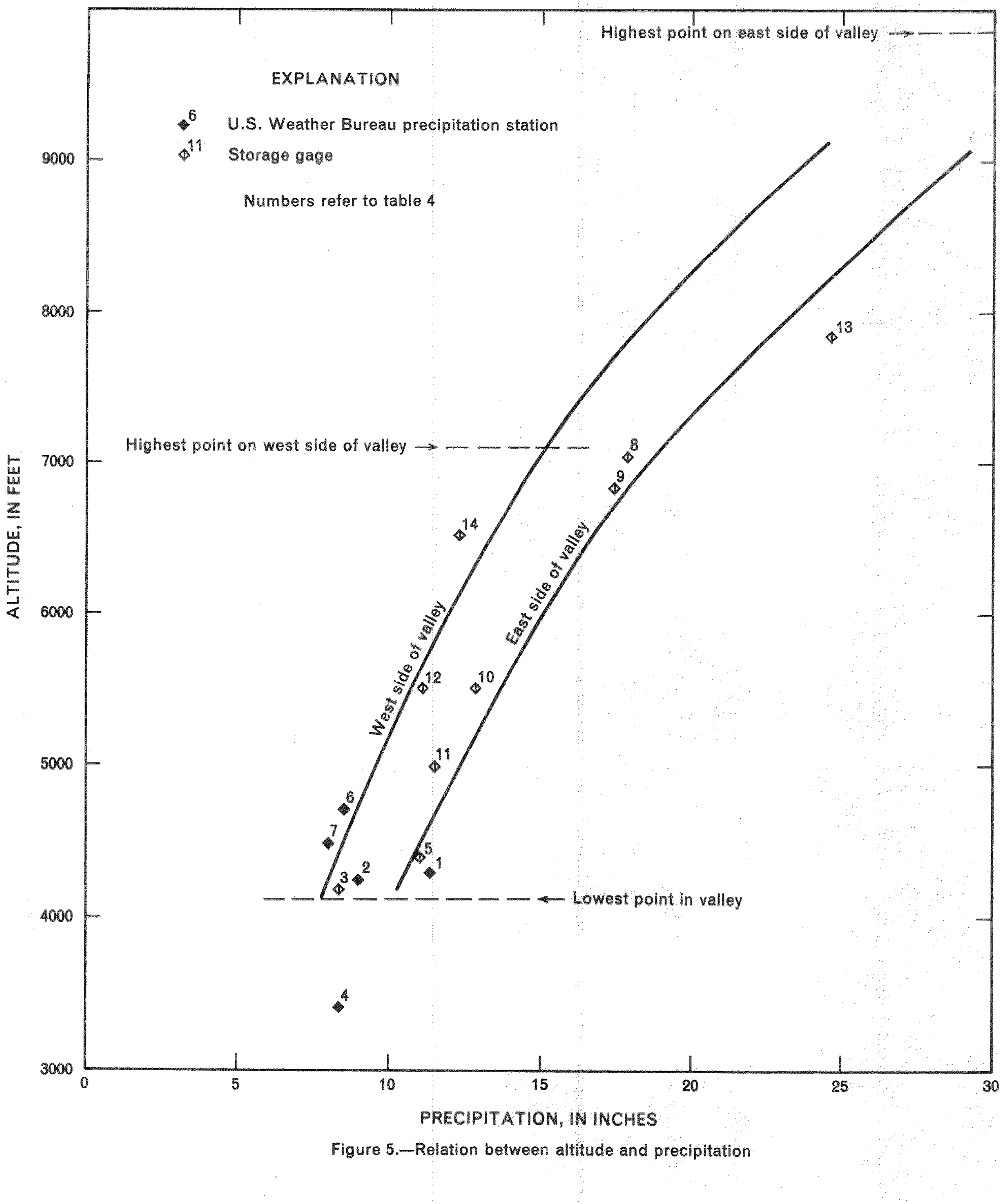

Figure 5.—Relation between altitude and precipitation

Ground-Water Recharge

Ground-water recharge to the valley-fill reservoir is principally by seepage loss from streams. A small amount occurs by ground-water flow across the bedrock-alluvial contact, which forms the leaky external hydraulic boundaries of the reservoir, and a very minor amount occurs by direct infiltration of precipitation on the valley floor in exceptionally wet years.

Eakin and others (1951, p. 79-81) devised a method of estimating the total recharge to a ground-water reservoir, based on the relation between precipitation and altitude and an empirical relation between this calculated precipitation and recharge. The method is used in this report principally to obtain a rough approximation of total recharge; the principal element of recharge, seepage from streams, is derived separately. (See table 8.)

Using the relationship of precipitation to altitude, shown in figure 5, precipitation rates are assigned to five altitude zones in the area. For equivalent altitude zones, the eastern side of the valley is wetter than the western side. This distinction is made in table 5. By applying percentages to the volume of precipitation in each zone, the estimated recharge is computed. The estimated total recharge is about 74,000 acre-feet per year, which is roughly 6 percent of the estimated precipitation of 1,200,000 acre-feet per year.

Table 5 also shows the estimated total recharge from precipitation by subareas. The estimates for each subarea in table 5 cannot be compared to those in table 8 without adjustment for intersubarea surface-water and ground-water flow.

Table 5. -- Estimated average annual precipitation and recharge to the valley-fill reservoir

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation			Estimated recharge	
		Range (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	Acre-feet per year
		OREGON CANYON SUBAREA (eastern part)				
Above 6,000	10,800	more than 15	1.4	15,000	15	2,300
5,000 to 6,000	46,700	12 to 15	1.1	51,000	7	3,600
Below 5,000	46,100	less than 12	.9	42,000	3	1,300
Subtotal (rounded)	104,000			110,000		7,200
		(western part)				
Above 7,000	6,000	more than 15	1.4	8,400	15	1,300
6,000 to 7,000	17,300	12 to 15	1.1	19,000	7	1,300
5,000 to 6,000	40,300	10 to 12	.9	36,000	3	1,100
Below 5,000	55,700	less than 10	.7	39,000	--	--
Subtotal (rounded)	119,000			100,000		3,700
Total for subarea (rounded)	223,000			210,000		11,000

Table 5. --(continued)

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation			Estimated recharge	
		Range (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	Acre-feet per year
MCDERMITT SUBAREA (eastern part)						
Above 8,000	1,500	more than 24	2.2	3,300	25	800
7,000 to 8,000	11,500	19 to 24	1.8	21,000	25	5,200
6,000 to 7,000	69,900	15 to 19	1.4	98,000	15	15,000
5,000 to 6,000	44,900	12 to 15	1.1	49,000	7	3,400
Below 5,000	73,700	less than 12	.9	66,000	3	2,000
Subtotal (rounded)	202,000			240,000		26,000
(western part)						
Above 8,000	1,900	more than 19	1.8	3,400	25	850
7,000 to 8,000	12,200	15 to 19	1.4	17,000	15	2,600
6,000 to 7,000	55,700	12 to 15	1.1	61,000	7	4,300
5,000 to 6,000	133,000	10 to 12	.9	120,000	3	3,600
Below 5,000	78,500	less than 10	.7	55,000	--	--
Subtotal (rounded)	281,000			260,000		11,000
Total for subarea (rounded)	483,000			500,000		37,000

Table 5. --(continued)

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation			Estimated recharge	
		Range (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	Acre-feet per year
		OROVADA SUBAREA (eastern part)				
Above 8,000	5,800	more than 24	2.2	13,000	25	3,200
7,000 to 8,000	19,400	19 to 24	1.8	35,000	25	8,800
6,000 to 7,000	19,200	15 to 19	1.4	27,000	15	4,000
5,000 to 6,000	28,100	12 to 15	1.1	31,000	7	2,200
Below 5,000	123,000	less than 12	.9	110,000	3	3,300
Subtotal (rounded)	195,500			220,000		22,000
		(western part)				
Above 6,000	20,400	more than 12	1.1	22,000	7	1,500
5,000 to 6,000	50,500	10 to 12	.9	45,000	3	1,400
Below 5,000	138,000	less than 10	.7	97,000	--	--
Subtotal (rounded)	208,900			160,000		2,900
Total for subarea (rounded)	404,400			380,000		25,000

Table 5.--(continued)

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation			Estimated recharge	
		Range (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	Acre-feet per year
		SILVER STATE SUBAREA				
Above 7,000	1,000	more than 15	1.4	1,400	15	210
6,000 to 7,000	4,800	12 to 15	1.1	5,300	7	370
5,000 to 6,000	30,700	10 to 12	.9	28,000	3	840
Below 5,000	154,500	less than 10	.7	110,000	--	--
Total for subarea (rounded)	191,000			140,000		1,400
Total for area (rounded)	1,300,000			1,200,000		74,000

Runoff

By J. E. Parkes

Distribution and Amount

Surface-water inflow in this report refers to the runoff crossing the contact between the consolidated rocks of the mountains and the unconsolidated valley fill. Nearly all runoff in the basin is generated in the 1,000 square-mile area lying above an altitude of 5,000 feet. Most of the annual runoff occurs during the spring and early summer. Base flow or ground-water runoff is a small part of the annual total and sustains the flow during late summer, fall, and winter when precipitation is small or accumulates in storage as snow and ice.

Streamflow data from three recording stream-gaging stations and current-meter measurements at 16 miscellaneous sites in the basin were analyzed as part of this study. Streamflow records from the three stations, McDermitt Creek at McDermitt, East Fork Quinn River at McDermitt, and Quinn River at McDermitt, for the water years 1949-60, are contained in U. S. Geological Survey Water-Supply Papers 1314 (1960) and 1734 (1963). Records for the years 1961-64 have been published in annual reports of the U. S. Geological Survey entitled, "Surface Water Records of Nevada." The current-meter measurements at miscellaneous sites were obtained during the 1964 water year and are listed in table 6. The locations of the three stream-gaging stations and the miscellaneous measuring sites are shown in plate 4.

Estimates of the long-term average annual runoff from the mountains were made using a general reconnaissance method described by D. O. Moore (Eakin and others, 1964, and Riggs and Moore, 1965). Measurements at miscellaneous sites were made on many of the major streams entering the valley (table 6). The measuring sites were chosen as near as possible to the bedrock-alluvium contact. Hydrographs for the 1964 water year were synthesized for each of the measured streams by comparing the miscellanous measurements with stream-flow records of McDermitt Creek and East Fork Quinn River. Table 7 shows the computed runoff for the 1964 water year and the estimated average annual runoff for the major streams in the area.

The 1964 runoff to the valley was computed from the synthesized hydrographs. To relate runoff for 1964 to a long-term average annual runoff, streamflow records from McDermitt Creek and East Fork Quinn River were correlated with records from Martin Creek in Paradise Valley (east of this area) for the period 1922-64. This analysis indicated that the 1964 runoff from McDermitt Creek was 75 percent of the long-term average, whereas runoff from East Fork Quinn River was 94 percent of the long-term average. The 1964 runoff of all other streams flowing from the west side of the basin also was assumed to be 75 percent of the long-term average and for those

Table 6.--Streamflow measurements at miscellaneous sites

Stream (pl. 4)	Measured discharge, in cubic feet per second				
	Sept. 1963	Jan. 1964	April 1964	June 1964	Sept. 1964
Crowley Cr.	--	0.08	7.68	2.08	dry
Washburn Cr.	0.12	0.04	0.49	0.34	0.08
Oregon Canyon Cr. 1/	dry	dry	dry	dry	dry
Oregon Canyon Cr. 2/	dry	dry	20.2	11.0	dry
Quinn River 3/	no flow	0.06	22.0	9.42	no flow
Eight Mile Cr.	dry	0.92	19.6	10.6	dry
Three Mile Cr.	0.08	0.38	5.77	3.50	0.09
Canyon Cr.	0.08	0.40	8.37	5.40	0.21
Flat Cr.	0.24	0.60	5.64	12.4	0.36
Willow Cr.	0.39	1.28	4.72	13.2	0.57
Rebel Cr.	--	1.20	4.44	18.7	0.88
Horse Canyon Cr.	--	--	4.23	11.4	0.55
Falls Canyon Cr.	--	--	3.10	8.99	0.27
Buffalo Canyon Cr.	--	--	--	10.9	0.48
Quinn River 4/	--	0.34	0.42	1.12	0.42
Quinn River 5/	dry	dry	dry	dry	dry

1. SW1/4NW1/4 sec. 33, T. 39 S., R. 42 W.
2. NE1/4SE1/4 sec. 31, T. 48 N., R. 38 E.
3. SW1/4SW1/4 sec. 8, T. 42 N., R. 36 E.
4. NW1/4NW1/4 sec. 9, T. 42 N., R. 36 E.
5. At Sod House.

flowing from the east side, 94 percent of the long-term average.

Figure 6 shows the computed long-term runoff-altitude relationship for the basin. The runoff map shown in figure 7 is based on the relationship illustrated in figure 6. The 5,000-foot contour line is the line of zero runoff and coincides closely with the bedrock-alluvium contact, except on the west side of the valley where the contact is at a slightly lower altitude. The estimated annual inflow from areas for which no stream-flow measurements are available, such as the Oregon Canyon and Silver State subareas, was based on the runoff map shown in figure 7.

These estimates together with those in table 7 were used to compute the average annual surface-water inflow to the area. Table 8 shows that the estimated total surface-water inflow averages about 100,000 acre-feet per year. Surface-water outflow at Sod House is estimated to be about 5,000 acre-feet per year. (See section on surface-water outflow.) The difference, or roughly 95,000 acre-feet per year, is consumed within the study area.

Diversions for Irrigation

Diversions for irrigation from the Quinn River and its tributaries are made in the Oregon Canyon, McDermitt, and Orovada subareas. A field canvass in 1964 showed that a total of about 28,000 acres of land was irrigated by surface water. The estimated total surface-water diversions and losses total 31,000 acre-feet per year and include: (1) about 22,000 acre-feet applied to the 22,400 acres of native meadowgrasses which also receives about 22,000 acre-feet of ground water by natural subirrigation (table 9); (2) about 6,000 acre-feet of surface-water diversions to about 5,000 acres of pasture grass and 1,000 acres of alfalfa around the sides of the valley; (3) about 2,000 acre-feet evaporated from ponds behind diversion dams; and (4) about 1,000 acre-feet of runoff which is ponded on and evaporated from the playa in Silver State Valley. The estimated amounts used in each subarea are shown in table 8.

Recharge from Streams

Ground-water recharge from streams is the difference between the total surface-water inflow and the surface-water losses plus the surface-water outflow at Sod House. Most of the surface-water loss is by diversions for irrigation. Other losses include some overbank flooding at the south end of the Orovada subarea and flow to the playa in Silver State subarea. Table 8 shows that the estimated total recharge from streams averages about 63,000 acre-feet per year. Also shown is the approximate stream recharge for each of the four subareas.

The estimated total recharge from precipitation shown in table 5 is about 74,000 acre-feet and includes principally recharge to the valley-fill reservoir from streams and by underflow from the mountains across the bedrock-alluvium contact. Although considerable variation occurs in the estimates by individual subareas, a comparison of the area recharge totals in tables 5 and 8 suggests that on the order of 10,000 acre-feet per year, or about 15 percent of the total recharge, may occur by under-flow from the mountain blocks to the valley-fill reservoir.

Table 7. --Runoff of major streams about at the bedrock-alluvium contact

Name	Site Location	Drainage area (sq. mi.)	Approximate altitude of measuring site (feet)	Computed runoff for 1964 water year (acre-feet)	Estimated average annual runoff (acre-feet)
McDermitt Creek 1/	SE1/4SE1/4 sec. 8, T. 47N., R. 37 E.	225	4,560	13,820	18,430
Washburn Creek	NE1/4SW1/4 sec. 19, T. 47N., R. 37 E.	82	4,700	223	297
E. Fk. Quinn River 1/	SE1/4NE1/4 sec. 9, T. 47N., R. 39 E.	140	4,720	15,150	16,120
Eight Mile Creek	NW1/4NW1/4 sec. 19, T. 46N., R. 39 E.	17.5	4,820	3,810	4,050
Three Mile Creek	NW1/4SW1/4 sec. 31, T. 46N., R. 39 E.	8.6	5,000	1,390	1,480
Canyon Creek	SW1/4NW1/4 sec. 18, T. 45N., R. 39 E.	15.2	4,960	2,060	2,190
Flat Creek	NW1/4SE1/4 sec. 3, T. 44N., R. 38 E.	9.9	5,040	3,100	3,300
Willow Creek	SW1/4SE1/4 sec. 30, T. 44N., R. 38 E.	19.7	4,750	4,210	4,480
Crowley Creek	SE1/4SW1/4 sec. 8, T. 44N., R. 36 E.	101	4,390	1,530	2,040
Rebel Creek	SW1/4NW1/4 sec. 18, T. 43N., R. 38 E.	10.6	4,800	3,770	4,010
Horse Canyon Cr.	SW1/4SW1/4 sec. 17, T. 42N., R. 38 E.	6.8	5,120	2,760	2,940
Falls Canyon Cr.	SE1/4SE1/4 sec. 19, T. 42.N. R. 38 E.	4.6	5,090	2,080	2,210
Buffalo Canyon Cr.	SE1/4NE1/4 sec. 36, T. 42N., R. 37 E.	7.1	4,900	2,440	2,600
TOTAL		648			64,147

1. Gaging stations. All other runoff measuring stations are at miscellaneous sites.

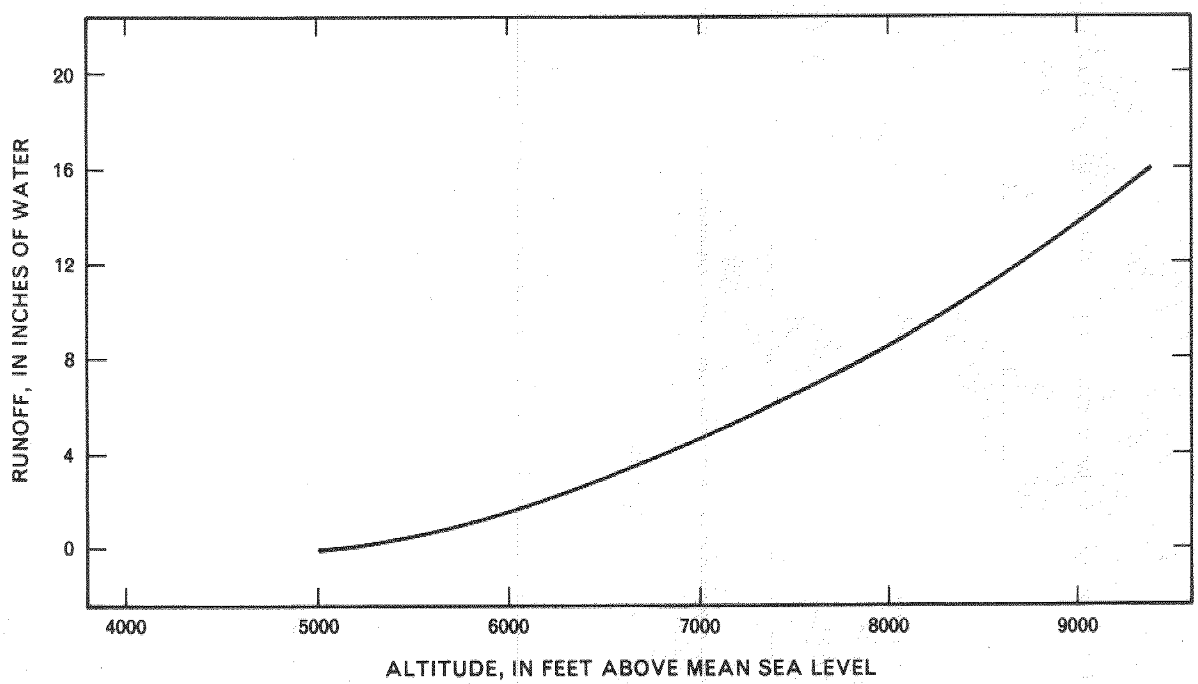

Figure 6.—Relation of altitude to computed long-term average annual runoff.

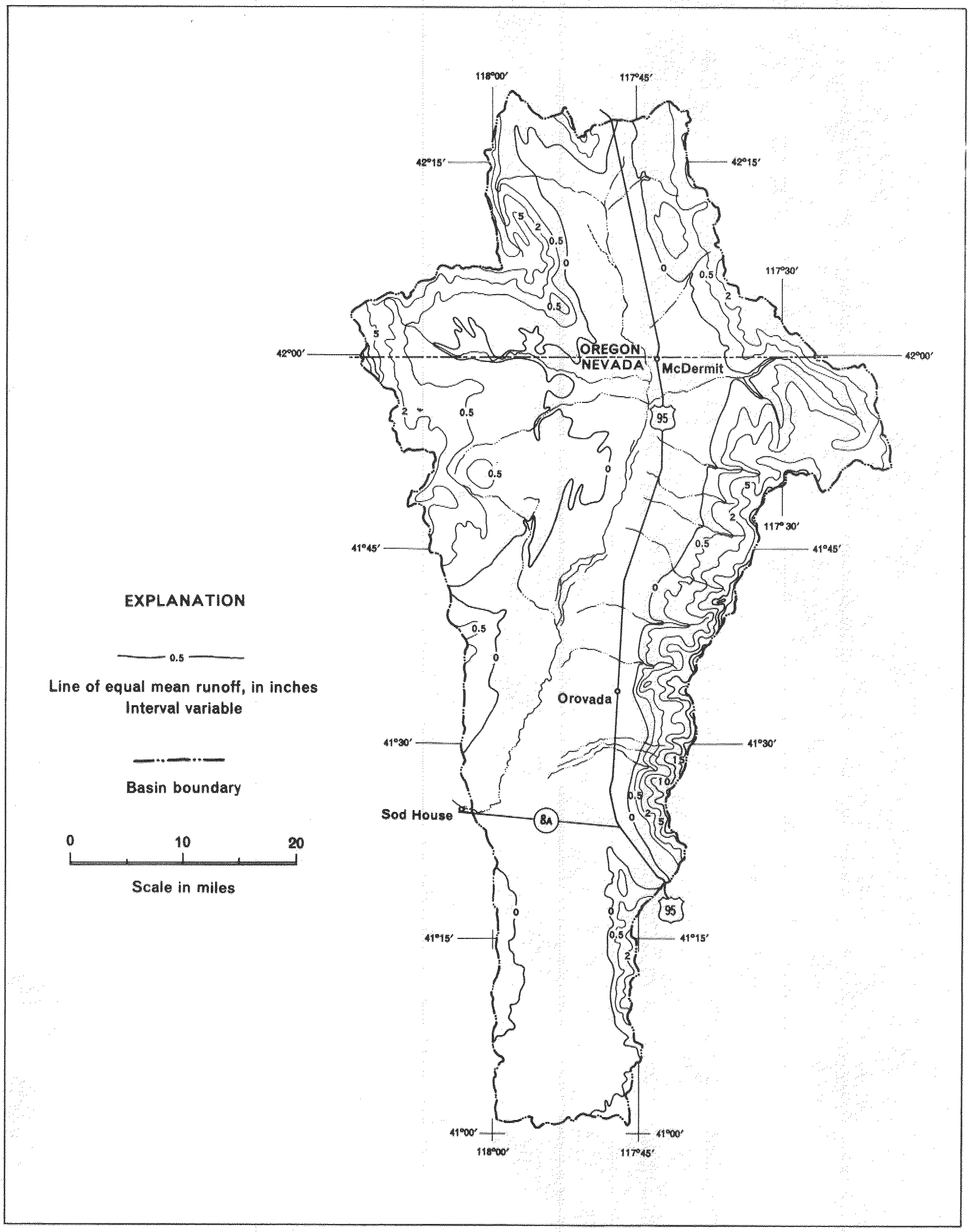

Figure 7.—Distribution of runoff

Table 8. --Estimated average annual surface-water inflow, outflow, and recharge to the valley area

Subarea	Mountain block	Inflow over bedrock-alluvium contact (acre-feet)	Inflow from upgradient subarea (acre feet)	Total inflow to subarea (acre feet)	Outflow from subarea 1/ (acre-feet)	Diversions for irrigation (acre feet)	Ground-water recharge (acre-feet)
Oregon Canyon	East side	a 8,400	0	13,000	1,000	4,300	7,700
	West side	a 4,600					
McDermitt	East side	b27,100 a 5,200	1,000	52,000	17,000	11,000	24,000
	West side	b18,700 a 300					
Orovada	East side	b16,200 a13,800	17,000	50,000	5,000	15,000	30,000
	West side	b 2,000 a 1,000					
Silver State	East side	a 2,300	0	2,600	Minor	c 1,000	1,600
	West side	a 300					
Total for area (rounded)		100,000	--	--	5,000	31,000	63,000

1. Surface-water outflow from one subarea contributes to surface-water inflow in adjacent downstream subarea.
a. Computed from runoff map (fig. 7).
b. Estimated from streamflow measurements at miscellaneous sites and gaging station records (table 7).
c. Evaporation from playa north of Daveytown mining camp.

NATURAL OUTFLOW FROM THE VALLEY-FILL RESERVOIR

The major component of natural outflow is evapotranspiration in areas of phreatophytes. Minor discharge occurs from springs in the bordering mountains and by surface and subsurface outflow near Sod House (pl. 1). Also, for each of the subareas, subsurface outflow from one subarea to another, although small, is a pertinent part of the outflow from each subarea. Estimates for each of these processes are presented in the following sections.

Evapotranspiration

More than 160,000 acres on the floor of the Quinn River valley area supports phreatophytes and locally is subject to evaporation from bare soil. The dominant phreatophytes are greasewood, rabbitbrush, saltgrass, rye grass, and native meadowgrass. Also present are minor assemblages of pickleweed, sumpweed, and buffalo berry. Plate 3 shows the areal distribution of the dominant phreatophyte types, based on U. S. Bureau of Land Management range surveys, previous work by Visher (1957, p. 33-34), and field observations by the author in 1963 and 1964.

Table 9 shows the estimated average annual ground-water discharge by evapotranspiration in phreatophyte areas. The depth to water is based on measurements made in the autumn of 1963. The annual-use factors for the several phreatophyte assemblages and bare soil are modified from work done by White (1932, p. 84-93), Young and Blaney (1942, p. 41, 95, 98), Robinson (1958, p. 49-66), and Houston (1950, p. 21-22). The estimated draft on the valley-fill reservoir in phreatophyte areas is about 63,000 acre-feet per year. The discharge by subareas is also shown in table 9.

Springs

The hot spring 40/42-23cdl, north of McDermitt, is one of the largest springs in the area; it discharges about 0.6 cfs (cubic feet per second), or 400 acre-feet annually. The discharge by all springs in the valley is about 1,000 acre-feet per year. Most of the discharge is consumed by evaporation and transpiration in and downstream from the springs and seep areas. Therefore, the estimated discharge from springs by subareas is included in the estimated evapotranspiration (table 9).

Surface-Water Outflow

The surface-water outflow from the Quinn River valley area occurs at the gap near Sod House. Outflow occurs only during years of excessive floods and is crudely estimated to range between 1,000 and 5,000 acre-feet per year. For the purposes of this report the higher figure of 5,000 acre-feet per year is used. (See table 8.)

Table 9.--Estimated average annual ground-water discharge by evapotranspiration

Phreatophyte assemblage (see pl. 3)	Depth to water (feet)	Annual use factor (feet)	OREGON CANYON		MCDERMITT		OROVADA		SILVER STATE		TOTAL	
			Area (acres)	Annual use (acre-feet)	Area (acres)	Annual use (acre-feet)	Area (acres)	Annual use (acre-feet)	Area (acres)	Annual use (acre-feet)	Area (acres)	Annual use (acre-feet)
Greasewood and rabbitbrush of moderate density	5 to 30	.3	--	--	6,400	1,900	51,500	15,000	11,800	3,500	69,700	20,000+
Greasewood, rabbitbrush, and saltgrass of moderate density	5 to 30	.3	--	--	5,400	1,600	24,300	7,300	--	--	29,700	8,900
Greasewood, rabbitbrush, and others[1] of moderate density	5 to 30	.3	8,400	2,500	--	--	--	--	6,300	1,900	14,700	4,400
Saltgrass and ryegrass of moderate density	less than 10	1.0	--	--	2,600	2,600	--	--	--	--	2,600	2,600
Greasewood of low density	10 to 30	.1	--	--	1,500	150	5,400	540	3,600	360	10,500	1,000+
Greasewood, rabbitbrush, saltgrass, and rye grass of low density	less than 10	.2	7,300	1,500	4,700	940	--	--	--	--	12,000	2,400+
Native meadowgrasses	less than 10	1.0	1,800	1,800	9,800	9,800	10,800	10,800	--	--	22,400	22,000+
Total (rounded)			17,500	5,800	30,400	17,000	92,000	34,000	21,700	5,800	162,000	63,000

1. Others include sumpweed, pickleweed and buffaloberry

Ground-Water Outflow and Intersubarea Flow

Ground-water outflow, or subsurface outflow, from the valley-fill reservoir occurs in the gap near Sod House where the Quinn River leaves the area. Outflow principally from Orovada and in small part from Silver State subareas discharges through this gap. This type of discharge also occurs from the Oregon Canyon subarea to the McDermitt subarea, and from the McDermitt subarea to the Orovada subarea.

Ground-water flow through a ground-water reservoir can be computed at a selected section by use of a form of Darcy's law:

$$Q = 0.00112\ TIW$$

in which $\underline{Q}$ is the quantity of flow, in acre-feet per year; $\underline{T}$ is the coefficient of transmissibility, in gallons per day per foot; $\underline{I}$ is the hydraulic gradient, in feet per mile; $\underline{W}$ is the width of the flow section, in miles; and 0.00112 is a factor for converting gallons per day to acre-feet per year.

The distribution of transmissibility is shown on figure 3, and the hydraulic gradients and widths are taken from plate 1 (1947 data). The estimated transmissibility along the Nevada-Oregon border, not shown on figure 3, is about 20,000 gpd per foot. Table 10 shows the estimated outflows for these several subareas. The outflow through the alluvium near Sod House from the Quinn River valley area is only about 300 acre-feet per year. Additional outflow may occur through the volcanic rocks underlying and adjacent to the alluvium.

Table 10. --Estimated ground-water outflow from the valley-fill reservoir and intersubarea flow

Outflow section	Coefficient of transmissibility (gpd/ft)	Hydraulic gradient (feet per mile)	Effective width (miles)	Estimated average annual outflow 1/ (acre-feet)
Oregon Canyon subarea to McDermitt subarea	20,000	Nearly 0	1±	Minor
McDermitt subarea to Orovada subarea	100,000	10	5	5,000
Quinn River Valley near Sod House				
a. Orovada subarea part of section	50,000	2±	1.5	>200
b. Silver State subarea part of section	30,000	2±	1	<100
c. Subtotal, about				300
Outflow from area	--	--	--	300

1. Under natural conditions.

HYDROLOGIC EQUATION FOR NATURAL CONDITIONS

Most hydrologic equations, or water budgets, are based on the premise that over the long term and for natural conditions, the inflow to and outflow from an area are equal. If reasonably accurate estimates or measurements of the elements of inflow and outflow can be made, the two totals should be about the same.

For the Quinn River valley area, equilibrium conditions existed up to the time that man began to develop the area agriculturally. Surface-water diversions from the principal streams for irrigation of native meadow-grass began many years ago and has continued to date. This change modified somewhat the natural water balance in the valley-fill reservoir.

Table 11 summarizes the several components of inflow and outflow made in the preceding sections of the report, and reflects the water balance under near natural conditions. The imbalance in table 11 suggests that inflow exceeds outflow for the area as a whole and for all subareas except Silver State. However, the imbalance is the result of errors in the estimates of inflow and outflow, and the larger components of runoff and phreatophyte use are the most likely to be in error.

Table 11. --Summary of the estimated inflow to and outflow from the valley-fill reservoir, in acre-feet per year

	Total (rounded)	Oregon Canyon subarea	McDermitt subarea	Orovada subarea	Silver State subarea
INFLOW:					
Runoff (table 8)	100,000	13,000	51,000	33,000	2,600
Surface-water inflow from upgradient subarea (table 8)	--	0	1,000	17,000	0
Ground-water inflow from upgradient subarea (table 10)	~~-~~ --	~~0~~ 0	~~Minor~~ Minor	~~5,000~~ 5,000	~~0~~ 0
Ground-water inflow across the bedrock-alluvium contact (p. 24)	10,000	a 1,000	a 5,000	a 3,000	a 200
Subtotal (1):	110,000	14,000	57,000	58,000	2,800
OUTFLOW:					
Evapotranspiration (table 9)	63,000	5,800	17,000	34,000	5,800
Surface-water diversions (table 8)	31,000	4,300	11,000	15,000	b1,000
Surface-water outflow (table 8)	5,000	1,000	17,000	5,000	Minor
Ground-water outflow (table 10)	300	0	5,000	200	100
Springs	(c)	(c)	(c)	(c)	(c)
Subtotal (2):	100,000	11,000	50,000	54,000	6,900
IMBALANCE (1) - (2):	10,000	3,000	7,000	4,000	-4,100

a. Assumed to be on the order of 10 to 15 percent of the subarea recharge (table 5).
b. Streamflow to playa areas.
c. Included in evapotranspiration and surface-water diversions.

GROUND WATER IN STORAGE

The amount of ground water stored, or more precisely in transient storage, in the valley-fill reservoir to any selected depth below the water table is the product of the area, the selected depth, and the specific yield of the deposits. The selected depth for this study is the uppermost 100 feet of saturation, which in most places probably is within economic reach in areas where the depth to water is 100 feet or less (pl. 3).

The specific yield of a deposit with respect to water is the ratio of (1) the volume of water which, after being saturated, the deposit will yield by gravity to (2) its own volume (Meinzer, 1923, p. 28). This ratio is usually expressed as a percentage. The average specific yield of the materials in the upper 100 feet of saturation was estimated from drillers' logs of wells. The materials recorded in the logs were grouped into five general lithologic categories, using the method described by Davis and others (1959, p. 202-206) in estimating the specific yield of similar alluvial deposits in the San Joaquin Valley, California. Table 12 shows the five general categories and the assigned specific yields, which are based on studies and tests of the Hydrologic Laboratory of the U. S. Geological Survey (written communication, 1965).

Nearly all the available well logs are in the Orovada subarea. Table 13 shows the pertinent data for the Orovada subarea; the average specific yeield for the uppermost 100 feet of saturated deposits as of the spring 1964 is 13 percent. This same value is used for the Silver State and Oregon Canyon subareas where considerable fine-grained material occurs. Because the deposits are coarser in the McDermitt subarea, a specific yield of 15 percent is assigned to the uppermost 100 feet of saturated deposits in this subarea.

Table 14 shows that the estimated total amount of ground water in storage in the uppermost 100 feet of saturation in 1964 was somewhat more than 7 million acre-feet. However, the volume of water in storage in the area where the depth to water in 1964 was 100 feet or less was nearly 5 million acre-feet.

Table 12--Lithologic categories and assigned specific yields

Lithologic category (Drillers' designation)	Symbol	Assigned specific yield 1/ (percent)
Gravel, gravel and sand, sand and gravel	G	25
Sand, medium to coarse	S	30
Muddy and dirty gravel or sand, gravel with clay layers, lava rock, granite sand or gravel, decomposed sand or gravel	F	15
Cemented sand or gravel, gravelly clay, gravel and clay, rocks and clay, silt, fine sand, clay with gravel layers	Cg	10
Clay, hardpan, decomposed granite	C	5

1. Based on studies and tests by the Hydrologic Laboratory, U. S. Geological Survey (written communication, 1965).

Table 13--Summary of data used to estimate specific yield of deposits in the Orovada subarea 1/

Storage unit	Area (acres)	Number of well logs	Lithologic category symbol (table 12) 2/ (percent of total footage penetrated by wells)					Average specific yield (percent)
			G	S	F	Cg	C	
Tps. 40 and 41 N.	56,000	12	12	1	0	75	13	11
T. 42 N.	48,000	33	20	2	13	32	33	12
T. 43 N.	42,000	49	27	2	13	35	23	14
T. 44 N.	40,000	22	52	0	2	40	6	18
T. 45 N.	15,000	6	17	0	7	57	19	12
TOTAL	201,000	100	Average specific yield					13

1. For the uppermost 100 feet of saturated deposits below the spring 1964 water level (fig. 2).

2. Multiply percentage of each category by assigned specific yields in table 12, then add to obtain average specific yield.

Table 14. --Estimated ground water in storage in the valley-fill reservoir [1/]

Subarea	Specific yield (percent)	Area of valley fill (acres)		Stored water (acre-feet)	
		Entire subarea	Where depth to water 100 feet or less [2/]	Entire subarea	where depth to water 100 feet or less [2/]
Oregon Canyon	13	102,000	62,000	1,300,000	810,000
McDermitt	15	114,000	67,000	1,600,000	1,000,000
Orovada	13	204,000	145,000	2,600,000	1,900,000
Silver State	13	129,000	73,000	1,600,000	950,000
Total (rounded)		549,000	345,000	7,100,000	4,700,000

1. Uppermost 100 feet of saturation below spring 1964 water level (fig. 2).

2. See plate 3 for area where depth to water in 1964 was 100 feet or less.

CHEMICAL QUALITY OF WATER

By D. E. Everett

Water samples were collected and analyzed as part of the present study to make a general appraisal of the suitability of the water for agricultural and domestic uses and to help define potential water-quality problems. Sampling sites were chosen in the Quinn River valley area to achieve the widest possible areal coverage. Tables 15 and 16 show the analyses for selected wells, streams, and springs in the area.

Suitability for Agricultural Use

According to the U. S. Department of Agriculture (1954, p. 69), the most significant factors with regard to the chemical suitability of water for irrigation are dissolved-solids content, the relative proportion of sodium to calcium and magnesium, and the concentration of elements and compounds that are toxic to plants. Dissolved-solids content commonly is expressed as "salinity hazard," and the relative proportion of sodium to calcium and magnesium as "alkali hazard."

The Salinity Laboratory Staff suggests that salinity and alkali hazards should be given first consideration when appraising the quality of irrigation water, then consideration should be given to boron or other toxic elements, any one of which may change the quality rating. The above properties of water are described by Visher (1957, p. 36-42).

The salinity and alkali hazards of water from different sources and locations are shown on figure 8. All the streams discharge water which most of the time is suitable for irrigation. During periods of low flow, however, the Quinn River at Giacometto Ranch (47/38-8cd) contains water having a medium-high salinity hazard and a medium alkali hazard. Spring 40/42-23cdl yields water having a medium salinity hazard, a very high alkali hazard, and a high residual sodium carbonate (RSC) value. This water may be suitable for irrigation, if used under favorable conditions of drainage and with tolerant plants. Water from most wells in the valley has a low to medium salinity hazard and a low alkali hazard. Locally, however, some wells yield water with medium to very high salinity and alkali hazards. Well 41/36-4ddl yields water with a very high salinity and alkali hazard and probably is unsuitable for irrigation. Wells 38/36-35aal, 38/37-37-30cal, and 41/35-14ccl, in the southern part of the valley, yield water with a high salinity hazard, a medium alkali hazard, and a high RSC value. Accordingly, this water is at best marginal and may be unsuitable for irrigation. In general, water in most of the valley probably is suitable for irrigation, whereas water in the Silver State subarea, the southwestern part of the Orovada subarea, and in the area immediately north of the confluence of the East Fork Quinn River and McDermitt Creek, is marginal or unsuitable.

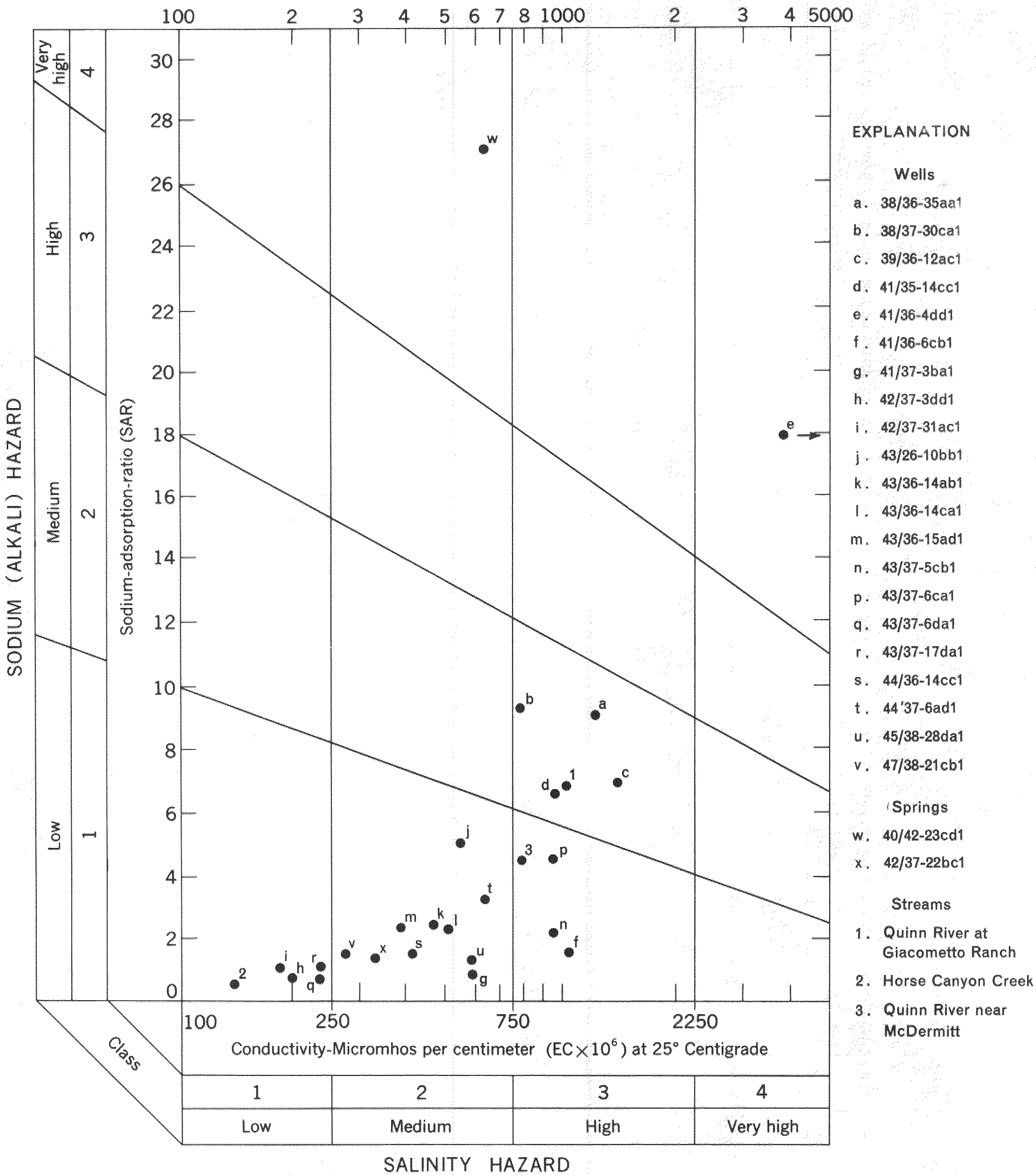

Figure 8.—Classification of irrigation water (after U.S. Department of Agriculture, 1954)

Table 15.--Chemical analyses, in parts per million, of water from selected wells in the Quinn River valley area, Humboldt County, Nev.

(Analyses by the U.S. Geological Survey)

Location (well no.)	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)	Hardness as $CaCO_3$ Calcium Magnesium	Hardness as $CaCO_3$ noncarbonate	RSC	SAR	Specific conductance (micromhos at 25°C)	pH
39/36-12ac1	6- 2-64	58	61	0.01	58	17	234	12	194	0	106	293	0.4	29	0.9	907	214	55	0.00	7.0	1,530	7.9
41/35-22db1	10-29-64	53	59	.04	83	29	120	12	369	0	114	118	.9	2.4	--	720	326	24	.00	2.9	1,130	7.2
41/36- 6cb1	7-23-64	58	51	.01	74	25	119	9.4	316	0	128	110	1.1	.0	.4	674	288	29	.00	1.7	1,050	7.8
41/37-29da2	4-24-52	--	39	.07	44	6.6	23	2.9	167	0	27	15	.2	1.1	.1	241	137	0	.00	.9	355	7.7
41/37-33aa1	7-23-64	64	38	.01	43	6.0	23	3.8	153	0	26	18	.2	.8	.1	234	132	7	.00	.9	379	7.6
42/37-10dc1	6- 2-64	57	31	.01	16	3.4	13	1.4	76	0	9.0	10	.0	.9	.0	122	54	0	.17	.8	166	7.4
42/37-17ad1	6- 3-64	61	30	.01	23	3.8	15	1.3	95	0	13	14	.1	1.1	.0	148	73	0	.10	.8	217	7.6
42/37-33ba1	6- 3-64	61	23	.01	18	6.3	13	1.6	91	0	12	10	.0	1.1	.0	130	71	0	.07	.7	201	7.6
43/36-33dc1	6- 3-64	60	61	.01	24	4.1	55	4.8	154	0	35	26	.7	1.6	.2	288	77	0	.98	2.7	393	7.6
43/37- 5cb1	4-25-52	--	39	.08	84	21	88	4.7	181	0	155	125	.1	1.5	.1	608	296	148	.00	2.2	960	7.2
43/37- 6da1	6- 3-64	62	21	.01	24	4.9	18	1.8	109	0	21	7.5	.3	1.9	.0	154	80	0	.19	.9	237	7.8
43/37-17da1	6- 2-64	62	22	.01	27	2.1	19	1.8	102	0	19	12	.1	2.1	.0	155	76	0	.15	1.0	239	7.9
43/37-33da2	4-25-52	--	28	.09	42	6.6	15	2.3	117	0	29	18	.2	24	.0	223	132	36	.00	.6	335	7.2
43/37-34cc1	4-22-53	57	30	.00	19	3.6	14	1.5	90	0	9.2	8.5	.1	.5	.0	131	62	0	.24	.8	187	7.7
44/37- 3dd1	6- 2-64	58	48	.02	42	6.1	14	3.9	139	0	35	12	.1	2.3	.1	232	130	16	.00	.5	327	7.7
44/37- 4dd1	6- 3-64	58	39	.01	42	5.1	17	3.4	124	0	37	22	.1	2.5	.0	229	126	24	.00	.7	340	7.7
44/37-28aa1	6- 2-64	59	23	.01	58	9.8	20	1.8	134	0	52	38	.0	12	.0	281	185	75	.00	.6	463	7.5
44/37-36bd1	6- 2-64	64	24	.07	53	11	23	2.2	183	4	47	16	.2	2.3	.1	273	176	19	.00	.8	437	8.3
48/38-32db1	10-15-54	--	67	.03	103	21	53	6.5	109	0	104	185	.2	5.0	--	599	344	254	.00	1.2	985	7.0

Table 16.--Chemical analyses, in parts per million, of water from selected wells, springs, and streams in the Quinn River valley area

(Field analyses by U.S. Geological Survey)

Location	Date of collection	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium[1] (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: noncarbonate	RSC	SAR[2]	Specific conductance (micromhos at 25°C)	pH
38/36-35aa1	2-25-64	56	32	6.1	217	208	24	160	141	105	0	2.11	9.2	1,290	8.7
38/37-30ca1	2-25-64	55	12	3.2	143	216	22	67	50	43	0	3.41	9.5	772	8.7
40/36-15cb1	2-29-64	59	79	21	157	184	0	141	232	285	134	.00	4.0	1,440	7.8
40/37-8db1	2-11-64	54	48	10	114	208	0	196	25	163	0	.15	3.9	1,010	7.7
40/37-12ab1	2-12-64	--	40	4.4	18	136	6	16	13	118	0	.07	.7	323	8.5
41/35-14cc1	2-27-64	53	19	18	161	218	23	117	92	120	0	1.94	6.4	965	8.7
41/35-22db1	2-27-64	51	37	25	139	200	19	120	124	194	0	.03	4.3	1,040	8.6
41/36-1cb1	2-11-64	52	31	4.5	41	124	7	27	32	96	0	.34	1.8	366	8.5
41/36-2bb1	2-11-64	52	33	5.2	41	123	8	24	38	104	0	.21	1.7	397	8.5
41/36-4dd1	2-11-64	52	199	59	1,090	160	10	680	1,600	738	591	.00	18	6,310	8.4
41/36-6bb1	2-11-64	--	63	16	--	303	0	--	101	221	0	.55	--	1,060	7.8
41/36-17dd1	2-11-64	--	64	15	--	76	0	--	542	222	160	.00	--	2,200	7.4
41/37-3ad1	2-11-64	--	48	5.8	--	160	0	--	10	144	13	.00	--	351	8.2
41/37-3ba1	2-11-64	--	68	13	20	120	0	72	65	222	124	.00	.8	600	7.5
41/37-3da1	2-11-64	52	29	8.1	22	99	0	34	27	106	25	.00	.9	319	7.5
41/37-3db1	4-29-64	61	43	9.1	22	127	0	45	30	145	41	.00	.8	393	8.2
41/37-4da1	7-21-64	65	25	3.3	14	101	0	12	8.0	76	0	.14	.7	215	8.0
41/37-5ba1	2-11-64	52	19	3.5	20	87	0	10	16	62	0	.19	1.1	205	7.5
41/37-8cb1	2-11-64	53	47	6.9	46	198	0	23	42	146	0	.33	1.6	498	7.8
41/37-22bb1	2-11-64	57	42	5.4	25	114	0	24	44	127	34	.00	1.0	380	7.6
41/37-29da3	2-11-64	52	41	5.2	29	156	0	30	19	124	0	.08	1.1	366	7.9
42/36-12ca1	2-27-64	53	27	5.2	24	133	4	12	10	89	0	.53	1.1	266	8.4
42/36-25dc1	2-11-64	53	83	18	53	202	15	49	109	280	89	.00	1.4	821	8.5
42/37-3dd1	7-21-64	55	21	4.5	13	86	0	12	12	71	1	.00	.7	204	7.5
42/37-15cc1	2-11-64	55	37	8.1	32	163	0	48	8.0	126	0	.15	1.2	391	7.2
42/37-21ba1	7-23-64	63	18	1.7	22	91	0	12	9.5	52	0	.45	1.4	197	7.6
42/37-22bb1	2-11-64	52	26	6.6	16	122	0	16	7.6	92	0	.16	.7	256	7.2
42/37-22bc1[a]	2-11-64	--	30	6.1	34	166	0	20	8.1	100	0	.72	1.5	331	7.3
42/37-22cb1	2-11-64	54	37	7.4	40	164	0	33	29	123	0	.23	1.6	427	7.4
42/37-31ac1	7-23-64	56	20	2.4	18	86	0	12	12	60	0	.21	1.0	193	7.7
43/36-2aa1	2-12-64	52	38	7.5	75	192	12	56	38	126	0	1.03	2.9	576	8.6
43/36-2da1	2-12-64	52	33	5.5	63	164	12	44	30	105	0	.99	2.6	483	8.6
43/36-10bb1	2-14-64	54	17	4.5	92	130	6	56	61	61	0	1.11	5.1	569	8.4
43/36-11ca1	2-12-64	54	26	5.4	55	147	8	36	24	87	0	.94	2.5	414	8.5
43/36-12dd1	2-11-64	52	77	16	152	315	20	120	122	258	0	.68	4.1	1,210	8.6
43/36-14ab1	2-12-64	53	37	5.2	62	178	20	34	24	114	0	1.31	2.5	481	8.5
43/36-14ca1	2-12-64	50	37	6.2	57	180	0	44	34	118	0	.59	2.3	512	8.2
43/36-15ad1	2-12-64	57	26	4.1	52	135	8	36	24	82	0	.84	2.5	390	8.5
43/37-5cb1	2-12-64	53	59	12	43	152	12	63	57	198	54	.00	1.3	603	8.5
43/37-6ca1	2-12-64	51	48	12	137	285	20	108	62	169	0	1.96	4.6	946	8.6
43/37-7bd1	2-12-64	51	55	8.5	28	181	13	37	17	172	2	.00	.9	442	8.6
43/37-8ad1	7-22-64	58	29	4.3	19	120	0	20	9.0	90	0	.17	.9	283	7.8
43/37-8bc2	2-14-64	--	29	4.5	15	99	0	20	15	91	10	.00	.7	251	8.1
43/37-8dc1	2-12-64	54	28	4.4	16	99	0	20	15	88	7	.00	.7	251	8.2
43/37-9ac1	2-12-64	54	42	6.8	17	97	6	57	15	133	44	.00	.6	354	8.4
43/37-10ad1	7-22-64	62	72	15	20	232	0	61	22	242	52	.00	.5	566	7.5
43/37-16da3	2-11-64	--	23	3.5	24	100	0	25	13	72	0	.20	1.2	237	8.2
43/37-18cc1	2-12-64	53	25	2.8	18	104	0	17	8.1	74	0	.22	.9	227	8.2
43/37-28ac1	2-12-64	54	32	5.4	16	92	0	18	31	102	27	.00	.7	306	8.1
43/37-31cd1	2-12-64	--	31	6.0	32	130	6	24	21	102	0	.29	1.4	337	8.4

Table 16.--Chemical analyses, in parts per million, of water from selected wells, springs, and streams in the Quinn River valley area

(Field analyses by U.S. Geological Survey)

Location	Date of collection	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium[1] (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: noncarbonate	RSC	SAR[2]	Specific conductance (micromhos at 25°C)	pH
38/36-35aa1	2-25-64	56	32	6.1	217	208	24	160	141	105	0	2.11	9.2	1,290	8.7
38/37-30ca1	2-25-64	55	12	3.2	143	216	22	67	50	43	0	3.41	9.5	772	8.7
40/36-15cb1	2-29-64	59	79	21	157	184	0	141	232	285	134	.00	4.0	1,440	7.8
40/37-8db1	2-11-64	54	48	10	114	208	0	196	25	163	0	.15	3.9	1,010	7.7
40/37-12ab1	2-12-64	--	40	4.4	18	136	6	16	13	118	0	.07	.7	323	8.5
41/35-14cc1	2-27-64	53	19	18	161	218	23	117	92	120	0	1.94	6.4	965	8.7
41/35-22db1	2-27-64	51	37	25	139	200	19	120	124	194	0	.03	4.3	1,040	8.6
41/36-1cb1	2-11-64	52	31	4.5	41	124	7	27	32	96	0	.34	1.8	366	8.5
41/36-2bb1	2-11-64	52	33	5.2	41	123	8	24	38	104	0	.21	1.7	397	8.5
41/36-4dd1	2-11-64	52	199	59	1,090	160	10	680	1,600	738	591	.00	18	6,310	8.4
41/36-6bb1	2-11-64	--	63	16	--	303	0	--	101	221	0	.55	--	1,060	7.8
41/36-17dd1	2-11-64	--	64	15	--	76	0	--	542	222	160	.00	--	2,200	7.4
41/37-3ad1	2-11-64	--	48	5.8	--	160	0	--	10	144	13	.00	--	351	8.2
41/37-3ba1	2-11-64	--	68	13	20	120	0	72	65	222	124	.00	.8	600	7.5
41/37-3da1	2-11-64	52	29	8.1	22	99	0	34	27	106	25	.00	.9	319	7.5
41/37-3db1	4-29-64	61	43	9.1	22	127	0	45	30	145	41	.00	.8	393	8.2
41/37-4da1	7-21-64	65	25	3.3	14	101	0	12	8.0	76	0	.14	.7	215	8.0
41/37-5ba1	2-11-64	52	19	3.5	20	87	0	10	16	62	0	.19	1.1	205	7.5
41/37-8cb1	2-11-64	53	47	6.9	46	198	0	23	42	146	0	.33	1.6	498	7.8
41/37-22bb1	2-11-64	57	42	5.4	25	114	0	24	44	127	34	.00	1.0	380	7.6
41/37-29da3	2-11-64	52	41	5.2	29	156	0	30	19	124	0	.08	1.1	366	7.9
42/36-12ca1	2-27-64	53	27	5.2	24	133	4	12	10	89	0	.53	1.1	266	8.4
42/36-25dc1	2-11-64	53	83	18	53	202	15	49	109	280	89	.00	1.4	821	8.5
42/37-3dd1	7-21-64	55	21	4.5	13	86	0	12	12	71	1	.00	.7	204	7.5
42/37-15cc1	2-11-64	55	37	8.1	32	163	0	48	8.0	126	0	.15	1.2	391	7.2
42/37-21ba1	7-23-64	63	18	1.7	22	91	0	12	9.5	52	0	.45	1.4	197	7.6
42/37-22bb1	2-11-64	52	26	6.6	16	122	0	16	7.6	92	0	.16	.7	256	7.2
42/37-22bc1[a]	2-11-64	--	30	6.1	34	166	0	20	8.1	100	0	.72	1.5	331	7.3
42/37-22cb1	2-11-64	54	37	7.4	40	164	0	33	29	123	0	.23	1.6	427	7.4
42/37-31ac1	7-23-64	56	20	2.4	18	86	0	12	12	60	0	.21	1.0	193	7.7
43/36-2aa1	2-12-64	52	38	7.5	75	192	12	56	38	126	0	1.03	2.9	576	8.6
43/36-2da1	2-12-64	52	33	5.5	63	164	12	44	30	105	0	.99	2.6	483	8.6
43/36-10bb1	2-14-64	54	17	4.5	92	130	6	56	61	61	0	1.11	5.1	569	8.4
43/36-11ca1	2-12-64	54	26	5.4	55	147	8	36	24	87	0	.94	2.5	414	8.5
43/36-12dd1	2-11-64	52	77	16	152	315	20	120	122	258	0	.68	4.1	1,210	8.6
43/36-14ab1	2-12-64	53	37	5.2	62	178	20	34	24	114	0	1.31	2.5	481	8.5
43/36-14ca1	2-12-64	50	37	6.2	57	180	0	44	34	118	0	.59	2.3	512	8.2
43/36-15ad1	2-12-64	57	26	4.1	52	135	8	36	24	82	0	.84	2.5	390	8.5
43/37-5cb1	2-12-64	53	59	12	43	152	12	63	57	198	54	.00	1.3	603	8.5
43/37-6ca1	2-12-64	51	48	12	137	285	20	108	62	169	0	1.96	4.6	946	8.6
43/37-7bd1	2-12-64	51	55	8.5	28	181	13	37	17	172	2	.00	.9	442	8.6
43/37-8ad1	7-22-64	58	29	4.3	19	120	0	20	9.0	90	0	.17	.9	283	7.8
43/37-8bc2	2-14-64	--	29	4.5	15	99	0	20	15	91	10	.00	.7	251	8.1
43/37-8dc1	2-12-64	54	28	4.4	16	99	0	20	15	88	7	.00	.7	251	8.2
43/37-9ac1	2-12-64	54	42	6.8	17	97	6	57	15	133	44	.00	.6	354	8.4
43/37-10ad1	7-22-64	62	72	15	20	232	0	61	22	242	52	.00	.5	566	7.5
43/37-16da3	2-11-64	--	23	3.5	24	100	0	25	13	72	0	.20	1.2	237	8.2
43/37-18cc1	2-12-64	53	25	2.8	18	104	0	17	8.1	74	0	.22	.9	227	8.2
43/37-28ac1	2-12-64	54	32	5.4	16	92	0	18	31	102	27	.00	.7	306	8.1
43/37-31cd1	2-12-64	--	31	6.0	32	130	6	24	21	102	0	.29	1.4	337	8.4

Table 16.--(continued)

Location	Date of collection	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium[1] (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: noncarbonate	RSC	SAR[2]	Specific conductance (micromhos at 25°C)	pH
43/37-33cd1	7-23-64	60	20	1.7	20	91	0	12	8.9	57	0	0.35	1.1	190	7.7
43/37-34cd1	6-19-64	57	21	4.0	14	91	0	10	11	69	0	.11	.8	200	7.6
43/37-35bb1	2-12-64	--	70	10	23	169	8	71	29	217	65	.00	.7	561	8.4
43/37-35bb2	2-11-64	--	30	3.9	68	185	0	60	18	91	0	1.21	3.1	451	7.5
43/38-7ac1[a]	3-26-64	--	25	20	36	135	4	67	25	144	28	.00	1.3	438	8.4
44/36-14cc1	2-12-64	57	36	7.3	38	164	8	29	18	120	0	.56	1.5	417	8.5
44/36-23ab1	2-29-64	56	35	8.6	39	159	13	28	19	123	0	.58	1.5	412	8.6
44/36-24aa1	2-29-64	53	40	7.1	27	128	7	41	21	129	13	.00	1.0	366	8.4
44/36-25cd1	2-12-64	51	72	13	69	251	23	69	47	232	0	.24	2.0	728	8.7
44/36-26bb1	2-12-64	54	22	4.1	33	116	4	20	15	72	0	.59	1.7	285	8.4
44/36-26dd1	2-12-64	--	49	10	145	274	21	110	76	165	0	1.89	4.9	967	8.6
44/36-33bc1	2-28-64	54	19	5.0	76	137	7	49	42	68	0	1.12	4.0	483	8.5
44/37-2aa1	7-22-64	53	37	11	19	136	0	29	26	137	26	.00	.7	360	8.0
44/37-6ad1	2-29-64	52	31	15	89	212	16	70	43	139	0	1.22	3.3	654	8.6
44/37-7bc1	2-12-64	52	44	13	62	204	12	56	36	162	0	.54	2.1	628	8.6
44/37-20da1	7-22-64	53	37	9.4	14	138	0	28	14	131	18	.00	.5	322	7.9
44/37-22bd1	2-12-64	57	31	6.0	22	64	0	44	36	102	50	.00	.9	338	7.7
44/37-25ac1	2-12-64	--	58	12	29	205	11	48	14	192	6	.00	.9	492	8.5
44/37-30da1	2-29-64	53	33	10	36	136	2	52	23	124	9	.00	1.4	401	8.3
44/37-33aa1	7-22-64	59	64	12	110	447	0	44	26	210	0	3.13	3.3	833	8.0
45/38-28da1	2-12-64	52	48	17	41	102	0	85	74	188	105	.00	1.3	604	8.2
46/38-5cd1	2-11-64	--	24	9.2	--	136	0	--	8.7	98	0	.27	--	300	7.4
46/38-7cc1	2-11-64	--	41	9.1	--	254	0	--	28	140	0	1.36	--	588	8.0
46/38-19ca1	2-11-64	--	23	6.7	--	108	0	--	9.2	85	0	.07	--	246	7.8
46/38-31cb1	2-12-64	52	43	16	43	176	10	59	31	172	12	.00	1.4	525	8.4
47/37-2ab1	2-12-64	46	23	6.0	38	136	4	27	14	82	0	.72	1.8	328	8.4
47/38-14dd1	3- 8-64	46	28	6.8	29	131	7	18	16	98	0	.42	1.3	312	8.4
47/38-17ca1	2-12-64	47	29	5.7	31	146	0	21	16	96	0	.47	1.4	333	8.2
47/38-21cb1	2-12-64	--	17	4.5	28	99	1	20	13	61	0	.43	1.6	236	8.4
48/37-35dd1	2-12-64	--	24	6.1	35	136	4	26	12	85	0	.66	1.7	315	8.4
38/41-33dd1[b]	3- 6-64	52	48	17	42	228	35	17	14	191	0	1.09	1.3	494	8.8
40/42-23cd1[a/b]	2-12-64	128	1.6	.2	141	170	51	48	26	5	0	4.39	27	637	9.3
41/42-23bb1[b]	3-10-64	51	32	10	36	169	13	20	14	123	0	.74	1.4	393	8.6
Quinn R. below Quinn R. Ranch 42/36-9ba	9-30-64	68	28	8.3	124	176	0	91	94	104	0	.80	5.3	799	7.8
Buffalo Canyon Creek 42/37-36ad	9-30-64	54	24	3.9	16	108	0	12	6.5	76	0	.25	.8	189	8.2
Horse Canyon Creek 42/38-17cc	9-30-64	53	17	3.3	13	80	0	8.0	6.7	56	0	.19	.7	151	7.7
Falls Canyon Creek 42/38-19dd	9-30-64	59	15	1.8	12	68	0	8.0	5.0	45	0	.21	.8	144	7.5
Rebel Creek 43/38-18bc	9-28-64	61	29	8.1	14	120	0	23	9.3	106	8	.00	.6	237	8.0
Willow Creek 44/38-30dc	9-28-64	67	46	17	20	197	0	45	14	185	24	.00	.6	400	8.1
Quinn R. near McDermitt, Nev. 45/37-15cd	9-27-64	63	38	15	128	207	8	148	69	156	0	.54	4.5	799	8.5
Flat Creek 45/38-3db	9-28-64	72	16	5.8	16	84	0	16	9.9	64	0	.10	.9	189	7.8
Canyon Creek 45/39-18bc	9-28-64	71	26	16	24	168	0	20	16	129	0	.17	.9	323	8.1
Three Mile Creek 46/39-31cc	9-28-64	70	30	17	22	164	0	37	14	144	10	.00	.8	367	8.2
McDermitt Creek 47/37-8dd	9-28-64	53	26	9.7	32	152	0	24	18	105	0	.39	1.3	314	8.1
Washburn Creek 47/37-19ca	9-28-64	59	31	8.6	49	182	0	28	29	113	0	.72	2.0	400	8.0
Quinn River at Giacometto Ranch 47/38-8cd	9-28-64	65	33	19	200	525	0	44	84	160	0	5.40	6.9	1,030	7.9
East Fork Quinn R. 47/39-9ad	9-27-64	64	17	4.3	25	96	0	12	16	60	0	3.7	1.4	211	7.9

1/ Sodium computed by difference.

2/ SAR values are approximate because sodium was computed by difference.

a/ Spring

b/ Oregon

Nineteen water samples were analyzed for boron content. The highest concentration, 0.9 ppm (parts per million), was found in the water from well 39/36-12acl. This concentration is well within the tolerance limits of crops grown in the Quinn River valley area.

Suitability for Domestic Use

The limits recommended by the U. S. Public Health Service (1962, p. 32) for water used on interstate carriers for drinking purposes commonly are cited as standards for domestic use. Most of the ground water and surface water sampled in the Quinn River valley area meet these requirements. Listed below are some of the chemical substances which should not be present in water in excess of the listed concentrations where more suitable supplies are available.

Substance	Concentration in ppm (parts per million)
Chloride (Cl)	250
Iron (Fe)	0.3
Nitrate (NO_3)	45
Sulfate (SO_4)	250
Fluoride (F)	a 1.7
Total dissolved solids	500 (1,000 permitted)

a. Varies with mean temperature in sense that higher temperature results in more water intake.

Of the elements and compounds listed above, only sulfate and chloride occur in amounts significantly larger than those recommended by the U. S. Public Health Service. Wells 39/36-12acl and 41/36-4ddl yield water which contains 293 and 1,600 ppm chloride, respectively. Chloride in excess of 250 ppm may impart a salty taste to water. Well 41/36-4ddl also yields water which contains 680 ppm sulfate. Cathartic effects are commonly experienced with water having sulfate concentrations greater than 600 ppm, particularly if much magnesium or sodium is present. Locally, a few wells yield water with more than 1,000 ppm dissolved solids; however, in general most of the wells yield water containing less than 500 ppm.

Excessive hardness of water, which is caused principally by calcium and magnesium, adversely affects its suitability for domestic use, especially for cooking or washing. The U. S. Geological Survey uses the following classification of water hardness:

Hardness range (ppm)	Classification
0 - 60	Soft
61-120	Moderately hard
121-180	Hard
Greater than 180	Very hard

As shown in tables 15 and 16, water in the Quinn River valley area ranges from soft to very hard. The range was from 5 ppm in spring 40/42-23cd1 to 738 ppm in well 41/36-4dd1. However, most of the water in the area is moderately hard.

Relation to the Flow System

Ground water in the northern and central parts of the Quinn River valley area is derived largely from precipitation on the Santa Rosa Range and the Quinn River Mountains. Ground water derived from precipitation on the Santa Rosa Range generally is a calcium bicarbonate type, whereas ground water derived from precipitation on the Quinn River Mountains is a mixed sodium-calcium bicarbonate type.

Although the quality of ground water varies from place to place, in general the dissolved-solids content is low in the recharge areas in the mountains and increases as it moves toward the areas of discharge in the lower parts of the valley. For example, water from wells 43/37-17da1 and 43/37-6da1 have specific-conductance values of 237 and 239 micromhos, respectively (table 16). As the ground water moves westward, it dissolves additional mineral matter, as shown by the increase in specific conductance of the water from well 43/36-14ca1 of 512 micromhos. This increase probably is due to the greater distance the water has traveled from the recharge area.

The movement of ground water is then southward toward Sod House, where a small amount discharges annually into Kings River valley. Water from well 41/36-6bc1, which is a sodium bicarbonate type, has a specific conductance value of 1,050 micromhos--about twice that at well 43/36-14ca1. The increase in sodium probably is due to the movement of water through clay and silt deposits which contain sodium soluble compounds.

The analyses do not suggest any noticeable deterioration of water quality due to recycling of irrigation water. Possibly one-third of the irrigation water applied to crops penetrates below the root zone and returns to the ground-water system. The return water occupies the uppermost part of the saturated deposits and hence probably is considerably above the perforated intervals in the casings of most irrigation wells. In time, however, as water levels are lowered and as the lens of return water grows thicker, the return water may be repumped. If the return water should be of poor quality, the pumped water would start to deteriorate at that time.

DEVELOPMENT IN THE OROVADA SUBAREA

The preceding sections of the report described the flow components of the valley-fill reservoir under near natural equilibrium conditions. The large-scale development of ground water by pumping in the Orovada subarea upset this natural equilibrium by depleting storage in and near the area of development. As a result the system in this part of the valley is now in a nonequilibrium condition. Water levels will continue to decline as the system strives to reach a new equilibrium through the process of decreasing the natural discharge or intercepting streamflow. If pumpage exceeds the salvable discharge, the nonequilibrium condition will continue, and water levels eventually will decline to the economic limit. The simple nonequilibrium hydrologic equation is:

Inflow = Outflow - change in stored water

The several elements of this equation are estimated and compared in the following sections of the report.

Pumpage

Pumping for irrigation is a relatively recent development in the valley. The first irrigation wells were drilled in the 1920's, but prohibitive pumping costs made irrigation from ground-water sources impractical, and the project was abandoned (Visher, 1957, p. 42). The present pumping development began in the late 1940's and was accelerated by the disposition of public land under the Desert Land Entry Acts. By 1955 about 20 irrigation wells were producing about 5,000 acre-feet of ground water annually (Visher, 1957, p. 43). By 1964 nearly 115 irrigation wells had been drilled; 82 wells were pumped and discharged about 40,000 acre-feet. Additional wells are expected to go into production in the next several years.

Plate 4 shows areas irrigated by surface water and ground water in 1964. Most of the lands irrigated by ground water are concentrated in the eastern part of the Orovada subarea. Very minor pumping for irrigation occurs in the other subareas.

The estimated pumpage for the 15-year period 1950-64 is shown in table 17. The estimates of gross pumpage are based on work by Visher for the years 1954-55 (1957, p. 42-43), on records of the Nevada State Engineer for 1956-58, crop acreage figures furnished by the Humboldt County Extension Agent for 1962, and electrical power consumption and field observations for 1963-64. Pumpage estimates for the years 1950-53 and 1959-62 are based on extrapolation from years preceding and following those periods and from records of crop production furnished by the U. S. Bureau of the Census for 1959 (1961).

In other areas the amount of the pumped water that returns to ground water commonly ranges from 25 to 40 percent of the gross pumpage

(Thomasson and others, 1960, p. 235). Accordingly, for this study the net pumping draft, or the amount permanently removed from the valley-fill reservoir, is assumed to be roughly two-thirds of the gross pumpage. The gross pumpage for the 15-year period 1950-64 was 230,000 acre-feet; the net draft, about 150,000 acre-feet.

The Nonequilibrium Condition

Water-Level Decline, 1947-64

Water-level fluctuations over a period of time are largely the result of an imbalance between recharge to and discharge from the ground-water reservoir and represent changes of ground water in storage. If recharge to the ground-water reservoir exceeds discharge, the surplus water goes into storage, causing water levels to rise. On the other hand, if discharge exceeds recharge, the deficit is made up by removal of ground water from storage, causing a decline in water levels.

Records of water-level fluctuations in wells in the Quinn River valley area are available since 1947. Water-level observations during this period have been made by the U. S. Geological Survey, the Nevada Department of Conservation and Natural Resources, and by well drillers. In 1947 water levels in many of the wells in the valley were measured. From 1947 to 1963 only scattered water-level observations were made in selected wells. In the fall of 1963 and the spring of 1964 water-level measurements were made on nearly all wells in the valley as part of this study. Water-level contour maps, based on water-level measurements made in 1947 and in the spring of 1964, are shown in plate 1 and figure 2. Comparison of the 1947 and 1964 water-level surfaces indicates that a moderate net decline in water levels had taken place, and nearly all the decline had occurred within the Orovada subarea.

Figure 9 is a first difference, or net-change, map and shows the magnitude and the area of the water-level decline caused by pumping. The maximum net decline from the near equilibrium water levels in 1947 to the spring high water levels in 1964 is somewhat more than 25 feet. The weighted average areal net decline within the zero contour was about 12 feet; the area is about 75,000 acres.

Storage Depletion

Table 18 shows that the average specific yield of the dewatered deposits is estimated to be 15 percent--about 2 percent more than average for the upper 100 feet of saturated deposits in the Orovada subarea (table 13). The approximate volume of dewatered deposits, determined from the contours of water-level decline (fig. 9), is 900,000 acre-feet. The storage depletion is the product of the specific yield and the volume of dewatered material, or 0.15 times 900,000 acre-feet, which is about 135,000 acre-feet of ground water depletion.

The estimated gross pumpage during the comparable period 1950-63 can be computed from table 17 to be about 190, 000 acre-feet. The net draft, or approximately two-thirds of the gross, is about 130, 000 acre-feet, which is nearly the same as the estimated storage depletion. This in turn suggests that virtually all the pumpage in the Orovada subarea has been derived from ground water stored in the valley-fill reservoir.

Cyclic Water-Level Fluctuations

In addition to the major downward trend in water levels caused by storage depletion, water-level fluctuations are caused by the annual pumping pattern and by variations in rainfall and recharge. Figure 10 shows the hydrographs for five index wells and the cumulative departure from average rainfall at Orovada. Water-level records are available for four of the five index wells since 1947.

The hydrographs show that the annual high water levels in the spring of 1953 are 1 to 3 feet higher than those in the spring of 1952, following the above-average precipitation and recharge in 1952. This indicates that in this part of the valley a time lag of not more than 1 year occurs between climatic events and the corresponding water-level response in the index wells.

A period of deficient precipitation and recharge from 1953-55 was accompanied by declining water levels in all four wells for the years 1954 to 1956 or 1957. Above-average precipitation and recharge in the years 1956-58 caused water levels to rise nearly 4 feet in well 42/37-33bdl during the period 1957-59. The annual high water level in well 43/37-4cal rose more than 1 foot between 1957 and 1958. Also, during the same period 1957-59, water levels in wells 42/37-28acl and 42/37-3bbl leveled off and held steady in spite of heavy pumping from nearby irrigation wells. Annual precipitation remained about average from 1959-64 (fig. 10), whereas annual gross pumpage increased markedly. The hydrographs for this period show a rapidly increasing rate of water-level decline in all five index wells.

All the index wells are affected by the pumping of irrigation wells. Superimposed on the long-term regional water-level changes described above are short-term fluctuations caused by seasonal (May-September) discharge from nearby irrigation wells. In general, the hydrographs show an annual low water level in the autumn after pumping has stopped and an annual high water level in the following spring before pumping resumes. Hydrographs for all five index wells show annual fluctuations caused by pumping.

Table 17. --Estimated pumpage for irrigation, in acre-feet, in the Orovada subarea

Year	Gross pumpage	Year	Gross pumpage
1950	500	1960	24,000
1951	500	1961	28,000
1952	1,000	1962	30,000
1953	3,000	1963	35,000
1954	4,000	1964	40,000
1955	5,000	Total	230,000
1956	6,000	Total net draft	a150,000
1957	14,000		
1958	18,000		
1959	22,000		

a. The net draft is assumed to be roughly two-thirds of the gross pumpage.

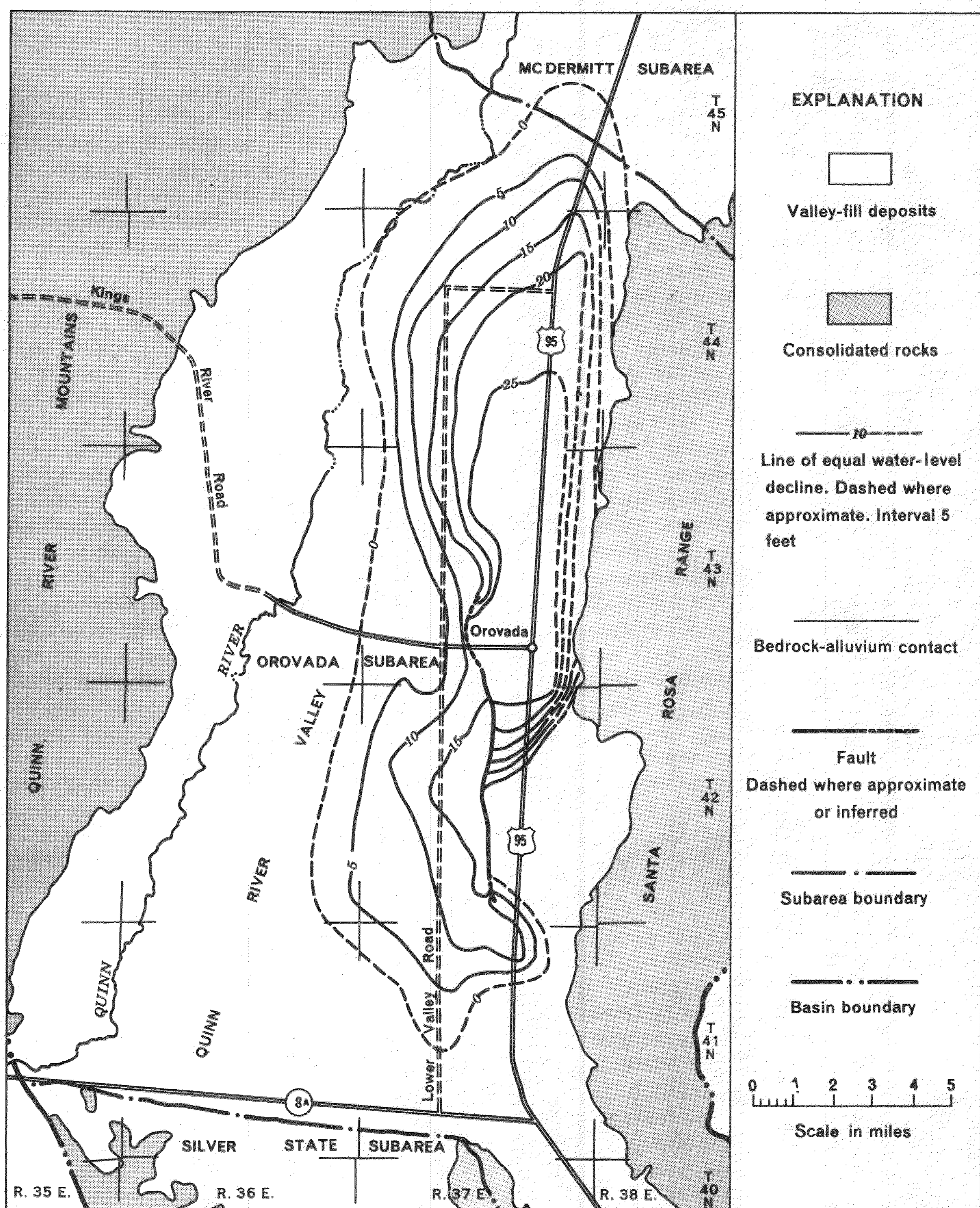

Figure 9.—Water-level decline in the Orovada subarea, 1947-64

Table 18. --Estimated specific yield of the dewatered deposits in the Orovada subarea[1]

Storage unit	Area dewatered (acres)	Number of well logs	Lithologic category (table 12) [2] (percent of total footage penetrated by wells) G	S	F	Cg	C	Average specific yield (percent)
T. 41 N.	5,800	9	48	0	0	52	0	17
T. 42 N	18,400	27	19	0	14	34	33	12
T. 43 N.	20,900	26	34	1	8	43	14	15
Tps. 44 and 45 N.	30,200	38	42	0	0	51	7	16
Total	75,300	100			Average			15

1. Extent and magnitude of dewatering shown on figure 9.

2. Multiply percentage of each category by assigned specific yields in table 12, then add to obtain average specific yield.

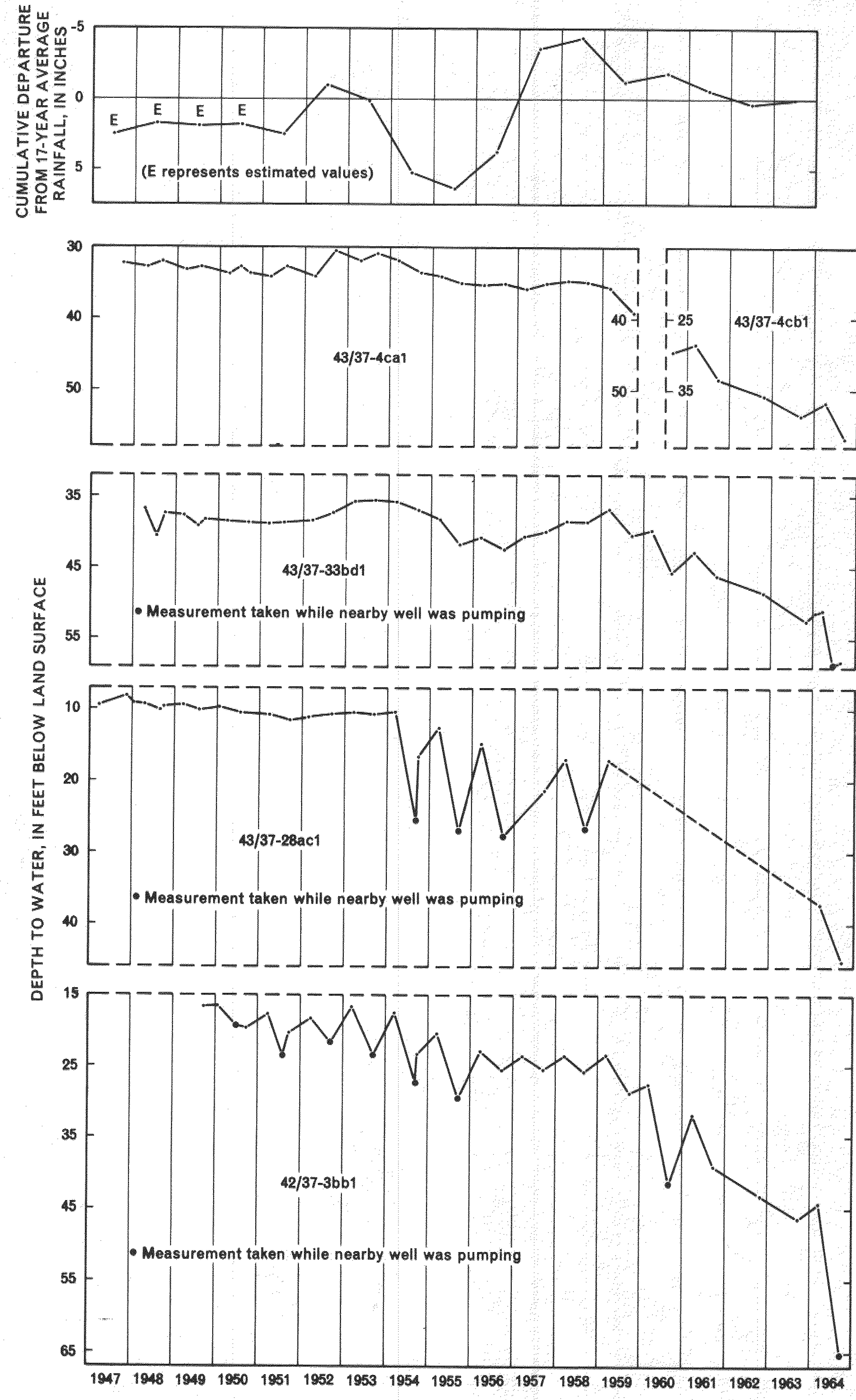

Figure 10.—Hydrographs of five index wells and cumulative departure of precipitation from average, 1947-63 at Orovada

Ground-Water Budget, 1950-63

Table 19 shows the ground-water budget for the Orovada subarea for the 14-year period 1950-63. During this period of development and storage depletion, the estimates of discharge exceeded those of recharge by more than 80,000 acre-feet. The estimated storage depletion, computed independently, was 135,000 acre-feet. If all estimates were accurate, the two values should agree. The difference of about 50,000 acre-feet, which averages about 3,500 acre-feet per year, is the imbalance or error in the estimates. The errors probably are in the larger estimates, principally the recharge from streams, evapotranspiration, and net pumping draft.

Table 19.--Ground-water budget, in acre-feet, for the Orovada subarea, 1950-63

(most estimates rounded)

	14-year period
RECHARGE:	
Seepage from streams (table 8)	420,000
Ground-water inflow from upgradient subarea (table 10)	70,000
Ground-water inflow across bedrock-alluvium contact (table 11), about	40,000
Subtotal (1):	530,000
DISCHARGE:	
Evapotranspiration (table 9)	480,000
Net pumping draft (p. 41)	130,000
Ground-water outflow (table 10)	3,000
Subtotal (2):	613,000
IMBALANCE (3): (1) - (2)	- 83,000
STORAGE DEPLETION (p. 41) (4):	-135,000
DIFFERENCE BETWEEN METHODS: (3) - (4)	- 52,000

PERENNIAL YIELD

The perennial yield of a ground-water reservoir may be defined as the maximum amount of water of usable chemical quality that can be withdrawn and consumed economically each year for an indefinite period of time. If the perennial yield is continually exceeded, water levels will decline until the ground-water reservoir is depleted of water of usable quality or until the pumping lifts become uneconomical to maintain. Perennial yield can not exceed the long-term natural recharge to or discharge from an area. Most pertinent is the fact that the perennial yield ultimately is limited to the maximum amount of natural discharge that can be economically salvaged for beneficial use.

The concept of perennial yield in the development of a ground-water basin is three-fold: (1) In a state of nature before pumping begins, the hydrologic system is in an equilibrium condition--recharge equals natural discharge and over the long term no change in stored water occurs; (2) after pumping starts, the system is in a nonequilibrium condition--natural discharge plus pumpage exceed recharge; the deficit over the years is made up by a substantial depletion of stored water; and (3) if the net pumping draft is held to a rate about equal to the salvable natural discharge, and most critical, if the distribution and amount of the pumpage are strategically situated so as eventually to reduce the salvable natural discharge to zero, then the system attains a new equilibrium--recharge equals net pumping draft, natural discharge is virtually zero, and over the long term no change in storage occurs.

The amount of time that it takes to make the full transition from equilibrium under natural conditions to the new equilibrium under pumping conditions is largely a function of the annual pumping rate and the amount of stored water that must be removed to terminate natural discharge. Ordinarily the time involved is measured in decades, provided that the annual net pumping draft is maintained at a rate roughly equal to the perennial yield.

What has happened in the Quinn River valley area is typical of most ground-water basins in the west: the terms of condition (3) above are violated. As shown in plate 3 and estimated in quantitative terms in table 11, evapotranspiration and other natural water losses occur from the Oregon Canyon subarea southward into the Silver State subarea. Yet all the pumpage is concentrated in the Orovada subarea where pumping never will affect materially the natural discharge in the more distant parts of the area. This type of concentrated development commonly leads to a paradox where local overdraft occurs in one part of the valley while at the same time an excess, or water available for development by pumping, goes to waste in another part of the same valley.

Valley-Fill Reservoir

For the Quinn River valley area, the estimated total natural outflow averages about 100,000 acre-feet per year (table 11). As previously described, the perennial yield is limited to the maximum amount of natural discharge that can be economically salvaged. The estimated maximum salvage over the long term, if pumpage were strategically distributed throughout the entire area, would include most of the evapotranspiration losses, about half of the surface-water diversions, and possibly half of the surface-water and ground-water outflow near Sod House (table 11). Thus, the perennial yield of the entire valley-fill reservoir is estimated to be about 75,000 acre-feet.

About half the surface-water diversions are included in the yield because the points of diversion from the Quinn River or its two major tributaries are on the valley floor. As water levels are drawn down to eliminate the evapotranspiration losses, much of the nonflood runoff would sink into the stream channels before reaching these points of diversion. In other words, those ranchers now depending on streamflow to irrigate crops would have to line ditches or drill wells and pump water. Moreover, about 22,000 acres of native meadowgrass now is in part subirrigated naturally by ground water, but as water levels were drawn down, more irrigation water would be required to raise the same crops (table 19).

If the entire 75,000 acre-feet were to be developed in proportion to where the salvable supply occurs and concurrently throughout the valley area, the approximate distribution of net pumpage would be: Oregon Canyon subarea, 6,000 acre-feet per year; McDermitt subarea, 25,000 acre-feet per year; Orovada subarea, 40,000 acre-feet per year; and Silver State subarea, 4,000 acre-feet per year. The Oregon Canyon subarea is wholly within the State of Oregon, and of course any development, large or small, would not be subject to control under the water law of Nevada.

These estimates are considerably larger than those made by Visher (1957), who estimated that the total discharge was about 25,000 acre-feet per year. However, that study did not include the Oregon Canyon subarea of this report. Moreover, this report used a somewhat higher average annual evapotranspiration rate of 0.4 foot (computed from table 9) compared to about 0.2 foot (computed from estimates by Visher (1957, p. 33-34). Finally, the average annual surface-water inflow in this report, based on somewhat more accurate methods of estimation and a longer period of streamflow records, is about 87,000 acre-feet (excluding 13,000 in the Oregon Canyon subarea, table 8) compared to 50,000 acre-feet, as calculated by Visher (1957, p. 32).

Orovada Subarea

Ground-water development has not been strategically distributed throughout the area in the idealized proportions just described; instead, it has been concentrated in the Orovada subarea. Moreover, nearly all rights to pump additional water have been granted in this same subarea. Accordingly, the estimated yield of 40,000 acre-feet per year under conditions of valley-wide development would be a minimum yield for the Orovada subarea if nearly all the future pumpage continues to be concentrated in this part of the valley. If little development occurs in the adjacent subarea, the local yield of the Orovada subarea will be increased by the additional amount of natural discharge and streamflow that can be salvaged in this part of the valley by pumping.

The extent and magnitude of the future pumping effects are difficult to predict. Nevertheless, figure 9 shows that pumping effects have already reached the southernmost part of the McDermitt subarea, and over the long term probably would extend into the Silver State subarea. Although the amount of additional natural discharge that would be salvaged is also difficult to predict, probably most of the evapotranspiration loss in the Silver State subarea and possibly a fourth of the loss in the McDermitt subarea (table 11 and pl. 3) would eventually be salvaged. Thus, the preliminary estimate of the total discharge that may be salvaged is on the order of 50,000 acre-feet per year. This in turn suggests that by concentrating all the pumping in the Orovada subarea, only about two-thirds of the potential yield of the Quinn River valley area will be realized.

FUTURE DEVELOPMENT

Potential Overdraft

Overdraft may be defined as the amount by which the net pumping draft exceeds the perennial yield. Similarly, local overdraft is the amount by which the net pumping draft in a given part of an area, such as the Orovada subarea, exceeds the local yield. Under the idealized distribution of pumping in the entire Quinn River valley area, previously described, no overdraft would occur until the net pumping draft exceeded about 75,000 acre-feet per year. Similarly, no local overdraft would occur in the Orovada subarea until the net pumping draft exceeded about 50,000 acre-feet per year.

In 1964 the estimated gross pumpage in the Orovada subarea was 40,000 acre-feet (table 17), suggesting a net pumping draft of 25,000 to 30,000 acre-feet, which is roughly one-half the estimated yield of the subarea. Obviously, as of 1964, no overdraft existed in the Orovada subarea or in the Quinn River valley area. If the surface-water diversions of about 15,000 acre-feet are added to the net pumpage (table 11), total use would be more than 40,000 acre-feet, which still is somewhat less than the total available supply in the Orovada subarea.

Rights to pump about 96,000 acre-feet of ground water have been granted by the State of Nevada, and most are in the Orovada subarea. Exercise of all these rights would result in a new pumping draft of roughly 65,000 acre-feet per year, which would create a local overdraft of about 15,000 acre-feet per year in the Orovada subarea.

If an overdraft of this magnitude should occur, a new equilibrium between inflow and net pumping draft never could be achieved. A continued net pumping draft in excess of inflow would cause a continued depletion of stored water, water levels would become progressively deeper, pumping lifts would increase, and eventually the cost of pumping ground water would become economically impractical to maintain.

At the same time, water levels and natural discharge in the northern and southern parts of the valley would be largely unaffected or only slightly affected by the local overdraft in the Orovada subarea. Water that could be put to beneficial use would be wasting in these areas at that future time as it is today.

Storage Depletion in the Orovada Subarea

The water level in index wells 42/37-3bb1, 33bd1, 43/37-4ca1, 4cb1, and 28ac1 (fig. 10) declined an average of 22 feet from 1950 to the spring of 1964. However, the rate of decline has accelerated in recent years as the annual pumpage has increased. Pumpage probably will continue to increase during the next 10 years, and the rate of water-level decline also will continue to increase, subject to several controlling factors.

First, the ground-water budget for 1950-63 (table 19) and the water-level decline map for the period 1947-64 (fig. 9) strongly suggest that virtually all the pumpage through 1963 has been derived from ground water in storage and that practically no natural discharge or streamflow has been salvaged. Second, as pumping continues, the area of water-level decline will expand into the areas of evapotranspiration thereby decreasing the water now wasted. Third, at the same time, water levels beneath the Quinn River will be lowered, thereby inducing an increasing amount of recharge from that source. Eventually the pumping may reduce the amount of streamflow entering the Orovada subarea.

The second and third items above will reduce substantially the rate of water-level decline caused by increased pumpage. To eliminate virtually all the evapotranspiration losses, water levels in phreatophyte areas would have to be drawn down about 50 feet below the levels of 1964 (fig. 2). If water levels in the future were drawn down an average of 50 feet throughout the Orovada subarea, the storage depletion probably would be on the order of a million acre-feet, or about half that shown in table 14.

Economic Effects

Pumping costs increase in about the same proportion as pumping lifts. If the average pumping lift in the future should double, pumping costs also would nearly double, provided that well and pumping plant efficiencies remained about the same. In 1964 the electric power used to pump 40,000 acre-feet of water for irrigation cost more than $150,000, or about $4 per acre-foot. The value of the crops produced, exclusive of native hay, was nearly 1.3 million dollars (table 3). Thus, the ratio of pumping costs to crop value was about 1 to 8. If pumping costs double and if crop values do not increase appreciably, the ratio would approach 1 to 4.

The concentration of pumping in the Orovada subarea results in mutual interference among the water-level drawdowns in the pumped wells. This will occur in any area where substantial development occurs. However, the extent of the interference in large part is controlled by the distance between pumped wells; that is, the closer together the wells, the greater the interference drawdowns and, of course, increased pumping costs. Therefore, ranch operators can realize a savings in pumping costs by spacing wells as far apart as possible.

SUMMARY AND CONCLUSIONS

This second appraisal of the water resources of the Quinn River valley area suggests that a total of 90,000 acre-feet per year of water could be developed--about 75,000 acre-feet from ground-water sources and about 15,000 acre-feet by surface-water diversions, which is about half that now being diverted. Under full development, most of the surface water now being diverted from streams on the valley floor in areas of shallow ground water would become ground-water recharge before reaching the points of diversion. Diversions from streams and springs around the margins of the valley floor would be largely unaffected by full-scale ground-water development.

However, because nearly all the pumpage to date has been concentrated in the Orovada subarea and because nearly all the total permitted rights to pump about 96,000 acre-feet per year for irrigation also have been granted in the Orovada subarea, the total available supply cannot be fully utilized. Under the present pattern of water development, the local yield of the subarea is about 50,000 acre-feet per year plus about 8,000 acre-feet of surface water that probably would be unaffected by extensive ground-water pumpage. If all rights to pump were exercised and if a third of the pumped water returned to ground water, the potential net pumping draft would be about 65,000 acre-feet per year. This would result in a local overdraft in the Orovada subarea of roughly 15,000 acre-feet per year.

Pumping started in about 1950, and during the period 1950-63 the estimated total net pumping draft was 130,000 acre-feet. The estimated depletion of stored ground water due to pumping during this period was about 135,000 acre-feet, which is about the same as the estimated net pumping draft. This in turn suggests that virtually all the pumped water came from storage and that natural discharge and streamflow had not yet been affected by pumping.

In 1964 the gross pumpage was about 40,000 acre-feet, or a net pumping draft of 25,000 to 30,000 acre-feet. Thus, the yield of the Orovada subarea was not exceeded. However, with the net pumping draft increasing at a rate of about 3,000 to 4,000 acre-feet per year during the period 1962-64 and if this rate continues, the yield could be equaled or exceeded starting sometime between 1970 and 1975.

In the next several years, pumping in the Orovada subarea probably will begin to reduce the flow of the Quinn River. In 1964 the effects of pumping had just reached the river near the north end of the subarea (fig. 9). Within the next two decades, pumping may intercept most of the medium to low flow of the Quinn River in most of the Orovada subarea and in the southern part of the McDermitt subarea. This would adversely affect the vested rights to the diversion of streamflow in this part of the Quinn River Valley.

Finally, continued water-level measurements and periodic pumpage inventories will provide the necessary information to determine the cause-and-effect relations in the area. Projections of cause-and-effect relations can be approximated from these data as needed to assist in making administrative and management decisions. Based on the foregoing analysis of the hydrology and if a serious local overdraft seems imminent, a reappraisal of the Quinn River valley area, and particularly the Orovada subarea, would seem advisable between 1970 and 1975.

Table 20.--Records of selected wells, testholes, and springs in the Quinn River valley area

Use: D, domestic; I, irrigation; O, observation; S, stock; PS, public supply; Ind, industrial; T, testhole; U, unused; Des, destroyed.
Yield: In gallons per minute (gpm).
Altitude: Determined from topographic maps.
Water-level measurements: Depth in feet below land-surface datum.
Log number: Number is log number in the files of the State Engineer.

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
38/36-12bb1	Hazel Bishop	1964	628	16	I	- -	--	--	--	7929
38/36-35aa1	Southern Pacific Railroad	--	61	8	I	- -	4165	9-28-47	41.64	--
								2-25-64	42.46	
38/37-30ca1	U.S. Bureau of Land Management	--	60	6	S	- -	4165	9-28-47	38.52	--
								2-25-64	38.06	
39/36-12ac1	do.	1916	76	24	U	- -	4175	2-26-64	38.35	--
39/36-25bc1	do.	--	--	16	U	- -	4200	2-25-64	66.70	--
40/36-4ba1	U.S. Geological Survey	1963	34	2	O	- -	4134	2-26-64	16.90	--
40/36-15cb1	U.S. Bureau of Land Management	--	--	-	S	- -	4195	do.	30.63	--
40/36-35cd1	Consolidated Mines	1912	77	12	U	- -	4180	9-28-47	46.00	--
								2-26-64	46.06	
40/37-8db1	U.S. Bureau of Land Management	--	--	8	S	- -	4159	do.	32.00	--
40/37-12ab1	do.	--	--	6	S	- -	4641	do.	148.27	--
41/35-2cb1	do.	--	155	8	S	- -	4300	9-26-47	134.1	--
								3-10-64	dry	
41/35-12dd1	- - -	--	--	-	S	- -	4126	2-27-64	10.36	--
41/35-14cc1	U.S. Bureau of Land Management	--	28	8	S	- -	--	do.	9.72	--
41/35-22db1	John McErquiaga	--	27	6	S	- -	4110	9-28-47	8.35	--
								2-27-64	7.80	
41/35-25ba1	U.S. Geological Survey	1963	43	2	O	- -	4125	do.	10.26	--

Table 20.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
41/36-1cb1	U.S. Bureau of Land Management	--	--	6	S	- -	4144	2-27-64	8.22	--
41/36-2bb1	- - -	--	--	6	S	- -	4140	do.	7.31	--
41/36-4dd1	U.S. Bureau of Land Management	--	--	6	S	- -	4132	do.	8.13	--
41/36-6bb1	John McErquiaga	--	70	10	S	- -	4131	do.	11.29	--
41/36-6cb1	do.	1963	222	16	I	- -	4129	do.	11.89	3707
41/36-7cb1	U.S. Geological Survey	1963	22	2	O	- -	4127	do.	5.55	--
41/36-17dd1	U.S. Bureau of Land Management	1930	63	8	S	- -	4127	9-28-47	8.70	--
								2-26-64	9.06	--
41/36-18cc1	River Ranch	--	--	6	S	- -	4125	2-27-64	10.46	--
41/36-29bc1	U.S. Geological Survey	1963	80	2	O	- -	4126	2-26-64	9.81	--
41/36-31bd1	- - -	--	--	10	S	- -	4200	do.	38.34	--
41/37-3ad1	Andorno Ranch	1947	161	6	U	- -	4340	9-12-47	129.55	--
								3-12-64	142.72	--
41/37-3ba1	do.	--	175	10	S	- -	4263	3-24-64	81.91	4927
41/37-3ca1	do.	1963	600	16	I	- -	4271	3-10-64	82.80	7205
41/37-3cd1	do.	1962	110	10	S	- -	4262	- -	- -	--
41/37-3da1	do.	--	200	10	D	- -	--	- -	- -	--
41/37-3db1	do.	1959	404	16	I	- -	4301	3-10-64	113.62	4721
41/37-3dd1	do.	1948	251	6	S	- -	4390	3-12-64	193.28	--
41/37-4da1	Herbert B. Urwin	1958	795	16	I	1000/58	4239	3-10-64	57.52	4545
41/37-4dd1	Hutman	1963	500	16	I	- -	4240	do.	54.95	--
41/37-5ba1	Woodrow Eriksen	1962	74	10	S	- -	4179	3-24-64	22.16	7018
41/37-5da1	U.S. Geological Survey	1963	46	2	O	- -	4186	3-10-64	28.58	--
41/37-8aa1	Melba E. Jackson	1962	415	16	I	- -	4184	do.	26.41	7019
41/37-8cb1	U.S. Bureau of Land Management	1947	46	--	S	- -	4156	9-16-47	8.63	--
								3-10-64	10.74	
41/37-8da1	Mrs. Viola Brinkenhoff	1957	464	18	I	1630/108	4180	do.	24.13	4054

Table 20.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
41/37-9ca1	Riley Potter	1943	54	18	U	- -	4192	9-11-47	19.20	--
								3-10-64	26.78	
41/37-9cb1	do.	--	20	8	Des.	- -	4190	9-11-47	19.00	--
41/37-20aa1	U.S. Geological Survey	1963	46	2	O	- -	4178	3-26-64	27.49	--
41/37-21ca1	G. F. Collins	1958	342	16	I	- -	4210	10-31-63	36.3	4366
41/37-22bb1	U.S. Bureau of Land Management	1958	144	6	S	- -	4280	11- 1-63	90.43	4312
41/37-29da1	Lyle Frey	1920's	55	6	U	- -	4190	9-11-47	48.76	--
								5-12-64	51	
41/37-29da2	do.	1949	121	6	D	- -	4190	do.	51.94	754
41/37-29da3	do.	1950	138	14	I	- -	4190	9-11-47	52.02	5113
41/37-33aa1	do.	1963	112	16	I	- -	4280	2-26-64	9.44	--
41/37-33db1	Eldorado Mining Co.	--	22	12	U	- -	4280	9-11-47	16.05	--
								2-26-64	15.51	
41/37-34cb1	do.	1947	77	6	U	- -	4340	do.	7.37	46
42/36-3bd1	U.S. Geological Survey	1963	42	2	O	- -	4155	2-27-64	10.60	--
42/36-4ab1	- - -	--	--	-	S	- -	4154	2-28-64	8.28	--
42/36-12ca1	- - -	--	--	14	S	- -	4158	2-27-64	8.69	--
42/36-19cd1	U.S. Geological Survey	1963	32	2	O	- -	4140	do.	10.32	--
42/36-25dc1	U.S. Bureau of Land Management	1947	47	8	U	- -	4158	9-15-47	6.35	--
								2-27-64	9.38	
42/36-35aa1	U.S. Geological Survey	1963	22	2	O	- -	4145	do.	6.09	--
42/37-3bb1	Geo. Reed	1949	160	12	U,O	- -	4260	9-15-49	16.80	2196
								3-12-64	44.18	
42/37-3dd1	Keys	1960	366	16	I	1550/--	4320	do.	107.42	5210
42/37-4ba1	Peter & Bessie Christensen	1961	405	16	I	- -	4237	do.	70.90	4146

Table 20.--Continued

Well number		Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
42/37-4bb1	Stewart Marshall	1947	53	40	Des.	- -	4220	9-16-47	48	--
42/37-4bb2	Peter Christensen	--	--	6	D	- -	4220	3-12-64	54.29	--
42/37-5ad1	- - -	1961	450	16	I	1450/77	4223	do.	58.48	6198
42/37-5dd1	Harris	1927	43	60	Des.	- -	4225	9-16-47	dry	--
42/37-5dd2	Moser	1956	465	16	I	1300/79	--	3-11-64	60.31	3519
42/37-7cd1	Persson	--	21	-	Des.	- -	4183	9-17-47	20.17	--
42/37-8da1	Harman	1962	502	16	I	- -	--	3-13-64	65.77	3380
42/37-9ac1	McBride	--	--	16	U	- -	4258	3-12-64	93.63	--
42/37-9ad1	do.	1961	340	16	U	- -	4265	do.	102.82	6202
42/37-9ad2	Keys	1963	500	16	I	- -	4265	do.	102.90	--
42/37-9da1	Orville Jay	1960	475	16	I	- -	4265	do.	104.03	6773
42/37-10ba1	Keys	--	370	16	I	2100/66	4290	do.	63.99	--
42/37-10cd1	Eriksen	1964	82	10	S	- -	4275	3-11-64	21.82	--
42/37-10da1	do.	1954	340	12	I	- -	4299	do.	47.49	--
42/37-10db1	do.	1947	--	3	D	- -	4288	9-17-47	26.41	--
								3-11-64	39.30	
42/37-10de1	do.	1962	520	16	I	2000/--	4299	do.	40.59	--
42/37-15cb1	Buffalo Ranch	--	18	3	Des.	- -	4260	9-15-47	8.18	--
42/37-15cc1	do.	--	--	8	S	- -	4275	3-11-64	12.63	--
42/37-16aa1	Harman	1961	500	16	I	- -	4260	do.	95.53	6095
42/37-16ca1	Taylor	1957	430	12	I	1200/--	4236	do.	74.46	4053
42/37-17ad1	Harman	1956	432	14	I	1700/--	4223	3-21-64	67.43	6897
42/37-17dd1	Mararity	--	46	43	Des.	- -	4220	9-15-47	45.3	--
42/37-17dd2	Harman	1957	470	14	I	- -	4221	4-10-64	60.30	3636
42/37-18ad1	McClintick	1953	327	12	I	- -	4197	3-11-64	39.22	2697
42/37-20ba1	Buffalo Ranch	1961	585	16	I	- -	4209	do.	49.24	6847

Table 20.--Continued

Well number		Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
42/37-20ca1	Buffalo Ranch	1964	528	16	I	2000/52	4200	3-11-64	41.62	--
42/37-21aa1	do.	1964	250	10	D	- -	4257	3-12-64	80.52	--
42/37-21ba1	Ralph Hetrick	1957	562	16	I	2300/73	4237	3-11-64	72.37	3695
42/37-21cd1	Hetrick	--	425	16	U	- -	4229	do.	63.29	--
42/36-21cd2	Marvin Hetrick	1961	623	16	I	- -	4228	do.	59.04	--
42/37-22ba1	Buffalo Ranch	1963	600	16	I	- -	4237	do.	18.80	--
42/37-22bb1	do.	--	--	-	S	- -	--	2-11-64	flows	--
42/37-22bc1[a/]	do.	--	--	-	S	- -	4270	do.	do.	--
42/37-22ca1	do.	--	38	3	Des.	- -	4263	9-15-47	do.	--
42/37-22cb1	do.	1947	--	6	S	- -	4258	do.	63.35	--
42/37-27bb1	H. A. Drees	--	400	16	I	- -	4260	3-11-64	76.58	--
42/37-28da1	do.	1960	465	16	I	1800/--	4248	do.	80.14	5414
42/37-29ba1	Buffalo Ranch	1962	514	16	I	- -	4200	do.	46.10	--
42/37-30ad1	do.	--	32	6	S	- -	4183	9-15-47	17.23	--
42/37-31ab1	- - -	--	--	-	S	- -	4169	3-13-64 3-26-64	26.09 18.08	--
42/37-31ac1	Brinkerhoff	1964	300	16	I	- -	4168	do.	19.91	--
42/37-32aa1	Runow	1964	380	16	I	- -	4201	3-11-64	40.03	--
42/37-33aa1	J. J. Kern	--	80	6	U	- -	4250	9-12-47	62.90	--
42/37-33aa2	do.	--	75	30	U	- -	4245	3-11-64 9-13-47	Dry 57.78	--
42/37-33aa3	Jim Dorian	1963	200	10	S	- -	--	3-11-64 do.	Dry 81.79	--
42/37-33ba1	H. A. Drees	1955	320	16	I	1680/83	4220	3-24-64	52.07	3023
42/37-33ba2	do.	1922	80	12	D	- -	4220	9-13-47	43.62	--
42/37-33bb1	do.	--	33	12	Des.	- -	4203	do.	28.44	--

Table 20.--Continued

Well number	Owner	Date drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement: Date	Water-level measurement: Depth	State log number
42/37-33bc1	H. A. Drees	--	39	6	Des.	- -	4197	9-13-47	26.45	--
42/37-33bd1	Solomon	1948	95	18	O	- -	4215	8-15-48	38.00	459
								3-10-64	50.75	
42/37-33ca1	T. C. Barber	1950	200	16	I	- -	4220	3-29-51	42.68	1432
								3-10-64	49.31	
42/37-33dd1	Melvin Smith	1960	310	16	I	- -	4240	do.	68.12	5134
43/36-2aa1	Home Ranch	--	22	12	S	- -	4171	3- 3-64	4.40	--
43/36-2da1	do.	--	--	-	S	- -	4169	do.	2.76	--
43/36-4ad1	do.	--	20	6	S	- -	4174	2-28-64	7.81	--
43/36-10bb1	do.	1930	45	6	S	- -	4172	9-19-47	8.45	--
								2-28-64	8.04	
43/36-11ca1	- - -	--	--	-	S	- -	4168	--	- -	--
43/36-12dd1	- - -	--	51	12	S	- -	4174	3- 5-64	8.88	--
43/36-14ab1	- - -	--	69.7	8	S	- -	4171	3- 3-64	3.75	--
43/36-14ca1	Home Ranch	--	--	12	S	- -	--	do.	6.54	--
43/36-15ad1	do.	--	--	8	S	- -	--	do.	6.02	--
43/36-26ac1	U.S. Geological Survey	1963	24	2	O	- -	4163	2-27-64	11.97	--
43/36-27ca1	Frank McErquiaga	--	--	-	S	- -	4155	2-28-64	3.35	--
43/36-27cc1	do.	1961	385	16	S,I	- -	4152	2-27-64	3.07	6197
43/36-33dc1	Henry McErquiaga	1954	62	8	S	- -	--	2-28-64	8.34	2954
43/36-34cc1	Frank and John McErquiaga	1964	375	16	I	- -	--	--	- -	7771
43/37-3cb1	Henry Lomax	1962	265	16	I	- -	4300	3-12-64	122.43	6672
43/37-3dd1	Paul Kochis	1961	465	16	I	- -	4400	3-12-64	217.26	6171
43/37-4ca1	Norris and Collins	--	42	6	Des.	- -	4230	9-18-47	32.05	--
43/37-4cb1	C. S. Collins	1941	56	6	O	- -	4219	7-16-47	17.74	--
								3-12-64	36.52	

Table 20.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement		State log number
								Date	Depth	
43/37-5cb1	Home Ranch	1950	50	10	S	- -	4194	3- 5-64	17.80	--
43/37-6ca1	Willow Creek Ranch	--	--	12	S	- -	4179	do.	11.05	--
43/37-6da1	do.	1958	390	16	I	2200/84	4185	3- 5-64	14.17	4762
43/37-7bd1	do.	--	--	12	S	- -	4177	do.	9.[illegible]5	--
43/37-7dd1	do.	1961	500	16	I	2000/80	4180	5-21-64	1[illegible].60	--
43/37-8ad1	C. W. Jackson	1957	560	16	I	- -	4229	[illegible]-27-64	46.93	4003
43/37-8bc1	do.	1960	435	16	I	- -	4195	3-12-64	25.73	6713
43/37-8bc2	do.	1961	71	10	-	- -	4195	--	--	6714
43/37-8dc1	- - -	1925	64	6	U	- -	4212	9-18-47	22.54	754
								3-10-64	34.00	
43/37-8dd1	Lodd and Tilbury	1956	256	16	I	1900/45	4230	3-12-64	48.18	3343
43/37-9ac1	- - -	--	--	8	S	- -	4265	3-13-64	86.38	--
43/37-9da1	Jackson	1961	725	16	I	- -	4235	3-12-64	105.54	--
43/37-10ad1	McDixon	1960	510	16	I	- -	4415	do.	228.02	5373
43/37-13cb1	Rebel Creek Ranch	--	70	6	D	- -	--	--	--	--
43/37-16aa1	Valley Farm	1957	425	16	I	- -	4302	3-13-64	116.65	3766
43/37-16bd1	Lee Jordan	1958	536	16	I	1800/58	4260	3-12-64	77.15	5096
43/37-16da1	Valley Farm	1955	320	16	I	- -	4301	do.	105.61	2893
43/37-16da2	do.	--	--	16	U	- -	4301	3-13-64	111.14	--
43/37-16da3	do.	--	225	-	D	- -	--	--	--	--
43/37-17aa1	Wm. C. Wildman	1954	247	16	I	- -	4231	3-12-64	50.05	2591
43/37-17da1	do.	1958	410	16	I	2000/71	4228	do.	50.50	4127
43/37-17db1	do.	--	--	6	U	- -	4206	3-26-64	34.22	--
43/37-18cc1	U.S. Bureau of Land Management	1940	68.7	6	U	- -	4172	9-17-47	10.34	--
								3- 5-64	10.48	
43/37-18db1	- - -	--	--	6	U	- -	4177	do.	10.14	--
43/37-20aa1	R. A. McClintick	1956	346	16	I	2300/41	4223	3-12-64	52.01	3392

Table 20.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Depth	State log number
43/37-20ab1	R. A. McClintick	1920's	--	12	I	640/--	4213	9-17-47	33.70	--
								3-12-64	40.92	
43/37-21aa1	Chas. Jordan	1957	465	16	I	- -	4290	do.	95.99	3701
43/37-21ba1	do.	--	525	16	D,I	- -	4255	do.	70.90	4151
43/37-26cc1	P. Christensen	1964	406	16	I	- -	4335	6- 6-64	120.97	--
43/37-27ca1	E. H. & John Brandt	1956	385	16	I	1600/--	4281	3-12-64	75.33	3377
43/37-28ac1	Brandt	1946	57	12	D,O	- -	4240	10- 9-46	9.55	--
								3-12-64	37.01	
43/37-28ac2	do.	1954	320	16	I	1450/70	4240	do.	38.72	2547
43/37-28ad1	do.	1959	420	16	I	1300/47	4255	do.	50.79	4720
43/37-28ba1	Peter & Bessie Christensen	1957	204	16	I	- -	4226	do.	52.77	3709
43/37-29ab1	- - -	--	--	8	S	- -	--	do.	30.52	--
43/37-29ac1	- - -	--	--	16	I	- -	4201	do.	31.92	--
43/37-29bb1	Marvin Baldwin	1960	204	16	I	- -	4184	do.	18.29	5206
43/37-29cd1	Myrtle Baldwin	1960	270	16	I	- -	4194	do.	30.23	5207
43/37-29da1	Herman Loest	--	31	48x72	U	- -	4201	9-18-47	30.02	--
								3-10-64	Dry	
43/37-30dd1	U.S. Geological Survey	1963	46	2	O	- -	4182	3-25-64	16.57	--
43/37-31cd1	- - -	--	--	6	S	- -	4173	2-28-64	14.97	--
43/37-32aa1	Dufferina	1964	480	16	I	- -	4212	3-12-64	41.60	--
43/37-32dd1	Pine Grove Farm	1949	678	12	I	- -	4219	1-20-50	21.40	2195
								3-12-64	53.31	
43/37-32dd2	do.	1949	117.5	6	Des.	- -	4219	1-20-50	45.69	--
43/37-33aa1	do.	1956	328	20	U	- -	4246	3-12-64	43.36	3676
43/37-33ca1	do.	--	--	16	I	- -	4230	3-13-64	62.73	--

Table 20.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
43/37-33cd1	Pine Grove Farm	1953	460	12	I	- -	4234	3-12-64	66.84	2249
43/37-33da1	do.	--	95	6	Des.	- -	4242	9-17-47	65.95	--
43/37-33da2	do.	--	100	8	Des.	- -	4242	1-15-64	63.60	--
43/37-33da3	do.	--	90	6	U	- -	4242	3-12-64	67.39	--
43/37-33da4	do.	--	145	10	S	- -	4239	do.	67.62	--
43/37-33da5	do.	1961	500	16	I	1760/90	4250	do.	80.43	5979
43/37-34cb1	do.	1952	515	12	U	- -	4260	6-27-50	20	2197
								3-12-64	47.11	
43/37-34cc1	do.	1949	488	12	U	- -	4261	do.	46.51	2194
43/37-34cd1	do.	--	735	16	I	- -	4270	do.	53.30	--
43/37-34dc1	do.	--	52	12	U	- -	4289	9-12-47	40.08	--
								3-12-64	Dry	
43/37-35ba1	Nevada Highway Department	1941	140	6	U	- -	4335	9-16-47	94.45	--
								3-26-64	128.14	
43/37-35bb1	Orovada School	1960	186	10	PS	- -	4310	--	--	5350
43/37-35bb2	Paul Sweeney	1959	150	8	PS	- -	4330	2-28-64	125.16	--
43/38-7ac1[a]/	J. Rice	--	--	-	D	- -	--	3-26-64	flows	--
44/36-8ca1	Home Ranch	--	--	8	S	- -	--	2-28-64	6.47	330
44/36-13bd1	do.	--	--	12	S	- -	4190	2-29-64	9.99	--
44/36-14cc1	do.	--	76	12	S	- -	4200	do.	17.74	--
44/36-15c1	U.S. Bureau of Land Management	--	413	16	-	- -	--	--	--	2936
44/36-22dd1	do.	1951	420	16	U	- -	4215	2-28-64	34.70	1835
44/36-23ab1	Home Ranch	--	--	12	S	- -	4191	2-29-64	14.15	--
44/36-24aa1	do.	--	--	12	S	- -	--	--	--	--
44/36-24ca1	do.	--	--	-	S	- -	4184	2-27-64	8.22	--

Table20 .--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
44/36-25cd1	Home Ranch	1946	19	12	S	- -	4176	9-23-47	7.16	--
								2-29-64	5.87	
44/36-26ac1	U.S. Bureau of Land Management	--	--	-	S	- -	4179	2-28-64	8.24	--
44/36-26bb1	do.	1954	35	10	S	- -	4194	do.	11.28	--
44/36-26dd1	do.	--	--	12	S	- -	4177	2-29-64	8.12	--
44/36-33bc1	Home Ranch	1954	95	6	S	- -	4179	5-12-64	7.00	384
44/36-34ac1	do.	--	--	12	S	- -	4179	2-28-64	11.42	--
44/37-2aa1	Helen Ball	1960	410	16	I	- -	4362	3-12-64	151.42	5107
44/37-2cd1	Lydia Lomax	1959	111	16	U	- -	4332	--	--	4452
44/37-2dd1	Kenneth Wedel	--	520	16	U	- -	--	--	--	5410
44/37-3aa1	Harman	1964	320	16	I	- -	--	3-28-64	80(R)	--
44/37-3da1	do.	1958	--	16	U	- -	4283	3-11-64	80.05	--
44/37-3dc1	Alice Harman	1958	350	16	I	- -	4275	do.	81.72	5032
44/37-3dd1	Hugo Harman	1958	725	16	I	1720/80	4295	do.	94.50	5034
44/37-4dd1	Clifford Donalson	1961	250	16	I	1550/34	4254	do.	62.06	6091
44/37-5bd1	Home Ranch	1954	460	16	I	2000/--	4217	3-13-64	26.65	--
44/37-6ad1	do.	--	--	-	S	- -	4211	2-29-64	21.21	--
44/37-7bc1	do.	--	--	12	S	- -	4200	do.	14.55	--
44/37-9da1	U.S. Bureau of Land Management	--	46.5	10	Des.	- -	4270	9-24-47	46.30	--
44/37-10ac1	Virgil Lammey	1962	400	16	I	- -	4297	3-11-64	99.63	6559
44/37-10ad1	do.	1958	640	12	D,I	- -	4310	do.	99.20	4214
44/37-10dc1	Mary Roeser	1955	710	12	I	- -	4323	3-12-64	140.49	3315
44/37-11bd1	Floyd Lomax	1958	68	16	I	- -	4325	3-11-64	122.48	3472
44/37-20ac1	George Hill	1960	280	16	I	- -	4235	do.	58.65	5266
44/37-20cd1	C. S. Collins	--	25	48	Des.	- -	4220	10-29-47	24.46	--
44/37-20da1	Bob Hadley	1960	450	16	I	2650/36	4251	3-11-64	67.42	5173

Table 20.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
44/37-20da2	Bob Hadley	--	150	6	D	- -	4249	--	--	--
44/37-21aa1	Orval Roeser	1960	304	16	I	- -	4300	3-11-64	109.38	5149
44/37-22bd1	U.S. Bureau of Land Management	--	--	10	S	- -	4335	3-12-64	157.74	--
44/37-25ac1	Willow Creek Ranch	--	--	-	D	- -	4595	do.	10.59	--
44/37-27cc1	Harman	1957	367	13	I	1660/29	4298	3-11-64	112.11	4038
44/37-28aa1	do.	1957	385	16	I	- -	4301	do.	109	3687
44/37-28da1	do.	1957	400	13	I	- -	4289	do.	106.08	4039
44/37-30da1	Home Ranch	--	--	12	S	- -	4197	3-13-64	22.71	--
44/37-31ca1	U.S. Geological Survey	1963	102	2	O	- -	4183	2-29-64	12.29	--
44/37-33aa1	Earl Walters	1957	550	16	I	- -	4280	3-11-64	95.04	3992
44/37-36bd1	U.S. Bureau of Land Management	1959	350	6	S	- -	4620	3-13-64	300	--
45/37-2ca1	U.S. Geological Survey	1963	37	2	O	- -	4277	do.	19.34	--
45/37-14ad1	- - -	--	--	12	S	- -	4308	3- 4-64	72.28	--
45/37-22ba1	Home Ranch	1960	423	16	I	- -	4251	--	--	--
45/37-24bc1	U.S. Bureau of Land Management	--	--	6	S	- -	4345	3- 4-64	113.55	--
45/37-27bd1	U.S. Geological Survey	1963	46	2	O	- -	4245	3-13-64	29.47	--
45/37-33bb1	Home Ranch	--	--	10	U	- -	4230	2-29-64	30.65	--
45/37-33dd1	Valenta	1947	44	12	Des.	- -	4235	10-27-47	34.12	--
45/37-33dd2	Alton Kunkel	1960	320	16	I	- -	4235	3-11-64	41.40	5636
45/37-34aa1	Alfred Woodard	1957	287	12	I	- -	4296	3-13-64	84.75	--
45/37-34da1	Chester Axtell	1954	295	16	I	1940/55	4287	3-11-64	80.04	--
45/37-34dc1	do.	1957	285	16	I	1120/--	4258	do.	56.59	--
45/37-35da1	Carl Ball	1960	390	16	I	1560/73	4368	3-12-64	154.79	--
45/38-7cd1	Arthur Moore	1960	500	16	I	- -	4385	3- 4-64	120.44	6020
45/38-28da1	Flat Creek Ranch	1948	123	6	S	- -	4665	8- 6-48	53(R)	624
								3- 4-64	54.71	
45/38-28db1	do.	--	--	12	S	- -	--	do.	11.44	--

Table 20.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
45/38-33ab1	Flat Creek Ranch	---	--	-	S	- -	--	3- 4-64	37.99	--
45/38-33ab2	do.	1950	460	12	S	- -	4710	do.	72.43	1395
46/37-24bb1	Hoppin Ranch	--	--	-	S	- -	4309	do.	5.17	--
46/38-5cb1	Nevada-Garvey Ranches	--	60	8	S	- -	4344	do.	4.15	--
46/38-5cd1	do.	--	30	10	D	- -	--	--	--	--
46/38-7a	Frank McCleary Cattle Company	--	32.5	12	Des.	- -	--	10-29-47	4.52	--
46/38-7cc1	Nevada-Garvey Ranches	--	60	8	S	- -	4244	--	--	--
46/38-9dd1	U.S. Bureau of Land Management	1947	54	6	S	- -	4455	7-16-47	7.67	--
								9-25-47	16.34	
								3- 4-64	7.73	
46/38-19ca1	- - -	--	--	-	S	- -	4318	--	--	--
46/38-19cb1	Hoppin Ranch	1925	26.5	12	U	- -	4316	9-26-47	6.20	--
								3- 4-64	5.74	
46/38-21cc1	Nevada Highway Department	--	--	10	U	- -	4375	do.	37.44	--
46/38-31cb1	U.S. Bureau of Land Management	--	--	6	S	- -	4338	do.	52.99	--
46/38-33cc1	do.	1950	100	6	U	- -	4430	3-26-64	83.08	--
47/37-1cd1	- - -	--	--	120	S	- -	4443	3-10-64	4.82	--
47/37-2ab1	- - -	--	--	100	S	- -	4460	do.	7.62	--
47/37-13ba1	- - -	--	--	-	S	- -	4443	6-19-64	4.53	--
47/37-20bd1	J. Mintaberry	--	97	6	S	- -	--	3- 5-64	10.75	3161
47/37-28dd1	Cordero Mining Co.	1941	442	6	I	- -	--	8-54	200	--
47/37-28dd2	do.	1943	510	7	I	- -	--	do.	165	--
47/37-33ac1b/	do.	1950	420	-	T	- -	4777	8-64	225	--
47/37-33db1b/	do.	--	--	-	T	- -	4847	do.	482	--
47/38-5aa1	Boat Albisu	1955	600	16	I	- -	4423	--	--	2964
47/38-5ba1	- - -	--	--	6	S	- -	4414	3-10-64	6.32	--

Table 20.--Continued

Well number		Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
47/38-5db1	Tomasa Albisu	--	13	60	Des.	- -	--	7-15-47	11.70	--
47/38-7ac1	Ralph Garfield	--	--	120	S	- -	4410	3- 5-64	8.37	--
47/38-8aa1	- - -	--	--	6	U	- -	4413	--	--	--
47/38-14dd1	Ft.McDermitt Indian Reservation	--	32	6	D	- -	4520	3-1[illegible]-64	12.36	--
47/38-17bb1	do.	--	17.8	8	S	- -	440[illegible]	3- 5-64	5.63	--
47/38-17ca1	do.	--	--	-	S	- -	4409	3- 4-64	5.24	--
47/38-17da1	John Nougue & T. Pedroli	1955	701	16	I	1060/--	4417	3- 5-64	19.47	3202
47/38-17dc1	Ft.McDermitt Indian Reservation	--	--	-	S	- -	4406	do.	6.21	--
47/38-17dd1	- - -	--	--	8	U	- -	4415	do.	12.43	--
47/38-20db1	Ft.McDermitt I dian Reservation	--	--	6	S	- -	4400	do.	7.58	--
47/38-21cb1	do.	--	30	36	D	- -	4408	do.	12.80	--
47/38-29aa1	- - -	--	--	-	S	- -	4395	do.	8.69	--
47/38-32db1[a]/	Nevada-Garvey Ranches	--	--	-	S	30	4360	3-12-64	flows	--
47/39-7cb1	Ft.McDermitt Indian Reservation	--	--	60	D	- -	4600	do.	5.32	--
47/39-8ba1	do.	--	--	6	D	- -	--	do.	2.50	--
48/37-35dd1	Lucky Seven Ranch	--	--	10	D	- -	4445	--	--	--
48/38-32da1	C. Olavarria	--	132	6	D	- -	4430	3-20-51	16.34	--
48/38-32da2	B. Albisu	1940	100	8	PS	- -	--	5-25-55	13.36	--
48/38-32db1	- - -	--	--	6	D	- -	4430	9-20-63	19.55	--

Table 20.--Continued

Well number		Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Depth	State log number
OREGON										
38/41-28cc1	- - -	--	29.5	7	D	- -	4970	10-28-47	9.60	--
38/41-32ac1	Martin Echeva	old	30	-	S	- -	--	--	--	--
38/41-33da	do.	--	100	10	U	- -	4900	10-29-63	11.03	--
38/41-33db1	do.	--	215	6	S	- -	--	--	--	--
38/41-33dd1	do.	1963	350	6	S	- -	4900	do.	112.38	--
38/41-33dd2	do.	--	330	4	-	- -	4900	- -	- -	--
39/41-1cb1	Archibald Ranch	--	--	96	S	- -	4750	3- 9-64	5.40	--
39/41-36cc1	- - -	--	--	60	D	- -	4880	10-22-64	9.65	--
39/41-36dd1	- - -	--	--	6	U	- -	4700	3- 9-64	7.93	--
39/42-3aa1	U.S. Government	--	--	6	Des.	- -	4750	7-10-54	267.1	--
39/42-32ad1	U.S. Bureau of Land Management	1955	--	8	S	- -	4525	3- 9-64	24.67	--
40/42-15bd1	- - -	--	85	6	S	- -	4400	10-29-63	6.18	--
40/42-23cd1[a]/	- - -	--	--	-	S,I	300	4400	2-12-64	flows	--
40/43-29bd1	Bankofier	--	--	60	S	- -	4700	10-22-64	8.29	--
41/42-10ac1[a]/	McCormick Ranch	--	--	-	S	20	--	3-10-64	flows	--
41/42-15bb1	do.	--	--	12	S	- -	4420	3- 9-64	7.84	--
41/42-15bb2	do.	1948	250	6	U	- -	4420	do.	8.55	--
41/42-16dc1	do.	1947	30	4 or 6	S	- -	4440	10-30-63	9	--
41/42-22ba1	Lucky Seven Ranch	--	--	96	- -	- -	4440	3-10-64	6.59	--
41/42-22bb1	do.	--	--	16	I	1150/167	4455	do.	15.76	--
41/42-23bb1	do.	--	--	96	S	- -	4435	do.	8.44	--

a. Spring
b. Data furnished by A. Kraiscovits, Desert Research Institute.

Table 21. --Selected drillers' logs of wells in Quinn River Valley, Nevada

Material	Thickness (feet)	Depth (feet)
38/36-12bc1 Hazel Bishop		
Topsoil	8	8
Clay, brown	25	33
Sand and pea gravel	9	42
Clay, brown	6	48
Sand, hard and pea gravel	4	52
Clay, brown	26	78
Sand and pea gravel	15	93
Clay, brown	24	117
Clay, soft, brown	9	126
Sand and pea gravel loose	102	228
Gravel, cemented	8	236
Sand and pea gravel	24	260
Clay, sticky, brown	67	327
Clay and shale, blue	36	363
Clay, soft, brown	29	392
Clay, sticky, alternating blue and brown beds	131	523
Clay, soft, brown	31	554
Clay, dark blue	19	573
Clay, gray blue	20	593
Clay, soft, brown	3	596
Clay, hard, brown	29	625
Sand and gravel	3	628
41/36-6cb1 - John McErquiaga		
Soil	12	12
Sand with clay seams	20	32
Gravel, clean	68	100
Gravel, large, loose	48	148
Sand	8	156
Sand, hard	44	200
Rock with sand seams	30	230
41/37-4da1 - Herbert Urwin		
Topsoil	10	10
Gravel and clay	70	80
41/37-4da1 - Herbert Urwin, cont.		
Sand and gravel	3	83
Clay and gravel	27	110
Sand and gravel	3	113
Clay and gravel	33	146
Clay, sandy	4	150
Clay and gravel	21	171
Clay, sandy	3	174
Clay and gravel	127	301
Clay	24	325
Gravel	2	327
Clay	98	425
Clay, soft, sandy	3	428
Clay	7	435
Gravel	3	438
Clay	87	525
Gravel	2	527
Clay	48	575
Gravel	2	577
Clay	73	650
Gravel	3	653
Clay	72	725
Gravel	2	727
Clay	53	780
Gravel	2	782
Gravel and sand	8	790
Gravel	5	795
41/37-8da1 - Mrs. Viola Brinkerhoff		
Topsoil	3	3
Clay, sandy	28	31
Sand	4	35
Clay and gravel	55	90
Clay, sandy	55	145
Sand and gravel with some clay	37	182
Sand, cemented with some gravel	39	221

Table 21.--(Continued)

Material	Thickness (feet)	Depth (feet)
41/37-8dal-continued, Mrs. Viola Brinkerhoff		
Clay, soft, sandy	11	232
Clay, stiff, sandy	4	236
Clay, soft, sandy and gravel	7	243
Sand and gravel, cemented	9	252
Clay with layers of sand and gravel	16	268
Clay, soft and gravel	12	280
Sand and gravel	4	284
Clay, soft, sandy	4	288
Sand and gravel	6	294
Clay, sandy	26	320
Sand and gravel	4	324
Clay	8	332
Clay, sandy	8	340
Clay and gravel	11	351
Clay, sandy and gravel	34	385
Clay	4	389
Sand and gravel	16	405
Sand	20	425
Clay, sandy	5	430
Clay, hard	34	464
41/37-21aal- G. F. Collins		
Topsoil	18	18
Clay, sandy	47	65
Clay, yellow	55	120
Gravel, large	100	220
Clay, yellow	45	265
Gravel and sand	10	275
Clay, yellow	35	310
Gravel and sand	10	320
Clay, yellow	22	342
42/37-3ddl Bob Key		
Topsoil	1	1
Sand	2	3
42/37-3ddl, continued		
Sand and gravel	17	20
Cobble stones	16	36
Clay, rocky	27	63
Sand and gravel	17	80
Clay, rocky	43	123
Sand and gravel	72	195
Clay, brown	2	197
Sand, packed	4	201
Sand and gravel	15	216
Clay, brown	2	218
Sand and gravel, cemented	16	234
Clay, yellow	7	241
Clay, rocky	18	259
Sand and gravel	11	270
Sand and gravel, cemented	12	282
Sand and gravel	6	288
Clay, rocky	9	297
Sand and gravel	19	316
Sand and gravel, cemented	4	320
Clay, rocky	22	342
Sand and gravel, cemented	8	350
Cobble stones	11	361
Sand and gravel	5	366
42/37-16aal- Florence Davis		
Topsoil	3	3
Clay, hard, white	2	5
Clay, brown	15	20
Decomposed granite	5	25
Clay, brown	10	35
Decomposed granite	7	42
Clay, brown	21	63
Decomposed granite and clay mix	23	86
Clay, brown	19	105
Decomposed granite	20	125

Table 21.--(Continued)

Material	Thickness (feet)	Depth (feet)
42/37-16aa1, continued		
Florence Davis		
Clay, brown	12	137
Decomposed granite	24	161
Clay, brown	25	186
Decomposed granite and clay mix	18	204
Clay, brown	46	250
Sand and small rocks	21	271
Clay, brown	29	300
Decomposed granite	20	320
Granite sand	92	412
Clay and sand mix	8	420
Clay	12	432
Gravel and sand	14	446
Clay	34	480
Gravel, cemented	5	485
Clay, brown	5	490
Decomposed sand and gravel	5	495
Sand and gravel	10	505
42/37-28da1-		
H. A. Drees		
Topsoil	5	5
Clay, rocky	31	36
Gravel, dry	38	74
Clay, yellow	12	86
Sand and gravel	18	104
Clay, rocky	69	173
Clay, yellow	25	198
Sand and gravel	28	226
Clay, rocky	85	311
Sand and gravel	8	319
Clay, yellow	28	347
Sand, hard	7	354
Sand and gravel	9	363
Clay, yellow	23	386
Clay, rocky	36	422
Sand and gravel	11	433
Clay, sandy	13	446
Clay, rocky	11	457

Material	Thickness (feet)	Depth (feet)
42/37-28da1, continued		
Sand and gravel	8	465
43/36-27cc-		
Frank McErquiaga		
Topsoil	23	23
Pea gravel	29	52
Clay, hard, sandy	2	54
Pea gravel	3	57
Clay, yellow	4	61
Pea gravel	39	100
Gravel, coarse and sand	41	141
Clay, hard, yellow	7	148
Pea gravel, free	7	155
Sand, fine and pea gravel	5	160
Pea gravel	11	171
Clay, yellow, sandy	3	174
Pea gravel, free	4	178
Clay, sandy, yellow	6	184
Pea gravel	16	200
Clay, hard, yellow	2	202
Sand rock	20	222
Boulders and clay	38	260
Gravel	23	283
Sand rock and gravel	9	292
Clay, sticky, yellow	46	338
Clay, brown sandy	38	376
Soap stone	2	378
Clay, sandy	7	385
43/37-6da1-		
Willow Creek Ranch		
Topsoil	9	9
Sand	8	17
Clay, soft	10	27
Sand and gravel	6	33
Clay, soft and rocks	21	54
Gravel	2	56
Clay and rock	37	93
Clay	4	97

Table 21.--(Continued)

Material	Thickness (feet)	Depth (feet)
43/37-6dal-continued, Willow Creek Ranch		
Gravel and sand	13	110
Clay	31	141
Sand and gravel	7	148
Clay and gravel	36	184
Clay	7	191
Clay and sand	45	236
Clay	38	274
Gravel	3	277
Clay	13	290
Clay and sand	22	312
Gravel	4	316
Clay	12	328
Gravel, sandy	3	331
Clay	53	384
Gravel and sand	10	394
43/37-8adl-C. W. Jackson		
Topsoil	15	15
Clay with gravel	177	192
Gravel, sharp	3	195
Clay with gravel	45	240
Gravel, sharp	3	243
Clay, soft	9	252
Gravel, sharp	2	254
Clay, soft	52	306
Gravel, sharp	6	312
Clay, soft	6	318
Gravel, sharp	4	322
Clay	98	420
Gravel, sharp	3	423
Clay, soft	15	438
Gravel, washed	12	450
Clay	2	452
Gravel, washed	15	467
Clay	5	472
Gravel, washed	13	485
Clay, tough	20	505
Sand and washed gravel	5	510
Clay, soft	15	525
43/37-8adl, continued		
Sand, granite and gravel	5	530
Clay, soft	30	560
43/37-16bd-Lee Jordan		
Topsoil	6	6
Gravel and clay	18	24
Clay, blue	50	74
Clay and gravel	66	140
Gravel and sand	20	160
Clay and gravel	50	210
Gravel and sand	50	260
Clay	20	280
Sand and gravel	50	330
Clay and rock	80	410
Sand gravel, packed	20	430
Clay	20	450
Sand and gravel	20	470
Sand and gravel, packed	50	520
Sand and gravel	16	536
43/37-28adl-Brandt Bros.		
Clay, sandy	10	10
Clay, rocky	13	23
Sand and gravel	7	30
Clay	2	32
Clay and gravel	22	54
Sand and gravel, dirty	12	66
Sand and gravel, cemented	18	84
Clay, rocky	12	96
Sand and gravel, rocky	19	115
Gravel, washed	8	123
Sand and gravel	46	169
Sand and gravel, dirty	24	193
Clay, soft	23	216
Clay, sandy and gravel	27	243
Clay, brown	13	256

Table 21. --(Continued)

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
43/37-28adl, continued			43/37-32ddl, continued		
Brandt Bros.			Gravel, cemented	5	600
Gravel, cemented	25	281	Clay	12	612
Clay, brown	19	300	Sandstone and clay	20	632
Clay, rocky, brown	5	305	Clay	23	655
Sand and gravel	3	308	Small gravel and sand	5	660
Clay, brown	57	365	Clay	5	665
Sand and gravel	2	367	Small gravel and sand	11	676
Clay, sandy	23	390	Clay	2	678
Sand and gravel	5	395			
Clay, rocky, brown	12	407	43/37-33aal-Jackson		
Sand and gravel	3	410	Soil	20	20
Clay, brown	5	415	Clay, gray	30	50
Sand and gravel	5	420	Clay, brown	20	70
			Clay, gray	10	80
43/37-32ddl-Jackson			Gravel, cemented	10	90
Soil	8	8	Sandstone	10	100
Clay	40	48	Gravel, cemented	10	110
Sand, muddy	34	82	Sandstone	10	120
Sandstone	13	95	Clay, gray	15	135
Sand, muddy	21	116	Sandstone	5	140
Sandstone	14	130	Gravel, cemented	10	150
Sand, muddy	23	153	Clay, brown	15	165
Sand and pea gravel	2	155	Gravel, cemented	20	185
Sand, muddy	24	179	Clay, brown	5	190
Clay	7	186	Clay and gravel,		
Sand and pea gravel	3	189	water-bearing	10	200
Sand, muddy	11	200	Clay, brown	10	210
Sand and pea gravel	2	202	Sandstone	5	215
Clay	16	218	Clay, gray	10	225
Gravel, cemented	4	222	Sandstone	10	235
Clay, sandy	12	234	Clay, gray	20	255
Sand, coarse, muddy	6	240	Clay, blue	25	280
Clay, sandy	64	304	Clay, gray	5	285
Sand	6	310	Gravel	5	290
Clay	103	413	Clay, gray	10	300
Sand and pea gravel	6	419	Gravel	10	310
Clay	25	444	Clay, gray	10	320
Sand and pea gravel	6	450	Clay and gravel	8	328
Clay	118	568	Clay and stringers		
Gravel, cemented	7	575	of gravel	12	340
Clay	20	595	Clay	85	425

Table 21.--(Continued)

Material	Thickness (feet)	Depth (feet)
43/37-33aal, continued Jackson		
Gravel	3	428
Clay	10	438
Sand and gravel	4	442
Clay	11	453
Gravel	2	455
Clay with occasional stringers of sand	620	1075
43/37-34ccl-Pine Grove Farm		
Soil	16	16
Sand, muddy, and silt	52	68
Pea gravel, muddy	8	76
Clay, brown	14	90
Clay, brown, sticky	8	98
Sand, muddy	24	122
Sandstone, hard	6	128
Pea gravel, muddy	15	143
Gravel and clay	9	152
Sand, muddy	5	157
Sandstone	5	162
Clay, brown	22	184
Sand and gravel, cemented	10	194
Clay, hard, blue	10	204
Clay, soft, blue	19	223
Gravel, cemented	6	229
Clay, soft, white	2	231
Sandstone, hard	3	234
Clay, gray	9	243
Sandstone, hard	3	246
Clay, brown	39	285
Gravel, cemented	3	288
Clay, gray	4	292
Gravel, cemented	8	300
Clay, brown	14	314
Clay, gray	20	334
Gravel, cemented	36	370
Clay, brown	20	390
Gravel, cemented	5	395
43/37-34ccl, continued		
Clay, brown	18	413
Sandstone	3	416
Clay, sandy, gray	4	420
Sand, coarse, firm	5	425
Clay, gray	15	440
Sand and pea gravel	4	444
Clay	2	446
Sand and gravel, firm	5	451
Sand and pea gravel	4	455
Sandstone	5	460
Sand and gravel	10	470
Gravel, cemented	3	473
Sand and pea gravel	6	479
44/36-22ddl-Home Ranch		
Topsoil	9	9
Gravel, coarse	13	22
Clay, brown	66	88
Clay and gravel	57	145
Clay, blue	70	215
Clay and gravel	123	338
Clay, blue	82	420
44/37-4ddl-Clifford Donalson		
Topsoil	12	12
Sand and gravel	32	44
Clay, sandy	2	46
Sand and gravel	19	65
Sand and gravel, loose	8	73
Clay, sandy, hard	15	88
Sand and gravel	12	100
Clay and shale	3	103
Sand and gravel	77	180
Clay	9	189
Sand and gravel	61	250
44/37-5bal-Home Ranch		
Soil	17	17
Gravel	54	71
Clay with gravel	94	165
Clay	15	180

Table 21.--(Continued)

Material	Thick-ness (feet)	Depth (feet)
44/37-5ba1, continued Home Ranch		
Clay with some gravel	75	255
Clay	205	460
Sand with some pea gravel	7	467
Clay	28	495
Gravel	3	498
44/37-10dc1-Mary Roeser		
Gravel soil	6	6
Cobbles and clay	69	75
Sand and gravel, loose	7	82
Sand and gravel, coarse	48	130
Clay, brown	10	140
Sand and gravel, loose	40	180
Clay and gravel	12	192
Sand and gravel, loose	13	205
Sand and gravel, cemented	10	215
Sand and gravel, fine, cemented	15	230
Gravel, loose, coarse	12	242
Gravel conglomerate, red	52	294
Clay with gravel, brown	46	340
Gravel, cemented	15	355
Clay with gravel, brown	35	390
Gravel conglomerate, red	20	410
Gravel, cemented, red	25	435
Gravel with clay, hard	38	473
Conglomerate, red	97	570
Clay, brown	22	592
Sand and gravel, cemented	18	610
Clay, brown	5	615
Sand, cemented	5	620
Clay, brown	10	630
Sand, cemented	5	635
Clay, brown	10	645
44/37-10dc1, continued		
Sand and gravel, conglomerate	10	655
Clay, brown	5	660
Sand, cemented	15	675
Clay, brown	25	700
Sand	10	710
44/37-20da1-Bob Hadley		
Topsoil	2	2
Hardpan	1	3
Gravel	9	12
Gravel and clay	18	30
Gravel and sand	22	52
Gravel	18	70
Clay, brown	4	74
Gravel and sand	40	114
Clay, brown	6	120
Gravel	12	132
Clay, brown	5	137
Gravel	27	164
Clay, brown	4	168
Gravel	4	172
Clay, brown	11	183
Gravel	18	201
Clay, brown	3	204
Gravel, loose	18	222
Clay, sticky, brown	228	450
44/37-27cc1-Harman		
Topsoil	2	2
Gravel, loose	6	8
Gravel, cemented	9	17
Clay with large gravel	13	30
Gravel, loose	5	35
Clay and gravel	14	49
Gravel, cemented	16	65
Clay and gravel	40	105
Gravel, loose	105	210
Gravel, cemented	35	245
Gravel, loose	19	264
Gravel, cemented	80	344

Table 21.--(Continued)

Material	Thickness (feet)	Depth (feet)
44/37-27cc1, continued Harman		
Large gravel and cobbles, loose	23	367
45/37-22ba1 Home Ranch		
Topsoil	20	20
Clay, rocky	130	150
Sand, black	13	163
Clay, yellow	47	210
Clay, gray	7	217
Sand, hard	5	222
Sand, black	9	231
Clay, yellow gray	15	246
Sand, hard	8	254
Sand, black	9	263
Clay, yellow	21	284
Sand, hard	9	293
Sand, black	19	312
Clay, yellow	72	384
Sand, hard	12	396
Sand, black	27	423
45/38-7cd1-Arthur Moore		
Topsoil	4	4
Gravel	136	140
Clay, sandy	30	170
Clay	30	200
Gravel	5	205
Clay	57	262
Gravel	5	267
Clay	16	283
Gravel	15	298
Clay	22	320
Gravel	11	331
Clay	16	347
Gravel	8	355
Clay	40	395
Gravel	10	405
Clay	13	418
Gravel	5	423
Clay	25	448
45/38-7cd1, continued		
Gravel	5	453
Clay	17	470
Gravel	7	477
Clay	18	495
Pea gravel	5	500
47/38-5aa1-Boat Albisu		
Soil	3	3
Clay and gravel	103	106
Gravel	10	116
Clay with stringers of gravel	154	270
Gravel	23	293
Clay and gravel	62	355
Clay, brown	217	572
Gravel and sand	8	580
Clay, brown	20	600
47/38-17da1- Nouque and Pedroli		
Soil	4	4
Gravel	6	10
Gravel, Clayey	2	12
Gravel, water-bearing	16	28
Gravel, cemented	37	65
Clay, gravelly	2	67
Gravel, cemented	47	114
Clay, soft, sandy	6	120
Gravel, cemented	48	168
Clay, brown	11	179
Gravel, cemented	14	193
Clay, gray and gravel	26	219
Gravel, clayey	47	266
Clay, sandy, brown	21	287
Gravel, hard, cemented	14	301
Clay, sticky, gray	21	322
Gravel, cemented	78	400
Clay, sandy, gray	11	411
Gravel, cemented and boulders	43	454

Table 21.--(Continued)

Material	Thick-ness (feet)	Depth (feet)
47/38-17dal - continued		
Nouque and Pedroli		
Clay, sandy, brown	7	461
Gravel, cemented	19	480
Clay, sandy, brown	11	491
Gravel, cemented	11	502
Clay, gravelly	24	526
Clay, sticky	2	528
Gravel, cemented	8	536
Clay, gravelly	25	561
Volcanic rock	11	572
Clay, hard, gravelly	22	594
Volcanic rock	8	602
Clay, sticky, brown and thin sand streaks	42	644
Sandrock, porous	5	649
Clay, sandy and water-bearing sand streaks	13	662
Sand and gravel, slightly cemented	7	669
Volcanic lava rock	3	672
Gravel, hard, cemented	6	678
Sand and gravel, clayey	5	683
Clay, sticky	1	684
Sand and gravel	1	685
Clay, sticky, and thin sand-streaks	16	701

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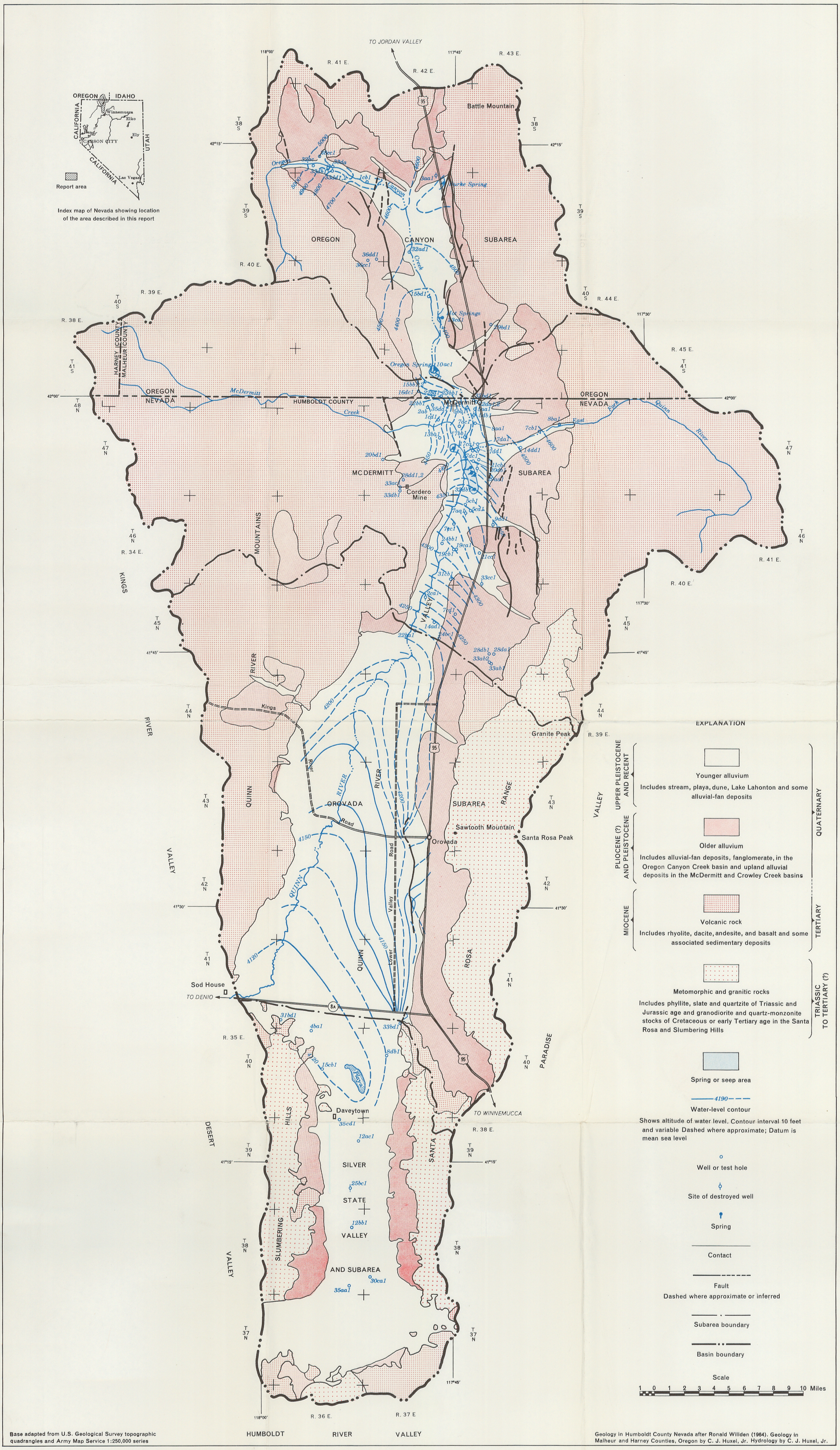

PLATE 1.—MAP SHOWING GENERALIZED GEOLOGY, SUBAREA BOUNDARIES, SPRING AND SEEP AREAS, AND LOCATION OF WELLS, TEST HOLES, AND MAJOR SPRINGS OUTSIDE THE OROVADA SUBAREA, AND WATER-LEVEL CONTOURS FOR SEPTEMBER-OCTOBER 1947, QUINN RIVER VALLEY AREA, NEVADA-OREGON

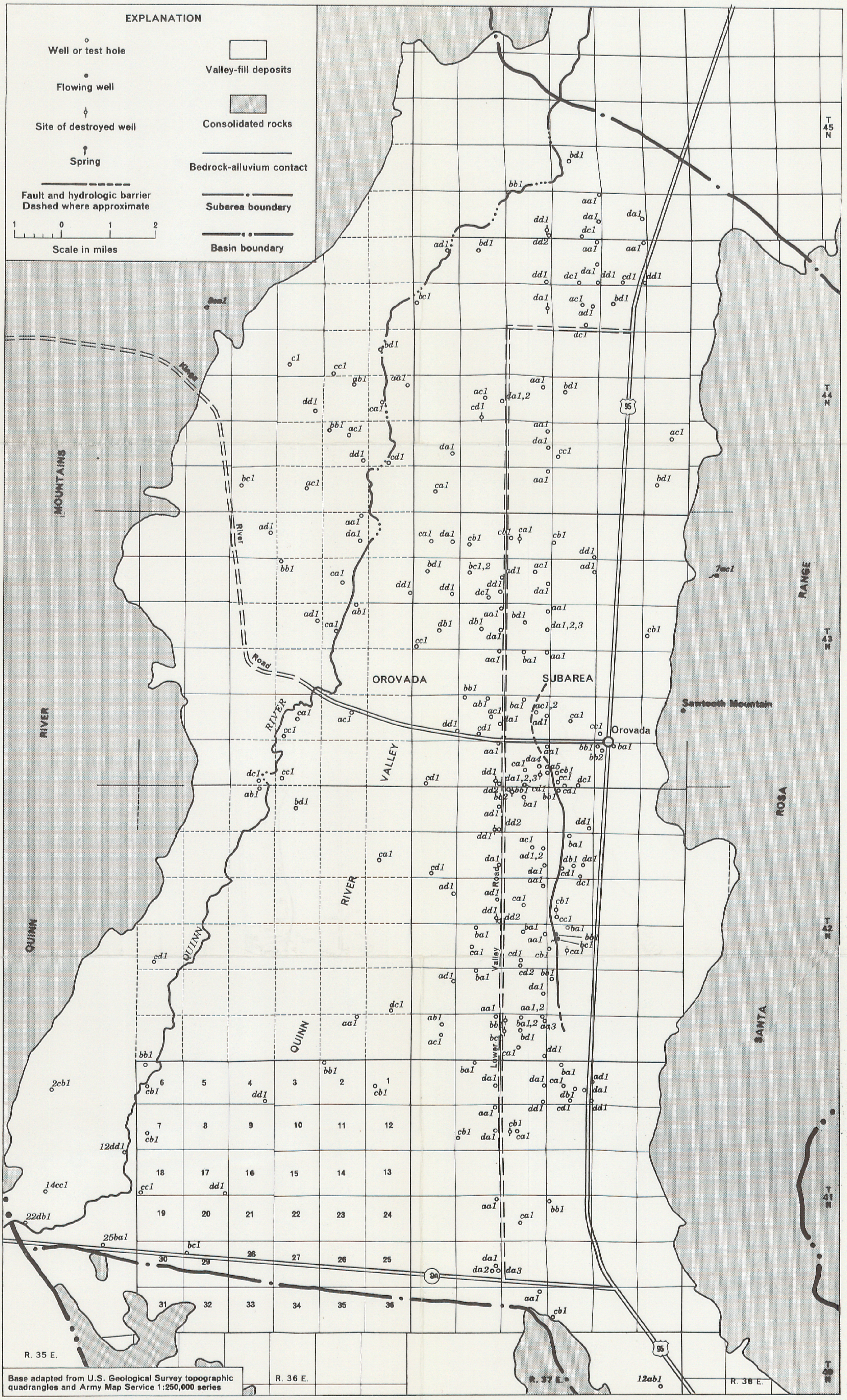

PLATE 2.— MAP SHOWING LOCATIONS OF WELLS, TEST HOLES, AND MAJOR SPRINGS IN THE OROVADA SUBAREA, QUINN RIVER VALLEY AREA, NEVADA

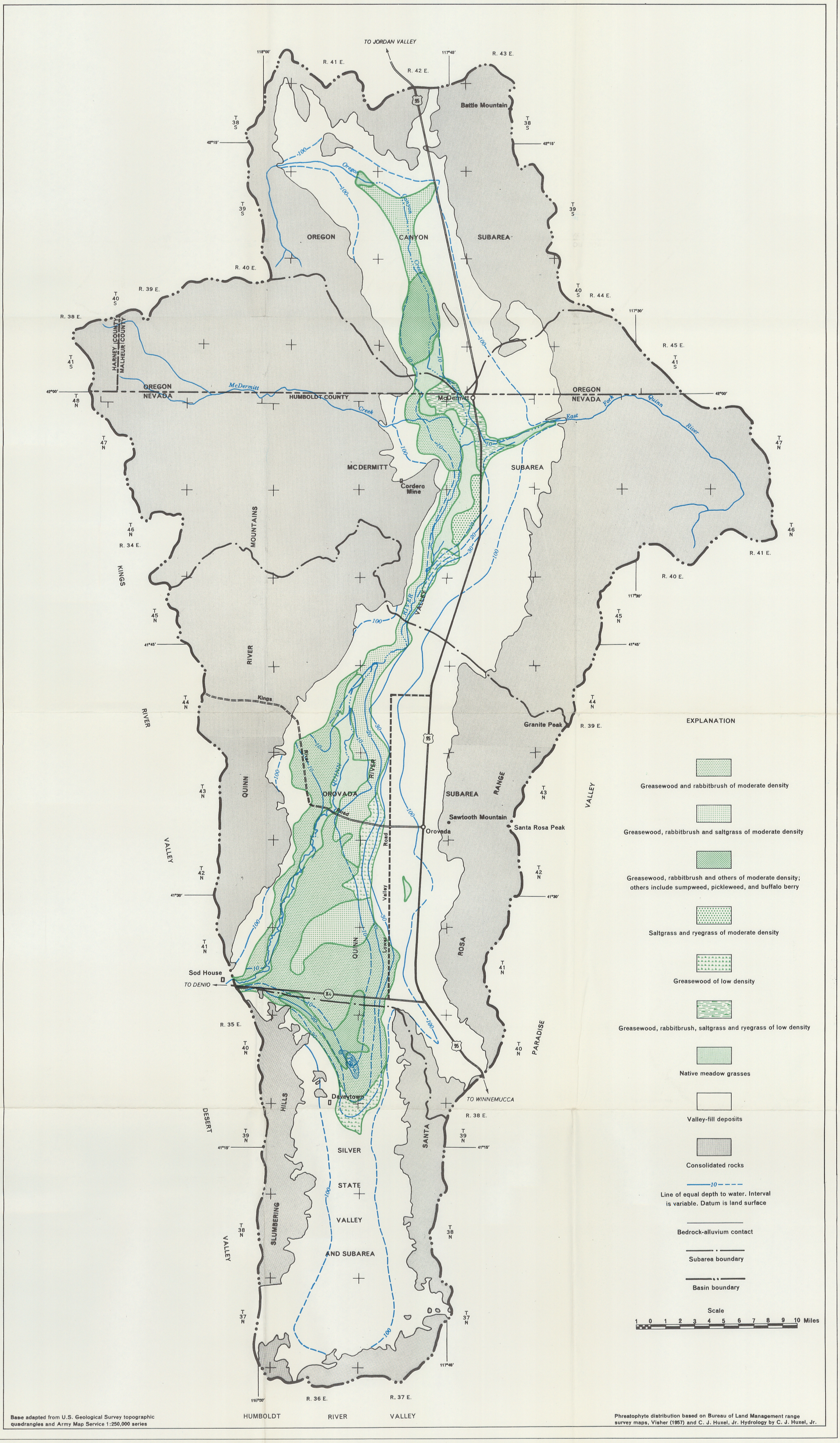

PLATE 3.— MAP SHOWING PHREATOPHYTE DISTRIBUTION AND DEPTH-TO-WATER CONTOURS FOR SEPTEMBER 1963, QUINN RIVER VALLEY AREA, NEVADA-OREGON

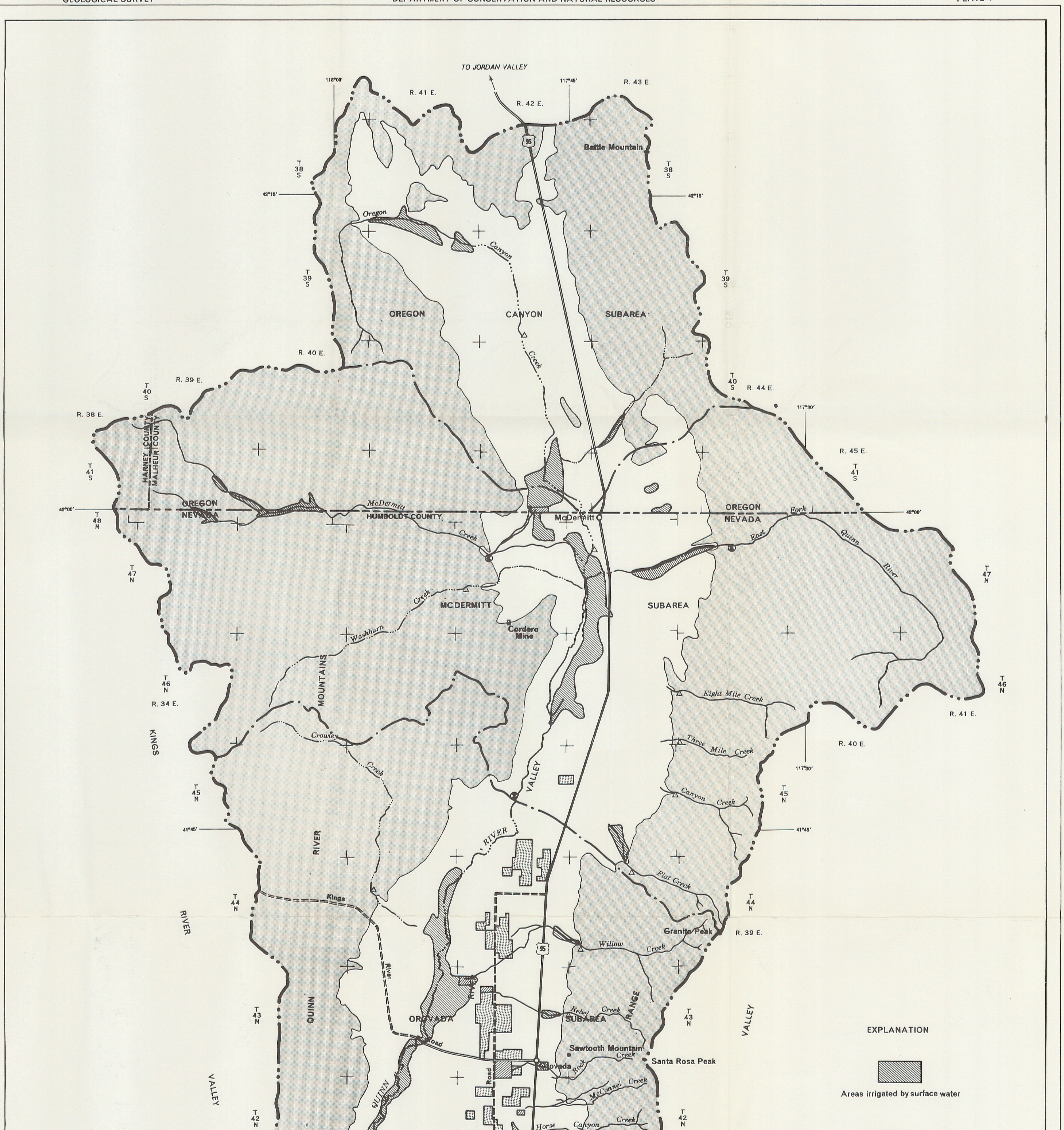

PLATE 4.— MAP SHOWING IRRIGATED LAND DISTRIBUTION AND DRAINAGE FEATURES, 1964, QUINN RIVER VALLEY AREA, NEVADA-OREGON