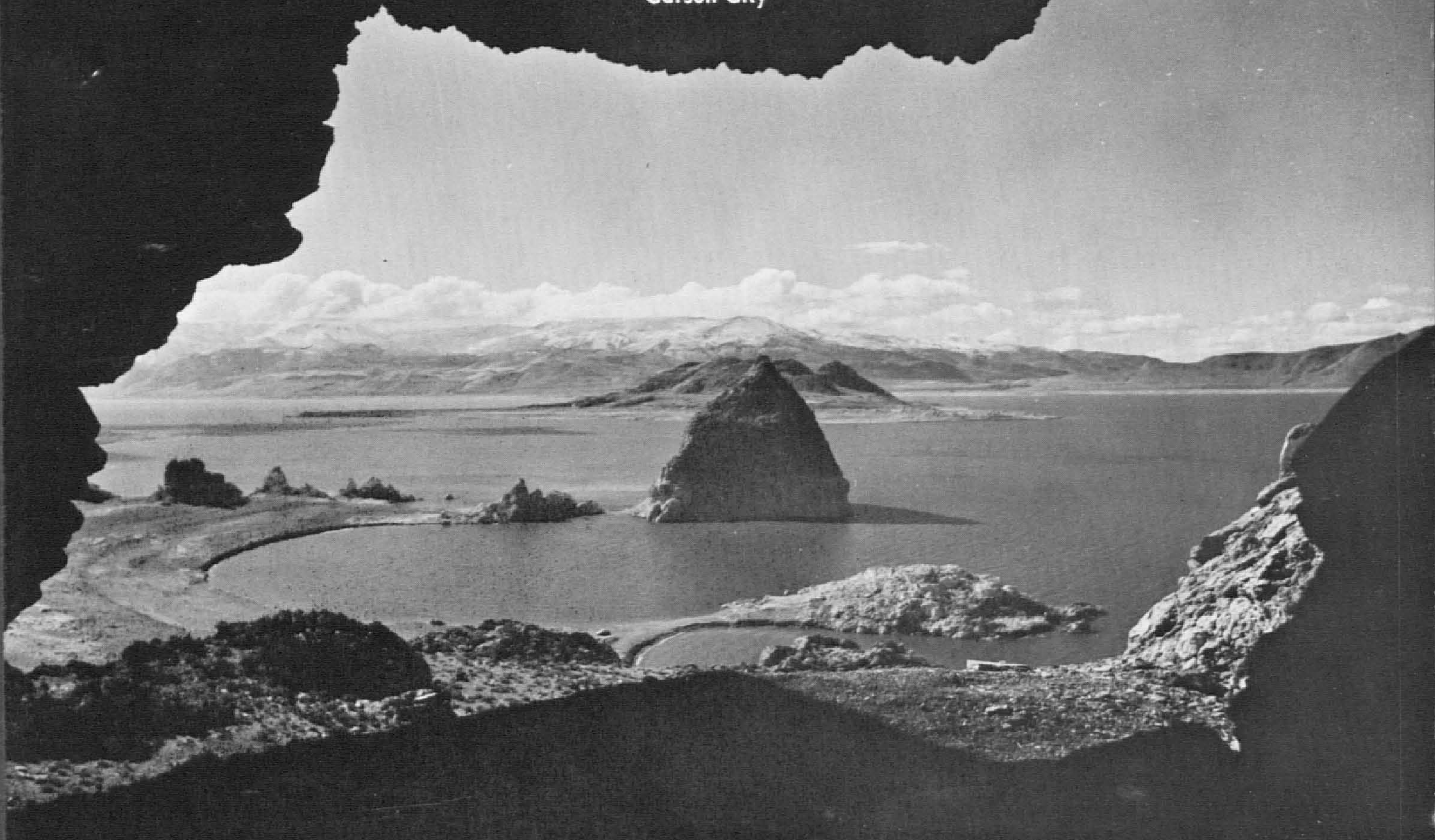
STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DIVISION OF WATER RESOURCES

Carson City



WATER RESOURCES—RECONNAISSANCE SERIES

REPORT 57

A BRIEF WATER–RESOURCES APPRAISAL OF THE TRUCKEE RIVER BASIN, WESTERN NEVADA

By

A. S. Van Denburgh,

R. D. Lamke,

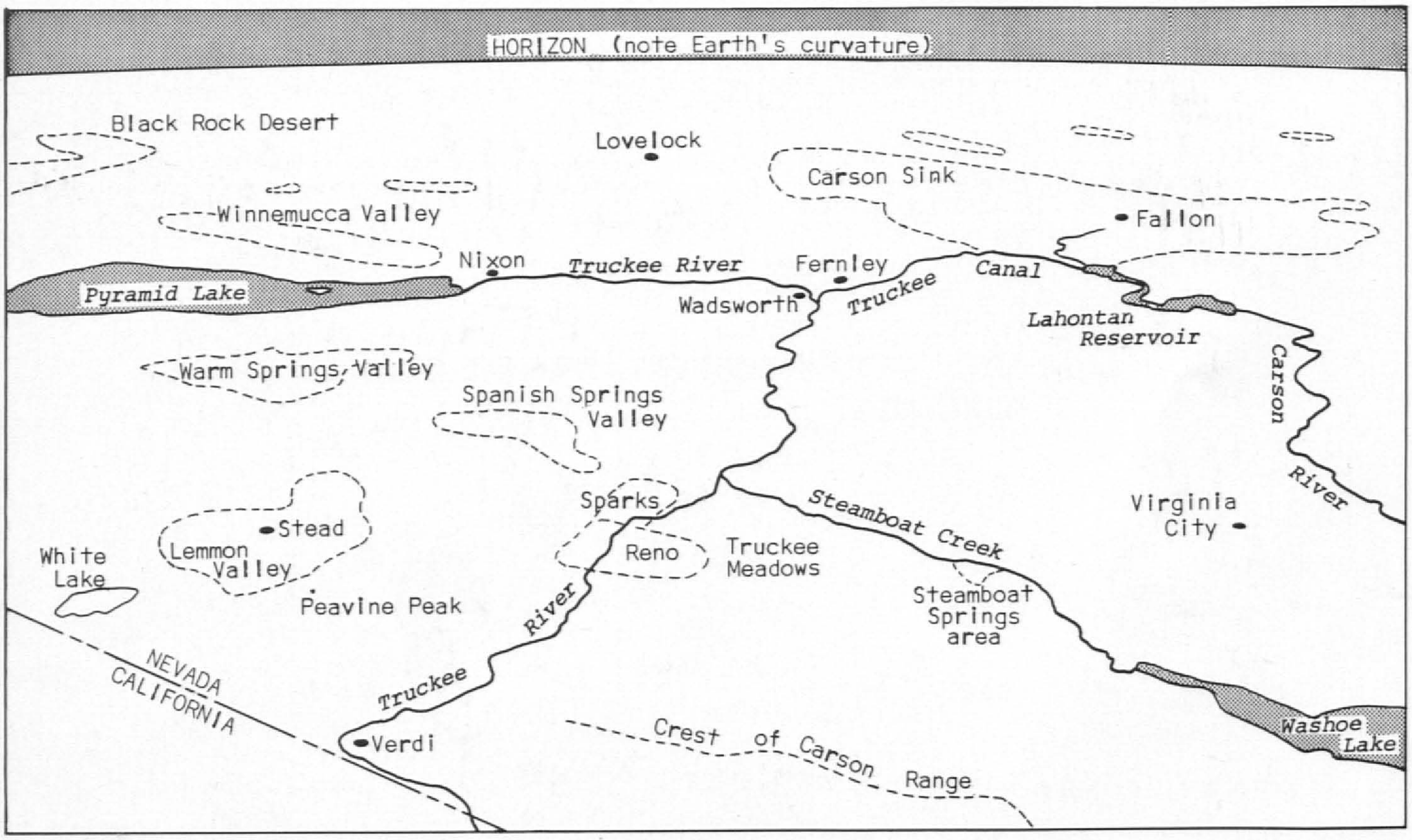
and

J. L. Hughes

Prepared cooperatively by the

Geological Survey, U.S. Department of the Interior

1973



HORIZON (note Earth's curvature)
Black Rock Desert
Lovelock
Carson Sink
Winnemucca Valley
Fallon
Nixon
Truckee River
Fernley
Truckee
Canal
Pyramid Lake
Wadsworth
Lahontan
Reservoir
Warm Springs Valley
Spanish Springs
Valley
Carson
River
Sparks
Steamboat Creek
Virginia
City
Stead
White
Lake
Lemmon
Valley
Reno
Truckee
Meadows
Peavine Peak
Steamboat
Springs
area
River
NEVADA
CALIFORNIA
Truckee
Verdi
Crest of Carson Range
Washoe
Lake

WATER RESOURCES - RECONNAISSANCE SERIES

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FOREWORD

The program of reconnaissance water-resources studies was authorized by the 1960 Legislature to be carried on by the U.S. Geological Survey in cooperation with the Department of Conservation and Natural Resources, Division of Water Resources.

This report is the 57th report prepared by the staff of the Nevada District Office of the U.S. Geological Survey. These 57 reports describe the hydrology of 202 hydrographic areas.

The reconnaissance surveys make available pertinent information of great and immediate value to many State and Federal agencies, the State cooperating agency, and the public. As development takes place in any area, demands for more detailed information will arise, and studies to supply such information will be undertaken. In the meantime, these timely reconnaissance-type studies meet the immediate needs for information on the water resources.

Roland D. Westergard
Roland D. Westergard
State Engineer

1973

Division of Water Resources

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A BRIEF WATER-RESOURCES APPRAISAL OF THE TRUCKEE RIVER BASIN, WESTERN NEVADA

By A. S. Van Denburgh, R. D. Lamke, and J. L. Hughes

SUMMARY

The study area lies at the western edge of the Great Basin, and encompasses 12 hydrographic areas (table 1) but excludes the Lake Tahoe basin. Eleven of the areas are part of the Truckee River drainage basin, and the 12th, the Fernley Area, borders the basin to the east. Altitudes in the study area range from 10,778 feet atop Mt. Rose to 3,460 feet at the deepest point in Pyramid Lake (depth, 335 feet). Precipitation averages 5 to 10 inches per year at lower altitudes, and more than 40 inches in the higher mountain areas. The study area is dominated hydrologically by Truckee River, Pyramid Lake (into which the river empties), and Truckee Canal (which carries almost half of the river flow out of the basin for irrigation use in the nearby Fernley and Fallon areas). The Reno-Sparks metropolitan area, which straddles the river in Truckee Meadows, boasts the second greatest concentration of people in Nevada.

Table 1 summarizes the quantitative hydrologic character of the 12 hydrographic areas. Within the Truckee River basin in 1969, 43,000 acre-feet of water was withdrawn for domestic, public-supply, and industrial use (much of this water returns to the hydrologic system after use). About 70 percent of the total is obtained from the Truckee River and Hunter Creek. The remainder, about 12,000 acre-feet per year, is pumped from wells, most of which are less than 300 feet deep and obtain their water from alluvium. The greatest ground-water withdrawal, about 6,600 acre-feet in 1969, is made to supply the Reno-Sparks municipal system.

Withdrawals for irrigation of lands within the study area come almost entirely from streams, and much of the withdrawals return to the system after use. Electric-power generation required nonconsumptive diversions from the Truckee River totaling almost 750,000 acre-feet during 1969.

Ground water in the study area characteristically ranges from dilute (specific conductance less than about 600 micromhos, dominated by calcium, sodium, and bicarbonate) in and near recharge areas and near streams, to saline (more than 5,000 micromhos, dominated by sodium

Table 1.--Hydrologic summary

[Reconnaissance estimates are in acre-feet per year, except as indicated; and are rounded]

Hydrographic area (in downstream order, with mainstem areas capitalized)	Area (sq mi)	Surface-water runoff at the mountain front	Potential ground-water recharge from precipitation	Inflow (I) and outflow (X) via streams for reference period 1919-69	Imported (I) and exported (X) water for reference period 1919-69	Subsurface inflow (I) and outflow (X) through alluvium	Ground water stored in upper 100 feet of saturated valley fill (acre-feet)
TRUCKEE CANYON SEGMENT, CALIF. AND NEV.[1]	80	15,000	24,000	a/509,000 I b/530,000 X	b/ X	400 I 700 X	50,000
Sun Valley	10	100	50	20 X	c/ 245 I	25 X	20,000
Spanish Springs Valley	76	1,500	600	9,000 X	16,000 I	100 X	170,000
Washoe Valley	82	23,000	15,000	1,000 X	4,000 I c/1,300 X	50 X	270,000
Pleasant Valley	39	9,000	10,000	1,000 I 8,000 X	2,000 X	50 I 300 X	30,000
TRUCKEE MEADOWS	203	22,000	27,000	b/530,000 I 480,000 X	b/ I c/17,000 X	820 I minor X	450,000
TRACY SEGMENT	285	1,800	6,000	480,000 I 245,000 X	235,000 X	2,100 I 700 X	100,000
Fernley Area	120	200	600	minor X	235,000 I 180,000 X	6,000 X	420,000
DODGE FLAT	92	200	1,400	245,000 I 250,000 X	--	2,800 I 300 X	260,000
Warm Springs Valley	247	14,000	6,000	70 X	--	200 X	420,000
PYRAMID LAKE VALLEY	672	6,400	6,600	250,000 I	--	500 I 400 X	1,900,000
Winnemucca Lake Valley	371	2,900	2,900	minor I	--	400 I	960,000
TRUCKEE RIVER BASIN[2]	2,157	96,000	100,000	509,000 I	2,000 I 240,000 X	4,600 I	4,600,000

1. Includes area tributary to river below Farad gage.
2. Includes area described in footnote 1; does not include Lake Tahoe basin or Fernley Area.
a. Inflow at State line about 520,000 acre-feet per year.
b. Flow in irrigation ditches is included with streamflow.
c. Includes municipal imports or exports as of 1969.

and chloride) in the lowest, downgradient areas. The quality of surface waters deteriorates in a downstream direction, culminating in the saline waters of Pyramid Lake (about 5,000 milligrams per liter of dissolved solids) and Fernley Sink (more than 50,000 milligrams per liter). Water of suitable quality for domestic use and public supply is available in all of the valleys studied, but problem areas do exist. The poorest quality water from wells occurs: northeast of Fernley and Wadsworth; near Nixon northwest of Pyramid Lake; in the central and eastern parts of Winnemucca Lake Valley; and north of Reno. In Truckee Meadows, manganese and arsenic are excessive at depths of more than about 250 feet, particularly in eastern parts of the valley. Warm to hot, fluoride-rich water occurs along the west side of Truckee Meadows (the water there also includes excessive arsenic) and northwest of Pyramid Lake. For agricultural use, ground water downstream from the Tracy Segment is least suitable, whereas most water in the other valleys is acceptable. The inorganic chemical character of almost all stream waters is suitable for domestic, public-supply, and agricultural use.

INTRODUCTION

Purpose and Scope of the Study

Ground-water development in Nevada has increased substantially in recent years. A part of this increase is due to the effort to bring new land into cultivation. The growing interest in ground-water development has created a substantial demand for information on ground-water resources throughout the State. Recognizing this need, the State Legislature enacted special legislation (Chapter 181, Statutes of 1960) authorizing a series of reconnaissance studies of the ground-water resources of Nevada. As provided in the legislation, these studies are being made by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources, Division of Water Resources. This is the 57th report prepared as part of the reconnaissance studies (fig. 1 and p. 117).

In the early studies, little information on the surface-water resources was presented. Later, this reconnaissance series was broadened to include a preliminary quantitative evaluation of surface water in the valleys studied.

The objectives of this brief reconnaissance are to (1) describe the hydrologic environment, (2) appraise the source, occurrence, movement, and chemical quality of water in the area, (3) estimate average annual potential recharge to the ground-water reserviors, (4) evaluate the surface-water resources of the valleys, (5) provide preliminary estimates of stored ground water, (6) estimate present water development in the area, and (7) evaluate the gross water resources of the several hydrographic areas. Most of the hydrologic field work for this report was done by the authors between July 1969 and April 1970.

Location and General Features of the Area

The study area lies near the western edge of the Great Basin, along the Nevada-California State line (lat 39°10'-40°25' N., long 119°-120° W.; see fig. 1), and encompasses 12 hydrographic areas (table 2). Eleven of the areas lie in the Truckee River basin[1/], and the 12th, the Fernley Area, borders the basin to the east. Within the Truckee Canyon Segment, along the State line, two areas with different western boundaries are discussed in this report. The first includes all drainage in Nevada that is tributary to the Truckee River; for this area, the western boundary is the State line. The second

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1. The only part of the Truckee River basin in Nevada not included in this study is the Lake Tahoe Basin.

Table 2.--Physiographic summary

Name (listed alphabetically)	Area (sq mi)1/	Principal alluvial area (acres)2/	Approximate altitude (feet) Highest	Lowest
Dodge Flat	92	32,000	8,367	3,940
Fernley Area	120	53,000	7,260	4,005
Pleasant Valley	39	6,400	10,778	4,595
Pyramid Lake Valley	672	240,000	8,722	3,450
Spanish Springs Valley	76	21,000	7,404	4,410
Sun Valley	10	2,500	5,890	4,560
Tracy Segment	285	19,000	8,035	4,045
Truckee Canyon Segment3/	75	5,600	10,610	4,640
Truckee Meadows	203	56,000	10,778	4,370
Warm Springs Valley	247	52,000	8,722	4,205
Washoe Valley	82	18,000	9,900	5,010
Winnemucca Lake Valley	371	120,000	8,237	3,765

1/ From Rush (1968, table 1), except for Truckee Canyon Segment.
2/ Does not include small, isolated or nearly isolated areas of alluvium on plate 1. Total alluvial area listed, almost 630,000 acres, represents 43 percent of the entire study area.
3/ Data are for Nevada part of area only. Area in Nevada and California tributary to Truckee River below the Farad, Calif., streamflow gage totals about 80 square miles.

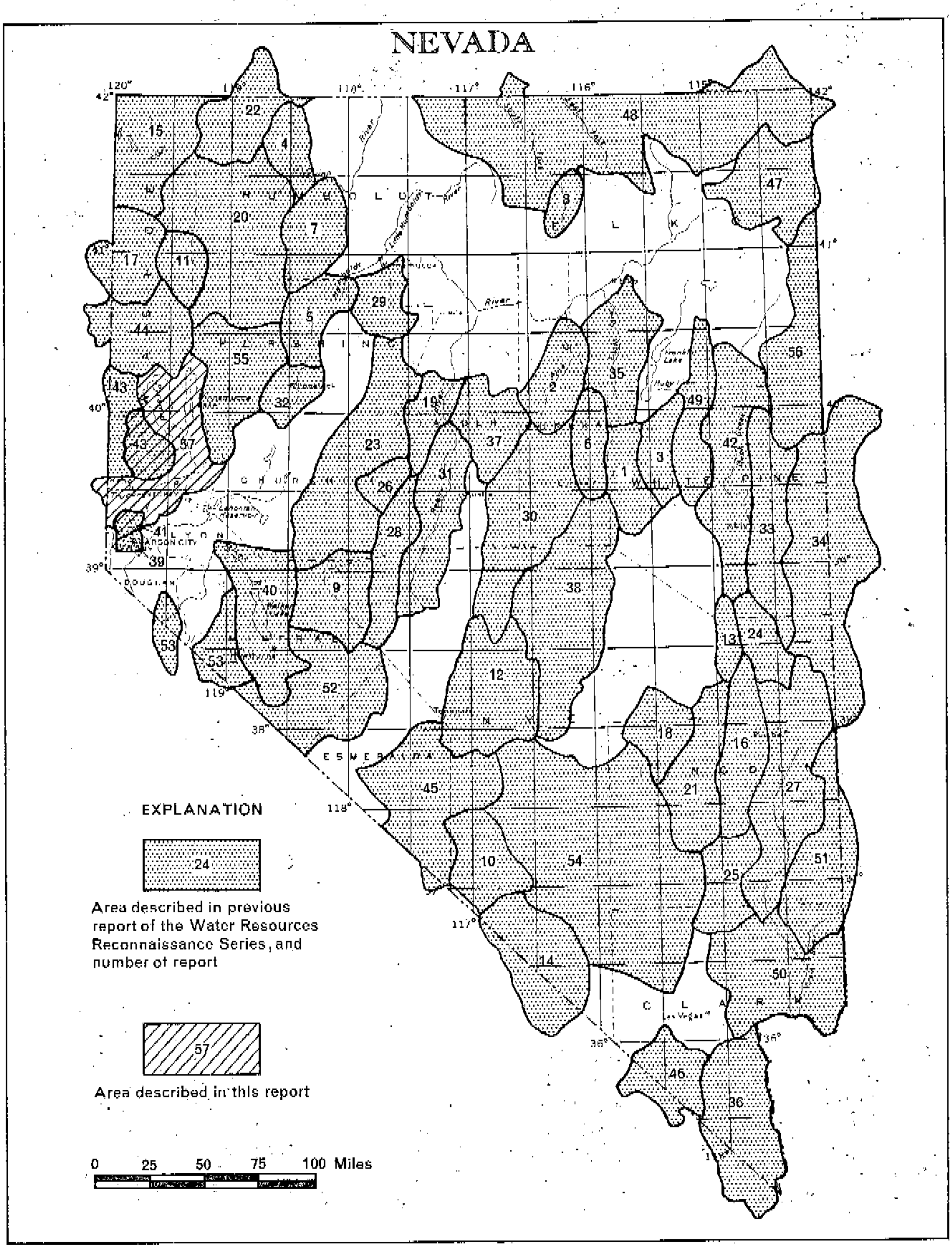


Figure 1.—Areas described in previous reports of this series, and the area described in this report

area, which is more convenient for hydrologic budget purposes, includes drainage in both Nevada and California that is tributary to the river downstream from the Farad, California streamflow gage. This area does not include drainage in Nevada that feeds the river above the gage. The relationship of these two areas is shown by the small inset map in the upper right-hand corner of plate 1.

The overall area studied includes Reno and Sparks, which together boast the second greatest concentration of people in Nevada, with a population of about 100,000. Elsewhere in the study area, population is characteristically sparse, with only a few small towns and settlements--Verdi, Wadsworth, Fernley, Nixon, and Sutcliffe--plus the residents of Sun, Pleasant, and Washoe Valleys, and the unincorporated parts of Truckee Meadows (pl. 1). Outside the commercial-industrial area associated with Reno and Sparks, the principal activity is ranching. The Pyramid Lake Paiute Indian Reservation covers about 600 square miles, including the lake itself, in the northeastern part of the study area (the reservation covers an additional 140 square miles outside the study area).

Other Studies and Data Related to Hydrology

Several parts of the present study area have already been evaluated to various degrees from a hydrologic standpoint. Selected recent reports discuss the following major areas (see "References" section for complete titles):

- Entire Truckee River basin (Pyramid Lake Task Force, 1969, 1971)
- Fernley-Wadsworth area (Sinclair and Loeltz, 1963)
- Lower Truckee River basin (Clyde-Criddle-Woodward, Inc., 1968; Wilsey & Ham, 1970)
- Pyramid Lake (Harris, 1970; Harding, 1965)
- Spanish Springs, Sun, and Warm Springs Valleys (Rush and Glancy, 1967)
- Steamboat Springs area (White, 1968)
- Truckee Meadows (Cohen and Loeltz, 1964; Guyton & Associates, 1970)
- Washoe Valley (Rush, 1967)
- Winnemucca Lake Valley (Zones, 1961)

Basic water-resources data for the study area are listed in several Geological Survey report series. Streamflow and lake-level records through 1965 are summarized in Water-Supply Papers 1314, 1734, and 1927. Records after 1965 appear in annual publications titled, "Water resources data for Nevada" (1965-69). Water-quality data for streams are published in the annual summaries titled "Water quality records in Idaho and Nevada, 1964," and "Water resources data for Nevada" (1965-69). Ground-water levels through 1965 are published in Water-Supply Papers titled "Ground-water levels in the

United States; southwestern States" (the most recent of which is no. 1855).

Reports that inventory water use and water resources in Nevada (Nevada Division Water Resources and U.S. Geological Survey, 1971 a and b) include data for the study area. Other reports of hydrologic interest are included in the section titled "References".

Several current (1971) groups and activities pertinent to hydrology of the study area are:

1. The Department of Interior Committee on Operating Criteria and Procedures, Truckee and Carson River Basins, has developed procedures to minimize the diversion of water from the Truckee River in the operation of the Newlands Project.

2. The State-Federal Pyramid Lake Task Force has investigated methods of stabilizing the lake level; their final report was released in December 1971 (see "References").

3. A Type I Comprehensive Framework Study for the Great Basin Region has been completed and presented in a series of reports prepared by a work group within the Pacific Southwest Inter-Agency Committee.

4. A hydrologic simulation model of the Truckee River basin is being developed by the Center for Water Resources Research, Desert Research Institute, University of Nevada. An outgrowth of this study is the report by Cooley and others (1971), which was released after completion of this Geological Survey reconnaissance report.

5. An investigation of water and related land resources and problems in the Truckee River basin is being made as part of the U.S. Department of Agriculture's Central Lahontan River Basin Survey. First report issued is by U.S. Forest Service and U.S. Soil Conservation Service, 1970 (see "References").

Acknowledgments

Many individual well owners throughout the report area provided helpful information. In addition, C. T. Snyder and R. E. Smith of the U.S. Geological Survey provided valuable data on well and spring locations and ground-water quality. Likewise, Eldon Dobyns and R. S. Leighton of Sierra Pacific Power Co., James Long of the U.S. Bureau of Indian Affairs, Dick Holland and Jim Schalnus of the U.S. Bureau of Land Management, P. R. Taylor of the U.S. Bureau of Reclamation, and H. E. Winchester of the State Engineer's Office contributed important information on wells and water use. The help of all these people is greatly appreciated.

GENERAL HYDROLOGIC ENVIRONMENT

Physiographic Setting

The report area is dominated to the west by the lofty Sierra Nevada, and to the east by starkley beautiful Pyramid Lake (pl. 1). The two are linked by the Truckee River, which flows eastward from the State line to Wadsworth, then northward to the lake--a total distance of about 90 river miles, with a drop in altitude of more than 1,200 feet. This reach of the river drains a system of generally north-trending mountain ranges, the highest of which is topped by 10,788-foot Mt. Rose, and valleys, including the populous Truckee Meadows. Small perennial streams, the largest of which is Steamboat Creek, and many ephemeral drainages feed the river in and upstream from the Meadows. Below Vista, all tributaries are ephemeral. The lowest point in the study area, at about 3,460 feet, is the deepest spot in Pyramid Lake. The 170-square-mile desert lake is the largest body of water lying entirely within Nevada. The lake is a remnant of pluvial Lake Lahontan, which covered a maximum area of almost 8,700 square miles in western Nevada and easternmost California during the late Pleistocene epoch, about 50,000 years ago (Morrison, 1965, p. 279; Morrison and Frye, 1965, fig. 2). The huge lake's maximum extent within the report area is shown on the small index map on plate 1.

Table 2 summarizes the physiographic features of the 12 hydrographic areas discussed in this report, and the small map in the upper left corner of plate 1 shows some of the hydrographic relationships among the areas.

Geologic Units

Rocks in the report area can be grouped in three gross geologic units: younger alluvium and older alluvium, which together form the valley-fill ground-water reservoir, and consolidated rocks. This division is based in part on hydrologic properties, though such properties vary widely depending on physical and chemical differences. The surficial extent of the three units is shown on plate 1, and their geologic and hydrologic character is summarized in table 3. The geology shown on plate 1 and summarized in table 3 was in large part adapted from Bonham (1969), Cohen and Loeltz (1964), Moore (1969), Rush (1967), Rush and Glancy (1967), Tatlock (1969), and Willden and Speed (1968).

Criteria for separating the two alluvial units are as follows: Older alluvium characteristically is unconsolidated to semiconsolidated, dissected, and locally deformed; it mostly commonly is exposed on the intermediate slopes between mountains and valley floors. Younger alluvium, in contrast, is generally unconsolidated, undissected, and undeformed; it is largely restricted to the valley lowlands and stream channels (and is generally underlain by older alluvium). In some areas the two units are difficult to distinguish, or their extent is too limited to be shown on plate 1. In such places, the two units are

Table 3.--Generalized lithologic units and their water-bearing properties

Geologic age: Period	Geologic age: Epoch	Lithologic unit[1]		Thickness (feet)[1]	General characteristics and extent[1] (See pl. 1)	Water-bearing properties
QUATERNARY	Holocene and Pleistocene	Valley fill	Younger alluvium	0-100±	Unconsolidated deposits of fluvial and lacustrine boulders, gravel, sand, silt, and clay; derived mainly from upland consolidated rocks and reworking of older alluvium, or transported into the area by Truckee River; although younger alluvium may thinly mantle the other two units in places, its hydrologic significance is mainly restricted to valley floors and stream channels.	Younger and older alluvium together form the valley-fill reservoir, the principal source of water from wells in the area; well yields are variable both in quantity (from a few gallons per minute to several thousand gallons per minute and quality, depending on lithologic character of deposits encountered, and source and quantity of recharge.
TERTIARY AND QUATERNARY	Pleistocene and Pliocene	Valley fill	Older alluvium	0-4,000+	Unconsolidated to semiconsolidated deposits of fluvial and lacustrine boulders, gravel, sand, silt, and clay; generally exposed on intermediate slopes between mountains and valley floors, and buried beneath younger alluvium; probably thickest in valley troughs; mantles consolidated rock near mountains. Includes lacustrine deposits of Pleistocene Lake Lahontan, the Truckee Formation and its equivalents, and glacial and landslide deposits. Locally includes young but unsaturated dune sand, and active alluvial-fan deposits near the mountain front northwest of Wadsworth.	
PRE-TERTIARY TO QUATERNARY	Pre-Pleistocene and Pleistocene	Consolidated rocks		--	Igneous, metamorphic, and sedimentary rocks; igneous rocks are mainly Mesozoic granitic intrusive rocks and Cenozoic volcanic rocks; metamorphic rocks include metavolcanic and metasedimentary deposits, generally of Mesozoic age or older(?); sedimentary rocks, mainly of Tertiary age, are least prevalent of major rock types, and commonly are associated with volcanic rocks.	Generally untested by wells; yield minor amounts of water to springs; can yield small amounts of water to wells locally; considered poorest water-yielding unit in area.

1. Synthesized from various reports and maps, as credited in text.

combined, and labeled as either younger or older alluvium, depending on which is thought to dominate.

Valley-Fill Reservoirs

Extent and Boundaries

Alluvium (pl. 1) forms the valley-fill reservoirs, which are the principal source of ground water in the area. The reservoirs beneath the central parts of most of the valley floors probably are at least 500 feet thick, with the valley fill in Truckee Meadows possibly thicker than 4,000 feet (Cohen and Loeltz, 1964, p. S12). Although bedrock reportedly has been encountered in wells at much shallower depths, such wells are near the bedrock-alluvium contact, where the valley fill is generally thin. The general character of valley-fill sedimentary deposits penetrated by wells in the study area is indicated by representative well logs in table 22.

External hydraulic boundaries are formed by the consolidated rocks (pl. 1), which underlie and surround the valley-fill reservoir. These boundaries are leaky to varying degrees. The principal internal hydraulic boundaries are lithologic changes and faults that cut the valley fill. The extent to which these lithologic and structural barriers impede ground-water flow is uncertain in most places.

Occurrance and Movement of Ground Water

Ground water, like surface water, moves from areas of higher head (water-level altitude) to areas of lower head. Unlike surface water, however, it moves very slowly, commonly at rates ranging from a fraction of a foot to several hundred feet per year, depending on the permeability of the deposits and the hydraulic gradient.

In the Truckee River basin, ground water moves from recharge areas in the mountains or on the adjacent alluvial slopes to the lowlands, where the water either is consumed by evapotranspiration or leaves a valley as stream and ground-water outflow. Two other less important "sink" or terminal-discharge areas are the floor of Winnemucca Lake Valley (for streamflow and ground water generated in that valley, plus an occasional small amount of nonconsumed irrigation water from the Nixon area, and Fernley Sink (for streamflow and ground-water generated in the Fernley and adjacent Bradys Hot Springs Areas, plus nonconsumed irrigation water and leakage from the Truckee Canal).

Ground-water movement from valley to valley can occur through alluvium or consolidated rocks. There is no firm evidence that sizable quantities of ground water move to, from, or between valleys of the study areas through consolidated rocks. In contrast, intervalley movement by way of alluvium involves every valley of the study area. Estimates of these quantities, though small, are made in the section titled "Subsurface inflow."

Availability of ground water in the several valleys is indicated in a general way in table 21 by well drillers' reports of the depth at which water was first encountered during drilling, by reported well yields, and by the static and pumping water levels in the completed wells.

Fluctuating ground-water levels reflect seasonal and long-term changes in the quantity of stored ground water. Table 26 lists water levels for 13 observation wells in the study area, and figure 2 shows water-level fluctuations for two additional wells. The data indicate both seasonal and long-term trends, but in general, no major long-term changes of ground water in storage have occurred. Of particular interest are minor long-term water-level declines at several of the wells: for example, between April 1959 and March 1970, the water level in well 19/19-24ccc declined about 4½ feet (fig. 2). These trends are substantiated by monthly data collected by Sierra Pacific Power Co. since 1960 from a network of observation wells in the Truckee Meadows (Guyton & Associates, 1970, p. 15). The long-term declines reflect climatic fluctuations, changes in land use and drainage (for example, from largely agricultural to largely urban in parts of Truckee Meadows), and increases in the amount of ground water withdrawn for public supply.

The level of Pyramid Lake declined about 75 feet between 1909 (shortly after completion of Truckee Canal) and 1969, largely as a result of diversion of potential inflow from the Truckee River to areas outside the basin. The lake-level decline has been accompanied by partial dewatering of the peripheral valley-fill reservoir, as evidenced by declining water levels in wells 24/21-15aca, 26/20-26adb, and 28/22-30 bcb, west and north of the lake (table 21). The total quantity of ground water lost from storage during this period is unknown, but may have averaged about 1,500 acre-feet per year.

Neighboring Winnemucca Lake last received appreciable inflow of Truckee River water in about 1910. Between then and about 1940, when the lake finally dried up, the level declined about 80 feet. Just as at Pyramid Lake, the decline caused a partial dewatering of the valley fill, as reflected in the declining water level in well 28/24-7cab, north of the lakebed. The overall quantity of ground water lost from storage at Winnemucca Lake may be of the same order of magnitude as at Pyramid Lake.

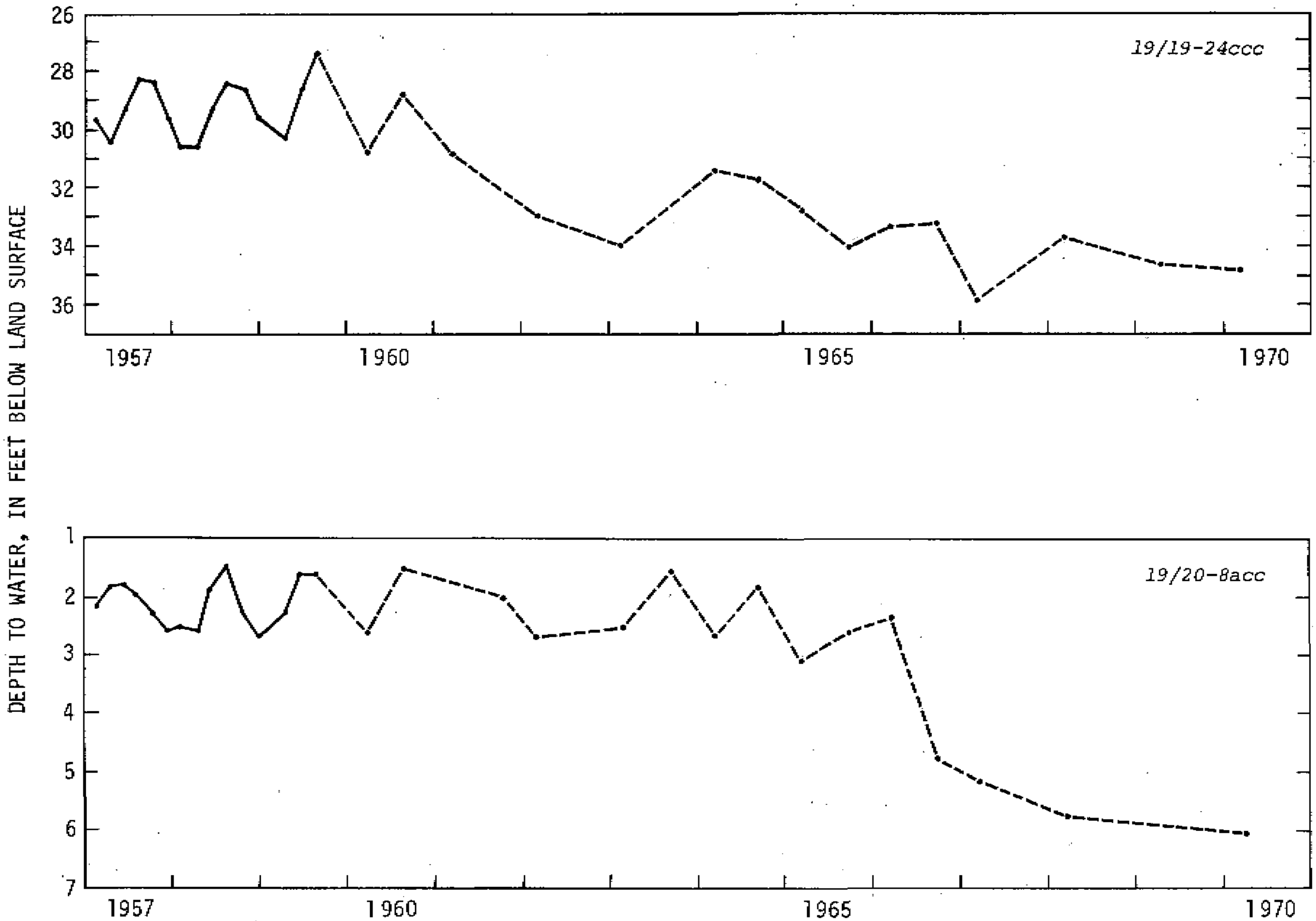
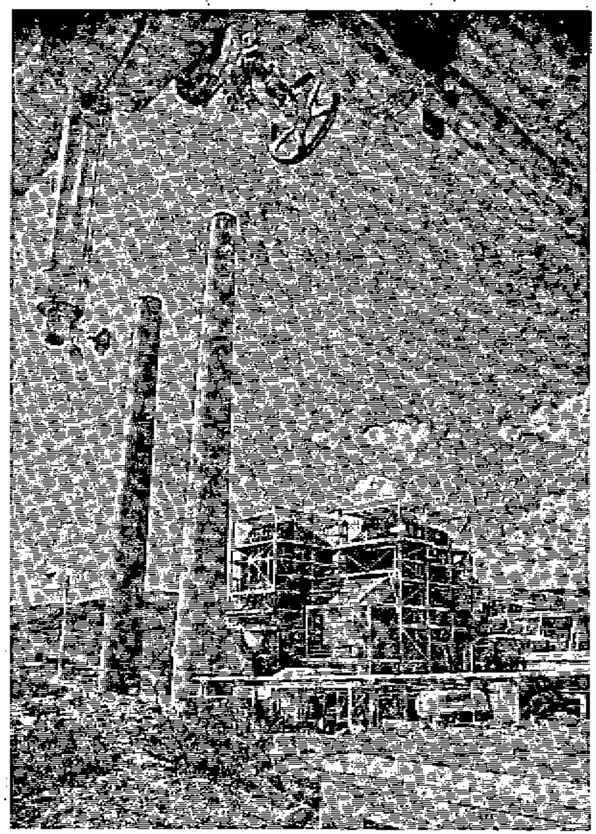


Figure 2. - Seasonal and long-term water-level fluctuations in wells 19/19-24ccc and 19/20-8acc

A



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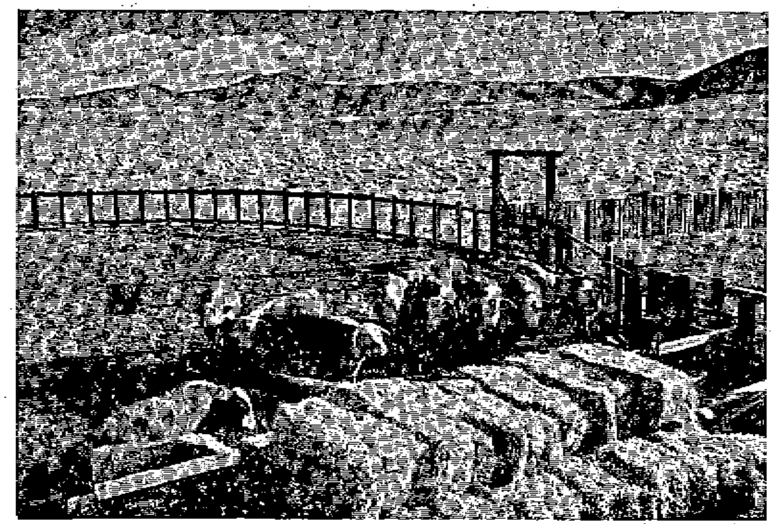

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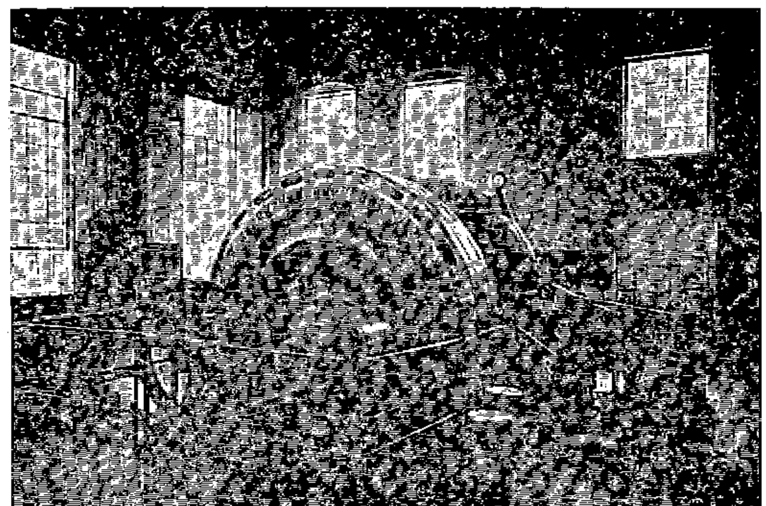


Photographs 3A-C.--A. Sierra Pacific Power Company's Tracy generation plant, on the Truckee River 17 miles east of Reno. In 1970, plant reportedly used about 50,000 acre-feet of streamflow for cooling purposes, of which almost all was returned to river. B. Bulls corralled 4 miles southeast of Nixon in February 1970, for supplemental feed prior to breeding season. Livestock throughout the Truckee River basin probably consume about 120 acre-feet of water per year. C. Generator and, behind it, turbine in hydroelectric power plant at Verdi. Plant annually uses about 225,000 acre-feet of water from Truckee River, nonconsumptively.

INFLOW TO THE VALLEYS

Precipitation

Precipitation patterns in the study area are strongly influenced by the presence of the high Sierra Nevada to the west. During the winter, storm-system airmasses moving over the Sierra lose much of their moisture crossing the mountains. The result is smaller amounts of precipitation in the study area (the rain shadow) than in areas to the west. During the summer, thundershowers associated with northward air movements provide most of the moisture (Gifford and others, 1967, p. 11).

Table 4 and the data of Hardman and Mason (1949, p. 10) show that annual precipitation in the study area averages 5 to 10 inches at lower altitudes, and more than 30 inches at the higher stations. In high mountain areas the precipitation probably exceeds 40 inches. Monthly data indicate that the dominance of winter storm precipitation over summer thundershower contributions diminishes from west to east.

Surface Water

The surface-water hydrology of the report area has been evaluated quantitatively in terms of (1) the quantities of flow entering and leaving each hydrographic area, and, insofar as possible, (2) the interactions of surface water and other components of the hydrologic system. Surface water enters Nevada in the Truckee River from California. Also, minor amounts enter from Dog Creek and from the headwaters of Third Creek in the adjacent Lake Tahoe basin. Surface water leaves the Truckee River basin by export to the Fernley Area and Carson River basin, through the Truckee Canal. Small amounts of surface water are exported from Washoe Valley for part of the municipal supply to Carson City and all the supply to Virginia City, and from Truckee Meadows to the Stead area of Lemmon Valley. Surface water is augmented by local runoff from precipitation and local ground-water inflow; it is decreased by evapotranspiration and seepage loss to ground water.

Records Available

A gaging station near the Nevada-California State line, Truckee River at Farad, has been in operation since 1899. Four other gaging stations have been operated downstream on the Truckee River for more than 40 years. Additional short-term flow records have been obtained on the main stem, diversions, and tributary streams. Also, some data on lake altitudes

Table 4.--Average annual precipitation at weather stations in and adjacent to the study area

[From published records of the U.S. Weather Bureau]

Station[1]	Location (latitude and longitude)	Altitude (feet)	Period of reliable full-year record used	Average annual precipitation for period of record (inches)	Estimated long-term average precipitation for key stations (inches)[2]
Marlette Lake	39°10'/119°55'	8,000	1930-44, 1948-52	28.5	29
Marlette Lake No. 2 (storage gage)	39°10'/119°53'	7,820	1959-65	a/ 28	28
Mt. Rose Hwy. Sta.	39°20'/119°53'	7,360	1960-63	29.1	33
Brockway Summit, Cal. (storage gage)	39°16'/120°04'	7,200	1964-67	a/ 34	31
Spooners Station (storage gage after 1942)	39°06'/119°55'	7,100	1940-42, 1954-67	27	26
Little Valley (storage gage)	39°15'/119°52'	6,300	1957-58, 1961-63, 1966-67	a/ 29	29
Virginia City	39°18'/119°38'	6,002	1953-60, 1966	7.2	9
Truckee Ranger Station, Cal.	39°20'/120°11'	5,995	1934-69	32.4	32
Boca, Cal.	39°23'/120°06'	5,575	1937-69	22.1	22
Lewer's Ranch	39°14'/119°51'	5,200	1930-36, 1938-43	25.0	26
Carson City	39°09'/119°46'	4,651	1924-69	10.9	11
Reno WB AP	39°30'/119°47'	4,404	1931-69	7.7	7.6
Sand Pass	40°24'/119°50'	4,198	1915-31, 1934-41	6.5	--
Fernley	39°37'/119°15'	4,160	1955-69	6.1	--
Sand Pass	40°19'/119°48'	3,900	1943-62, 1967-68	6.5	--
Nixon	39°48'/119°20'	3,900	1929-47, 1949, 1952	7.1	--
Nixon	39°50'/119°21'	3,898	1963-69	7.3	--

1/ In Nevada, except as noted. Stations are listed in descending order of altitude.
2/ Based on 40-year period of record, 1930-69, in small part estimated, for Truckee Ranger Station, Boca, Carson City, and Reno WB AP.
a/ Partly estimated.

and annual maximum peak discharges have been collected at gaged sites. Table 5 summarizes the availability of data for selected gages. The locations of stations listed in table 5 are shown on plate 1. Basic data on surface water are available in various U.S. Geological Survey publications and files. Additional data are available in reports or files of the U.S. Bureau of Reclamation, Federal Court Watermaster, and Truckee-Carson Irrigation District.

Flow of the Truckee River

Table 6 lists the annual flows of the Truckee River at selected gaging stations. Additional data are listed in table 7 for two short-term stations. Yearly and cumulative variations in streamflow in Truckee River at Farad, California, are shown in figure 3. Annual streamflow data listed in this report are tabulated on the basis of the "water year," which is the 12-month period, October 1 to September 30, designated by the calendar year in which it ends. Thus, the year ending September 30, 1910, is called the "1910 water year."

No attempt is made in this report to adjust the measured streamflow in the Truckee River for increasing regulation, diversions, storage, and use over the years. Various reports have given virgin-flow values for the Truckee River at Farad. For example, the California State Water Resources Board (1951, p. 511) indicates that the gaged flow was increased by 6,000 to 9,000 acre-feet annually to obtain the virgin flow for the period 1900-38. The average annual depletion upstream from Farad, for 1967 conditions, has been estimated as 16,000 acre-feet (Pyramid Lake Task Force, 1969, app. summ., p. 1 and 2). In this same report, it is estimated that average depletions in the year 2000 could range from 35,000 to 55,000 acre-feet annually.

Streamflow records were adjusted to a common reference period (water years 1919-69) to compare quantities at the several gaging stations listed in table 6. The longest continuous streamflow record, for Truckee River near Farad, spans the water years 1900-69. The record obtained at the gage below Derby Dam is continuous since 1918 (water years 1919-69; diversions from Derby Dam have been made since 1905). Although various reference periods have been used in other studies, the average flows are in reasonable agreement. Table 8 lists average annual streamflow for different reference periods taken from these reports.

Table 5.--Selected surface-water records

Site no. on pl. 1	Station number[1/]	Station name	Location[2/]	Drainage area (sq mi)	Period of record (calendar years)[3/]	Remarks
1	3365	Pyramid Lake near Nixon	24/22-3bac	a 2,720	b 1867-91 c 1904-69+	See fig. 4.
2	3460	Truckee River at Farad, Calif.	18/17-12a	932	d 1890 e 1899-1969+	See table 6, fig. 3.
3	3473	Dog Creek near Verdi	20/18-30cc	16.2	f 1956-61	See table 7 and figures 5 and 6.
4	3476	Hunter Creek near Reno	19/19-19cc	11.5	1961-69+	See table 7 and figures 5 and 6.
5	3478	Peavine Creek near Reno	19/19-5ad	2.34	1963-69+	See table 7.
6	3480	Truckee River at Reno	19/20-7b	1,067	g 1906-69+	See table 6.
7	3485	Franktown Creek at Franktown	16/19-9	h 14	1948-55	See table 7 and figures 5 and 6.
8	3487	Washoe Lake near Carson City	16/20-19db	i 83.8	1963-69+	Monthly altitudes only.
9	3488	Little Washoe Lake near Steamboat	17/19-24ab	i 83.8	1963-69+	Monthly altitudes only.
10	3489	Galena Creek near Steamboat	17/19-2cc	h 8.5	1961-69+	See table 7 and figures 5 and 6.
11	3493	Steamboat Creek at Steamboat	18/20-33c	123	d 1900-01 1961-69+	See table 7 and figures 5 and 6.
12	3497	Whites Creek near Steamboat	18/19-34bd	8.02	1961-66	See table 7 and figures 5 and 6.
13	3500	Truckee River at Vista	19/20-13ab	1,429	1899-1907 j 1932-54 1958-69+	See table 6.
14	3501	Long Valley Creek near Happy Valley	19/21-27ca	79.9	1967-69+	Annual maximums only.
15	3505	Truckee River at Clarks	20/22-26d	h 1,740	k 1907-15	See table 7.
16	3513	Truckee Canal near Wadsworth	20/24-17ab	--	1966-69+	See table 7.
17	3514	Truckee Canal near Hazen	19/26-4ca	--	m 1963-69+	See table 7.
18	3516	Truckee River below Derby Dam, near Wadsworth	20/23-19db	1,670	n 1909-10 n 1916 n 1918-69+	See table 6.

Table 5.--Selected surface-water records--Continued

Site no. on pl. 1	Station number[1]	Station name	Location[2]	Drainage area (sq mi)	Period of record (calendar years)[3]	Remarks
19	3516.5	Truckee River at Wadsworth	21/24-34cc	1,719	1965-69+	See table 7.
20	3517	Truckee River near Nixon	22/24-18bc	1,815	o 1928-69+	See table 6.
21	3518.5	Pyramid Lake tributary near Nixon	23/22-14dc	h 1.9	1968-69+	Annual maximums only.

1. Gaging stations at which streamflow records have been collected are listed and numbered in a downstream direction along the mainstem of the river, with all stations on a tributary entering above a mainstem station listed before that station. The complete number for each station, such as 10-3516.50, includes the part number "10," assigned to the Great Basin, and a six-digit station number. In this report, only the essential digits of the station number are shown; for example, the complete number 10-3516.50 appears as 3516.5.

2. See explanation in section entitled "Numbering system for hydrologic sites."

3. Sources of non-Geological Survey data are listed by footnote. Records are not complete for all listed calendar years. Symbol "+" indicates stations still in operation following water year 1969.

a. Includes lake.
b. Single altitudes in 1867, 1871, 1882, 1890, and 1891; data from various sources.
c. Occasional altitudes in some years prior to 1925 and in each year thereafter; data for 1904-48 furnished by Bur. Indian Affairs and, in 1948, by Fed. Watermaster.
d. Monthly discharge only.
e. Data furnished as follows: Aug. 1912-Sept. 1929, U.S. Bur. Reclamation; Oct. 1929-Aug. 1957, Fed. Watermaster.
f. Supplementary data after water year 1961 available in U.S. Forest Service files.
g. Data for Oct. 1919-Dec. 1946 furnished by Fed. Watermaster; actual periods of record, Oct. 1919-Sept. 1921, June 1925-Sept. 1926, Jan. 1930-Dec. 1935, Jan. 1943-Dec. 1943, and Jan. 1946-Dec. 1946.
h. Approximate.
i. Includes Washoe and Little Washoe Lakes.
j. Data furnished by Fed. Watermaster.
k. Data furnished by U.S. Bur. Reclamation.
m. Records for water years prior to 1967 in U.S. Bur. Reclamation files.
n. Data through July 1958 furnished by Truckee-Carson Irrig. Dist.
o. Records for water years prior to 1958 furnished by Fed. Watermaster; computed by combining flow below Numana Dam, about 1 mile downstream from present site, and diversions at dam.

Table 6.--Annual flows of Truckee River, water years 1900-69, in thousands of acre-feet

[Measured flows are rounded to three significant figures above 100,000 acre-ft, and to two significant figures below.]

Water year	At Farad (3460)	At Reno (3480)	At Vista (3500)	Below Derby Dam (3516)	Near Nixon (3517)
1900	444		383		
1901	677		654		
1902	545		527		
1903	520		575		
1904	1,130		1,380		
1905	638		594		
1906	984		1,090		
1907	1,430	1,370	1,660		
1908	681	522			
1909	1,010	933			
1910	790	712			
1911	1,110	1,020			
1912	438	285			
1913	429	286			
1914	846	818			
1915	593	455			
1916	807	699			
1917	708	595			
1918	491	348			
1919	583	456	a 540	284	
1920	410	288	a 350	85	
1921	503	416	a 450	203	
1922	631		a 650	403	
1923	521		a 560	298	
1924	270		a 200	55	
1925	355		a 350	95	
1926	276	194	a 230	52	
1927	614		a 630	338	
1928	509		a 500	291	
1929	262		a 200	20	b 33
1930	345		a 300	36	48
1931	133	77	a 90	4.4	13
1932	390	338	b 355	110	123
1933	207	125	162	23	40
1934	207	121	145	13	28
1935	373		326	123	134
1936	489		429	167	190
1937	413		353	170	200
1938	844		877	721	747
1939	352		297	140	159

Table 6.--Annual flows of Truckee River--Continued

Water year	At Farad (3460)	At Reno (3480)	At Vista (3500)	Below Derby Dam (3516)	Near Nixon (3517)
1940	572		558	271	290
1941	482		448	180	206
1942	750		738	549	562
1943	849		909	701	712
1944	384		355	79	96
1945	452		430	134	153
1946	506		484	205	222
1947	366	249	325	51	90
1948	390	271	350	20	38
1949	353	238	323	9.5	22
1950	480	373	470	90	105
1951	784	709	809	427	554
1952	1,280	1,230	1,320	937	1,040
1953	643	544	648	312	288
1954	417	284	367	70	56
1955	364	224	b 310	9.3	24
1956	861	784	a 850	515	b 590
1957	521	404	a 490	99	101
1958	887	794	a 830	b 430	521
1959	370	232	320	14	24
1960	379	231	307	14	25
1961	249	133	206	7.4	18
1962	345	237	303	35	47
1963	578	507	608	308	320
1964	382	269	352	18	42
1965	700	614	736	413	437
1966	485	355	430	129	153
1967	892	830	913	620	640
1968	443	333	413	180	241
1969	1,120	1,080	1,160	940	974
Average for period of full-year record	575	488	579	c 223	c 251
Average for base period 1919-69	509	a 420	a 480	223	a 250

a. Estimated (and rounded).
b. Partly estimated (and rounded).
c. Includes years of partly estimated flow.

Table 7.--Annual flows at short-term gaging stations, in thousands of acre-feet

[Measured flows rounded to three significant figures]

Water year	Dog Creek (3473)	Hunter Creek (3476)	Peavine Creek (3478)	Franktown Creek (3485)	Galena Creek (3489)	Steamboat Creek (3493)	Whites Creek (3497)	Truckee River at Clarks (3505)	Truckee River at Wadsworth (3516.5)	Truckee Canal near Wadsworth (3513)	Truckee Canal near Hazen (3514)
1908								582			
1909								1,010			
1910								778			
1911								1,150			
1912								382			
1913								383			
1914								1,060			
1915								654			
1949				5.56							
1950				10.6							
1951											
1952				20.2							
1953				11.7							
1954				6.80							
1955				5.65							
1956											
1957	2.11										
1958	8.41										
1959	1.09										
1960	1.62										
1961	.330										
1962		4.98			4.56	4.54	3.27				
1963		9.28			6.34	8.42	5.67				
1964		5.94	0.000		4.12	3.40	4.21				262
1965		10.2	.111		9.18	10.3	6.33				250
1966		5.14	.000		4.30	8.29	4.20		144		237
1967		9.80	.101		14.7	14.0	a 7.7		650	272	216
1968		5.58	.000		5.28	9.55	a 3.9		234	181	122
1969		10.5	.143		9.27	26.4	a 6.3		1,030	171	114
Average	2.71	7.68	0.059	10.1	7.22	10.6	4.73	750	--	--	200

a. Estimated.

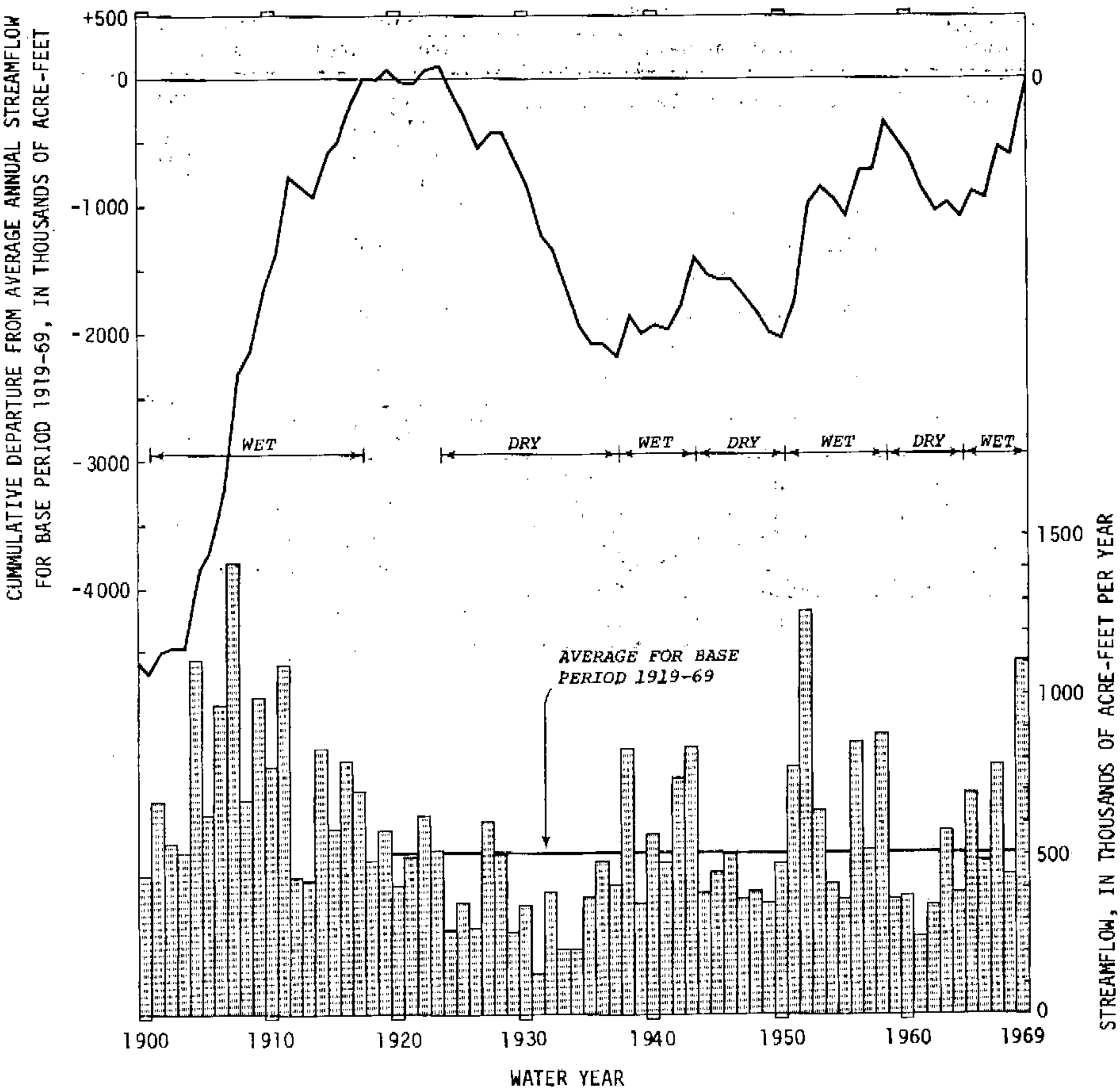


Figure 3.- Annual streamflow at gaging station on Truckee River at Farad, Calif. and cummulative departure from the 1919-69 (base period) average

Table 8.--Average annual streamflow at Truckee River gaging stations, in thousands of acre-feet, for different reference periods

Station number	Station name	Period (water years)	Average annual streamflow
3460	Truckee River at Farad, Calif.	a 1900-69	575
		b 1919-69	509
		c 1917-50	447
		d 1931-60	e 518
		f 1919-67	496
--	Truckee River at Derby Dam	c 1917-50	408
		f 1919-67	461
3516	Truckee River below Derby Dam	ab 1919-69	223
		f 1919-67	211
3517	Truckee River near Nixon	a 1929-69	251
		b 1919-69	g 250
		d 1931-60	e 240

a. Period of record.
b. Reference period used in this report.
c. U.S. Bureau of Reclamation, 1954, p. 35 of Substantiating Materials.
d. Eakin, 1970-71, oral communication. From Great Basin Region Comprehensive Framework Study (Type I).
e. Modified for 1965 conditions.
f. Pyramid Lake Task Force, 1969, app. summ., p. 2-4.
g. Estimated.

Harding (1965, p. 123) has derived values for annual runoff in the drainage area of the Truckee River during the 181-year period 1780-1960. A comparison with Harding's figures suggests that the 1919-69, 1931-60, and 1919-67 reference periods are comparable to the 1780-1960 reference period. Generally, the 1919-69 reference period of 51 water years is used in this report.

Maximum sustained streamflows generally occur in the spring as the result of snowmelt runoff; however, winter rainstorms that cause flooding have produced large flows. The seasonal pattern of streamflow has changed over the years because of increased artificial upstream storage and an evolving policy regarding storage, releases, and diversions.

The momentary peak discharges of record at the mainstem Truckee River stations listed in table 6 are:

Station number	Station name	Date	Discharge (cfs)
3460	At Farad	Nov. 21, 1950	17,500
3480	At Reno	Dec. 23, 1955	20,800
3500	At Vista	Feb. 1, 1963	21,300
3516	Below Derby Dam	Feb. 1, 1963	18,400
3517	Near Nixon	Feb. 2, 1963	14,400

In most years, sustained low flows are controlled by the so-called "Floriston Rates," which are flows that, according to decree, are to be maintained in the Truckee River at Farad. These rates are dependent upon the amount of water stored in Lake Tahoe, and are summarized as follows (Pyramid Lake Task Force, 1969, app. summ., p. 2):

Lake Tahoe level (ft above mean sea level)	Period	Floriston rate (cfs)	Period	Floriston rate (cfs)
6,226 or above	Nov.-Feb.	400	Mar.-Sept.	500
6,225.25 to 6,226	Nov.-Mar.	350	Apr.-Sept.	500
Below 6,225.25	Nov.-Mar.	300	Apr.-Sept.	500
At all stages	October	400		

During the drier years, such as 1924-37, not enough water was stored to maintain these discharges. For example, the average streamflow for the month of September 1933 passing the gage at Farad was only 47 cfs (cubic feet per second). Downstream stations had even less flow--the average flow below Derby Dam was only 1 cfs for several months and there was no flow August 8 - 11, 1924, and September 1 - 7, 1956.

The extreme high and low flows have been and will be modified by the increasing amount of available upstream storage. If the existing and proposed storage reservoirs had been in operation during 1924-37, the deficits below "Floriston Rates" probably would have been less severe.

The amount of water diverted at Derby Dam has averaged about 260,000 acre-feet annually for the reference period 1919-69. Not all this water leaves the Truckee River basin; some of it spills back into the river between the dam and Wadsworth. The amount of water leaving the Truckee River basin in the 1919-69 reference period is estimated to have averaged about 235,000 acre-feet per year.

Average 1919-69 streamflow at the Truckee River gaging station near Nixon (3517), is estimated as 250,000 acre-feet per year. The maximum and minimum annual streamflows were 1,040,000 and 13,000 acre-feet, in the 1952 and 1931 water years, respectively.

A record of the changing elevations of Pyramid Lake has been kept since 1867, and is illustrated in figure 4. Harris (1970) presents more complete data on Pyramid Lake.

Local Runoff

Short-term streamflow records have been collected at seven gaging stations (table 5 and pl. 1) on small tributary streams. Annual flow data and the average streamflow for the period of record are presented in table 7.

The gaging station on Dog Creek near Verdi measures the streamflow of an area north of the Truckee River in California. Dog Creek is estimated to have an average annual flow of about 3,000 acre-feet at the Nevada boundary, about 3 miles downstream from the gaging station. The seasonal pattern of streamflow at the Dog Creek station is shown in figure 5 for the period of record. The gaging station on Peavine Creek near Reno measures the outflow downstream from a flood-control dam for a 2.34-square-mile area on Peavine Peak north of the Truckee River. Minor amounts of flow have occurred during 3 of the 6 years of record.

Four gaging stations, on Hunter Creek near Reno, Franktown Creek at Franktown, Galena Creek near Steamboat, and Whites Creek near Steamboat, are at the base of the east side of the Carson

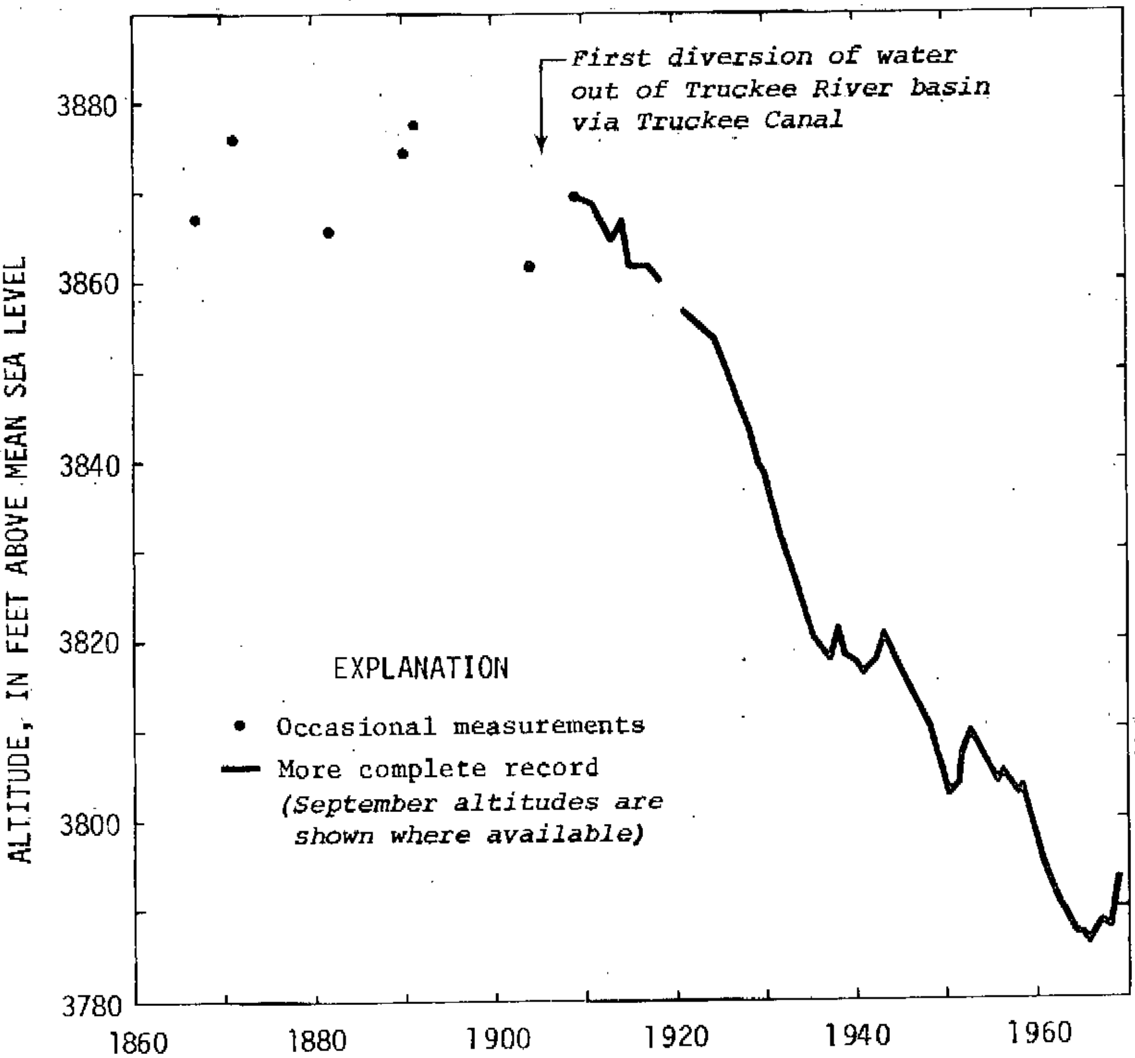


Figure 4.- Water-surface fluctuations of Pyramid Lake, 1867-1969. Lake levels for 1867 and 1871 (3,867 and 3,876 ft.) are revisions of those listed in U.S. Geological Survey Water-Supply Paper 1314 and shown by Harris, 1970 (3,876 and 3,885 ft.), on the basis of data and conclusions of Hardman and Venstrom (1941, p. 74-76) and Harding (1965, p. 88).

Range (pl. 1). The gaging station on Steamboat Creek at Steamboat measures the outflow of the Pleasant Valley hydrographic area and includes water released from Little Washoe Lake. Seasonal patterns of streamflow at these five gaging stations are shown in figure 5. The seasonal flow pattern for Franktown Creek can be affected by transbasin supplemental summer diversions from the Lake Tahoe basin. Also, water is diverted in the winter months from Galena and Browns Creeks to Little Washoe Lake.

Flow in the tributary streams is variable, as shown by the range in annual and monthly discharges (table 7, fig. 5). Although figure 5 shows the predominant influence of prolonged snowmelt runoff in the spring, the relative magnitudes of maximum monthly values in figure 6 suggests that short periods of abundant runoff from regional winter rainstorms and localized summer thunderstorms also are important. The peaks of record at these gaging stations have generally occurred in the winter. Table 9 lists maximum rates of flow in streams tributary to the Truckee River.

Streamflow in much of the report area is ungaged, particularly downstream from Vista. The amount of runoff from the mountains, prior to depletion by seepage into the valley alluvium, can be estimated by techniques described by Moore (1968). Altitude-runoff relations for general areas, based on streamflow records, have been developed for Nevada. However, the local altitude-runoff relations may differ from the general relations because of local differences in geology, precipitation, and vegetation. Three types of information were used to adjust the general relations for local conditions: the few available streamflow records, a few streamflow measurements at miscellaneous sites, and measurements of channel geometry. Runoff estimates for the hydrographic areas are listed in table 10. The average annual runoff estimated for Winnemucca Lake Valley (2,900 acre-feet per year) is considerably less than the amount proposed by Zones (1961, p. C11; 19,000 acre-feet per year), but is considered to be far more accurate, on the basis of the more refined techniques of estimation presently used.

Inflow to Hydrographic Areas

Table 11 lists surface-water inflow to the several hydrographic areas for the long-term reference period 1919-69. Quantities estimated in this report are discussed below.

The inflow to Truckee Meadows from the Truckee Canyon Segment, including the amounts carried by the river and by Steamboat, Highland, and Last Chance Ditches, has averaged about 530,000 acre-feet per year during 1919-69 (on the basis of budget computations in table 16). Adequate records are not available to permit

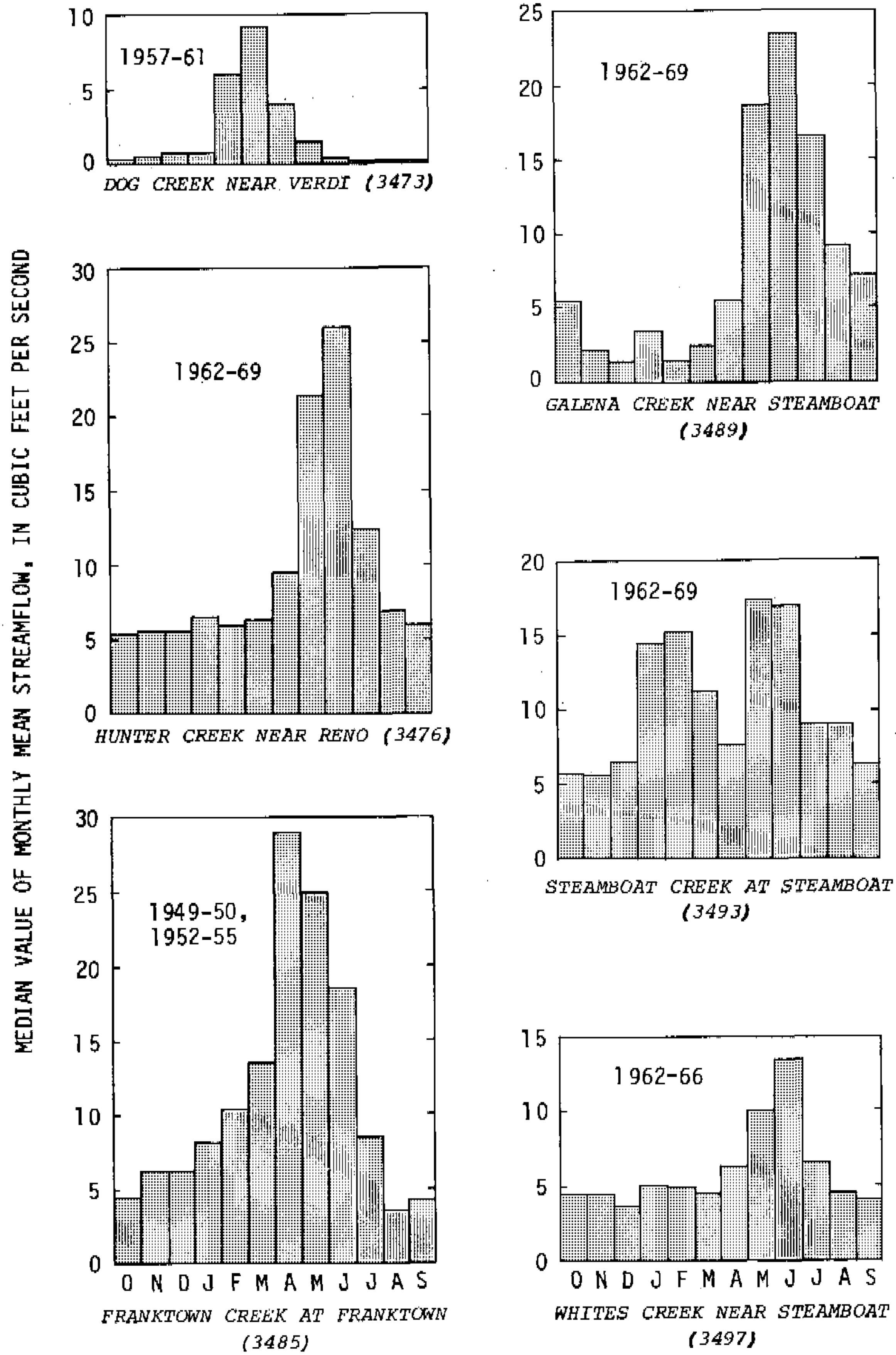


Figure 5.- Seasonal pattern of streamflow tributary to Truckee River

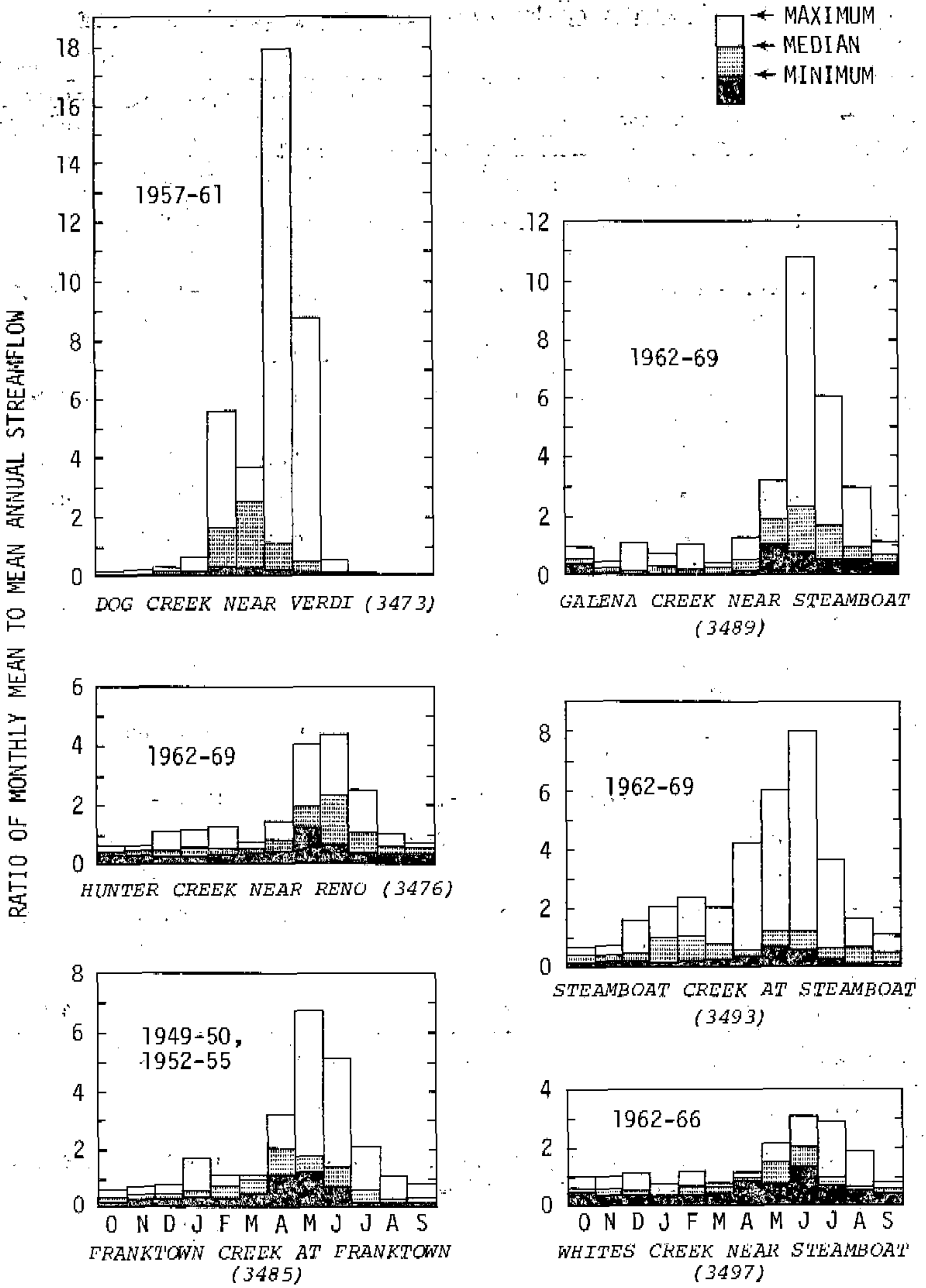


Figure 6.- Range in monthly flow of streams tributary to the Truckee River

Table 9.--Maximum recorded rates of flow in tributary streams

Station number	Station name or stream	Location[1]	Drainage area (sq mi)	Maximum discharge Date	Cubic feet per second
3473	Dog Creek near Verdi	20/18-30cc	16.2	12-23-55	880
3476	Hunter Creek near Reno	19/19-19cc	11.5	1-31-63	986
3478	Peavine Creek near Reno	19/19-5ad	2.34	3-16-67	a 32
--	Peavine Creek	19/19-4	b 3.2	7-20-56	c 2,190
3485	Franktown Creek at Franktown	16/19-9	b 14	12- 3-50	d 800
--	Ophir Creek	17/18-3caa	1.46	8-15-65	259
--	Galena Creek	17/19-9a	--	7-20-56	4,730
3489	Galena Creek near Steamboat	17/19-2cc	b 8.5	8-15-65	3,670
3493	Steamboat Creek at Steamboat	18/20-33c	123	1-31-63	1,000
3497	Whites Creek near Steamboat	18/19-34bd	8.02	8-15-65	2,280
3501	Long Valley Creek near Happy Valley	19/21-27ca	79.9	1-25-69	2,560
--	Long Valley Creek	19/21-21	--	12-23-55	2,500
--	Unnamed	19/21-2cd	3.68	8-23-61	484
--	Unnamed	20/22-35d	53.9	8-24-61	6,120
3518.5	Pyramid Lake tributary near Nixon	23/22-14dc	b 1.9	1-25-69	160
--	Threemile Canyon	28/23-11cd	b 2	7-28-64	4,610

1. See section titled "Numbering system for hydrologic sites."
a. Regulated.
b. Approximate.
c. Prior to regulation.
d. Peak of Dec. 23, 1955 was estimated as 10,000 to 20,000 cfs and was caused mostly by failure of Hobart Dam.

Table 10.--Estimated average annual runoff at the mountain front

[Numbers in parenthesis for California excluded from totals]

Hydrographic area	Runoff area (acres) Partial	Runoff area (acres) Total	Runoff (acre-feet) Partial	Runoff (acre-feet) Total
Truckee Canyon Segment				
Carson Range				
Nevada[1]	20,300		22,000	
Nevada[2]	12,900		6,900	
California[2]	(1,460)		(300)	
North of Truckee River				
Nevada[2]	15,100		1,500	
California[2]	(22,000)		(6,400)	
Subtotal		48,300		30,000
Sun Valley[3]		2,200		100
Spanish Springs Valley[3]		18,600		1,500
Washoe Valley[4]		49,600		23,000
Pleasant Valley				
Carson Range	14,800		8,700	
Virginia Range	6,000		300	
Subtotal		20,800		9,000
Truckee Meadows				
Carson Range	38,200		20,000	
Virginia Range	15,400		1,200	
North of Truckee River	10,500		500	
Subtotal		64,100		22,000
Tracy Segment				
Virginia Range	96,400		1,300	
Pyramid Range	36,000		500	
Subtotal		132,400		1,800
Fernley area		14,700		200
Dodge Flat		21,900		200
Warm Springs Valley[3]		98,800		14,000
Pyramid Lake Valley		108,000		6,400
Winnemucca Lake Valley		67,800		2,900
Total (rounded)		647,200		110,000

1. Area tributary to mainstem upstream from gage at Farad (see small map, upper right-hand corner of pl. 1).
2. Area tributary to mainstem downstream from gage at Farad (see upper right-hand corner of pl. 1); total runoff from these four areas is about 15,000 acre-feet per year.
3. Rush and Glancy, 1967, p. 18.
4. Rush, 1967, p. 17.

Table 11.--Average annual surface-water inflow to hydrographic areas, 1919-69

[Mainstem hydrographic area names are capitalized]

Inflow to:	From:	Name of stream or canal, with site and station number if gaged	Acre-feet per year: Mainstem inflow	Acre-feet per year: Other inflow
TRUCKEE CANYON SEGMENT	UPSTREAM AREAS[1]	Truckee River at Farad (3460)	509,000	--
TRUCKEE MEADOWS	TRUCKEE CANYON SEGMENT	Truckee River plus Steamboat Highland, and Last Chance Ditches	a 530,000	--
Do.	Sun Valley	Unnamed stream	--	b 20
Do.	Spanish Springs Valley	North Truckee Drain	--	b 9,000
Do.	Pleasant Valley	Steamboat Creek at Steamboat (3493)	--	8,000
Spanish Springs Valley	TRUCKEE MEADOWS	Orr Ditch from Truckee River	--	c 16,000
Washoe Valley	Third Creek basin[1]	Unnamed ditch	--	d 2,000
Do.	Pleasant Valley	Unnamed ditches from Browns and Galena Creeks	--	d 2,000
Pleasant Valley	Washoe Valley	Steamboat Creek	--	d 1,000
TRACY SEGMENT	TRUCKEE MEADOWS	Truckee River at Vista (3500)	480,000	--
Do.	Fernley Area	Unnamed stream in 21/24-3d	--	minor
Fernley Area	TRACY SEGMENT	Truckee Canal near Wadsworth (3513)	--	a 235,000
DODGE FLAT	do.	Truckee River at Wadsworth (3516.5)	a 245,000	--
PYRAMID LAKE VALLEY	DODGE FLAT	Truckee River near Nixon (3517)	a 250,000	--
Do.	Warm Springs Valley	Mullen Creek	--	b 70
Winnemucca Lake Valley	PYRAMID LAKE VALLEY	Mud Lake Slough	--	minor

1. Outside study area.
a. See section titled "Water budgets."
b. Rush and Glancy, 1967, p. 30.
c. Rush and Glancy, 1967, p. 28.
d. Rush, 1967, p. 18.

separate estimates of inflow for the river and the three ditches. The order of magnitude of the individual irrigation-season flows is indicated by measurements made on August 11, 1966 (Water Resources Division, 1967, p. 161).

Inflow to Truckee Meadows from Pleasant Valley, by way of Steamboat Creek, is measured at Steamboat. The record there is short (1961-69), and includes a period of greater-than-average releases from Little Washoe Lake. Therefore, the long-term (1919-69) average is assumed to be about 8,000 acre-feet per year, in contrast to the short-term measured average of 10,600 acre-feet (table 7).

Mainstem inflow to the Tracy Segment from Truckee Meadows is measured at the Vista gage. Combining 34 years of record with estimates for the remainder of the period 1919-69, the estimated mean flow is about 480,000 acre-feet per year (table 6).

Average inflow to the Fernley Area, by way of the Truckee Canal, has been an estimated 235,000 acre-feet per year during 1919-69 (p. 99). The flow has been measured since 1967, and has averaged only 208,000 acre-feet per year for the first 3 years of record (table 7).

At the Truckee River gage near Nixon, inflow from Dodge Flat to Pyramid Lake Valley has been measured since 1928 (table 6). These data suggest that the long-term average is about 250,000 acre-feet per year. Farther upstream, the average inflow to Dodge Flat, at Wadsworth, is more difficult to estimate, because the period of record at that gage is short (table 7). On the basis of a comparison of concurrent data at Wadsworth and near Nixon, the river is thought to gain at least 5,000 acre-feet per year between the two gages. This would make the long-term average at Wadsworth, upstream from the gain, about 245,000 acre-feet per year.

Inflow to Winnemucca Lake Valley from Pyramid Lake Valley has been negligible since the early 1900's, when the level of Pyramid Lake dropped below the altitude of overflow into Mud Lake Slough (Harding, 1965, p. 102). Prior to that time, the inflow was great during some years.

Ground-Water Recharge

Most recharge is provided by precipitation in mountainous areas, with the water reaching the valley-fill reservoirs by seepage loss from streams on the alluvial slopes and by underflow from the consolidated rocks. Even in the mountains and on alluvial slopes, however, most of the precipitation is evaporated before infiltration, whereas some of the remainder adds to soil moisture, and some runs off and reaches the already-saturated lowland areas. Thus, only a very small percentage actually finds its way to the ground-water reservoir. On most valley floors in the study area, precipitation quantities are small, and deep infiltration to the ground-water reservoir is generally minimal.

Potential recharge is estimated in this report using the general method described by Eakin and others (1951, p. 79 - 81). The method assumes that for any given altitude zone, a particular increment of total precipitation potentially recharges the ground-water reservoir, with that increment, or percentage, depending on the average amount of snow and rainfall within the zone. The term "potential recharge" is used because in certain areas, such as the canyon segments, much of the computed recharge is rejected, and therefore does not actually reach the ground-water reservoir. In upstream areas--particularly the Truckee Canyon Segment--where (1) alluvial deposits are small and mostly saturated, (2) potential recharge quantities are large, and (3) stream gradients are steep, much of the runoff reaches the Truckee River rather than infiltrating the alluvium. In the Truckee Canyon Segment, almost all the potential recharge probably runs off to the river. The same is doubtless true to a much lesser degree on the west sides of Washoe Valley, Pleasant Valley, and Truckee Meadows, and in parts of the Tracy Segment. Likewise, a minor amount of peripheral streamflow in addition to the large contribution of Truckee River enters Pyramid Lake along the west and east sides.

Table 12 lists the estimates of precipitation and potential recharge for the study area. For Truckee Meadows, the estimated potential recharge from precipitation is 27,000 acre-feet per year. Cohen and Loeltz (1964, p.23) estimate that several other forms of recharge total at least 35,000 acre-feet per year; these include seepage losses from the river, underflow from nonmainstem valleys, and infiltration of irrigation water, but <u>not</u> infiltration of precipitation. Thus, the two values are not comparable.

Total precipitation and potential recharge for the entire Truckee River basin in Nevada (not including the Fernley Area) are about 1,100,000 and 100,000 acre-feet per year, respectively. For the individual hydrographic areas, potential recharge ranges from about 1 to almost 25 percent of total precipitation. The lowest percentages are for valleys in the eastern part of the area in which only a small proportion of the total area is high enough to produce potential recharge.

Table 12.—Estimated average annual precipitation and potential ground-water recharge

Altitude zone (feet)	Area (acres)1/	Estimated precipitation: Range (inches)	Estimated precipitation: Average (feet)	Estimated precipitation: Average (acre-feet)	Estimated potential recharge: Percentage of total precipitation	Estimated potential recharge: (acre-feet per year)
DODGE FLAT						
8,000- 8,367	minor	>20	—	minor	25	minor
7,000- 8,000	2,750	15-20	1.5	4,100	15	620
6,000- 7,000	6,020	12-15	1.1	6,600	7	460
5,000- 6,000	13,100	8-12	.8	10,000	3	300
4,000- 5,000	34,400	5-8	.6	22,000	minor	—
3,940- 4,000	1,550					
Total (rounded)	57,800	—	—	43,000	3	1,400
FERNLEY AREA						
7,000- 7,260	156	15-20	1.5	230	15	35
6,000- 7,000	3,900	12-15	1.1	4,300	7	300
5,000- 6,000	10,700	8-12	.8	8,600	3	260
4,005- 5,000	60,500	5-8	.5	30,000	minor	—
Total (rounded)	75,300	—	—	43,000	1	600
PLEASANT VALLEY						
10,000-10,778	230	>39	3.3	760		
9,000-10,000	1,400	36-39	3.1	4,300		
8,000- 9,000	2,650	33-36	2.9	7,700	25	6,200
7,000- 8,000	2,340	30-33	2.6	6,100		
6,000- 7,000	2,500	25-30	2.3	5,800		
5,000- 6,000	10,800	15-25	1.7	18,000	20	3,600
4,595- 5,000	3,590	8-15	1.0	3,600	5	180
Total (rounded)	23,500	—	—	46,000	22	10,000
PYRAMID LAKE VALLEY						
8,000- 8,722	1,390	>20	1.8	2,500	25	620
7,000- 8,000	9,680	15-20	1.5	15,000	15	2,200
6,000- 7,000	28,100	12-15	1.1	31,000	7	2,200
5,000- 6,000	69,200	8-12	.8	55,000	3	1,600
4,000- 5,000	144,000	5-8	.6	130,000	minor	—
3,790- 4,000	a 67,600					
Total (rounded)	320,000	—	—	230,000	3	6,600
SPANISH SPRINGS VALLEY (Rush and Glancy, 1967, p. 23)						
Total (rounded)	46,600	—	—	30,000	2	600

Table 12.—Estimated precipitation and potential recharge—Continued

Altitude zone (feet)	Area (acres)1/	Estimated precipitation: Range (inches)	Estimated precipitation: Average (feet)	Estimated precipitation: Average (acre-feet)	Estimated potential recharge: Percentage of total precipitation	Estimated potential recharge: (acre-feet per year)
		SUN VALLEY (Rush and Glancy, 1967, p. 23)				
Total (rounded)	6,330	--	--	4,000	1	50
		TRACY SEGMENT				
8,000- 8,035	minor	>20	--	minor	25	minor
7,000- 8,000	1,750	15-20	1.5	2,600	15	390
6,000- 7,000	46,000	12-15	1.1	51,000	7	3,600
5,000- 6,000	83,600	8-12	.8	67,000	3	2,000
4,045- 5,000	56,700	5-8	.5	28,000	minor	--
Total (rounded)	188,000	--	--	150,000	4	6,000
		TRUCKEE CANYON SEGMENT, NEV.				
10,000-10,610	300	>39	3.3	990	25	24,000
9,000-10,000	5,240	36-39	3.1	16,000		
8,000- 9,000	10,900	33-36	2.9	32,000		
7,000- 8,000	10,200	30-33	2.6	27,000		
6,000- 7,000	8,700	25-30	2.3	20,000		
5,000- 6,000	8,270	15-25	1.7	14,000	20	2,800
4,640- 5,000	4,990	8-15	1.0	5,000	5	250
Total (rounded)	48,600	--	--	110,000	24	27,000
		TRUCKEE CANYON SEGMENT, NEV. AND CALIF.2/				
9,000- 9,300	50	>36	3.1	150	25	19,000
8,000- 9,000	3,280	33-36	2.9	9,500		
7,000- 8,000	8,670	30-33	2.6	23,000		
6,000- 7,000	19,600	25-30	2.3	45,000		
5,000- 6,000	14,500	15-25	1.7	25,000	20	5,000
4,640- 5,000	5,200	8-15	1.0	5,200	5	260
Total (rounded)	51,300	--	--	110,000	22	24,000

Table 12.--Estimated precipitation and potential recharge--Continued

Altitude zone (feet)	Area (acres)1/	Estimated precipitation: Range (inches)	Average (feet)	Average (acre-feet)	Estimated potential recharge: Percentage of total precipitation	(acre-feet per year)
TRUCKEE MEADOWS						
Western part (Sierra Nevada, and area west of Steamboat Cr. and N. Truckee Drain)						
10,000-10,778	300	>39	3.3	990		
9,000-10,000	2,430	36-39	3.1	7,500		
8,000- 9,000	6,550	33-36	2.9	19,000	25	16,000
7,000- 8,000	6,410	30-33	2.6	17,000		
6,000- 7,000	8,980	25-30	2.3	21,000		
5,000- 6,000	21,700	15-25	1.7	37,000	20	7,400
4,370- 5,000	52,000	8-15	.8	42,000	5	2,100
Subtotal (rounded)	98,400	--	--	140,000	19	26,000
Eastern part (Virginia Range, and area east of Steamboat Cr. and N. Truckee Drain)						
7,000- 7,770	923	15-20	1.5	1,400	15	210
6,000- 7,000	6,310	12-15	1.1	6,900	7	480
5,000- 6,000	10,900	8-12	.8	8,700	3	260
4,370- 5,000	14,200	5-8	.5	7,100	minor	--
Subtotal (rounded)	32,300	--	--	24,000	4	950
Total (rounded)	131,000	--	--	160,000	17	27,000
WARM SPRINGS VALLEY (Rush and Glancy, 1967, p. 22)						
Total (rounded)	160,000	--	--	130,000	5	6,000
WASHOE VALLEY (Rush, 1967, p. 14)						
Total (rounded)	49,600	--	--	87,000	17	15,000
WINNEMUCCA LAKE VALLEY						
8,000- 8,237	minor	>20	--	minor	25	minor
7,000- 8,000	2,460	15-20	1.5	3,700	15	560
6,000- 7,000	14,300	12-15	1.1	16,000	7	1,100
5,000- 6,000	51,800	8-12	.8	41,000	3	1,200
4,000- 5,000	81,900	5-8	.5	41,000	minor	--
3,765- 4,000	80,100	<5	.4	32,000		
Total (rounded)	230,000	--	--	130,000	2	2,900

1/ Areas are based on planimeter data using U.S. Geological Survey 1:250,000-scale topographic maps. They do not agree exactly with those listed in table 2, which were obtained from a less accurate 1:500,000-scale map.

2/ Includes areas in Nevada and California tributary to Truckee River downstream from Farad streamflow gage; does not include area in Nevada that feeds river above gage.

a/ Excludes average area of Pyramid Lake (about 108,000 acres); precipitation on lake directly enters surface-water storage.

The recharge estimated for Winnemucca Lake Valley (2,900 acre-feet per year) is considerably less than the quantity suggested in 1961 by Zones (p. C12; 8,000 acre-feet per year). The revised value is based on a different technique of estimation, and is considered to reflect more nearly the actual situation at Winnemucca Lake Valley. The estimate of recharge for the Fernley Area (600 acre-feet per year) agrees favorably with the earlier one of Sinclair and Loeltz (1963, p. AA10) for approximately the same area.

Subsurface Inflow

Subsurface inflow to the valley-fill reservoirs can be of two types: (1) inflow from an adjacent upgradient valley through alluvium or consolidated rocks, as previously described; and (2) inflow from the surrounding consolidated rocks within a valley watershed, which originates in the mountains as infiltrated precipitation and runoff. This second type of inflow is included in the estimates of potential recharge in table 12; it is assumed to be only a small to moderate part of the total recharge in each valley.

Ground-water inflow to a valley through alluvium can be computed using 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 transmissivity, 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 the factor 0.00112 converts gallons per day to acre-feet per year. Computations of this type for valleys of the report area are given in table 13. Several of the listed values are from Rush and Glancy (1967, p. 37). Cohen and Loeltz (1964, p. 22-23) also made estimates. For underflow from the Truckee Canyon Segment and Pleasant Valley to Truckee Meadows, their sites of estimate are different from those in the present report, because they used different hydrographic-area boundaries for Truckee Meadows. For underflow from Spanish Springs Valley to Truckee Meadows, Cohen and Loeltz estimated 150 acre-feet of underflow per year, compared with the 100 acre-feet per year of Rush and Glancy.

Concurrent streamflow records at the Wadsworth and Nixon gages indicate that the net increment in that reach during periods of low flow averages about 15 cfs. Most of the inflow is thought to be ground water that originates in the Fernley Area (Sinclair and Loeltz, 1963, p. AA8). A group of low-flow measurements made on September 2, 1971, substantitate the inflow below the Wadsworth gage, and indicate that additional water enters the stream in the reach above the gage but below the last canal spill-back:

Location	Discharge (cfs)
About 2½ miles upstream from Wadsworth (20/24-8db)	44
At Wadsworth (20/24-3bc)	52
About 2 miles downstream from Wadsworth (21/24-27cc)	61
At Nixon gage (22/24-18bc)	63

The overall net inflow of almost 20 cfs, if sustained throughout the year, would total about 14,000 acre-feet. Thus, the data indicate that estimates of ground-water inflow to the Tracy Segment and Dodge Flat from the Fernley Area (table 13) may be quite conservative.

Field evidence suggests that little if any ground water moves into Pyramid Lake Valley from neighboring Honey Lake Valley through the narrow band of alluvium in Astor Pass.

Postive evidence of ground-water flow from one valley to another in the study area by way of consolidated rocks is lacking (p. 13).

Imported Water

Water is imported to the report area at two places: A ditch carries an estimated 2,000 acre-feet per year from the headwaters of Third Creek basin (tributary to Lake Tahoe) to Ophir Creek in Washoe Valley (Rush, 1967, p. 18), and during dry years varying but unknown quantities of water (probably less than 500 acre-feet per year) are pumped from Marlette Lake, in the Lake Tahoe basin, to Hobart Creek Reservoir in Washoe Valley to supplement the Virginia City-Carson City public supply, (P. A. Glancy, U.S. Geological Survey, oral commun., 1971). In addition, a flume that supplies the hydroelectric power generation plant at Fleisch, California, 2½ miles upstream from Verdi, carries about 220,000 acre-feet per year across the State line (p. 48). The water is diverted from the Truckee River between the Farad gage and State line, and for convenience is not considered an import in this report, because the entire flow returns to the river at the power plant.

In the 1800's, a significant quantity of water was imported to Washoe Valley from Marlette Lake by a tunnel, to help supply mining and municipal needs in the Virginia City area. The tunnel

Table 13.--Estimated ground-water inflow to valleys of the study area through alluvium

Inflow to (in downstream order):	From:	Location of flow section	Assumed transmissivity (gpd/ft) (T)	Estimated hydraulic gradient (feet per mile) (I)	Approximate width of section (miles) (W)	Estimated subsurface flow (ac-ft/yr, rounded) (Q)
Truckee Canyon Segment	Upstream areas (outside study area)	Truckee River channel at Farad gage	100,000	70	0.05	400
Truckee Meadows	Truckee Canyon Segment	Truckee River channel[1]	100,000	30	.2	700
Pleasant Valley	Washoe Valley	Steamboat Creek channel[1]	50,000	40	.02	50
Truckee Meadows	Pleasant Valley	Steamboat Creek channel and adjacent area	25,000	40	.3	300
Do.	Sun Valley[2]	Stream channel in 20/20-30ca	25,000	50	.02	25
Do.	Spanish Springs Valley[2]	Stream channel in 20/20-27cd	30,000	30	.1	100
Tracy Segment	Truckee Meadows	Truckee River channel[3]	--	10	.05	minor
Do.	Fernley Area	Stream channel in 20/24-3d, and adjacent area	25,000	50	1½	a 2,100
Dodge Flat	Tracy Segment	Truckee River channel and adjacent area	25,000	10	2½	700
Do.	Fernley Area	Alluvial divide in 21/24-26, 35, 34	25,000	30	2½	a 2,100
Pyramid Lake Valley	Dodge Flat	Truckee River channel	25,000	5	2	300
Do.	Warm Springs Valley[2]	Mullen Creek channel and adjacent area	20,000	20	.4	200
Winnemucca Lake Valley	Pyramid Lake Valley	Mud Lake Slough channel and adjacent area	25,000	20	.8	400

1. Only younger alluvium is considered.
2. Data from Rush and Glancy, 1967, p. 37.
3. River channel is on or very close to bedrock.
a. Discharge measurements at several places along Truckee River during periods of low flow indicate that these reconnaissance estimates may be too low (see text).

has since collapsed, and no longer transmits lake water to the reservoir.

Within the report area, water is imported to one hydrographic area from another at several places. Flow diverted from the river in the Truckee Canyon Segment enters Truckee Meadows in the Steamboat, Highland, and Last Chance Ditches, for municipal and agricultural use. The amount imported is unknown (p.). Water is transported to Sun Valley from Truckee Meadows by pipeline for domestic use (245 acre-feet in 1969; p.). The Orr Ditch carries about 16,000 acre-feet of river water annually from Truckee Meadows into Spanish Springs Valley for irrigation (Rush and Glancy, 1967, p. 28). An average of about 2,000 acre-feet per year is diverted by ditch from Browns and Galena Creeks in Pleasant Valley to neighboring Washoe Valley.

Irrigation water imported to the Fernley Area from the Tracy Segment, by way of Truckee Canal, has averaged about 235,000 acre-feet per year during 1919-69. Much of the canal flow continues into the adjacent Carson River basin.

OUTFLOW FROM THE VALLEYS

Surface and Subsurface Outflow

Outflow from most valleys of the study area by way of streams and the subsurface is to adjacent segments of the area, and is discussed in the sections titled "Inflow to hydrographic areas" (see table 11) and "Subsurface inflow" (table 13), respectively.

Three outflows are not discussed above. Two of them are near Fernley Sink, where, according to Harrill (1970, p. 16, 17), about 4,000 acre-feet of surface water and 1,000 acre-feet of ground water from the Fernley Area move northward into the adjacent Bradys Hot Springs Area annually. The third point of outflow is 3 miles northwest of Hazen, where ground water is thought to move southeastward to the Carson Desert through alluvial deposits. Using the technique described on p. , the estimated outflow is about 800 acre-feet per year [assumed transmissivity, 50,000 gpd/ft (gallons per day per foot); gradient, about 7 feet per mile; and width, about 2 miles]. In addition, the hydrologic budget imbalance for Warm Springs Valley leads Rush and Glancy (1967, p. 42) to suggest that some ground water may flow northward out of that valley (and therefore, out of the Truckee River basin).

Exported Water

Water is exported from the Truckee River basin at three places: By pipeline from Truckee Meadows to adjacent Lemmon Valley for public supply, via pipeline from Washoe Valley to Virginia City and Carson City for public supply, and by Truckee Canal from the Tracy Segment at Derby Dam to the neighboring Fernley Area and Carson River basin for irrigation. Annual quantities exported to Lemmon Valley during 1956-65 are listed by Rush and Glancy (1967, p. 25). Additional data from Sierra Pacific Power Co. are:

Year	Acre-feet	Year	Acre-feet[1/]
1954	270	1967	220
1955	300	1968	500
1966	510	1969	690

1/ Recent data include supply for Raleigh Heights residential area, less than half of which lies within Truckee Meadows.

Water exported to Carson City and Virginia City totalled about 1,300 acre-feet in 1969 (J. R. Harrill, U.S. Geol. Survey, oral commun., 1970). Annual net quantities diverted out of the Truckee River basin via Truckee Canal have averaged about 235,000 acre-feet (table 11). Of this amount, about 180,000 acre-feet per year continues into the Carson River basin from the Fernley Area.

Within the Truckee River basin, water is exported from the Truckee Canyon Segment to Truckee Meadows via the Highland, Last Chance, and Steamboat Ditches, from Truckee Meadows to Spanish Springs Valley via Orr Ditch, and to Sun Valley via pipeline, and from Pleasant Valley to Washoe Valley via canals, as discussed above in the section titled "Imported water."

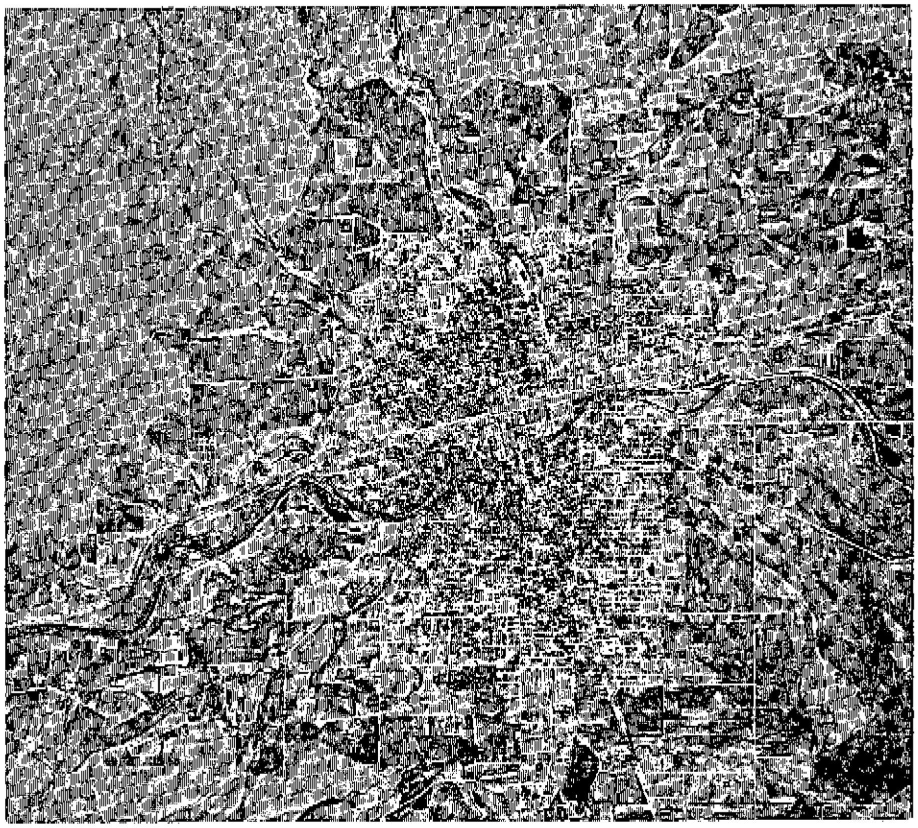
Domestic, Industrial, and Public Supplies

Most people in the study area, as well as industrial and commercial enterprises in Reno and Sparks, are served by public water supplies. The biggest system is that of Sierra Pacific Power Co., which serves an estimated population of about 100,000 (not counting the large tourist trade) plus most industrial and commercial requirements in the Reno-Sparks area. Most of the supply is furnished by diversion from Truckee River, and from Steamboat and Highland Ditches, which are fed by the river. Additional quantities are obtained from a network of large-capacity wells (table 21) and from Hunter Creek. The creek currently supplies an estimated 3,000 acre-feet per year (R. S. Leighton, Sierra Pacific Power Co., written commun., 1970). Total quantities of water diverted from streams or pumped from wells by Sierra Pacific Power Co. are listed in table 14. Part of the municipal supply is exported from Truckee Meadows to Sun Valley via pipeline. Annual totals since the exportation began (R. S. Leighton, Sierra Pacific Power Co., written commun., 1971) are:

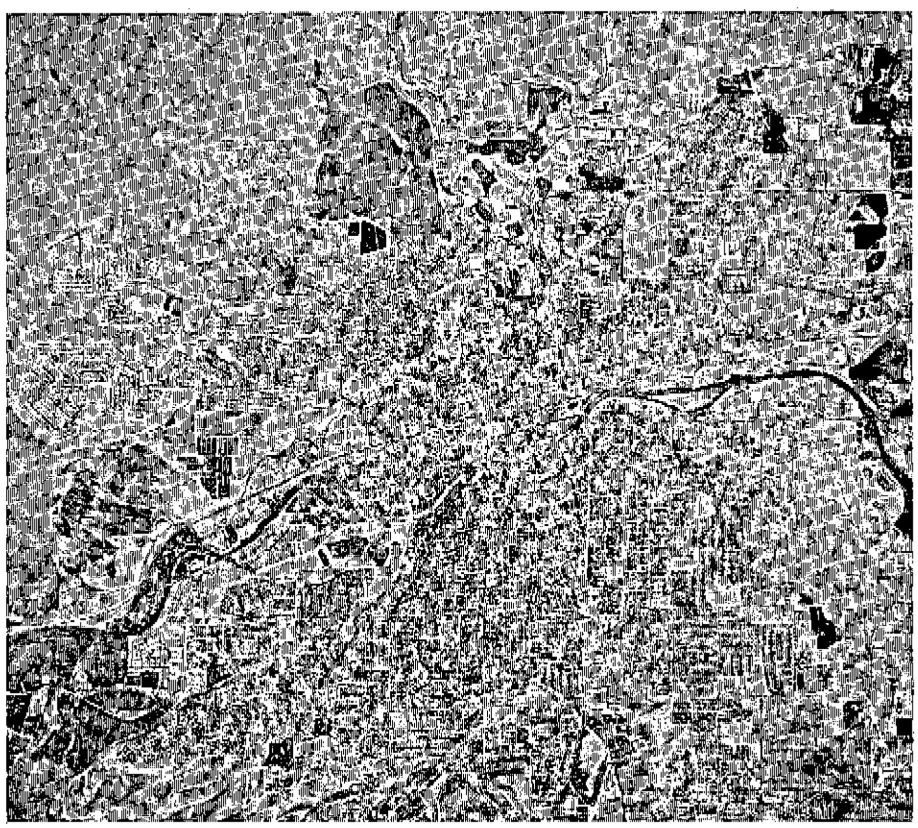
1967	84 acre-feet
1968	172 acre-feet
1969	245 acre-feet

The total quantity withdrawn by Sierra Pacific Power Co. in 1969 for municipal supply (37,500 acre-feet) was slightly more than twice the quantity of sewage inflow to the Reno-Sparks Joint Treatment Plant (about 18,000 acre-feet) during the same year (treatment-plant data from files of the Nevada Bureau of Environmental Health). The plant, which is east of Sparks (19/20-14a), discharges effluent into Steamboat Creek several hundred feet upstream from the confluence of the creek and Truckee River at Vista.

A



B



Photographs 4A and B.--Twenty years of change in Reno. Vertical aerial views taken (A) July 10, 1946, and (B) May 21, 1966. North at top; scale, about 1 mile per inch; U.S. Geol. Survey photos CV-2-88 and VBMQ-1-159. Reno-Sparks municipal water system serves most of this area. Between 1946 and 1966, municipal withdrawals doubled, from about 19,000 to about 38,000 acre-feet per year.

Table 14.--Water withdrawn annually for the Reno-Sparks municipal system, 1920-69

[Quantities in acre-feet per year, rounded; data from Sierra Pacific Power Co.]

Year	Source 1/			Year	Source 1/		
	Wells	Streams	Total		Wells	Streams	Total
1920	0	11,800	11,800	1945	353	17,200	17,600
1	0	12,200	12,200	6	209	19,000	19,200
2	0	12,000	12,000	7	0	18,300	18,300
3	0	9,970	9,970	8	86	17,100	17,200
4	0	11,800	11,800	9	1,260	19,400	20,600
5	0	10,500	10,500	1950	141	21,000	21,100
6	0	10,200	10,200	1	531	21,000	21,500
7	0	10,500	10,500	2	9.2	22,300	22,300
8	0	10,300	10,300	3	206	22,600	22,900
9	0	11,100	11,100	4	28	24,800	24,800
1930	1,190	9,820	11,000	5	0	23,800	23,800
1	3,340	8,260	11,600	6	107	24,300	24,400
2	921	10,000	10,900	7	1,750	23,600	25,400
3	767	9,790	10,600	8	921	24,500	25,400
4	1,010	9,080	10,100	9	3,070	24,700	27,800
5	301	10,300	10,600	1960	1,850	26,800	28,600
6	184	11,000	11,200	1	2,140	23,000	25,100
7	856	12,200	13,000	2	3,380	23,500	26,900
8	513	12,000	12,600	3	3,210	24,600	27,800
9	445	12,500	13,000	4	3,810	28,100	31,900
1940	276	10,600	10,900	5	4,160	26,700	30,900
1	150	14,200	14,300	6	5,700	32,100	37,800
2	252	15,300	15,500	7	4,190	29,700	33,900
3	534	15,200	15,700	8	4,240	33,700	37,900
4	285	16,100	16,400	9	6,630	30,900	37,500

1/ Data prior to 1954 include streamflow quantities exported to Stead Air Force Base (Lemmon Valley).

Other public-supply systems of significant size in the study area, which rely entirely on well water, are those of Fernley, Nixon, the Virginia Foothills area, and Hidden Valley. Metered quantities are available for the Fernley system (about 1,200 people; wells 20/24-24bbb1 and 2); annual amounts since 1963 (data from Mrs. Frank Kietzki) are:

Year	Acre-feet	Year	Acre-feet
1964	114	1967	143
1965	119	1968	150
1966	139	1969	143

Data for the other systems as of 1969 are:

Area	Wells	Approximate population served	Estimated annual pumpage (acre-feet)
Nixon	23/23-25bcd	a 350	50
Virginia Foothills	18/20-27bcd1 and 2	600-700	100
Hidden Valley	19/20-21bcb	700-800	b 370

a. Estimate from Frank Schulte (U.S. Public Health Service, Reno, oral commun., 1970).
b. Measured quantity, from Mrs. Zunino (Hidden Valley Water Div., oral commun., 1970).

The remaining people in the study area depend mostly on private domestic wells or wells that serve only a few families. This population, estimated at about 10,000 people in the Truckee River basin and about 300 in the Fernley Area, may have used about 2,000 and 50 acre-feet per year, respectively, in 1969.

Several industries use self-supplied well and stream water, mostly for cooling systems and plant personnel. Two of the largest users in the study area are discussed by Holmes (1966, p. 32, 55): The Eagle-Picher Industries, Inc. diatomite processing plant, and the Sierra Pacific Power Company electricity generation plant, both along the Truckee River near Clark.

In 1964-65, according to Holmes, Eagle-Picher pumped from wells 20/22-35aba and -35abc (table 21) at a rate of about 180 acre-feet per year, of which only about half was consumed. During the same period, Sierra Pacific pumped from two wells (about 8 acre-feet per year, of which 90 percent was consumed) and from the Truckee River (15,000 to 26,000 acre-feet per year, of which none was consumed). At present (1970), river-water use may total about 50,000 acre-feet per year, with little net consumption (Bob Proctor, Sierra Pacific Power Co., oral commun., 1970). Sierra Pacific also diverts water from the river at three sites for hydroelectric power generation. Powerplant names and estimated quantities of water used (nonconsumptively) during 1969, in acre-feet, are: Fleish, 220,000; Verdi, 225,000; and Washoe, 245,000 (J. R. Harrill, U.S. Geol. Survey, written commun., 1970). Guyton & Associates (1970, p. 14) estimate that industrial and commercial ground-water use in the Reno-Sparks area, in addition to water supplied by Sierra Pacific, totals about 2,200 acre-feet per year.

Total water used for domestic, industrial, and public supplies in 1969 may have been about 44,000 acre-feet in the Truckee River basin (about 70 percent surface water), and about 200 acre-feet in the Fernley Area. Much of this water returns to the hydrologic system after use. In addition, nearly 750,000 acre-feet was used for electric power generation and returned to the river.

Irrigation and Stock

Irrigation, using surface water almost exclusively, is an important activity in several parts of the study area--specifically in Washoe, Pleasant, and Spanish Springs Valleys; in Truckee Meadows; along the Truckee River in the Tracy Segment, Dodge Flat, and Pyramid Lake Valley; and east of Fernley. Irrigated areas are shown in combination with areas of natural evapotranspiration on plate 1. In a few places within Truckee Meadows, boundaries of irrigated areas were taken from a map prepared by Guyton & Associates (1970, fig. 5). Geological Survey reports that discuss irrigation in the study area pertain to: Washoe Valley (Rush, 1967), Spanish Springs Valley (Rush and Glancy, 1967), Truckee Meadows (Cohen and Loeltz, 1964), and Fernley Area (Sinclair and Loeltz, 1963). Irrigated acreages are listed in table 15. The area recorded for Truckee Meadows as of about 1969 (18,000 acres) is considerably less than the average area of 27,000 acres cited by Cohen and Loeltz (1964, p. S20) for the approximate period 1951-61. Presumably, the decrease is due mostly to urban expansion into formerly agriculture lands.

Table 15.--Approximate acreage of lakes, discharging playas, phreatophytes, and irrigated lands

Hydrographic area	Lakes	Discharging playa	Phreatophytes		Irrigated lands
Dodge Flat	--	--	a 2,200		b 950
Fernley Area	c 1,700	c 700	a 14,000		d 3,100
Pleasant Valley	--	--		e 1,400	
Pyramid Lake Valley	f 108,000	--	a 14,000		b 480
Spanish Springs Valley1/	--	50	800		1,700
Sun Valley1/	--	--	2		--
Tracy Segment	--	--		e 3,700	
Truckee Canyon Segment2/	--	--		e 1,500	
Truckee Meadows	200±	--	a 7,000		d 18,000
Warm Springs Valley1/	--	--	6,300		g 640
Washoe Valley3/	4,000	--	5,000		4,200
Winnemucca Lake Valley4/	--	40,000	6,100		--
TRUCKEE RIVER BASIN2/	h 113,000	40,000	41,000	e 6,600	26,000

1. From Rush and Glancy, 1967.
2. Includes only areas in Nevada; totals for Truckee River basin do not include Fernley Area, and are rounded.
3. From Rush, 1967.
4. Modified from Zones, 1961, p. 13-15.
a. Numerical difference between combined acreage of phreatophytes plus irrigation (mapped in field), and reported irrigated acreage.
b. Data from Wilsey & Ham (1970, p. 144) for 1967; includes idle land that has been irrigated in the past.
c. Average areas of Fernley Sink and adjacent playa estimated to be about two-thirds and one-third, respectively, of lake area shown on Geol. Survey 15-minute Two Tips quadrangle and on pl. 1. In addition, total includes two small reservoirs, which may cover an average of about 200 acres.
d. Based on information from P. R. Taylor (U.S. Bur. Reclamation, 1970-71); data for Fernley Area as of 1967.
e. Combined acreage (mapped in field).
f. Area at lake-surface altitude of 3,790 ft (Harris, 1970).
g. Includes about 300 acres in 22/21-5 and 8 that had not as yet been brought under irrigation at the time of Rush and Glancy's report (1967).
h. Includes about 1,000 acres of water-surface area for Truckee River.

In this report, net quantities of water consumed during irrigation are not estimated directly; instead, the subject is discussed in general terms in the section titled "Water budgets."

Wells, springs, and streams provide for the needs of livestock in the study area. The amounts consumed are small compared to other types of water use: Harrill and Worts (1968, p. 25) estimate that only about 120 acre-feet, 100 of which comes from surface-water sources, is withdrawn per year for livestock throughout the Truckee River basin. Quantities in the Fernley Area are even less--perhaps 30 acre-feet per year.

Natural Evapotranspiration

In areas of shallow ground water, natural discharge occurs by evaporation from bare soil, and by transpiration from plants called phreatophytes, whose roots tap the ground water. In the Truckee River basin and Fernley Area, principal phreatophytes are greasewood, rabbitbrush, and saltgrass, with lesser areas of marsh vegetation and cottonwood. Some native pasture or grass also is a phreatophyte, but in most areas it is irrigated for stock. Accordingly, pastureland is included with the irrigated acreage in table 15. Phreatophytic areas are shown in combination with irrigated tracts on plate 1. Areas of bare-soil evaporation from playa surfaces also are indicated. The phreatophyte and playa boundaries in Washoe Valley, Warm Springs Valley, and the northern part of Winnemucca Lake Valley are taken from Rush (1967, fig. 7), Rush and Glancy (1967, pl. 1), and Zones (1961, pl. 1), respectively.

Sizeable quantities of water are lost to the atmosphere by evporation from lakes in the study area.

In this report, most evapotranspiration quantities are not estimated directly; instead, the subject is discussed in general terms in the section titled, "Water budgets."

Evaporation from Pyramid Lake

During the base period 1919-69, the stage of Pyramid Lake declined about 66 feet, and the surface area decreased from about 139,000 to about 109,000 acres (computed from data given by Harris, 1970, table 1), and averaged roughly 118,000 acres. Estimated average net evaporation (annual gross evaporation of about 4 feet, minus annual precipitation of about 0.5 foot) was about 3.5 feet per year. This, times the average area, gives an average net evaporation from the lake of some 410,000 acre-feet per year.

The area in 1969 of about 109,000 acres, times the estimated net evaporation rate, suggests a present-day net evaporation of about 380,000 acre-feet per year. Thus, during the base period 1919-69, the surface area of Pyramid Lake has decreased by about 30,000 acres, and the net evaporation loss has diminished from nearly 490,000 acre-feet in 1919 to about 380,000 acre-feet in 1969--a decrease in loss rate of nearly 110,000 acre-feet per year.

Springs

In most of the hydrographic areas, the combined spring discharge is minor; it generally supports small areas of willow, rabbitbrush, and wildrose. Part of the flow seeps back into the ground and reenters the ground-water system, and part is consumed by evapotranspiration. Table 24 (at end of report) presents data on springs.

WATER BUDGETS

Water budgets have already been developed for Spanish Springs, Warm Springs, and Sun Valleys by Rush and Glancy (1967, p. 42-43), and for Washoe Valley by Rush (1967, p. 23). Budgets developed in this report for mainstem and nonmainstem hydrographic areas are listed in tables 16 and 17, respectively. Assumptions made in developing several of the budgets are discussed below.

Mainstem Areas

Truckee Canyon Segment

Virtually all mountain-front runoff (about 15,000 acre-feet per year downstream from the Farad gage, table 10), plus some ground-water recharge (table 12), largely through consolidated rocks, reaches the river or underlying alluvium. The two quantities are assumed to total about 20,000 acre-feet per year (table 16).

With regard to outflow, irrigated lands and phreatophytes include only about 1,500 acres (table 15); evapotranspiration from this small acreage probably is less than 4,000 acre-feet per year (on the basis of consumptive-use rates employed in other recent reports of this series). Exported water leaves the area via the Highland, Last Chance, and Steamboat Ditches. The quantity exported and the amount of outflow via the river are not known individually; the sum of the two is therefore estimated as the difference between total inflow and the other elements of outflow.

Truckee Meadows

Inflow from nonmainstem hydrographic areas (table 11) is provided by Pleasant Valley via Steamboat Creek (8,000 acre-feet per year), Sun Valley (minor contribution), and Spanish Springs Valley (9,000 acre-feet per year). Locally derived input to the valley area of Truckee Meadows includes mountain-front runoff (22,000 acre-feet per year, table 10), plus ground-water recharge occurring upstream from the mountain front. Such recharge probably is a relatively small part of the total potential recharge from precipitation (which is estimated to be 27,000 acre-feet per year; table 12). Some of the mountain-front runoff recharges the valley-fill ground-water reservoir, and another increment reaches the Truckee River as rejected recharge. The total amount of local runoff that reaches either the ground-water reservoir or Truckee River may not exceed 30,000 acre-feet per year.

The surface-water outflow at Vista has been measured for most of the long-term reference period. Water is exported to Spanish Springs Valley via the Orr Ditch, and to Lemmon Valley (Stead area) and Sun Valley via pipeline (17,000 acre-feet per year). Other outflow quantities are determined by difference, and include water

Table 16.--Reconnaissance water budgets for mainstem hydrographic areas for period 1919-69

[All estimates are in acre-feet per year, and are considered accurate to no more than two significant figures above 100,000, and one significant figure below 100,000; see text for discussion of budgets.]

Mainstem hydrographic area	Truckee Canyon Segment (between Farad gage and Lawton)1/	Truckee Meadows (between Lawton and Vista gage)	Tracy Segment (between Vista and Wadsworth gages)	Dodge Flat (between Wadsworth and Nixon gages)	Pyramid Lake Valley (downstream from Nixon gage)2/	Entire mainstem area downstream from Farad gage1 2/
INFLOW						
Mainstem inflow:						
Ground water (table 13)	400	700	minor	700	300	400
Streamflow (table 11)	509,000	530,000	480,000	245,000	250,000	509,000
Imported water (p. 43)	0		0	0	0	0
Inflow from nonmainstem hydrographic areas:						
Ground water (table 13)	0	400	2,100	2,100	200	4,800
Streamflow (table 11)	0	17,000	minor	minor	70	17,000
Input to system from within mainstem hydrographic area3/	20,000	30,000	5,000	a 6,400±	<10,000	70,000
TOTAL INFLOW (rounded)	530,000	580,000	490,000	255,000	260,000	600,000
OUTFLOW						
Mainstem outflow:						
Ground water (table 13)	700	minor	700	300	0	0
Streamflow (table 11)	b 530,000	480,000	245,000	250,000	0	0
Exported water (p. 47)		17,000	b 235,000	0	0	250,000
Outflow to nonmainstem hydrographic areas:						
Ground water (table 13)	0	0	0	0	400	400
Surface water (table 11)	0	0	0	0	minor	minor
Net lake-surface evaporation	minor	minor	minor	minor	c 410,000	410,000
Other outflow quantities4/	<4,000	b 80,000	<10,000	<5,000	5,000±	100,000±
TOTAL OUTFLOW (rounded)	530,000	580,000	490,000	255,000	420,000	760,000

1/ Includes area in Calif. tributary to river downstream from Farad gage; does not include area in Nevada tributary to river above gage.
2/ System is not in equilibrium because of net decrease in storage at Pyramid Lake (average for period, 157,000 acre-ft per year).
3/ Ground-water recharge plus surface inflow to river (or Pyramid Lake) generated within mainstem hydrographic areas.
4/ Includes water consumptively used for municipal, industrial, domestic, and agricultural purposes, plus evapotranspiration from phreatophytes and bare playas.
a. Exceeds quantity described in footnote 3. See discussion of budget for Dodge Flat in text.
b. Computed as difference (rounded) between total inflow and other estimated elements of outflow. Includes net error resulting from inaccuracy of other estimates in budget.
c. Average for entire period. Current (1970) rate may average about 380,000 acre-ft per year.

Table 17.--Reconnaissance water budgets for nonmainstem hydrographic areas for period 1919-69 1/

[All estimates are in acre-feet per year, and are considered accurate to no more than two significant figures above 100,000, and one significant figure below 100,000; see text for discussion of budgets.]

Hydrographic area	Pleasant Valley	Fernley Area	Winnemucca Lake Valley 1/
INFLOW			
Inflow from other hydrographic areas:			
Ground water (table 13)	50	0	400
Streamflow (table 11)	1,000	0	minor
Imported water (p. 43)	0	a 235,000	0
Input to system from within hydrographic area 2/	10,000	600	2,900
TOTAL INFLOW (rounded)	11,000	235,000	3,300
OUTFLOW			
Outflow to other hydrographic areas:			
Ground water (table 13; p. 47)	350	5,800	0
Surface water (table 11; p. 47)	8,000	4,000	0
Exported water (p. 47)	2,000	a 180,000	0
Net lake-surface evaporation	0	6,100	minor
Other outflow quantities	b 1,000	b 39,000	c 5,000
TOTAL OUTFLOW (rounded)	11,000	235,000	c 5,000

1/ Budget for Winnemucca Lake Valley is for conditions since lake dried in about 1940.
2/ Ground-water recharge and, in Pleasant Valley, surface inflow to Steamboat Creek, generated within the hydrographic area.
a. Truckee Canal.
b. Computed as difference (rounded) between total inflow and other estimated elements of outflow. Includes water consumptively used for municipal, industrial, domestic, and agricultural purposes, plus evapotranspiration from phreatophytes and bare playas. Also includes net error resulting from inaccuracy of other estimates in budget.
c. See discussion of budget for Winnemucca Lake Valley in text.

withdrawn and consumptively used in the Reno-Sparks metropolitan area, and evapotranspiration from some 25,000 acres of phreatophytes and irrigated lands (table 15). The computed total of 80,000 acre-feet per year (table 16) may exceed actual losses somewhat, owing to the inaccuracies in the estimation of certain other elements of the budget.

Tracy Segment

Input to the river and ground-water reservoir within the area from local runoff and precipitation is assumed to be nearly equal to the estimated potential recharge (table 12), or about 5,000 acre-feet per year.

Irrigated and phreatophyte lands total about 3,700 acres (table 15); evapotranspiration therefrom, plus other consumptive uses, presumably is less than 10,000 acre-feet per year. Large quantities of water (about 260,000 acre-feet per year) have been diverted from the river into Truckee Canal at Derby Dam during the reference period. However, part of the diversion, about 25,000 acre-feet per year, has returned to the river via spillways and leakage before the canal flow has entered the Fernley Area. Thus, the net amount actually exported from the Truckee River basin may average about 235,000 acre-feet per year.

Dodge Flat

Estimated elements of inflow, in addition to that of the Truckee River, include ground-water recharge (about 1,400 acre-feet per year; table 12) and ground-water inflow from other hydrographic areas (at least 2,800 acre-feet per year; table 13). Irrigated and phreatophyte areas total about 3,200 acres (table 15), and probably consume less than 5,000 acre-feet per year, which approximately balances the inflow quantities listed above. Despite this approximate balance, the river apparently gains an average of at least 5,000 acre-feet per year within the hydrographic area (p. 37). Part or all of this increase may represent unaccounted-for increments of recharge and ground-water inflow from the Fernley Area (p. 42), whereas some of it may be apparent rather than real, due to small errors in the measurement of large streamflow quantities. In summary, then, the total input to the system between the Wadsworth and Nixon gages may be on the order of 10,000 acre-feet per year.

Pyramid Lake Valley

For the 51-year base period 1919-69, estimated inflow via Truckee River has averaged about 250,000 acre-feet per year (table 6). Addition of surface- and ground-water inflow from Warm Springs Valley and from within the local valley area makes the average annual total about 260,000 acre-feet.

Phreatophytes and irrigated lands amount to about 14,000 acres (table 15). These areas may consume about 5,000 acre-feet per year. Net lake-surface evaporation is estimated to have averaged 410,000 acre-feet per year for the 51-year base period. This suggests an average annual deficiency between total inflow and outflow of about 160,000 acre-feet (rounded). Between 1919 and 1969, the level of Pyramid Lake dropped about 66 feet, and the volume diminished by 8 million acre-feet. Thus, the average annual decrease in storage during the 51-year period was 157,000 acre-feet, which corresponds well with the imbalance between estimated total inflow and outflow. Another form of storage depletion, which is too small annually to have a noticeable effect on the imbalance, is the net loss of stored ground water associated with the declining lake level. This quantity may average about 1,500 acre-feet per year (p. 14).

The present-day (1969) imbalance between inflow and outflow is not as great as that for the long term. Because the surface area has decreased as the lake level has declined, current net evaporation is estimated to average about 380,000 acre-feet per year. On the basis of average inflow for the 51-year base period, the current deficiency is on the order of 130,000 acre-feet per year (rounded), rather than 160,000.

Entire Mainstem Area

Downstream from Farad during the base period 1919-69, the Truckee River mainstem system gained an average of about 90,000 acre-feet of local inflow per year, but lost approximately 250,000 acre-feet by export (table 16). The total inflow averaged about 600,000 acre-feet per year, whereas total outflow was about 760,000 acre-feet per year. The net depletion (160,000 acre-feet per year) is almost entirely the result of loss by evaporation from Pyramid Lake.

Nonmainstem Areas

Pleasant Valley

Streamflow and ground water enter and leave the area by way of Steamboat Creek and underlying alluvium. Table 17 shows that within the area, ground-water recharge plus runoff that reaches Steamboat Creek may total about 10,000 acre-feet per year, on the basis of estimated values for potential recharge and mountain-front runoff (10,000 and 9,000 acre-feet per year, respectively). Water is exported to neighboring Washoe Valley by way of a canal. The net difference between total inflow and estimated elements of outflow, 1,000 acre-feet per year (table 17), is of the right order of magnitude but perhaps slightly smaller than the actual amount of water consumed by evapotranspiration in the hydrographic area.

Fernley Area

The Truckee Canal supplies nearly all the inflow to the area (table 17). Ground-water outflow is the sum of the amounts moving to the Tracy Segment, Dodge Flat, Bradys Hot Springs Area, and the Carson Desert (table 13 and p. 47). The amount of water exported from the Fernley Area via Truckee Canal is estimated on the basis of (1) canal-flow decrease between the Wadsworth and Hazen gages during the short period of concurrent record (table 7), and (2) an evaluation of diversions from the canal in the Hazen area, which is outside the Fernley Area but upstream from the Hazen gage. Canal flow was diminished by an average of 57,000 acre-feet per year between the two gages during 1967-69, whereas diversions in the Hazen area may total almost 4,000 acre-feet per year (on the basis of data provided by P. R. Taylor, U.S. Bureau of Reclamation, 1971). Thus, the net depletion of canal flow within the Fernley Area alone may be almost 55,000 acre-feet per year, which makes the exported quantity about 180,000 acre-feet annually (table 17).

Net lake-surface evaporation from Fernley Sink and two small reservoirs assumes an average open-water area of 1,700 acres (table 15) and an average net-evaporation rate of 3.6 feet per year (Harrill, 1970). Other outflow quantities, which together are calculated by difference, total almost 40,000 acre-feet per average year, and consist mostly of evapotranspiration from about 3,100 irrigated acres, 14,000 acres of phreatophytes, and 700 acres of playa (table 15).

Winnemucca Lake Valley

The budget for this valley is complicated by ground-water storage depletion associated with the desiccation of Winnemucca Lake (p. 14). The depletion causes an imbalance, with the elements of outflow exceeding those of inflow. The imbalance may average about 1,500 acre-feet per year (table 17). Crude estimates of acreage and discharge rates for phreatophytes and bare playa suggest about 5,000 acre-feet of evapotranspiration per year, as follows:

Type of water loss	Acreage[1/]	Probable range in depth to water (feet)	Evapotranspiration (feet per year)	Evapotranspiration (acre-feet per year)
Playa	40,000	0-10	0.1	4,000
Saltgrass	500	5-15	.3	150
Greasewood and saltbush	a 2,800	5-40	.2	560
Greasewood and saltbush	a 2,800	10-50	.1	280
Total (rounded)	46,000	--	--	5,000

1. Data modified from Zones (1961, p. 13-15)
a. Subdivision of total greasewood and saltbush acreage is estimated, rather than mapped in field.

The budget for Winnemucca Lake Valley, then, applies to conditions for the period since desiccation of the lake in about 1940, rather than for the entire base period 1919-69.

Entire Truckee River Basin Downstream from Farad Gage

For the entire report area, including mainstem and nonmainstem hydrographic areas exclusive of the Fernley Area, the total water supply has averaged about 630,000 acre-feet per year during the base period 1919-69. Of this total, about 110,000 acre-feet per year has been generated within the basin as ground-water recharge and surface flow into major streams and lakes, and about 510,000 acre-feet per year has entered the basin as mainstem inflow. The small remainder comprises ground-water inflow from hydrographic areas outside the basin (about 4,600 acre-feet per year), and imports (about 2,000 acre-feet per year).

Total outflow has averaged about 780,000 acre-feet annually, including (1) almost 240,000 acre-feet of exports, (2) 420,000 acre-feet of evaporation, mostly from Pyramid and Washoe Lakes, and (3) about 120,000 acre-feet of water consumptively used for municipal, industrial, domestic, and agricultural purposes, plus evapotranspiration from phreatophytes and bare playas.

As indicated before, changes in storage at Pyramid Lake are responsible for almost the entire net imbalance between total inflow and outflow.

CHEMICAL QUALITY OF THE WATER

General Chemical Character

Table 18 lists analyses of water from the report area. The data and discussions in this report deal largely with areas not evaluated in previous Geological Survey reports. However, a few recent or previously unpublished analyses are listed for the areas studied earlier. Additional water-quality data for the Truckee River (1) at Floriston, California (near the State line) for 1964-69, (2) at Wadsworth for 1965-69, and (3) near Nixon for 1964-69, and for Peavine Creek near Reno for 1964-60 are available in publications listed on page 117.

The specific conductances in table 18 can be used as a preliminary indication of chemical character, because the concentration of dissolved solids in a water, in milligrams per liter (mg/l), is generally 55 to 70 percent of the specific conductance, in micromhos per centimeter at 25°C (hereafter abbreviated "micromhos"). Milligrams per liter are equivalent to parts per million in most waters; see footnote 1, table 18.

The data in table 18 show that ground water in the report area is highly variable chemically, even within a single valley. However, several generalizations can be made. In and near the upland areas where recharge is appreciable, and adjacent to streams, the specific conductance of ground water characteristically ranges from less than 200 to about 600 micromhos, with calcium and bicarbonate or, at the higher salinities, sodium and bicarbonate as the principal ions in solution. Away from the streams and upland recharge areas, specific conductance typically ranges from 600 to 4,000 micromhos, with the domination of sodium and bicarbonate in the more dilute waters giving way to sodium and chloride in the more saline waters. Areas of saline ground water, dominated by sodium and chloride, are: At and near Steamboat Springs in Truckee Meadows (about 3,000 micromhos); northwest of Pyramid Lake (>3,000 micromhos); and on the floor of Winnemucca Lake Valley and presumably in the northeast part of the Fernley Area (>3,000 micromhos).

Sulfate-rich waters, many of which also are very hard, are associated with bleached (hydrothermally altered) consolidated rocks at several places around the margins of Truckee Meadows. The relations between rock type and water chemistry are discussed by Cohen and Loeltz (1964, p. S10, S44, and S51), and by Cohen (1962). Waters of the sulfate-rich type listed in table 18 include those from wells 20/19-23cac and -27bac (northern margin of Truckee Meadows), and 19/21-21acb (western Tracy Segment). Ground water containing greater-than-average amounts of sulfate has been encountered in several other parts of the study area as well (table 18).

Table 18.--Chemical analysis of well, spring, stream, and lake waters

PART A: GROUND WATER

Location	Source (with well depth where appropriate)	Date sampled	Analyst [3]	Temperature °F	Temperature °C	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K) [4]	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids [5]	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	SAR	Sodium hazard	RSC
							Milligrams per liter (upper number) and milliequivalents per liter (lower number) [1]												Factors affecting suitability for irrigation [2]			
									DODGE FLAT													
21/23-13dcc	Well (85 ft)	4-10-70	G	--	--	--	41 2.05	2 0.15	225 9.77	82 1.34	0 0.00	416 8.66	70 1.97	--	--	110	1,300	8.0	M	9.3	M	S
-29dca	Spring	2-20-70	G	55	13	--	78 3.89	20 1.65	23 1.01	296 4.85	0 0.00	68 1.42	11 0.31	--	--	279	610	7.9	L	.6	L	S
21/24-14aac	Well (344 ft)	2-20-70	G	--	--	--	62 3.09	49 4.06	532 23.16	108 1.77	0 0.00	104 2.14	936 26.40	0.3 0.00	--	358	3,500	7.9	V	12	V	S
-16aca	Well (>40 ft)	2-20-70	G	--	--	--	42 2.10	18 1.48	287 12.47	121 1.98	0 0.00	47 0.98	464 13.09	--	--	179	1,700	8.0	H	9.4	M	S
-28ddc	Well (12-14 ft)	2-19-70	G	--	--	--	40 2.00	14 1.14	31 1.36	199 3.26	0 0.00	35 0.73	18 0.51	--	--	157	450	7.4	L	1.1	L	S
-33dcb	Well (470 ft)	a/ 11- 1-68	N	65	18½	0.02	8 0.40	1 0.08	61 2.67	110 1.80	0 0.00	45 0.94	12 0.34	0.5 0.01	184	24	--	8.2	L	5.4	L	M
									FERNLEY AREA													
19/25-6ccc	Well (242 ft)	6-10-70	G	--	--	--	26 1.30	4 0.30	48 2.07	136 2.23	0 0.00	30 0.62	29 0.82	--	--	80	370	7.7	L	2.3	L	S
20/24-11bbd	Well (250 ft)	a/ 7- 9-68	N	66	19	0.20	56 2.79	35 2.88	108 4.69	298 4.88	0 0.00	224 4.66	22 0.62	12 0.19	622	284	--	8.0	M	2.8	L	S
-24bbb2	Well (199 ft)	a/ 3- 3-69	N	56	13½	0.06	30 1.50	10 0.82	34 1.46	176 2.88	0 0.00	16 0.33	11 0.31	16 0.26	221	116	--	8.2	L	1.3	L	S
20/25-7bdd	Well (206 ft)	2-20-70	G	--	--	--	294 14.67	113 9.31	214 9.31	204 3.34	0 0.00	1,170 24.36	198 5.59	--	--	1,200	3,000	8.1	H	2.6	L	S
-18ccc2	Well (155 ft)	b/ 2-20-70	G	--	--	--	7 0.35	5 0.43	112 4.88	268 4.39	11 0.37	27 0.56	12 0.34	--	--	39	570	8.6	L	7.8	M	U
-21acd	Well (212 ft)	3- 4-70	G	--	--	--	2 0.10	1 0.10	164 7.11	335 5.49	28 0.93	28 0.58	11 0.31	--	--	10	660	8.9	L	22	V	U
-23aba	Well (60 ft±)	7-14-70	G	--	--	--	10 0.50	6 0.52	273 11.89	338 5.54	32 1.07	249 5.18	38 1.07	3.0 0.05	--	51	1,400	9.0	M	17	V	U
-24cad	Well (123 ft)	3- 4-70	G	--	--	--	13 0.65	4 0.33	49 2.15	151 2.47	0 0.00	17 0.35	11 0.31	--	--	49	300	8.0	L	3.1	L	M
-25adb	Well (240 ft)	b/ 3- 4-70	G	67	19½	--	20 1.00	4 0.32	180 7.84	47 0.77	0 0.00	170 3.54	172 4.85	0.0 0.00	--	66	1,100	7.6	M	9.6	M	S
									PLEASANT VALLEY													
17/19-11abc	Well (135 ft)	4- 2-70	G	--	--	--	15 0.75	4 0.37	8 0.35	86 1.41	0 0.00	0 0.00	2 0.06	--	--	56	180	7.7	L	.5	L	S
-17aad	Well (385 ft)	3-18-70	G	--	--	--	13 0.65	6 0.47	10 0.42	94 1.54	0 0.00	0 0.00	0 0.00	--	--	56	140	7.9	L	.6	L	S
17/20-4bdd	Well (37 ft)	6-16-59	N	58	14½	--	42 2.10	18 1.50	26 1.13	270 4.43	0 0.00	10 0.21	3 0.08	0.5 0.01	292	180	--	--	L	.8	L	S
-4dc	Well (52 ft)	a/ 1949	G	98	37	--	19 0.95	8.7 0.72	(a)	149 2.44	0 0.00	7.2 0.15	3.9 0.11	--	228c	84	256	7.6	L	.9	L	S
-7aab	Well (168 ft)	3-24-70	G	70	21	--	34 1.70	12 0.98	61 2.66	229 3.75	0 0.00	68 1.42	6 0.17	--	--	134	520	7.8	L	2.3	L	S
-7cad	Well (150 ft)	4-10-70	G	--	--	--	13 0.65	6 0.47	7 0.29	80 1.31	0 0.00	5 0.10	0 0.00	--	--	56	140	7.7	L	.4	L	S
-18cca	Well (200 ft)	3-24-70	G	--	--	--	17 0.85	7 0.55	35 1.54	159 2.61	0 0.00	9 0.19	5 0.14	--	--	70	280	7.5	L	1.8	L	S
									PYRAMID LAKE VALLEY													
22/23-1bda	Well (60 ft)	5-21-62	N	--	--	4+	77 3.84	31 2.55	80 3.49	242 3.97	0 0.00	67 1.39	160 4.51	0.0 0.00	687	320	--	7.2	M	2.0	L	S
22/24-9bad	Well (200 ft±)	2-18-70	G	67+	19½	--	8 0.40	3 0.28	188 8.19	222 3.64	12 0.40	95 1.98	101 2.85	--	--	34	970	8.6	M	14	H	U
-13ac	Well (315 ft)	2-18-70	G	67+	19½+	--	33 1.65	12 0.97	107 4.65	86 1.41	0 0.00	71 1.48	154 4.34	2.5 0.04	--	131	800	8.1	M	4.1	L	S
23/21-15bbd	Spring	2-11-70	G	54	12½	--	122 6.09	21 1.70	36 1.58	173 2.84	0 0.00	292 6.08	16 0.45	--	--	390	900	7.8	M	8.0	M	S
23/22-26c, -27d	Springs	a/ 10- 1-67	D	--	--	--	27 1.35	13 1.07	(a)	148 2.43	0 0.00	22 0.46	3.6 0.10	--	198c	60	--	8.0	L	.8	L	S
23/23-1cac	Well (50 ft?)	2-11-70	G	59	15	--	17 0.85	7 0.59	344 14.94	440 7.21	22 0.73	156 3.25	184 5.19	--	--	72	1,800	8.5	H	18	V	U
-15cad	Well (>115 ft)	2-19-70	G	56	13½	--	119 5.94	59 4.83	269 11.70	287 4.70	0 0.00	581 12.10	201 5.67	--	--	539	2,400	7.3	H	5.0	M	S
-23bcb	Well (136 ft)	b/ 2-19-70	G	--	--	--	1 0.04	0 0.00	203 8.82	366 6.00	63 2.10	0 0.00	27 0.76	--	--	2	840	9.3	H	62	V	U
-25bcd	Well (350 ft)	2-19-70	G	--	--	--	4 0.20	1 0.12	145 6.31	193 3.16	0 0.00	65 1.35	75 2.12	--	--	16	700	8.2	L	16	H	U
-26ddc	Well (170 ft)	9-28-66	N	58	14½	2.8	8 0.40	2.9 0.24	189 8.22	165 2.71	22 0.73	125 2.60	98 2.76	4.0 0.06	578	32	--	9.0	L	15	H	U
-29cab2	Well	7-31-69	G	59	15	--	36 1.80	9 0.72	40 1.74	188 3.08	0 0.00	42 0.87	11 0.31	--	--	126	400	8.2	L	1.6	L	S
-36ddc	Well (60 ft±)	2-18-70	G	--	--	--	84 4.19	33 2.70	92 4.02	281 4.61	0 0.00	118 2.46	136 3.84	--	--	343	1,100	8.1	M	2.2	L	S
24/20-13d	Springs	a/ 9-24-67	D	--	--	--	24 1.20	7.1 0.58	(a)	119 1.95	0 0.00	6.1 0.13	2.6 0.07	0.35 0.01	141c	89	--	8.2	L	.5	L	S
24/21-15aac	Well (110 ft)	2-24-62	N	--	--	--	0 0.00	0 0.00	226 9.83	503 8.27	12 0.40	27 0.56	21 0.59	0.5 0.01	496	0	--	8.9	L	V	V	U
-15cad	Well (420 ft)	b/ 7-10-70	G	--	--	--	2 0.10	0 0.00	160 6.95	305 5.00	30 1.00	14 0.29	27 0.76	--	--	5	650	9.1	L	30	V	U

Table 18.--Chemical analysis of well, spring, stream, and lake waters--Continued

PART A: GROUND WATER--Continued

Location	Source (with well depth where appropriate)	Date sampled	Analyst 3/	Temperature °F	Temperature °C	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K) 4/	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids 5/	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	SAR	Sodium hazard	RSC
							Milligrams per liter (upper number) and milliequivalents per liter (lower number) 1/												Factors affecting suitability for irrigation 2/			
PYRAMID LAKE VALLEY--Continued																						
24/22-31ccc	Well (226 ft)	b/ 7-10-70	G	--	--	--	89 4.44	36 2.95	343 14.91	447 7.33	0 0.00	440 9.16	206 5.81	--	--	370	2,300	7.6	H	7.8	M	S
25/20-3a	Springs	a/ 10- 1-67	D	--	--	--	20 1.00	7.9 0.65	(a)	113 1.85	0 0.00	6.1 0.13	3.0 0.08	0.0 0.00	154	83	--	7.8	L	.5	L	S
25/21-18baa	Well (112 ft)	a/ 4- 8-69	N	68	20	0.27	0 0.00	0 0.00	148 6.43	214 3.50	70 2.33	13 0.27	10 0.28	0.0 0.00	403	0	--	9.7	L	V	V	U
25/22-2dcc	Well (64 ft)	7-21-70	G	--	--	--	25 1.25	17 1.37	106 4.60	307 5.03	0 0.00	51 1.06	40 1.13	--	--	131	710	8.1	L	4.0	L	M
26/20-12bad	Spring	2-14-69	G	132	55½	--	152 7.58	16 1.33	1,210 52.71	220 3.61	0 0.00	307 6.39	1,830 51.62	--	--	446	6,300	8.1	V	25	V	S
-26adb	Well (210 ft)	9-26-52	S	--	--	--	3.2 0.16	1.4 0.12	85 3.70	193 3.17	0 0.00	16 0.33	17 0.48	--	272	14	--	7.0	L	9.9	M	U
26/21-6ccb	Well (5,930 ft)	a/ 4- -68	B	--	--	--	250 12.48	6.3 0.52	(a)	0 0.00	26 0.87	351 7.30	2,100 59.22	--	3,940c	651	6,050	9.2	V	20	V	S
27/20-29bac	Well	2- 4-70	G	59	15	--	33 1.65	16 1.35	1,060 45.89	420 6.88	0 0.00	568 11.83	1,070 30.18	--	--	150	5,200	8.2	V	37	V	U
27/21-16abd	Well (44 ft)	b/ 10-24-70	G	--	--	--	31 1.55	61 5.04	2,100 91.71	1,620 26.55	172 5.73	190 3.96	2,200 62.06	--	--	330	9,380	8.6	U	50	V	U
27/22-16ada	Spring	8-22-69	G	77	25	--	56 2.79	22 1.83	54 2.34	277 4.54	0 0.00	70 1.46	34 0.96	--	--	231	640	8.2	L	1.5	L	S
28/21-31ccd	Well (60 ft)	b/ 10-24-70	G	--		--	5 0.25	15 1.25	3,600 157.5	270 4.42	620 20.66	200 4.16	4,600 129.8	--	--	75	15,600	10.0	U	180	V	U
28/22-30bcb	Well (420+ ft)	a/ 4- 8-39	A	--	--	--	0 0.00	0 0.00	471 20.48	c/561 9.20	--	222 4.63	236 6.65	--	--	0	2,030	--	H	V	V	U
29/21-35cbc	Spring	9- 4-69	G	64	18	--	54 2.69	15 1.27	34 1.46	137 2.25	0 0.00	94 1.96	43 1.21	--	--	198	530	8.0	L	1.0	L	S
TRACY SEGMENT																						
19/20-13add	Well (93 ft)	7-30-69	G	73	23	--	40 2.00	8 0.64	264 11.50	328 5.38	30 1.00	247 5.14	93 2.62	--	--	132	1,500	8.5	H	10	M	U
19/21-9dad	Well (330 ft)	3- 5-70	G	--	--	--	35 1.75	15 1.27	68 2.96	176 2.88	0 0.00	103 2.14	34 0.96	--	--	151	590	7.9	L	2.4	L	S
-16dbd	Well (122 ft)	7-28-69	G	59	15	--	67 3.34	30 2.43	55 2.37	183 3.00	0 0.00	75 1.56	48 1.35	138 2.23	--	289	770	8.2	M	1.4	L	S
-21acb	Well (94 ft)	a/ 11-23-69	N	--	--	1.4	157 7.83	52 4.24	45 1.94	346 5.67	0 0.00	350 7.29	25 0.71	20 0.32	1,190	604	--	7.6	H	.8	L	S
20/22-28bcc	Well (141 ft)	3- 5-70	G	--	--	--	11 0.55	7 0.57	17 0.74	93 1.52	0 0.00	8 0.17	6 0.17	--	--	56	190	7.7	L	1.0	L	S
-33bab	Well (133 ft)	a/ 5-30-61	C	56	13½	--	24 1.20	11 0.92	27 1.17	146 2.39	0 0.00	23 0.48	15 0.42	--	215	106	306	7.2	L	1.1	L	S
20/23-21daa	Well (76 ft)	3- 5-70	G	--	--	--	18 0.90	8 0.62	19 0.82	111 1.82	0 0.00	10 0.21	11 0.31	--	--	76	240	7.8	L	.9	L	S
20/24-4aaa	Well (90 ft?)	a/ 5-21-62	N	--	--	0.30	51 2.55	22 1.85	40 1.73	185 3.03	0 0.00	96 2.00	24 0.68	26 0.42	314	220	--	7.5	M	1.2	L	S
TRUCKEE CANYON SEGMENT																						
19/18-8ccc	Well (302 ft)	4- 2-70	G	--	--	--	12 0.60	7 0.56	19 0.84	108 1.77	0 0.00	6 0.12	4 0.11	--	--	58	220	8.1	L	1.1	L	S
-16dac	Well (150 ft)	4-12-70	G	--	--	--	27 1.35	21 1.75	15 0.65	210 3.44	0 0.00	8 0.17	5 0.14	--	--	155	330	7.9	L	.5	L	S
-19dhd	Well (500 ft)	4- 2-70	G	63	17½	--	27 1.35	20 1.67	13 0.55	208 3.41	0 0.00	5 0.10	2 0.06	--	--	151	390	8.2	L	.4	L	S
TRUCKEE MEADOWS																						
18/19-25cca	Well (102 ft)	3-24-70	G	--	--	--	17 0.85	9 0.75	12 0.53	128 2.10	0 0.00	0 0.00	1 0.03	--	--	80	210	7.3	L	.6	L	S
-26caa	Well (435 ft)	3-24-70	G	--	--	--	21 1.05	14 1.13	12 0.51	162 2.66	0 0.00	0 0.00	1 0.03	--	--	109	250	7.6	L	.5	L	S
18/20-6abb	Well (286 ft)	a/ 11-18-68	W	62	16½	<0.05	22 1.10	13 1.07	18 0.78	170 2.79	0 0.00	4 0.08	3 0.08	1.4 0.02	205	109	266	7.8	L	.7	L	S
-27bcb1	Well (112 ft)	3-24-70	G	--	--	--	22 1.10	6 0.50	167 7.24	350 5.74	0 0.00	31 0.65	87 2.45	--	--	80	880	7.6	M	8.1	M	U
19/19-12aaa	Well (583 ft)	a/ 11-11-69	B	--	--	0.17	50 2.50	17 1.32	(a)	201 3.29	0 0.00	43 0.90	12 0.34	13 0.21	306	193	437	7.9	L	.6	L	S
-12bcd	Well (530 ft)	a/ 8-27-69	B	63	17	0.17	37 1.85	13 0.99	(a)	138 2.27	0 0.00	67 1.39	11 0.31	2.4 0.04	266	144	382	8.2	L	.8	L	S
-12bdb	Well (588 ft)	a/ 8-27-69	B	64	18	0.06	63 3.14	18 1.40	(a)	193 3.16	0 0.00	112 2.33	18 0.51	5.8 0.09	388	229	553	8.0	L	.9	L	S
-24cba2 f/	Well (1,006 ft)	3-25-70	G	130	54½	--	20 1.00	3 0.24	186 8.07	135 2.21	0 0.00	298 6.20	32 0.90	--	--	62	980	8.2	M	10	M	S
19/20-4dcb	Well (662 ft)	a/ 11-11-69	B	63	17	0.20	19 0.95	8.4 0.70	(a)	110 1.80	0 0.00	70 1.46	8 0.23	2.4 0.04	268	82	343	7.9	L	1.6	L	S
-6dcd	Well (530 ft)	a/ 1- 3-69	W	64	18	<0.05	37 1.85	13 1.07	20 0.87	149 2.44	0 0.00	58 1.21	4 0.11	3.9 0.06	267	148	361	7.9	L	.7	L	S
-8baa	Well (280 ft)	a/ 8-12-69	W	60	15½	<0.05	26 1.30	9 0.74	16 0.70	109 1.79	0 0.00	37 0.77	3 0.08	1.4 0.02	194	100	256	7.9	L	.7	L	S
-8bdd2	Well (300 ft)	a/ 8-18-69	B	61	16	<0.01	27 1.35	8.9 0.72	(a)	106 1.74	0 0.00	37 0.77	6 0.17	2.3 0.04	200	104	270	8.0	L	.6	L	S
-8ddb	Well (274 ft)	a/ 8-18-69	B	57	14	<0.01	30 1.50	7.1 0.60	(a)	105 1.72	0 0.00	54 1.12	8 0.23	1.2 0.02	276	104	298	8.0	L	.9	L	S
-17acd	Well (563 ft)	a/ 7-23-69	B	66	19	<0.01	12 0.60	5 0.41	(a)	120 1.97	0 0.00	95 1.98	12 0.34	0.9 0.01	314	49	442	7.9	L	4.6	L	S
-18bba	Well (660 ft)	a/ 8-18-69	B	65	18½	<0.01	24 1.20	7 0.58	(a)	112 1.84	0 0.00	58 1.21	9 0.25	1.0 0.02	238	88	334	8.2	L	1.6	L	S

Table 18.--Chemical analysis of well, spring, stream, and lake waters--Continued

PART A: GROUND WATER--Continued

Location	Source (with well depth where appropriate)	Date sampled	Analyst [3]	Temperature °F	Temperature °C	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K) [4]	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids [5]	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	SAR	Sodium hazard	RSC
							Milligrams per liter (upper number) and milliequivalents per liter (lower number) [1]												Factors affecting suitability for irrigation [2]			
							TRUCKEE MEADOWS--Continued															
19/20-18dbd	Well (685 ft)	a/ 8-27-69	B	68	20	0.17	6 0.30	2.2 0.18	(a)	112 1.84	0 0.00	84 1.75	7 0.20	0.1 0.00	288	24	384	8.3	L	6.4	L	M
-21bcb	Well (346 ft)	a/ 11-11-69	B	59	15	0.23	22 1.10	8 0.66	(a)	163 2.67	0 0.00	45 0.94	8 0.23	<0.1 0.00	272	88	371	7.9	L	1.9	L	S
-30dab	Well (826 ft)	a/ 8-27-69	B	64	18	0.06	24 1.20	7.3 0.62	(a)	173 2.84	0 0.00	39 0.81	8 0.23	0.3 0.00	276	90	362	8.3	L	1.9	L	S
20/19-23cac	Well (86 ft)	3-25-70	G	—	—	--	124 6.19	68 5.60	66 2.86	183 3.00	0 0.00	538 11.20	16 0.45	--	--	590	1,500	7.8	M	1.2	L	S
-27bac	Well (214 ft)	10- 1-68	N	--	--	0.87	107 5.34	39 3.21	105 4.57	188 3.08	0 0.00	470 9.79	9.0 0.25	0.0 0.00	733	428	--	7.6	L	2.2	L	S
							WASHOE VALLEY															
16/19-3ba	Spring	a/ 10-19-59	G	120	49	0.02	3.2 0.16	1.0 0.08	(a)	32 0.52	26 0.87	36 0.75	4.0 0.11	0.0 0.00	180c	12	254	9.2	L	5.8	L	S
-21a	Spring	a/ 6- 2-60	G	53	12	0.02	14 0.70	1.7 0.14	(a)	75 1.23	0 0.00	1.2 0.02	0.5 0.01	0.0 0.00	88c	43	120	7.3	L	.5	L	S
16/20-17ac	Well (225 ft)	a/ 9-29-58	R	—	--	0.16	37 1.85	9.1 0.75	(a)	140 2.29	9.9 0.33	44 0.92	5.0 0.14	0.4 0.01	237	130	350	8.3	L	.7	L	S
							WINNEMUCCA LAKE VALLEY															
25/23-10bcd	Sevenmile Spring	7-30-69	G	64	18	--	32 1.60	7 0.60	47 2.06	200 3.28	0 0.00	21 0.44	19 0.54	--	--	110	410	8.0	L	2.0	L	S
25/24-8add	Well	a/ 6-24-42	N	—	--	—	54 2.70	15 1.23	6,400 278.1	2,050 33.59	154 5.13	1,740 36.23	7,350 207.0	--	17,000	197	25,400	--	U	198	V	U
-15d	Spring	a/ 7-24-41	N	—	--	--	504 25.15	185 15.22	196 8.53	203 3.33	0 0.00	1,430 29.77	560 15.80	--	2,920	2,020	--	--	V	1.9	L	S
26/23-10dba	Spring	7-30-69	G	65	18½	--	6 0.30	3 0.26	84 3.64	206 3.38	0 0.00	18 0.37	16 0.45	--	—	28	420	8.2	L	6.9	L	U
27/25-8dd	Lower Stonehouse Spring	9- 3-69	G	82	28	--	86 4.29	28 2.30	101 4.40	286 4.69	0 0.00	132 2.75	126 3.55	--	--	330	1,100	7.9	M	2.4	L	S
28/23-27d	Spring	7-30-69	G	72	22½	--	7 0.35	2 0.15	52 2.27	109 1.79	0 0.00	21 0.44	19 0.54	--	--	25	300	8.2	L	4.5	L	M

1. Milligrams per liter and milliequivalents per liter are metric units of measure that are virtually identical to parts per million and equivalents per million, respectively, for all waters having a specific conductance less than about 10,000 micromhos. The metric system of measurement is receiving increased use throughout the United States because of its value as an international form of scientific communication. Therefore, the U.S. Geological Survey recently has adopted the system for reporting all water-quality data. Where only one number is shown, it is milligrams per liter.

2. Salinity hazard is based on specific conductance (in micromhos) as follows: 0-750, low hazard (L; water suitable for almost all applications); 750-1,500, medium (M, can be detrimental to sensitive crops); 1,500-3,000, high (H; can be detrimental to many crops); 3,000-7,500, very high (V; should be used only for tolerant plants on permeable soils); >7,500, unsuitable (U). Salinity hazards for some analyses are estimated on basis of reported dissolved-solids content. SAR (sodium adsorption ratio) provides an indication of what effect an irrigation water will have on soil-drainage characteristics. SAR is calculated as follows, using milliequivalents per liter: $SAR = Na/\sqrt{(Ca + Mg)/2}$. Where sodium plus potassium are computed by difference rather than analyzed for (footnote 4), that value is used to compute SAR. Sodium hazard is based on an empirical relation between salinity hazard and sodium-adsorption ratio: low (L), medium (M), high (H), or very high (V). RSC (residual sodium carbonate): safe (S), marginal (M), or unsuitable (U). The several factors should be used as general indicators only, because the suitability of a water for irrigation also depends on climate, type of soil, drainage characteristics, plant type, and amount of water applied. These and other aspects of water quality for irrigation are discussed by the National Technical Advisory Committee (1968, p. 143-177), and the U.S. Salinity Laboratory Staff (1954).

3. Analysts: G, U.S. Geol. Survey; A, U.S. Dept. Agriculture; B, Brown and Caldwell Lab. (for Sierra Pacific and Hidden Valley wells, temperatures are those measured at end of 48-hour pump test following well completion); C, Curtis Labs.; D, Desert Research Inst. (Wilsey and Ham, 1970, p. 59); I, U.S. Bur. of Indian Affairs; N, Nevada State Health Div.; S, Southern Pacific Co.; R, U.S. Bur. of Reclamation; W, Edna Wood Lab. (except for arsenic, which was determined by Brown and Caldwell). All surface-water analyses (part B of table) by U.S. Geol. Survey. Analyses marked B and W were taken from a tabulation by Guyton and Associates (1970, table 4).

4. Computed as the milliequivalent-per-liter difference between the determined negative and positive ions; expressed as sodium (the concentration of sodium generally is at least 10 times that of potassium). Computation assumes that concentrations of undetermined negative ions--especially nitrate--are small.

5. Known or assumed to be residue on evaporation at 105°C, except where followed by "c" that indicates computed sum (with bicarbonate multiplied by 0.492 to make result comparable with residue values).

a. Detailed laboratory analysis; additional determinations are listed in part C of this table.

b. Sample bailed from unused well; may not represent chemical character of water yielded by well after appreciable pumping.

c. Bicarbonate plus carbonate, expressed as bicarbonate.

d. Lowest and highest values from composite and single samples collected during water year 1969.

e. Estimated values indicated by "e."

f. Fluoride content 2.5 mg/l for sample collected June 20, 1972.

Table 18.--Chemical analysis of well, spring, stream, and lake waters--Continued

PART B: SURFACE WATER (all analyses by U.S. Geol. Survey)

Location (in downstream order)	Source	Date sampled	Discharge (cfs) or lake level (ft) e/	Temperature °F	°C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K) a/	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Dissolved solids b/	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	SAR	Sodium hazard	RSC
						Milligrams per liter (upper number) and milliequivalents per liter (lower number) 1/											Factors affecting suitability for irrigation 2/			
18/18-30cb	Truckee River	Lowest a d/	379	32	0	5.4 0.33	1.7 0.14	(a)	26 0.43	0 0.00	2.0 0.04	0.8 0.02	48	20	52	6.7	L	0.3	L	S
		Highest a d/	3,880	64	18	9.9 0.49	3.2 0.26	(a)	54 0.89	0 0.00	4.0 0.08	3.7 0.10	69	38	133	7.9	L	.5	L	S
19/18-9d	do.	a/ 3-16-62	--	--	--	16 0.80	4.9 0.40	(a)	78 1.28	0 0.00	6.8 0.14	4.0 0.11	104c	60	151	7.2	L	.4	L	S
19/19-5ad	Peavine Creek	2- 1-69	.13	35	2	24 1.20	10 0.82	11 0.46	16 0.26	0 0.00	103 2.14	3 0.08	--	101	290	7.1	L	.5	L	S
Do.	do.	a/ 3-30-69	1.5	59	15	9.1 0.45	4.8 0.39	(a)	16 0.26	0 0.00	40 0.83	1.4 0.04	—	42	134	6.5	L	.5	L	S
19/20-7b	Truckee River	a/ 3-14-62	221	44	7	13 0.65	4.7 0.39	(a)	66 1.08	0 0.00	11 0.23	4.4 0.12	98c	53	137	8.1	L	.3	L	S
16/20-5ada	Stream	4- 2-69	3-5e	--	--	24 1.20	4 0.32	7 0.31	92 1.51	0 0.00	14 0.29	1 0.03	—	76	190	8.0	L	.4	L	S
16/19-3ccd	Franktown Creek	2-14-69	4e	36	2½	6 0.30	1 0.10	5 0.22	34 0.56	0 0.00	0 0.00	2 0.06	—	20	60	7.6	L	.5	L	S
16/20-19cd	Washoe Lake	a/ 4-29-59	—	--	--	38 1.90	14 1.15	(a)	325 5.33	0 0.00	19 0.40	7.8 0.22	361c	150	546	7.8	L	2.2	L	M
Do.	do.	a/ 11-10-59	—	--	--	43 2.15	18 1.48	(a)	464 7.60	10 0.33	37 0.77	15 0.42	546c	184	804	8.3	M	3.7	L	U
18/20-33cda	Steamboat Creek	a/ 3-14-62	6.4	54	12½	31 1.55	9.3 0.77	(a)	182 2.98	0 0.00	10 0.21	4.0 0.11	217c	115	323	7.4	L	.8	L	S
Do.	do.	2-14-69	9.6	40	4½	26 1.30	9 0.76	22 0.96	158 2.59	0 0.00	11 0.23	7 0.20	--	103	290	8.1	L	.9	L	S
18/20-28baa	do.	2-14-69	--	45	7½	27 1.35	9 0.77	100 4.36	186 3.05	0 0.00	32 0.67	98 2.76	--	106	690	8.0	L	4.2	L	S
19/20-34c	do.	a/ 3-14-62	--	51	11	38 1.90	15 1.23	(a)	275 4.51	0 0.00	36 0.75	89 2.51	471c	158	803	7.8	M	3.3	L	M
-13ab	Truckee River	a/ 3-15-62	296	40	4½	20 1.00	6.3 0.52	(a)	107 1.75	0 0.00	30 0.62	16 0.45	183c	76	287	7.2	L	1.3	L	S
19/21-22cca	Long Valley Creek	3- 5-70	.5e	54	12½	39 1.95	17 1.41	34 1.49	155 2.54	0 0.00	99 2.06	9 0.25	--	168	480	8.2	L	1.1	L	S
-16ccc	do.	3- 5-70	.5e	53	12	61 3.04	24 1.97	53 2.32	0 0.00	0 0.00	340 7.08	9 0.25	--	251	700	4.4	L	1.5	L	S
20/23-19b	Truckee River	a/ 3-15-62	300e	44	7	21 1.05	8.2 0.67	(a)	122 2.00	0 0.00	31 0.65	25 0.71	214c	87	342	7.3	L	1.5	L	S
-20a	do.	a/ 3-15-62	.2	52	11½	33 1.65	11 0.90	(a)	188 3.08	0 0.00	26 0.54	19 0.54	256c	128	389	8.2	L	1.2	L	S
20/24-3bc	do.	a/ 3-15-62	3-5e	48	9	36 1.80	12 0.99	(a)	186 3.05	0 0.00	38 0.79	20 0.56	262c	141	418	8.0	L	1.2	L	S
21/23-3caa	Stream	2-19-70	.15e	43	6½	46 2.30	43 3.53	85 3.71	465 7.62	0 0.00	49 1.02	32 0.90	—	292	860	8.2	M	2.2	L	M
22/24-18bc	Truckee River	5-17-69	3,560	56	13½	8 0.40	3 0.22	8 0.34	43 0.70	0 0.00	7 0.15	4 0.11	--	31	96	7.9	L	.6	L	S
	do.	12-15-69	33	44	7	56 2.79	21 1.75	86 3.73	163 2.67	0 0.00	106 2.21	122 3.44	--	227	900	8.2	M	2.5	L	S
22/23-1a	do.	a/ 3-15-62	5-10e	47	8½	82 4.09	27 2.22	(a)	179 2.93	0 0.00	184 3.83	198 5.59	741c	317	1,260	8.0	M	3.1	L	S
23/22-10dbb	Rodeo Creek	3-30-69	1½e	60	16	35 1.75	2 0.17	24 1.03	183 3.00	0 0.00	27 0.56	14 0.39	—	146	380	7.8	L	.9	L	S
Do.	do.	6-12-69	3/4e	78	26	46 2.30	19 1.56	41 1.78	222 3.64	24 0.80	33 0.69	18 0.51	--	193	500	8.9	L	1.3	L	S
23/21-2cc	Mullen Creek	2- 1-69	¼e	32	0	16 0.80	3 0.22	219 9.51	220 3.61	3 0.10	199 4.14	95 2.68	--	51	1,000	8.4	M	13	H	U
Do.	do.	3-30-69	5e	62	17	10 0.50	2 0.18	86 3.73	177 2.90	3 0.10	42 0.87	19 0.54	--	34	450	8.4	L	6.4	L	M
24/21-15cac	Hardscrabble Creek	2-11-70	.4e	47	8½	47 2.35	17 1.41	45 1.96	295 4.84	13 0.43	8 0.17	10 0.28	--	180	520	8.5	L	1.4	L	M
25/21-28cab	Stream	3-31-69	½e	51	11	20 1.00	6 0.50	20 0.85	113 1.85	0 0.00	24 0.50	0 0.00	--	75	190	8.1	L	1.0	L	S
25/20-11bdc	Stream	9- 5-69	.2e	61	16½	16 0.80	5 0.44	10 0.43	96 1.57	0 0.00	3 0.06	2 0.06	--	62	160	8.1	L	.6	L	S
26/20-25ccd	Big Canyon Creek	2-14-69	1e	43	6½	20 1.00	11 0.88	12 0.53	114 1.87	0 0.00	15 0.31	8 0.23	--	94	250	8.1	L	.5	L	S
Do.	do.	3-31-69	3½e	52	11½	13 0.65	7 0.61	8 0.36	82 1.34	0 0.00	8 0.17	4 0.11	—	63	170	7.7	L	.5	L	S
26/22-3bbc	Stream	9- 4-69	.5e	64	18	21 1.05	10 0.83	43 1.85	168 2.75	4 0.13	19 0.40	16 0.45	--	94	360	8.4	L	1.9	L	S
Lake center, 100 ft deep	Pyramid Lake	a/ 1-15-64	3,792.0e	--	--	8.8 0.44	121 9.96	(a)	1,020 16.72	236 7.87	266 5.54	2,080 58.68	5,120c	520	8,420	9.4	H	34	V	U
23/23-12	Mud Lake Slough	a/ 6-24-59	.2e	--	--	53 2.64	25 2.08	(a)	224 3.67	19 0.63	175 3.64	220 6.21	834c	236	1,370	8.7	M	.2	L	S

Footnotes are at end of part A.

Table 18.--Chemical analysis of well, spring, stream, and lake waters--Continued

PART C: ADDITIONAL DETERMINATIONS FROM DETAILED CHEMICAL ANALYSES

Location	Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1/]							
	Silica (SiO_2)	Manganese (Mn)	Arsenic (As)	Sodium (Na)	Potassium (K)	Fluoride (F)	Phosphate (PO_4)	Boron (B)
16/19-3ba	45	0.00	--	45 2.00	0.6 0.02	3.4 0.18	0.06	0.21
-21a	24	--	--	7.9 0.34	1.7 0.04	0.0 0.00	--	--
16/20-17ac	51	--	--	23 1.00	2.3 0.06	0.4	--	0.13
-19cd	46	--	--	62 2.70	9.6 0.25	1.4 0.07	1.1	0.21
Do.	61	--	--	114 4.96	16 0.41	2.1 0.11	--	--
17/20-4dc	88	--	--	19 0.83	9.5 0.24	--	--	0.03
18/18-30cb	15	--	--	2.6 0.11	0.8 0.02	0.1 0.01	--	0.00
Do.	17	--	--	6.4 0.28	1.8 0.05	0.2 0.01	--	0.04
18/20-6abb	56	<0.02	0.003	--	--	0.2 0.01	--	--
-33cda	46	--	--	21 0.91	5.6 0.14	0.3 0.02	--	--
19/18-9d	25	--	--	6.4 0.28	2.0 0.05	0.2 0.01	--	--
19/19-5ad	25	--	--	7.1 0.31	2.5 0.06	--	--	--
-12aaa	44	<0.01	0.001	18 0.78	2.2 0.06	0.4 0.02	--	--
-12bcd	35	0.01	0.005	21 0.91	2.2 0.06	0.1 0.01	--	--
-12bdb	33	<0.01	0.003	31 1.35	2.7 0.07	0.2 0.01	--	--
19/20-4dcb	44	0.18	0.054	33 1.44	5.2 0.13	0.5 0.03	--	--
-6dcd	46	0.02	0.010	--	--	0.2 0.01	--	--
-7b	23	--	--	7.5 0.33	1.7 0.04	0.2 0.01	--	--
-8baa	44	0.11	0.014	--	--	0.3 0.02	--	--
-8bdd2	44	<0.01	0.005	15 0.65	3 0.08	0.1 0.01	--	--
-8ddb	37	<0.01	0.019	22 0.96	3 0.08	0.2 0.01	--	--
-13ab	27	--	--	27 1.17	3.3 0.08	0.3 0.02	--	--
-17acd	43	0.04	0.07	74 3.22	4.5 0.12	0.8 0.04	--	--

PART C: ADDITIONAL DETERMINATIONS FROM DETAILED CHEMICAL ANALYSES--Continued

Location	Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1/]							
	Silica (SiO_2)	Manganese (Mn)	Arsenic (As)	Sodium (Na)	Potassium (K)	Fluoride (F)	Phosphate (PO_4)	Boron (B)
19/20-18bba	46	<0.01	0.048	35 1.52	3 0.08	0.2 0.01	--	--
-18dbd	46	<0.01	0.060	72 3.13	4.5 0.12	0.6 0.03	--	--
-21bcb	48	0.23	0.063	41 1.78	7 0.18	0.4 0.02	--	--
-30dab	62	<0.01	0.034	42 1.83	5.2 0.13	0.7 0.04	--	--
-34c	50	--	--	96 4.18	10 0.26	0.6 0.03	--	--
19/21-21acb	--	--	0.005	--	--	0.4 0.02	--	--
20/22-33bab	22	--	--	--	--	--	--	--
20/23-19b	30	--	--	33 1.44	4.7 0.12	0.3 0.02	--	--
-20a	35	--	--	32 1.39	7.0 0.18	0.4 0.02	--	--
20/24-3bc	27	--	--	32 1.39	4.8 0.12	0.2 0.01	--	--
-4aaa	--	--	--	--	--	0.0 0.00	--	--
-12bbd	--	--	0.01	--	--	0.1 0.01	--	--
-24bbb2	--	--	0.02	--	--	0.0 0.00	--	--
21/24-33dcb	--	--	0.10	--	--	1.2 0.06	--	--
22/23-1a	24	--	--	127 5.52	9.9 0.25	0.3 0.02	--	--
23/22-26c, -27d	44	--	--	14 0.61	1.4 0.04	--	--	--
23/23-12	11	--	--	205 8.92	12 0.31	0.4 0.02	1.3	0.83
24/20-13d	30	--	--	10 0.44	1.4 0.04	0.2 0.01	0.03	--
25/20-3a	48	--	--	10 0.44	2.7 0.07	0.2 0.01	0.04	--
25/21-18baa	--	--	0.15	--	--	0.9 0.05	--	--
25/24-6cdd	35	--	--	--	--	--	--	--
-15d	87	--	--	--	--	--	--	--
26/21-6ccb	8.8	--	--	1,160 50.46	37 0.95	--	--	--
28/22-30bcb	--	--	--	--	--	--	--	1.1
Pyramid Lake	0.7	--	--	1,770 77.00	120 3.07	2.0 0.11	--	12

Footnotes are at end of part A.

Ground-water temperatures characteristically range from 50° to 75°F (10° to 24°C) throughout most of the study area. Exceptions include thermal areas (1) on the west side of Truckee Meadows between Steamboat and Lawton Hot Springs (18/20-33 and 19/18-13, respectively), and (2) northwest of Pyramid Lake; in these areas, temperatures exceed 100°F (38°C).

Truckee River, economically the most important hydrologic feature of the area, varies in chemical character both seasonally and in a downstream direction. Near the Nevada-California State line (table 18, site 18/18-30cb), the stream is dilute (typically 60 to 120 micromhos), with silica, calcium, and bicarbonate dominant. Many miles downstream, near the mouth of Truckee River (site 22/24-18bc), both the average salinity and seasonal variability are greater. During periods of high flow in the spring, the specific conductance is 100-130 micromhos, and the dissolved solids are dominated by calcium, bicarbonate, and presumably, silica (not analyzed for). In contrast, during summer periods of low flow, sodium, chloride, and bicarbonate dominate, with a specific conductance that ranges from 600 to more than 900 micromhos.

Downstream trends for several important water-quality parameters are indicated in table 19. The data show a general downstream deterioration of quality that results largely from the activities of man. The greatest deterioration in mainstem water quality occurs below Boynton Lane, Sparks (tables 18, 19). Principal sources of poor-quality water are: Steamboat Creek, which contributes nutrient-rich sewage effluent and dissolved-solids increments from the Steamboat Springs thermal area and from irrigation returnflow; and ground-water inflow upstream and downstream from Wadsworth, which during periods of low streamflow causes a more than two-fold increase in dissolved-solids content. Most ground-water increments in the Wadsworth area (p. 42) probably originate as recharge associated with irrigation in the Fernley Area (Sinclair and Loeltz, 1963, p. AA8).

Data on suspended sediment in the Truckee River near its mouth (site 22/24-18bc) are summarized below:

Water year	Measured sediment concentration (mg/l)		Stream discharge at times of indicated concentration (cfs)	
	Maximum	Minimum	Maximum	Minimum
1965	819	2	552	38
1966	290	4	1,560	57
1967	2,530	2	4,480	44
1968	482	8	1,460	56
1969	2,400	4	3,460	33

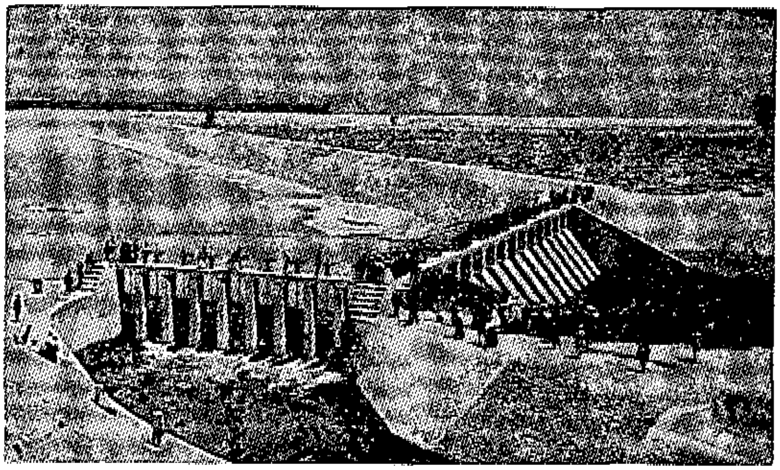
Table 19.--Water-quality data for six sites on Truckee River, June 1967-May 1969

[Data from Nevada State Health Division]

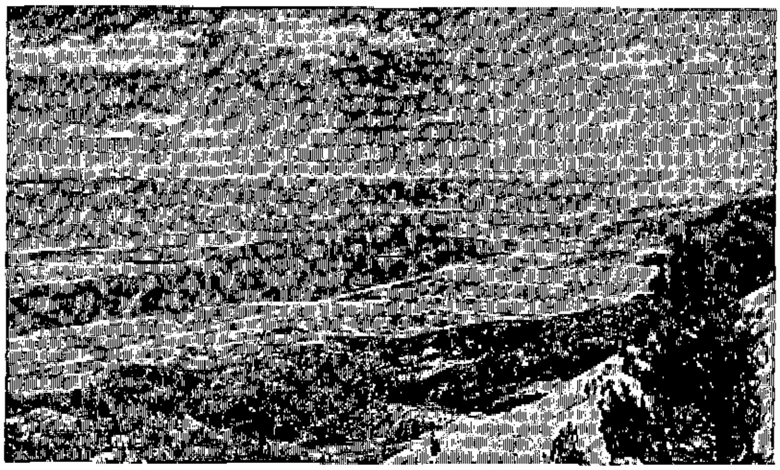
Maximum, minimum, and average values for samples collected about monthly (in milligrams per liter, except for temperature and pH)

Site (in downstream order)	Temperature °F	Temperature °C	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved solids (residue at 105°C)	pH	Dissolved oxygen
At Farad	63	17	5.9	0.17	83	8.2	13.4
(18/17-12a)	32	0	.0	.00	45	7.1	7.3
	46	8	.6	.05	63	7.7	10.0
At Idlewild	68	20	6.6	.32	87	8.3	12.5
Park, Reno	32	0	.0	.00	54	7.5	7.5
(19/19-10d)	47	8½	.6	.07	69	7.9	10.1
At Boynton	70	21	6.3	.17	170	8.6	13.0
Lane, Sparks	32	0	.0	.00	53	7.4	8.3
(19/20-16a)	48	9	1.0	.07	83	7.9	10.3
At Lockwood	70	21	7.7	1.9	189	8.0	12.0
(19/21-17d)	32	0	.0	.13	66	7.5	6.1
	49	9½	2.9	1.0	123	7.8	9.5
At Clark	79	26	14	2.5	193	8.1	11.7
(20/22-26d)	35	1½	.0	.05	57	7.5	5.0
	54	12	4.7	1.2	129	7.8	9.1
Below	73	23	10	1.7	360	8.6	12.3
Wadsworth	35	1½	.0	.08	48	7.4	5.7
(21/25-28d)	52	11	4.2	.82	166	7.9	9.3

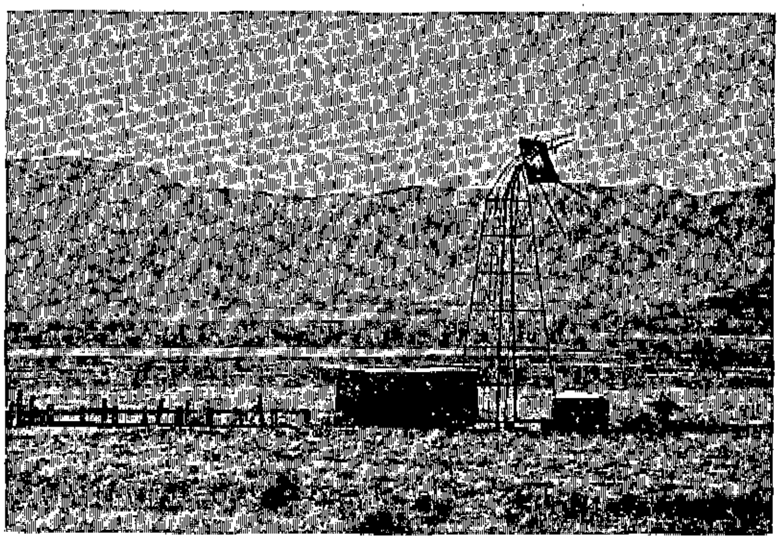
A



B



C



Photographs 5A-C.--A. Ceremonies at Derby Dam, probably at about the time of its completion in 1905. Since that time, diversions out of the Truckee River basin via the Truckee Canal have totaled more than 10 million acre-feet. Photograph from U.S. Geol. Survey Water-Supply Paper 250. B. Washoe Lake, viewed from Slide Mtn. ski area. At its greatest extent, the lake covers about 9 square miles, but has a maximum depth of only 13 feet. C. Abandoned water well 28/22-30bcb, 6 miles north of Pyramid Lake. View southwest, with The Needles in background. Declining ground-water level, presumably associated with shrinking of Pyramid Lake since about 1910, contributed to abandonment.

The chemical character of other streams in the study area is indicated by data in table 18.

Pyramid Lake is the terminal, or collection point, for the solute contributions of Truckee River. At present (1971), the lake contains about 140 million tons of dissolved solids--mostly sodium, bicarbonate, and chloride. In 1882, at a lake level of about 3,865 feet, the dissolved-solids content was about 3,500 mg/l. By 1970, when the lake had shrunk to 3,793 feet, the solute concentration had increased to about 4,800 mg/l. If the volume of the lake continues to shrink, the trend of increasing salinity can be expected to continue.

Suitability for Domestic Use and Public Supply

The U.S. Public Health Service (1962, p. 7-8) has formulated standards that are generally accepted as a guideline for drinking water; these standards have been adopted by the Nevada Bureau of Environmental Health in the State for public supplies. The standards, as they apply to data listed in table 18, are as follows:

Constituent	Recommended maximum concentration (milligrams per liter)
Iron (Fe)	0.3
Manganese (Mn)	.05
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	a About 1.2
Nitrate (NO_3)	45
Dissolved-solids content	b 500

a. Based on an annual average maximum daily air temperature of about 68°F. The optimum fluoride concentration is about 0.9 mg/l. Water containing more than about 1.8 mg/l should not be consumed regularly, especially by children.

b. Equivalent to a specific conductance of about 750 micromhos.

Most of these are only recommended limits, and water therefore may be acceptable to many users despite concentrations exceeding the given values. Excessive iron causes staining of porcelain fixture and clothing. Large concentrations of chloride and dissolved solids impart an unpleasant taste, and sulfate can have a laxative effect on persons who are drinking a particular water for the first time. Excessive fluoride tends to stain teeth, especially those of children, and a large amount of of nitrate is dangerous during pregnancy and infancy because it may increase the possiblity of "blue-baby" disease.

The arsenic content of drinking water is particularly important because of the possibility of long-term poisoning. The U.S. Public Health Service (1962, p. 8) states that arsenic should not exceed 0.05 mg/l in drinking water, and the World Health Organization, United Nations, has established a maximum allowable concentration of 0.2 mg/l (McKee and Wolf, 1963, p. 91). The bacteriological quality of drinking water also is important, but is outside the scope of this report.

The hardness of a water is of concern to many users. Therefore, the U.S. Geological Survey has adopted the following rating:

Hardness, as $CaCO_3$ (milligrams per liter)	Rating and remarks
0-60	Soft (suitable for most uses without artificial softening)
61-120	Moderately hard (usable except in some industrial applications; softening profitable for laundries)
121-180	Hard (softening required by laundries and some other industries)
More than 180	Very hard (softening desirable for most purposes)

The data in table 18 show that suitable water is available in all of the valleys, but that problem areas do exist. For example, though the majority (77 percent) of sampled ground waters in the study area contain less than 180 mg/l of hardness, very hard water has been encountered in many places. Only Washoe Valley, Pleasant Valley, and the Truckee Canyon Segment are free or nearly free of hardness problems. In Truckee Meadows, data in table 18, along with those listed by Cohen and Loeltz (1964, table 5), indicate that very hard ground water occurs commonly around the margins of the valley floor, but not in the central parts, nor on the broad alluvial slope in the Thomas Creek area, south of Reno (pl. 1).

The generally meager data on iron and nitrate in table 18 (part A) suggest that these two constituents are a problem in only a few localized areas. Data on manganese and arsenic also are meager, except for the northern half of Truckee Meadows.

There, the information in table 18 (part C) and additional information listed and discussed by Guyton & Associates (1970, p. 25-28 , fig. 4) indicate that objectionable concentrations of the two elements are commonplace in ground water deeper than about 250 feet, particularly beneath the eastern parts of the valley. Elsewhere in the report area, 2 of 5 arsenic determinations exceed the 0.05-mg/l limit (well 21/25-33dcb, northwest of Wadsworth and well 25/21-18baa, north of Sutcliffe).

Almost all fluoride concentrations listed in table 18 (part C) are less than the recommended maximum. However, data given by Guyton & Associates (1970, p. 27 , table 4), and by Cohen and Loeltz (1964, table 5), indicate that excessive fluoride (more than 1.2 mg/l, characteristically associated with excessive arsenic) is characteristic of warm to hot ground water on the west side of Truckee Meadows.

Water too hot for normal domestic and cooling purposes occurs in several areas (p. 75). In some places, such water is used for home heating.

The chemical character of major municipal ground-water supplies is summarized below. Almost without exception, the

	Milligrams per liter				
	Fernley	Virginia Foothills	Hidden Valley	Nixon	Reno-Sparks
	20/24-24bbb2	18/20-27bcb2 1/	19/20-21bcb	23/23-25bcd 2/	13 wells 3/
Total iron (Fe)	0.06	0.18	0.23	0.06	<0.01-0.20
Manganese (Mn)	--	--	.23	--	<.01-.18
Arsenic (As)	.02	.06	.06	<.01	<.01-.07
Sulfate (SO_4)	16	18	45	65	4-112
Chloride (Cl)	11	70	8	75	3-18
Fluoride (F)	.0	.3	.4	.4	.1-.8
Nitrate (NO_3)	16	8.3	<.1	<.1	.1-13
Dissolved solids	221	526	272	430	205-388
Hardness as $CaCO_3$	116	72	88	16	24-229

1/ Sample collected 3-21-70; analysis by Nev. State Health Div. (not listed in table 18).
2/ Several values are from an analysis by Nev. State Health Div. (sample collected 3-26-69) not listed in table 18.
3/ Minimum and maximum values are listed.

supplies are suitable for domestic use. Arsenic concentrations in the Virginia Foothills and Hidden Valley supplies, and in 3 of 13 Reno-Sparks well waters (table 18), are slightly above the U.S. Public Health Service limit, but well below the World Health Organization maximum. The Reno-Sparks wells provide less than 20 percent of the total municipal supply (table 14), and the wells that yield water of least desirable arsenic (and manganese) content in turn provide far less than half of the total ground-water contribution. The principal problem areas for ground-water quality are as follows:

Area	Problem
Dodge Flat	Overall poor quality east of river; excessive arsenic in at least one area (immediately northwest of Wadsworth).
Fernley Area	Overall poor quality northeast of Fernley.
Pleasant Valley	Warm water in some wells tapping bedrock.
Pyramid Lake Valley	Overall poor quality in much of the area near Nixon, and at northwest end of lake; excessive arsenic in at least one area (north of Sutcliffe).
Spanish Springs Valley	Overall poor quality at places along southwest side of valley.
Tracy Segment	Excessive hardness and specific conductance in several places.
Truckee Meadows	Excessive arsenic and manganese at depths exceeding about 250 feet, particularly in eastern parts of valley; excessive arsenic, fluoride, and water temperature on western side of valley; overall poor quality in and downgradient from areas of bleached bedrock north of Reno and at several others places around valley margins.
Winnemucca Lake Valley	Overall poor quality in central and eastern parts of area.

Data in table 18 (part B) indicate that almost all surface water in the report area is suitable for use from a major-constituent standpoint. The notable exceptions are the saline waters of Pyramid Lake and Fernley Sink.

If any doubt exists regarding the acceptability of a specific water supply for domestic use, contact the Nevada Health Division's Bureau of Environmental Health, Carson City.

Suitability for Agricultural Use

In evaluating the desirability of a water for irrigation, the most critical considerations include dissolved-solids concentration, the proportion of sodium relative to calcium plus magnesium, and the concentrations of constituents such as boron that can be toxic to plants. Four factors used by the U.S. Salinity Laboratory Staff (1954, p. 69 - 82) to evaluate the suitability of irrigation water are listed in table 18, and are discussed briefly in footnote 2 of that table. Minor amounts of boron (up to about 0.5 mg/l) are essential to plant nutrition, but larger concentrations can be highly toxic. The approximate upper limits recommended for boron in water irrigating sensitive, semitolerant, and tolerant crops are, respectively 0.5-1.0, 1.0-2.0, and 2.0-4.0 mg/l (National Technical Advisory Committee, 1968, p. 153).

The suitability of water in the report area for irrigation is variable. On the basis of specific conductance (salinity hazard) and sodium hazard, ground water in areas downstream from the Tracy Segment is characteristically least suitable, whereas most water in the other valleys is acceptable for irrigation.

Information on boron is scarce (table 18), but the available data suggest that the element is not a widespread problem.

As a precaution, the water from a newly drilled irrigation well should be analyzed to determine its chemical acceptability. The sample should be collected after the well is test-pumped for a period of time sufficient to provide water truly representative of the water-bearing strata. Analyses may be obtained free of charge by contacting the University of Nevada's Cooperative Agriculture Extension Service agent in Reno or Fernley.

Almost all sampled stream waters in the report area are acceptable for irrigation.

Most animals are more tolerant of poor water than man. Although available data are somewhat conflicting, a dissolved-solids content less than 4,000-7,000 mg/l (equivalent to a specific conductance of about 6,000-10,000 micromhos) apparently is safe and acceptable (McKee and Wolf, 1963, p. 112 - 113), provided that specific undesirable constituents are not present in excessive concentrations. Thus, almost all sampled water within the study area may be sufficiently dilute for livestock.

Suitability for Industrial Use

Water-quality requirements for industrial use vary greatly, depending on the particular use. A use-by-use discussion is outside the scope of this reconnaissance, but McKee and Wolf (1963, p. 92 - 106) and the National Technical Advisory Committee (1968, p. 185 - 215) discuss the general subject in detail.

AVAILABLE WATER SUPPLY

Ground-Water Storage in the Valley-Fill Reservoirs

The amount of ground water stored in the valley fill to any selected depth below the ground-water surface is the product of the area, the selected depth (in this study, 100 feet), and the specific yield of the deposits (assumed to average 10 percent for the study area). The estimates are listed in table 20.

Although the estimates of stored ground water are large, the amount available in areas where the depth to water is less than 100 feet and where land is suitable for cultivation is appreciably less. The amount of usable ground water in storage that is economically available depends in part on the distribution of water-storing deposits, the permeability of the deposits, the distribution and range in chemical quality of the ground water, the number and distribution of pumped wells, and the intended water use.

Available Supply, Mainstem Hydrographic Areas

The available water supply in mainstem areas of the Truckee River basin in Nevada consists principally of about half a million acre-feet per year of surface-water inflow at the California State line, and about 90,000 acre-feet per year of local surface- and ground-water inflow to the system between the State line and Pyramid Lake (table 16). In addition, several million acre-feet of untapped ground water is stored in the alluvial deposits of the study area (table 20). All these sources of supply have been developed to varying extents, as described in this report.

For the 51-year base period 1919-69, little overall net depletion of Truckee River flow occurred as far downstream as Derby Dam. At this site the flow was split nearly in two--about half going to the Fernley and Fallon areas via the Truckee Canal, and about half continuing down the river to Pyramid Lake.

As of this time (1970), interagency studies are underway to find efficient and equitable legal, economic, and physical solutions to the various water problems in the Truckee River basin. A major problem is the declining stage of Pyramid Lake, which would require about 130,000 acre-feet per year of additional inflow to stabilize at its present level, on the basis of data for 1919-69 and estimates already presented herein. It is beyond the scope of this reconnaissance to elaborate on

Table 20.--Estimated quantity of ground water stored in the upper 100 feet of saturated valley fill

Hydrographic area (in alphabetical order)	Area probably underlain by 100 feet or more of saturated valley fill (acres)[1]	Estimated quantity of stored ground water (acre-feet, rounded)
Dodge Flat	26,000	260,000
Fernley Area	a 42,000	420,000
Pleasant Valley	b 3,200	30,000
Pyramid Lake Valley	c 190,000	1,900,000
Spanish Springs Valley	17,000	170,000
Sun Valley	2,000	20,000
Tracy Segment	b 9,500	100,000
Truckee Canyon Segment, Nev.	4,500	40,000
Truckee Meadows	45,000	450,000
Warm Springs Valley	42,000	420,000
Washoe Valley[2]	c 18,000	270,000
Winnemucca Lake Valley	a 96,000	960,000
Total, exclusive of Fernley Area[3]	450,000	4,600,000

1. Assumed to be about 80 percent of the alluvial areas listed in table 2 (except as indicated), because of inward-sloping contact between valley fill and consolidated rocks.

2. Data from Rush (1967, p. 10).

3. Total, including Fernley Area (which is outside Truckee River basin), is 5,000,000 acre-feet.

a. Includes areas where ground water is too saline for irrigation or most other uses.

b. Saturated valley fill known or suspected to be less than 100 feet thick throughout much of area; therefore, "effective" acreage of valley fill for calculation of stored ground water is arbitrarily assigned as only about 50 percent of the area listed in table 2.

c. Includes alluvium underlying lake.

the several possible solutions to the water problems in the area.

Several probable future developments will affect the disposition of water in the Truckee River basin. More runoff may be stored upstream from Reno for flood control and for more effective seasonal use of water, and as a result, average annual streamflow entering and leaving Truckee Meadows presumably will decrease slightly, and the seasonal pattern of flow will change. The continuing shift from agricultural to urban land use surrounding Reno will affect runoff, recharge, and water-quality characteristics of the area, though overall water consumption may not change markedly in the near future. Measurestaken to increase the flow to Pyramid Lake may result in marked changes in the present disposition of Truckee River water.

Available Supply, Nonmainstem Areas

The supplies of Warm Springs, Spanish Springs, Sun and Washoe Valleys have already been described by Rush (1967), and Rush and Glancy (1967), and are not repeated here.

The Fernley Area is estimated to have less than 1,000 acre-feet per year of local supply (table 12), but has a substantial supply of imported water via the Truckee Canal. In addition, stored ground water, partly of poor quality, totals some 400,000 acre-feet (table 20).

Pleasant Valley is estimated to have a local supply of about 10,000 acre-feet per year, most of which now runs off to Truckee Meadows (table 11). Any substantial development in Pleasant Valley would decrease the amount reaching Truckee Meadows and the Truckee River via Steamboat Creek. Additional supply of some 30,000 acre-feet is stored in the alluvial deposits of the valley (table 20).

Finally, Winnemucca Lake Valley has a supply on the order of 3,000 acre-feet per year (table 12 and p. 42). In addition, stored ground water is estimated to total nearly a million acre-feet in the upper 100 feet of saturation (table 20). However, much of the stored water may be chemically unsuitable for agricultural, domestic, and stock use.

NUMBERING SYSTEM FOR HYDROLOGIC SITES

The numbering system for hydrologic sites in this report indicates location on the basis of the rectangular subdivision of public lands, referenced to the Mount Diablo base line and meridian. Each number consists of three units: the first is the township north of the base line; the second unit, separated from the first by a slant, is the range east of the meridian; the third unit, separated from the second by a dash, designates the square-mile section. The section number is followed by letters that indicate the quarter section, quarter-quarter section, and so on; the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 21/23-13dcc is in SW¼SW¼SE¼ sec. 13, T. 21 N., R. 23 E. In this report, most sites identified with three letters are in areas where detailed U.S. Geological Survey topographic mapping (scale, 1:62,500 and 1:24,000) is available. In other areas, sites have been located using aerial photographs and a less detailed 1:250,000-scale map. An index to Geological Survey topographic maps in Nevada can be obtained free of charge from the Distribution Section, Geological Survey, Federal Center, Denver, Colorado 80225.

Because of space limitation, wells and springs are identified on plate 1 only by section number and quarter-section letter. Township and range numbers are shown along the margins of the report area.

WELL AND SPRING DATA

Information regarding selected wells and springs is listed in the tables that follow. Included are well data (table 21), well logs (22), water-level measurements in observation wells (23), and spring data (24). For areas discussed in previous Geological Survey reports, tables 21-24 list only the data for certain key wells and springs. On the Truckee Meadows Valley floor, for example, almost all listed data are for municipal and observation wells; additional data are given by Cohen and Loeltz (1964) or are available in files of the Geological Survey and State Engineer, Carson City.

Table 21.--Well data

Depth: Depths followed by asterisk were measured by U.S. Geological Survey personnel (in feet below top of casing) at time of water-level measurement; all others are reported depths.

Use: C, commercial; D, domestic; E, exploratory; I, industrial; Ir, irrigation, P, public supply; S, stock; U, unused or abandoned (intended use in parentheses).

Water level: Measurements recorded to tenths or hundredths of a foot were made by U.S. Geological Survey personnel, and represent depth below land-surface datum; most measurements recorded to nearest foot were reported by well driller or owner.

Remarks: C, chemical analysis in table 18; F, depth, in feet, at which water was first encountered during drilling; L, driller's log in table 22, or in reference indicated; O, U.S.G.S. observation well; R, reported well depth when drilled; S, log in files of State Engineer (State log number is indicated); T, length of time between start of pump test and measurement of drawdown, in hours.

Location	Owner	Year drilled or dug	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement Depth (feet)	Water-level measurement Date measured	Remarks
DODGE FLAT										
21/23-10dcc	Depaoli Bros.	1948	85	6	S	—	4,190	35 37.4 35.1	11- -48 10-25-61 2-19-70	F=48; S=720; L; C.
21/24-14aac	Ceresola Bros.	1944	346	6	S	5/—	4,330	294?	5- -44	L; C.
-16aca	Helen Marye Thomas	--	>40	6	DS	--	4,010	19.53	2-20-70	C.
-28ddc	W. J. Ceresola, Sr.	Pre-1900	12-14	36	DS	--	4,040	8-10	—	C.
-30dbd	Pyramid Lake Paiute Tribe	--	>180	4?	U(S)	--	4,190	154.0	2-19-70	
-33dcb	do.	1963	470	26-11	I	1200/—	4,120	94	11- -68	S=10404; L; C.
22/23-27dca	Depaoli Bros.	1957	162	6	S	2/—	4,810	130±	—	F=148; S=3948; L.
FERNLEY AREA (See Sinclair and Loeltz, 1963, p. 16-22, for other well data.)										
19/25-6ccc	Bureau of Land Management	1940	242	6	DS	--	4,470	195 199.74	12- -40 6-10-70	C; see WSP 1619-AA.
20/24-11bbd	Nevada Cement Co.	1966	250	12	IP	750/36 1200/63	4,120	37	1966	T=>48; F=40; L; C.
-11ccc	Nevada Highway Dept.	--	33	6	I	--	4,151.8	See table 23.		O. See table 23 for specific-conductance data.
-24bbb1	Fernley Water District (well 1)	1958	207	20-8	P	1000/35	4,180	60	1958	F=78; S=4031; L (see WSP 1619-AA).
-24bbb2	do. (well 2)	1965	199	10	P	500/14 775/29	4,180	78	5- -65	F=83; S=8308; L; C.
20/25-7bdd	Sav'n Sam's Service Station	1965	206	6	C	--	4,140	36.43	2-20-70	F=68; S=8163; L; C; (water level 62 ft before well deepened from 83 ft).
-18ccc1	Joe Garbarino	--	28	6	U(D)	--	4,133.8	See table 23.		O.
-18ccc2	do.	--	155*	10	U(Ir)	900/45	4,135.2	do.		R=200; O; L; C.
-21acd	John Urizar	1951	212	6	D	--	4,145	23 5.50	12- -51 7-22-53	F=25; S=1840; L (see WSP 1619-AA); C.
-23aba	Jack Olson	1960±	60±	6	S	--	4,100	16.76	3- 4-70	C.
-24cad	Edna B. Brush	1950	123	6	DS	60/--	4,165	35 40.83	11- -50 7-22-53	F=118; S=1495; L (see WSP 1619-AA); C.
-25adb	Merritt Construction Co.	1965	240*	6	U(C)	--	4,250	170 167.15	8- -65 3- 4-70	R=258; F=135; S=8672; L; C.
PLEASANT VALLEY										
17/19-9abb	John S. Sinai	1952	109	6	D	14/2	6,155	47	6- -52	F=50; S=1960; L.
-11abc	Talcott Griswold	1960	135	6	D	--	5,440	93.5	4- 2-70	F=98; S=5247; L; C.
-17aad	Tannenbaum, Inc.	1964	385	6	P	5/10	7,060	320	11- -64	F=370; S=8280; L; C.
17/20-4bdd	H. O. Shelhamer	1959	37	6	D	--	4,640	1	6- -59	L; C.
-4dc	--	1940	52*	2	--	½/—	4,650	flows	1949	C.
-7aab	C. W. Lingenfelter	1958	168	6	DS	15/8	4,860	102 108.2	6- -58 3-24-70	T=1½; F=102; S=4134; L; C.
-7cad	Washoe County School District	1965	150	8	P	80/47	4,830	10	1- -65	T=24; F=18; S=8357; L; C.
-18aca	Merle Benet, Gloria Oberg	1956	290	6	P	--	4,990	195	1- -57	F=235; S=3694; L; C. Serves about 30 people.
PYRAMID LAKE VALLEY										
22/23-1bda	Pyramid Lake Paiute Tribe	1961±	60	6	P	15/--	3,910	--	—	C.
-1ddb	Roy Garcia?	1949	95	6	U(D)	7/--	3,930	30	3- -49	F=50; S=833; L.
22/24-9bad	Ceresola Bros.	1946±	200±	8	DS	--	4,155	125±	--	C.
-13ac	do.	1964	315	6	S	10/0	4,300	287	12- -64	T=2; F=287; S=8350; L; C.
23/21-15bcc	M. K. Hudlow?	1959	308	8	U(I)	--	4,400	35	7- -59	F=45; S=4722; L.
23/22-10cad	B. I. A. test well 2	1963	106	8	U(E)	—	3,927.9	44	11- 4-63	L.
-10dbb	W. R. Abraham	1958	185	6	U(C)	--	3,880	174?	7- -58	S=4496. Water-bearing, 150-185 ft.
23/23-1cac	Bob Irwin	—	32*	12	S	--	3,860	18.09	7-21-70	C. Land-surface datum is terrace 10 ft above well.
-15cad	Gilbert Greene	1964±	>115	6	S	--	3,885	28.84	7-27-71	C.
-23bcb	Harry Winnemucca	1948	136	4	U(D)	8/2	3,895	4 4.15	12- -48 2-19-70	T=2; F=12; S=797; L; C.
-25bcd	Pyramid Lake Paiute Tribe	1966	350	8	P	135/7	3,940	47	5- -66	T=24; C; serves about 60 families.
-25cba	do.	1954	287	8	P	40/64	3,945	43	6- -54	F=43; S=2655; L.
-26ddc	Nevada Highway Dept.	1966	170	6	I	21/3	3,940	30 31.58	9- -66 2-19-70	T=2; F=30; S=9184; L; C.
-29cab1	Warren Tobey	1962±	10*	48	S	—	3,885	7.22	7-31-69	
-29cab2	do.	1964±	35±	8	D	--	3,885	—	—	C.
-36ddc	Albert Aleck	1965±	50±	8?	D	--	3,910	—	—	C.
24/21-15aac	Fred Crosby	--	110	6	P	--	3,885	--	—	C. Serves 25-50 people.
-15aca	W. L. Pattridge	1955	222	6	D	—	3,900	48 61.99	6- -55 7-31-69	F=53; S=6201; L.
-15cad	B. I. A. test well 4	1963	420	8	U(E)	160/114	4,020.7	30? 26.5 28.81	10-17-63 9- -67 7-10-70	T=27; F=70?; L; C.
24/22-31ccb	B. I. A. test well 3	1963	296	8	U(E)	107/51	3,986.8	42? 47.0	12- 6-63 9- -67	T=48; F=130?. Cased to 190 ft; perforated from 130 to 190 ft?
-31ccc	B. I. A. test well 6	1963	226	8	U(E)	171/115	3,985.3	8? 12.5 11.3	12- 6-63 9- -67 7-10-70	T=45; F=76?; L; C.
24/23-36cba	Ceresola Bros.	1948	73	6	S	--	3,845	22 23.65 27.14	2- -48 7-31-69 7-14-70	F=22; S=414; L.
25/21-18baa	Nevada Div. of Parks	1968	112	6	U(P)	77/2.6	3,840	34	4- 8-69	T=5; F=49; L; C.
-32aaa	B. I. A. test well 5	1963	397	8	U(E)	dry(?)	3,984.8	dry(?)	1963	L.
25/22-2dcc	Pyramid Lake Paiute Tribe	--	6½*	48	S	—	4,034	3 2.76	5- 1-30 7-21-70	C; well may bottom on bedrock.
26/20-12abc	Western Geothermal, Inc.	1966	1,206	10-5½	U(E)	--	3,800	flows	8- 5-71	Temp. 205°F at 350 and 850 ft, 202°F at 1,155 ft.
-26adb	Southern Pacific Co.	--	210*	8	U(IP)	80/--	3,900	22 98.28 96.83	about 1914 2- 4-70 7-10-70	Layer of oil atop water; L; C.
26/21-6ccb	Western Geothermal, Inc.	1964	5,930	16-7	U(E)	7/0	3,815	flows	2- 4-70	L; C.
-6ccc	do.	1966	1,488	10-5½	U(E)	--	3,825	a few	1-29-66	Max. down-hole temp. 245°F.
27/20-28bbc	Pyramid Lake Paiute Tribe	1958	135	6	U(S)	20/--	3,994	35	11- -58	F=115; S=4425; L.
-29bac	Mrs. A. V. Beller	1961±	--	6	S	—	4,009	24±	2- 4-70	C.
27/21-9bda	U.S.G.S. test well 2	1967	47*	2	U(E)	--	3,845	See table 23.		O. Cased to 47 ft, screened 45-47 ft.
-16abd	U.S.G.S. test well 1	1967	44*	2	U(E)	--	3,837	do.		O; L; C.
28/21-33ccd	U.S.G.S. test well 3	1967	60*	2	U(E)	—	3,865	do.		O; L; C.
28/22-30bcb	Pyramid Lake Paiute Tribe	1930's	420+*	4	U(S)	--	4,245	400 dry at 420	1939? 8- 5-71	R=482; C.

Table 21.--Well data--Continued

Location	Owner	Year drilled or dug	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement Depth (feet)	Water-level measurement Date measured	Remarks
SANO VALLEY (north of Pyramid Lake)										
28/21-5cc		--	58*	6	U(S)	--	3,920	39.83	8-22-69	
SPANISH SPRINGS VALLEY (see Rush and Glancy, 1967, p. 60,66, for additional well data)										
21/20-26dc	North American Aviation, Inc.	1957	821	24,10	I	640/28	4,540	See table 23.		O. Cased to 787 ft; perf. 37-787 ft. See Rush and Glancy, 1967, p. 66, for well log.
SUN VALLEY (see Rush and Glancy, 1967, p. 60, 66, for additional well data)										
20/20-19ad	Anders	1949	83	12	U	--	4,670	See table 23.		O.
TRACY SEGMENT										
19/20-13add	Nevada Highway Dept.	1968	93	6	IP	60/0	4,390	13 14.67	1- -68 7-30-69	T=2; F=23; L; C.
19/21-9dad	Nevada Land Fill Corp.	1968	330	8	T	115/20	4,575	245 237.34	8- -68 3- 5-70	T=8; F=275?; S=10358; L; C.
-10aac	Bureau of Land Management Mustang well	1968	123½*	5	U(S)	--	4,420	77.74	7- 7-70	R=125; L.
-16dbd	Pari Bros.	--	122	8	D	--	4,340	19.11	7-28-69	C.
-21acb	B. E. M. Corp.	--	94*	6	U(IP)	200/--	4,420	9.89	3- 5-70	C.
20/22-28bcc	Bureau of Land Management Steidlmeyer well 2	1953	141	6	S	--	4,370	71	9- -53	F=89; L; C.
-33bab	Sierra Pacific Power Co.	1961	133	26-14	ID	200/34	4,260	7.3	5- -61	T=24; L; C; well 1.
-35aba	Eagle-Picher Industries, Inc.	1961	150	10,8	I	100/95	4,255	30	4- -61	F=46; S=5898; L.
-35abc	do.	1957	155	8	P	--	4,255	--	--	F=140; S=3823.
20/23-19ca	Riley Kelly	1968	50	6	DS	60/3	4,210	10	3- -68	T=6; F=8; S=9975; L.
-21daa	Mrs. R. W. Lutzow	1968	76	6	DS	20/12	4,180	28 28.0	3- -68 3- 5-70	T=½; F=38; S=9991; L; C.
20/24-4aaa	Pyramid Lake Paiute Tribe	--	90?	8	P	--	4,085	--	--	C; serves about 10 families.
-18bca	Nevada Highway Dept.	1970	195	12	U(P)	insufficient	4,150	--	--	L.
TRUCKEE CANYON SEGMENT										
19/18-8ccc	Washoe County School District	1962	302	8,6	P	50/--	4,905	23	5- -62	F=55; S=6879; L; C.
-14ccd	Mario Belli?	1957	109*	8,6	U(D)	14/14	4,710	21.26	4- 2-70	R=112; F=35; S=3787; L.
-16dac	Richard Fleischman	1969	150	8	D	21/31	4,895	69 73.29	2- -69 4- 2-70	T=3; F=70; S=10439; L; C.
-19dbd	Last Chance, Inc.	1949	503±	6	CP	30/--	5,027	115 120.1	7- -49 1-24-51	F=324; S=1050; L; C.
TRUCKEE MEADOWS										
18/19-12dbb	Paul Christman	1950	376*	14	U	245/90	4,581	42.91 See table 23.	5- 3-50	R=385; T=1; S=1401; O; L.
-25cca	Donna A. Curtis	1961	102	8	D	20/15	5,365	9 7.65	5- -61 3-24-70	F=18; S=5876; L; C.
-26caa	Morris C. Rush	1967	435	8	D	20/6	5,600	236	5- -67	F=287; S=9522; L; C.
18/20-6abb	Sierra Pacific Power Co. S. Virginia St. well	1968	286	24-12	P	1000/71	4,460	8	8- -68	T=48; S=10366; L; C.
-27bcb1	Trans-Sierra Corp.	1959	112	12	P	450/34	4,585	60	5- -59	F=63; S=5902; C. Perf. 56-108 ft.
-27bcb2	do.	1970	188	12	P	500/30	4,585	65.30	3-24-70	T=16; S=10947; L; water temp. 66°F.
19/19-12aaa	Sierra Pacific Power Co. 4th St. well	1958	583	24,18	P	2200/75	4,470	37	6- -68	T=9; F=40; S=4132; C; well 1B.
-12bcd	Sierra Pacific Power Co. High St. well	1961	530	30-12	P	3300/63	4,480	42	5-31-61	T=48; S=6022; L; C; well 8.
-12bdb	Sierra Pacific Power Co. Morrill St. well	1962	588	30-12	P	2800/84	4,490	51	6- -62	T=48; S=6504; C; well 10.
-22cda	John Belford	1945±	264*	6	U	--	4,760	See table 23.		O. Cased to about 135 ft; open hole below.
-24cba1	Nevada Lakeshore Co., Inc.	1961	1,125	12	P	65/--	4,480	24	1961	F=24; perforated interval 955-995 ft.
-24cba2	do.	1966	1,006	12,8	P	525/68	4,475	27	1966	F=30; S=9136; L; C.
-24ccc	J. B. Lindsey	1946	89	6	U	--	4,480	11	1- -46	S=29; O (see fig. 2); L.
19/20-4dcb	Sierra Pacific Power Co. Elgee well	1960	662	24-12	P	2800/111	4,400	+2	12- -60	T=48; S=5683; L; C; well 3B.
-6ded	Sierra Pacific Power Co. View St. well	1969	530	24-12	P	3000/64	4,440	50	12- -68	T=48; S=10388; L; C.
-8acc	J. G. Morrison	1948	42*	6	U	10/30	4,415	2	5- -48	F=6; S=537; O (see fig. 2); L.
-8baa	Sierra Pacific Power Co. Sparks Ave. well	1969	280	24-18	P	500/83	4,420	30	8- -69	T=48; S=10704; C.
-8bdd1	Sierra Pacific Power Co. 1st Poplar St. well	1959	665	20,12	P	3000/165	4,420	+10	9- 8-59	T=48; well 6.
-8bdd2	Sierra Pacific Power Co. 2nd Poplar St. well	1966	300	30-16	P	1500/60	4,420	10	10- -66	T=48; S=9612; C; well 11.
-8ddb	Sierra Pacific Power Co. Greg St. well	1967	274	30-18	P	1500/62	4,410	10	4- -67	T=48; S=9609; L; C; well 12.
-11abc	Vista Rock Products well 2	--	340±	--	U	25/--	4,400	See table 23.		O. Drilled mostly in clay.
-17acd	Sierra Pacific Power Co. Pezzi well	1959	266	18-12	P	2600/130	4,410	+10	10-27-59	T=48; S=4975; C; well 7 (originally 563 ft deep).
-18bba	Sierra Pacific Power Co. Mill St. well	1959	660	20,12	P	3000/127	4,440	2	9- -59	T=48; S=4976; C; well 4.
-18dbd	Sierra Pacific Power Co. Terminal Way well	1961	685	30-12	P	1400/182	4,410	6	4- 3-61	T=48; S=6021; L; C; well 5.
-21bcb	Land Corporation of Nevada	1960	346	30-14	P	1000/61+	4,395	flowing	11- 7-60	T=48; S=5854; L; C.
-30dab	Sierra Pacific Power Co. Peckham Lane well	1962	826	24-12	P	2200/122	4,415	42	4- -62	T=48; S=6667; L; C; well 9.
20/19-23adb	Panther Valley Water Users Association	1962	304*	8	U(P)	--	5,050	60 86.43	6- -62 3-25-70	R=300; F=66; S=6615; reported reconditioning subsequent to 1962 may explain difference in water level.
-23bda	do.	1955	200	8	U(P)	90/100	5,040	20 19.07	8- -55 3-25-70	F=40; S=3164.
-23cac	S. H. Newcomer	1964	86	6	D	20/10	5,040	55 54.01	4- -64 3-25-70	F=73; S=7798; L; C.
-27bac	L. E. Morton	1968	214	8	U(D)	7/50	5,160	130 135.45	4- -68 3-25-70	T=2; F=165; S=10262; L; C.
WARM SPRINGS VALLEY (see Rush and Glancy, 1967, p. 58, 64, for additional well data)										
22/20-12dbd	--	--	46	48,6	U	--	4,425	See table 23.		O.
WASHOE VALLEY (see Rush, 1967, p. 31-36, for additional well data)										
16/19-10bbd	Flying "ME" Ranch	--	94*	12	U	--	5,065	See table 23.		O.
16/20-17ac	J. Whitehead, H. Hardenreich	1957	225	14	Ir	2000/55	5,060	13.43	10-13-65	S=4028; C. See Rush, 1967, p. 36, for log.

Table 21.--Well data--Continued

Location	Owner	Year drilled or dug	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement Depth (feet)	Water-level measurement Date measured	Remarks
					WINNEMUCCA LAKE VALLEY					
24/23-25cca	Bob Irwin	1944	120	14	U(Ir)	880/13	3,850	39	3- -64	F=52; S=7712; L; initial high yield could not be maintained, despite deepening to 337 ft and reconditioning in 1968.
								55.3	7-31-69	
24/24-8cac	—	—	8+	3	U(S?)	—	3,820	>8.4	7-30-69	
25/23-23c	—	—	11½	—	S?	—	2,780	3.55	3-19-68	O; C (see WSP 1539-C).
								3.70	4- 9-69	
								3.30	3-24-70	
25/24-8cdd1	—	—	101*	12	U(I)	—	3,890	116.36	3- 5-59	Adjacent well about 50 ft south, dry at 78 ft on 7-14-70; C.
								Dry at 101	7-14-70	
27/25-8d	Cowles Ranch?	—	103*	8	U(S)	—	5,300±	73.32	10- 9-61	
28/24-7cab	Bureau of Land Management Gerlach well	1936	144*	8,6	U(S)	6/—	3,930	130	2- -54	R=152; F-145; L.
								138.98	3- 3-59	
								Dry at 144	7-30-69	
-24bb	Bureau of Land Management Limbo well	1936	240*	6,4	U(S)	10/—	4,500	17.24	10- 9-61	R=286; F=285?; L; well collapsed or filled with debris to shallow depth as of 11-14-69.

Table 22.--Well logs

(Asterisks indicate principal water-bearing zones where known. Several of the Sierra Pacific logs are for test holes drilled at the site of a subsequent producing well; however, the casing and screen data are for the producing well. Detailed information, including electric logs, are available for most Sierra Pacific wells.)

Material	Thickness (feet)	Depth (feet)
17/19-9abb (cased to 109 ft; perforated from 95 to 106 ft)		
Rocks, yellow clay; and boulders	35	35
Clay; sand, fine to coarse; and rocks	5	40
Clay with fine sand; water-bearing below 50 ft	18	58
Clay with coarse sand; water-bearing	2	60
Clay with coarse sand and a little gravel; water-bearing (depth to water 47.4 ft; bailed 5 gpm)	5	65
Clay with sand	13	78
Clay with fine to coarse sand and rocks; water-bearing	2	80
Boulders and rocks	5	85
Clay with fine to coarse sand; water-bearing	10	95
Boulders and clay, with fine to coarse sand; water-bearing (depth to water 48.8 ft)*	15	110
Boulders and clay, with fine to coarse sand; water-bearing*	5	115
17/19-11abc (cased to at least 115 ft; perforated from 90 to at least 115 ft)		
Boulders and clay	98	98
Sand, water-bearing	3	101
Clay, brown	4	105
Gravel, sand, and boulders; water-bearing	10	115
No record; water-bearing at least in part	20±	135±
17/19-17aad (cased to 380 ft; perforated from 340 to 380 ft)		
Clay, sandy, and boulders	94	94
Rock	44	138
Andesite, gray	11	149
Boulders, granitic	4	153
Andesite, red	61	214
Andesite, gray	72	286
Andesite, red	84	370
Gravel, water-bearing	15	385
17/20-4bdd (cased to 35 ft; open-end)		
Soil, black	6	6
Sand, granitic, with soil; water-bearing	12	18
Soil, black, sticky, with sand	2	20
Clay, black, with fine to coarse, stony sand; water-bearing	14	34
Clay, blue	1	35
Sand, fine to coarse, with silt and gravel; water-bearing*	2	37
17/20-7aab (cased to 168 ft; perforated from 100 to 160 ft)		
Gravel and topsoil	6	6
Rock and clay	25	31
Clay	4	35
Sand, hard, granitic	49	84
Boulders	12	96
Gravel and clay; water-bearing below 110 ft	63	159
Decomposed granite and clay; water-bearing	9	168

Table 22.--Well logs--Continued

Material	Thickness (feet)	Depth (feet)
17/20-7cad (cased to 150 ft; perforated from 60 to 150 ft)		
Topsoil	1	1
Sand, silt, and cobbles; yellow	25	26
Sand, coarse, hard, gray, with silt	10	36
Rock, hard, broken, black	12	48
Clay, sandy, soft, yellow, with decomposed black rock	2	50
Rock, hard, broken, black	6	56
Clay, same as above, water-bearing	4	60
Rock, hard, broken, black	14	74
Sand, coarse, with some yellow clay; water-bearing*	2	76
Rock, hard, broken, black	11	87
Clay, sandy, soft, yellow, water-bearing	6	93
Rock, hard, broken, black	38	131
Clay, sandy, yellow, water-bearing	3	134
Rock, very hard, black	16	150
17/20-18cca (cased to 24 ft; open-end)		
Boulders and clay	14	14
Bedrock, gray	26	40
Bedrock, red	65	105
Bedrock, gray	95	200
Bedrock, red, water-bearing below 235 ft	75	275
Bedrock, gray, water-bearing*	15	290
18/19-12dbb (cased to 299 ft; perforated from 181 to 280 ft; open hole below 299 ft; principal water-bearing zone, 287-376 ft)		
Clay, brown, sandy, with gravel and cobbles	8	8
Silt and fine sand	41	49
Gravel, coarse, and fine sand	33	82
Silt and fine sand, with some medium to coarse sand and gravel	48	130
18/19-12dbb Continued		
Gravel, coarse, with medium gravel to fine gravel	13	143
Silt, with fine to coarse sand and some gravel	14	157
Clay, with some silt to medium gravel	13	170
Silt, with some fine to coarse sand and a little gravel and clay	40	210
Silt and fine sand, with coarse sand and clay	15	225
Sand, fine to coarse, with clay and silt	5	230
Gravel, fine to coarse, with some sand and boulders	10	240
Silt and fine sand, with a little medium to coarse sand and clay	10	250
Clay, brown, sandy	2	252
Gravel, water-bearing	2	254
Clay, brown, sandy	1	255
Silt and fine sand, with a little medium to coarse sand and clay	7	262
Gravel	2	264
Silt and fine sand, with a little clay and fine gravel	23	287
Andesite, dark gray, very dense, slightly weathered	15	302
Same as above, but more weathered	12	314
Same, but badly weathered, with iron-stained fractures	4	318
Andesite, dark gray, very hard	5	323
Andesite, yellow, badly weathered, with much clay	3	326
Andesite, dark gray, hard, with iron-stained fractures	4	330
Sand, medium to coarse, with a little gravel and silt	10	340
Andesite, hard	12	352

(continued)

Table 22.--Well logs--Continued

Material	Thickness (feet)	Depth (feet)
18/19-12dbb Continued		
Andesite, light gray, clay-like, hydrothermally altered	15	367
Gravel, fine, to fine sand, with silt and clay; yellow- to buff-colored (badly weathered and altered andesite)	7	374
Clay, brown (badly weathered and altered andesite)	11	385
18/19-25cca (cased to 100 ft; perforated intervals unknown)		
Clay, yellow, with coarse sand, gravel, and boulders	18	18
Sand, fine to coarse, and gravel, with yellow clay; water-bearing (depth to water 15.0 ft)	6	24
Boulders	5	29
Clay, yellow, with coarse sand, gravel, and rocks; water-bearing 39-50 ft (depth to water 15.0 ft)	31	60
Gravel, coarse, stony, with clay; water-bearing (depth to water 15.8 ft)*	5	65
Clay, yellow, with rocks, fine to coarse sand, and gravel	10	75
Sand, fine, silty, water-bearing (depth to water 16.3 ft)	5	80
Clay, yellow, with fine to coarse sand and rocks	5	85
Rocks and cemented material; hard	5	90
Sand, fine to coarse; large, stony gravel; and rocks; water-bearing	13	103

Note: Sand mostly granitic; gravel washed and smooth

Material	Thickness (feet)	Depth (feet)
18/19-26caa (cased to 435 ft; perforated from 260 to 435 ft)		
Boulders and clay	173	173
Clay and gravel	36	209
Boulders and clay	78	287
Sand, water-bearing*	2	289
Boulders and clay	9	298
Sand, water-bearing	2	300
Boulders and clay	25	325
Clay	4	329
Rock, "unconsolidated" [broken?], and clay	106	435
18/20-6abb (cased to 286 ft; screened intervals: 110-144, 158-210, and 228-272 ft)		
Gravel, little clay	12	12
Gravel, big, clay streaks	8	20
Clay, yellow	10	30
Gravel, big, clay streaks	8	38
Clay, yellow	3	41
Gravel, big	2	43
Sand, coarse	8	51
Boulders, sand, and clay	7	58
Clay, brown	3	61
Boulders, sand, and clay	2	63
Sand, coarse	9	72
Clay, boulders, and sand	3	75
Sand, gravel, boulders, and clay	23	98
Boulders and clay	2	100
Sand, fine, and clay blocks	10	110
Sand, coarse	10	120
Sand, fine, and clay streaks	5	125
Sand, coarse, few clay streaks	13	138
Boulders, sand, and clay streaks	16	154
Sand, fine gravel, and clay streaks	10	164
Boulders and clay	1	165
Sand, fine gravel, and clay streaks	13	178
Clay	1	179
Sand, fine gravel, and clay streaks	24	203
Clay	2	205
Sand and clay	6	211

(continued)

Table 22.--Well logs--Continued

Material	Thickness (feet)	Depth (feet)
18/20-6abb--Continued		
Sand, fine, and clay streaks	12	223
Sand, gravel, and streaks of clay (good)	11	234
Sand, gravel, and clay, broken	11	245
Sand, gravel, and clay streaks	8	253
Sand, gravel, and clay, broken	22	275
Sand and gravel	4	279
Boulders and clay	3	282
Sand, gravel, and clay, broken	13	295
Sand and gravel, cemented	5	300
Clay streaks, blue, sand and gravel	12	312
Shale, blue, streaks of sandy clay	14	326
Shale, blue, sandy clay	4	330
Sand, gravel (good)	7	337
Shale, blue	1	338
Sand, gravel, and clay streaks	4	342
Shale, blue	5	347
Clay, sand, and gravel	3	350
Sand, gravel, and clay streaks	3	353
Clay, sandy	7	360
Sand and gravel	5	365
Clay	3	368
Sand, gravel, and clay, broken	10	378
Clay, sandy	9	387
Sand, gravel, and clay streaks	10	397
Clay	2	399
Clay and sandy clay	3	402
Sand, gravel, and clay streaks	5	407
Clay	2	409
Sand, gravel, and clay	8	417
Clay and sandy clay	4	421
Sand and gravel	4	425
Clay, sandy, and blue shale	16	441
18/20-6abb--Continued		
Sand, gravel, and clay	3	444
Clay, sandy, and blue shale	28	472
Sand, gravel, and clay streaks	3	475
Shale, hard, and rock	15	490
Bedrock	14	504
18/20-27bcb2 (cased to 188 ft; perforated from 80 to 140 and from 160 to 180 ft)		
Gravel and boulders	15	15
Clay, sandy	3	18
Gravel, cemented, with granite boulders and scattered clay stringers	22	40
Clay, sandy	3	43
Clay, sandy, with scattered gravel stringers and boulders	25	68
Boulders, granitic, very hard	4	72
Clay with scattered gravel stringers and boulders	10	82
Sand and gravel	4	86
Gravel and sand stringers	24	110
Clay, sandy	10	120
Boulders, granitic	1	121
Gravel, cemented, with scattered granitic boulders	16	137
Boulders and sandy clay, with scattered sand and gravel stringers	51	188

Table 22.--Well logs--Continued

Material	Thickness (feet)	Depth (feet)
19/18-8ccc (cased to 302 ft; perforated from 254 to 302 ft)		
Topsoil and rock	6	6
Sand and rock	13	19
Boulders	6	25
Sand, gravel, and boulders	2	27
Clay, brown	8	35
Clay, blue	20	55
Gumbo, blue, with gravel; water-bearing	2	57
Clay, brown	3	60
Clay, gray	10	70
Clay, sandy, brown	23	93
Clay, blue, with gravel; water-bearing	32	125
Clay and gravel, hard, with some organic material	75	200
Clay and gravel, hard	25	225
Clay, brown, with organic material	20	245
Clay, sandy, gray	5	250
Clay, brown, with organic material; water-bearing below 260 ft	20	270
Clay, sandy, gray, water-bearing	29	299
Limestone(?), gray, water-bearing	3	302
19/18-14ccd (cased to 108 ft; perforated from 102 to 106 ft)		
Soil, sticky, black	15	15
Clay, hard, sticky, yellow	15	30
Clay, blue, water-bearing below 35 ft (depth to water 21.5 ft)	10	40
Clay, hard, sticky	6	46
Clay, blue and shale; hard	7	53
Clay, hard, sticky, brownish black	2	55
Clay and shale, blue, with black, medium sand; water-bearing (depth to water 21.5 ft)	10	65
Clay, hard, sticky, blue	20	85
Clay, hard, sticky, yellow	5	90
19/18-14ccd--Continued		
Clay and shale, blue, with black, coarse sand; water-bearing (depth to water 27.2 ft)	5	95
Clay, yellow, and blue shale; water-bearing (water level 19.3 ft)	17	112
Rock, hard, with fine sand; water-bearing (water level 13.3 ft)	20	132
19/18-16dac (Cased to 150 ft; perforated from 90 to 150 ft)		
Topsoil, loamy	½	½
Decomposed granite	5½	6
Decomposed granite with a little silt	6	12
Boulders and coarse sand	6	18
Coarse sand with a little silt	2	20
Boulders	3	23
Sand, fine to coarse, with a little silt and angular gravel	1	24
Boulders and coarse sand	5	29
Sand, coarse, and rounded gravel	4	33
Sand, fine to coarse, and rounded gravel, with a little silt	9	42
Sand, coarse, with rounded gravel and a few cobbles	4	46
Boulders, small	3	49
Sand, fine to coarse, clean, with gravel and a few cobbles	4	53
Boulders, small	3	56
Sand, fine to coarse, with some silt and rounded gravel	2	58
Sand, coarse, with rounded gravel	5	63
Boulders	3	66
Sand, fine to coarse, with a little silt	2	68

(continued)

Table 22.--Well logs--Continued

Material	Thickness (feet)	Depth (feet)
19/18-16dac--Continued		
Boulders	2	70
Sand, fine to coarse, with small gravel; possibly water-bearing	3	73
Clay, black, with coarse sand and gravel	2	75
Clay, sandy, brown	3	78
Clay, sandy, hard to soft, possibly water-bearing in places	42	120
Clay, hard, gray, very sticky in places	25	145
Sand, black, cemented	5	150
19/18-19dbd (depth of casing and perforations unknown; much of hole reportedly uncased)		
Topsoil and gravel	2	2
Gravel and yellow clay	8	10
Clay, sandy, yellow	28	38
Shale, blue	4	42
Shale, broken, water-bearing at 324 ft	282	324
Coal and shale	11	335
Shale, blue	23	358
Sand, water-bearing	6	364
Shale, blue	11	375
Sand and shells	25	400
Shale, blue	17	417
Sand and shells	5	422
Shale, blue	3	425
Sand and shells	5	430
Coal	3	433
Shale, brown	2	435
Sand and blue shale	10	445
Sand with streaks of blue shale and shells	16	461
Sand and shells	9	470
Shells with thin streaks of sand and blue shale	20	490
Shale, blue	10	500
Gravel(?), water-bearing(*?) (this interval not reported by driller; information apparently obtained from owner in 1951)	3	503
19/19-12bcd (cased to 530 ft; screened at 13 intervals between 133 and 510 ft)		
No record	104	104
Sand, fine gravel, and yellow clay	16	120
Sand, gravel, and few boulders	18	138
Boulders	10	148
Clay and boulders	14	162
Gravel and sand	16	178
Clay, sandy	16	194
Sand and gravel	10	204
Clay and gravel streaks	49	253
Gravel	17	270
Clay	5	275
Gravel and sand	7	282
Boulders	4	286
Boulders, hard, and clay streaks	9	295
Boulders, hard, and clay	4	299
Sand, gravel, and clay broken	10	309
Clay and boulders	8	317
Sand and gravel	11	328
Clay and boulders	2	330
Sand and gravel	16	346
Clay and boulders	2	348
Sand, gravel, and clay streaks	5	353
Gravel, sandy	22	375
Clay and boulders	3	378
Sand and gravel	24	402
Clay and boulders	2	404
Clay, sandy, and boulders	11	415
Sand and little gravel	23	438
Clay, sandy, and boulders	16	454
Sand and gravel	12	466
Clay, blue, sandy	2	468
Sand and gravel	25	493
Sand, broken	4	497
Shale	6	503
Gravel, sand, and clay	19	522
Shale, sandy, hard	41	563
Sand, hard, and gravel	12	575
Shale, blue, sandy	8	583

(continued)

Table 22.--Well logs--Continued

Material	Thick-ness (feet)	Depth (feet)
19/19-12bcd--Continued		
Sand and shale breaks	34	617
Boulders	1	618
Sand and gravel, hard, cemented	8	626
Rock	1	627
Sand and clay, broken	28	655
Clay, sandy	9	664
Sand and clay, broken	48	712
Sand and more clay	10	722
Clay, sandy, and sand	31	753
19/19-24cba2 (cased to 1,006 ft; perforated from 600 to 1,006 ft)		
Clay and gravel	4	4
Boulders and gravel	18	22
Sand	2	24
Boulders and gravel	86	110
Clay, brown, and boulders	12	122
Clay, brown, and gravel	30	152
Sand	2	154
Sand and gravel	16	170
Clay, green	4	174
Clay, blue	71	245
Sand	21	266
Gravel, coarse, and clay	24	290
Clay, blue	42	332
Sand and clay	33	365
Clay, sandy	25	390
Gravel, coarse, water-bearing	13	403
Sand, gravel, and clay; bedded, water-bearing	167	570
Cobbles and clay	20	590
Sand and clay (see note below log)	10	600
Sand and gravel	26	626
Clay, sand, and gravel; bedded	45	671
Clay, blue	135	806
Sand, gravel, and clay; bedded	22	828
Clay and gravel	68	896
Sand, gravel, and clay	24	920
Clay and boulders	64	984
Clay, blue	22	1,006

Principal water-bearing zone reportedly 600-920 ft.

Material	Thick-ness (feet)	Depth (feet)
19/19-24ccc (cased to 89 ft; perforated interval uncertain, but may coincide with principal water-bearing zone, 70-89 ft)		
No information (old hand-dug well)	29	29
Clay, sandy	60	89
19/20-4dcb (cased to 662 ft; screened intervals: 215-250, 330-350, 360-370, 382-402, 416-466, 535-590, and 625-650 ft)		
Surface soil	1	1
Sand, gravel, and boulders	74	75
Clay, yellow	1	76
Clay, blue, few boulders	17	93
Sand, gravel, and clay	19	112
Sand and gravel	7	119
Clay, blue	3	122
Sand, gravel, and clay breaks	12	134
Clay, blue	1	135
Sand, gravel, and clay, broken	5	140
Clay, blue	6	146
Sand and gravel	9	155
Clay, blue, and boulders	10	165
Clay, blue, sandy	10	175
Sand and gravel	14	189
Sand, clay, and gravel	29	218
Sand, gravel, and few boulders	16	234
Sand, gravel, and clay streaks	20	254
Sand, clay, and boulders	16	270
Sand and gravel	5	275
Sand, clay, and sand streaks	59	334
Sand and gravel	13	347
Clay, sandy	5	352
Clay, sandy, and sand	9	361
Sand and gravel	12	373
Clay, sandy	9	382
Sand and gravel	25	407
Clay, blue	2	409
Clay, sandy	5	414
Sand and gravel	13	427
Clay, blue	2	429

(continued)

Table 22.--Well logs--Continued

Material	Thick-ness (feet)	Depth (feet)
19/20-4dcb--Continued		
Clay, sandy	3	432
Sand and gravel	27	459
Clay, sandy	3	462
Sand, gravel, and clay, broken	15	477
Clay, sandy	3	480
Sand and gravel	5	485
Clay and sandy clay	22	507
Sand, gravel, and clay, broken	13	520
Clay, blue	13	533
Sand and gravel	13	546
Clay, blue	2	548
Sand and gravel	10	558
Clay, sandy	8	566
Sand and gravel	14	580
Clay, gray	1	581
Sand and gravel	12	593
Clay, gray	5	598
Gravel, sandy	4	602
Clay, sandy	20	622
Gravel, sandy, and few clay streaks	38	660
Clay, hard streaks	7	667
Sand, gravel, and clay, broken	13	680
Clay	2	682
Sand, gravel, and clay, broken	5	687
Clay, sandy, and clay	5	692
19/20-6dcd (cased to 530 ft; screened at 11 intervals between 148 and 518 ft)		
Boulders and sand	53	53
Sand and gravel	41	94
Clay, sandy	22	116
Sand and gravel	24	140
Clay	8	148
Sand and gravel	24	172
Clay, sandy	10	182
Sand and gravel	8	190
19/20-6dcd--Continued		
Clay, sandy clay	16	206
Sand and gravel	30	236
Clay, sandy	8	244
Sand, gravel, and sand streaks	40	284
Clay	4	288
Sand and gravel	10	298
Shale, blue	14	312
Sand, gravel, and clay	38	350
Shale, blue	6	356
Sand and gravel	34	390
Shale, blue	6	396
Sand, gravel, and clay	36	432
Shale, blue	18	450
Sand and gravel	18	468
Clay, sandy	6	474
Sand and gravel	10	484
Shale, blue	18	502
Sand and gravel	16	518
Shale, blue	16	534
Sand and gravel	28	562
Shale, blue	32	594
Sand and gravel	16	610
Shale, blue	8	618
Sand, gravel, and blue shale	11	629
Clay, sandy	4	633
19/20-8acc (cased to 41 ft; perforated from 24 to 38 ft)		
Soil, yellow, with fine to coarse black sand, pebbles, and rocks; water-bearing (water level, 2 ft)	10	10
Soil, with fine black sand and some gravel, rocks, and boulders; less water	5	15
Soil, fine black sand, and rocks	4	19
Sand, black, fine to coarse, and soil; water-bearing (water level, 14½ ft)	2	21
Sand, black, fine to coarse, gravel, rocks, and soil; a little water	3	24

(continued)

Table 22.--Well logs--Continued

Material	Thickness (feet)	Depth (feet)
19/20-8acc--Continued		
Sand, black, fine to coarse, gravel, rocks, and soil; hard; a little water from 32 to 39 ft	15	39
Sand, black, coarse, and coarse gravel with rocks and soil; hard; a little water (water level, 2½ ft)	4	43
19/20-8ddb (cased to 270 ft; perforated intervals: 110-126, 130-170, and 176-260 ft)		
Gravel and sand	63	63
Sand, big gravel, few clay streaks	18	81
Gravel, big, and clay	5	86
Sand, big gravel, few clay streaks	23	109
Clay	3	112
Sand, big gravel, and clay streaks	14	126
Clay	3	129
Sand, gravel, few clay streaks	39	168
Clay	6	174
Sand, big gravel, few clay streaks	48	222
Clay	1	223
Sand, gravel, few clay streaks	17	240
Clay	2	242
Sand and gravel	20	262
Clay and sandy clay	9	271
Sand and gravel	13	284
19/20-13add (cased to 93 ft; perforated from 72 to 92 ft)		
Topsoil	2	2
Rock, hard	8	10
Clay, brown	13	23
Sandstone and silt, gray; water-bearing	7	30
Silt, gray	7	37
19/20-13add--Continued		
Rock, conglomeratic, with traces of organic material in bottom 10 ft	18	55
Silt, gray	4	59
Sand, gray	13	72
Sand and gravel; water-bearing	14	86
Rock, soft, conglomeratic, water-bearing	5	91
Rock, hard	2	93
19/20-18dbd (cased to 685 ft; screened intervals: 330-355, 405-445, 480-570, 595-610, and 625-665 ft)		
Topsoil, sand, gravel, and boulders	136	136
Clay, sandy, and gravel	7	143
Boulders, clay, and sand	22	165
Clay and boulders	13	178
Boulders, sand, and gravel	17	195
Clay and boulders	10	205
Boulders, sand, and gravel	28	233
Boulders and gravel	5	238
Clay and boulders	12	250
Sand, gravel, and boulders	42	292
Clay and sandy clay	38	330
Sand, broken	28	358
Clay and sand streaks	15	373
Clay, hard, and sandy clay	38	411
Sand, hard	32	443
Shale	2	445
Shale and sandy shale	37	482
Sand and gravel	18	500
Shale, sandy	18	518
Sand and gravel	10	528
Shale, sandy	3	531
Sand and gravel	21	552
Shale, sandy	18	570
Shale	22	592
Sand and gravel	16	608
Shale, sandy, and shale	17	625
Sand, gravel, and hard streaks	15	640
Shale	5	645
Sand	5	650
Shale	5	655
Sand and gravel	13	668
Shale	17	685

Table 22.--Well logs--Continued

Material	Thickness (feet)	Depth (feet)
19/20-21bcb (cased to 346 ft; screened intervals: 174-198, 210-270, and 311-335 ft)		
No record	77	77
Gravel and sand	6	83
Sand, gravel, and boulders	4	87
Boulders	1	88
Sand, gravel, and boulders	30	118
Clay	4	122
Sand, gravel, and boulders	32	154
Clay, sandy clay, and boulders	21	175
Sand and gravel	21	196
Clay, blue	12	208
Sand and gravel	10	218
Clay, sandy	4	222
Sand and gravel	31	253
Clay, sandy	4	257
Sand and gravel	13	270
Clay, sandy	6	276
Boulders	4	280
Clay and boulders	3	283
Clay, sandy	5	288
Clay, blue	8	296
Sand and gravel	2	298
Clay, sandy	3	301
Sand and gravel	5	306
Clay, sandy	4	310
Sand, gravel, few hard streaks	10	320
Clay, sandy	3	323
Sand and gravel	15	338
Clay	12	350
19/20-30dab (cased to 826 ft; screened at 10 intervals between 149 and 809 ft)		
Surface soil	3	3
Sand, fine gravel	10	13
Clay, sandy clay	9	22
Sand and gravel	6	28
Gravel and clay streaks, large	9	37
Clay, sandy clay	10	47
Sand	3	50
Clay, sandy clay	9	59
Sand, gravel, clay streaks	11	70
Sand, gravel, and boulders	20	90
19/20-30dab--Continued		
Boulders and clay	8	98
Clay, blue, few boulders	5	103
Sand, fine gravel	4	107
Clay, blue, streaks of sand and gravel	6	113
Sand, gravel, few clay streaks	17	130
Clay, sandy, and clay	11	141
Sand, gravel, and clay streaks	4	145
Clay, sandy	3	148
Sand, gravel, few boulders	22	170
Clay	3	173
Sand, gravel, and clay	5	178
Clay, streaks of gravel	7	185
Sand, gravel	5	190
Clay, sandy, streaks of clay	13	203
Sand, gravel, and clay--broken	22	225
Clay, sandy	6	231
Sand, gravel, and clay streaks	23	254
Clay, sandy	18	272
Sand, gravel, and clay breaks	10	282
Gravel, large	3	285
Clay and boulders	2	287
Sand, gravel	4	291
Clay, sandy, and sand streaks	11	302
Sand and gravel	8	310
Sand, gravel, and clay--broken	5	315
Clay, sandy	9	324
Sand, gravel	5	329
Clay, sandy	5	334
Sand, gravel, and clay streaks	43	377
Clay, sandy, and sand streaks	22	399
Sand and gravel	17	416
Sand and clay--broken	11	427
Clay, sandy	7	434
Sand and clay--broken	23	457
Clay, blue	7	464
Sand and gravel	9	473

(continued)

Table 22.—Well logs—Continued

Material	Thickness (feet)	Depth (feet)
19/20-30dab--Continued		
Clay	3	476
Sand and gravel	8	484
Clay	2	486
Sand, gravel, and clay streaks	26	512
Sand and clay--broken	16	528
Sand, gravel, and few clay streaks	19	547
Clay, sandy	13	560
Sand, gravel, and clay streaks	14	574
Clay	2	576
Sand and clay—broken	29	605
Clay	3	608
Sand and clay—broken	17	625
Clay, sandy	69	694
Sand and gravel	28	722
Clay, sandy	9	731
Sand and clay--broken	13	744
Sand and gravel	7	751
Clay	3	754
Sand-gravel	15	769
Clay	2	771
Sand, gravel	12	783
Sand, gravel, few clay streaks	24	807
Shale, tough	7	814
Sand	2	816
19/21-9dad (cased to 330 ft; perforated from 285 to 330 ft)		
Clay, soft, talc-like	125	125
Boulders, hard, green	75	200
Clay, soft, talc-like	75	275
Volcanic rock, water-bearing	55	330
19/21-10aac (cased to 125 ft; perforated from 105 to 125 ft)		
Topsoil	2	2
Hardpan	7	9
Gravel and boulders	63	72
Rock	24	96
Sand, water-bearing	1	97
Rock	19	116
Sand, water-bearing*	9	125
20/19-23cac (cased to 85 ft; perforated from 65 to 85 ft)		
Topsoil	1½	1½
Rock, brown	43½	45
Basalt	5	50
Clay, yellow	10	60
Basalt, black, water-bearing below 75 ft	25	85
20/19-27bac (cased to 200 ft; perforated from 154 to 194 ft)		
Clay, brown	20	20
Clay, brown, and weathered rock	139	159
Rock, hard, broken, water-bearing below 165 ft	26	185
Rock, broken, weathered, water-bearing	16	201
Clay, sticky, blue	7	208
Rock, hard	5	213
Shale, blue	1	214
20/22-28bcc (cased to 141 ft; perforated from 100 to 141 ft)		
Sand	3	3
Gravel and boulders	80	83
Clay	6	89
Gravel and boulders; water-bearing	39	128
Gravel and clay	5	133
Gravel and boulders; water-bearing*	8	141
20/22-33bab (cased to 133 ft; perforated and screened from 26 to 133 ft)		
Soil, sandy	15	15
Gravel	30	45
Gravel and boulders	48	93
Clay, brown, sandy	11	104
Gravel	29	133
Clay, brown, sandy	2	135

Material	Thickness (feet)	Depth (feet)
20/22-35aba (cased to 150 ft; perforated from 64 to 150 ft)		
Dirt and large boulders	28	28
Hardpan	18	46
Gravel and clay, water-bearing	6	52
Clay, brown	30	82
Gravel and some clay, water-bearing	14	96
Clay, brown	4	100
Gravel, water-bearing	4	104
Clay, brown	18	122
Gravel, water-bearing	4	126
Clay, brown	9	135
Gravel, water-bearing	2	137
Hardpan	13	150
20/23-19ca (cased to 47 ft; perforated from 42 to 47 ft)		
Topsoil, sandy, and boulders	8	8
Sand and boulders, water-bearing	13	21
Clay, sandy	23	44
Sand, water-bearing*	3	47
Clay, sandy	3	50
20/23-21daa (cased to 44 ft)		
Topsoil, sandy	5	5
Clay, sandy, hard	19	24
Clay and rock	14	38
Rock, broken, water-bearing	4	42
Volcanic rock, hard, brown	13	55
Volcanic rock, red	1	56
Volcanic rock, hard, brown, water-bearing	20	76
20/24-11bbd (cased to 250 ft; perforated from 150 to 250 ft)		
Sand	40	40
Sand, fine, and light brown clay	20	60
Clay, sandy, light blue	15	75
20/24-11bbd--Continued		
Sand and pea gravel	15	90
Clay, blue, with streaks of fine sand	15	105
Clay, blue	35	140
Sand, black, with pea gravel; water-bearing	20	160
Sand, hard, water-bearing	10	170
Clay, hard, brown	15	185
Sand, coarse, black, with streaks of clay; water-bearing	35	220
Clay, hard	10	230
Sand and gravel; water-bearing	25	255
20/24-18bca (uncased; insufficient water)		
Sand	6	6
Sandstone	30	36
Sand, gravel, and boulders	29	65
Basalt	130	195
20/24-24bbb2 (cased to 199 ft; perforated from 76 to 196 ft)		
Soil	2	2
Sand and gravel	8	10
Clay	31	41
Gravel	4	45
Clay	11	56
Gravel, rock, and clay	27	83
Gravel, water-bearing	21	104
Clay, sandy	2	106
Gravel, coarse, water-bearing	6	112
Clay	3	115
Gravel and rock; water-bearing	9	124
Clay	41	165
Gravel and clay; water-bearing	9	174
Clay, brown	10	184
Gravel, water-bearing*	13	197
Clay	2	199

Table 22.—Well logs—Continued

Material	Thickness (feet)	Depth (feet)
20/25-7bdd (original hole cased to 83 ft; perforated from 68 to 75 ft. Well later deepened to about 206 ft)		
Topsoil and sand	6	6
Sand, loose	20	26
Clay, brown	42	68
Sand, loose, water-bearing	10	78
Clay, brown	5	83
No record	123	206
20/25-18ccc2 (log approximate, from owner's memory)		
Clay	28	28
Gravel, water-bearing (good quality)	12	40
Clay	108±	148±
Gravel, water-bearing (poor quality)	12	160±
Clay	40±	200±
20/25-25adb (cased to 258 ft; perforated from 130 to 150 ft and 220 to 240 ft)		
Sand, gravel, and boulders	30	30
Clay, gray	86	116
Clay, green	4	120
Clay, sandy, brown	15	135
Clay, yellow, water-bearing*	4	139
Clay, brown, water-bearing*	16	155
Clay, gray	33	188
Clay, gray, and loose rock	30	218
Clay, sandy, brown, water-bearing	15	233
Hardpan, sandy, water-bearing	13	246
Clay, brown	12	258
21/23-13dcc (cased to 85 ft; perforated from 50 to 85 ft)		
Clay	44	44
Rock and clay	4	48
Gravel, water-bearing	37	85
21/24-14aac		
Sand	13	13
Rock, gray	29	42
Rock with a little clay	34	76
Lava	19	95
Lava, red	18	113
Rock, hard, gray	2	115
Rock, hard, brown	16	131
Lava, red	15	146
Lava, hard, blue	15	161
Rock, hard, gray, with some red rock below 190 ft	49	210
Lava, red, medium-hard	15	225
Lava, red, hard	7	232
Lava, red and black; water-bearing below 300 ft(?)	76	308
Lava, hard, red, porous, water-bearing	30	338
Rock, hard, black, water-bearing	6	344
21/24-33dcb (cased to 465 ft, perforated in 8 places between 240 and 455 ft)		
Sand, loose	3	3
Gravel, silt, and sand	7	10
Sand, medium, and small gravel	13	23
Sand and gravel	22	45
Sand with gravel stringers	35	80
Sand and gravel with gray clay stringers	12	92
Gravel, medium, with silty sand stringers	9	101
Sand with tight gravel stringers	11	112
Gravel, tight and hard	25	137
Sand with stringers of tight gravel and gray clay	11	148
Clay, sandy, gray	7	155
Clay, gray	3	158
Sand, medium, and gravel	8	166
Clay, blue	13	179

(continued)

Table 22.--Well logs--Continued

Material	Thick-ness (feet)	Depth (feet)
21/24-33dcb--Continued		
Gravel, medium to large, with hard streaks; water-bearing from 230 to 270 ft	91	270
Sand and gravel with hard streaks; water-bearing from 270 to 295 and from 305 to 315 ft	47	317
Sand and gravel with brown clay stringers and hard streaks	10	327
Sand and gravel, cemented, very hard	18	345
Clay, sandy, brown	11	356
Sand, medium, gray; water-bearing	9	365
Sand and gravel, cemented, hard; water-bearing	7	372
Clay, brown, sticky	3	375
Sand and gravel, tight, water-bearing from 375 to 380 ft	10	385
Clay stringers, brown, water-bearing from 390 to 395, 400 to 405, 410 to 420, and 430 to 455 ft	85	470
22/23-1ddb (cased to 85 ft; perforated from 75 to 85 ft; open-end)		
Sand and boulders	12	12
Rock	2	14
Sand	4	18
Sand and gravel	12	30
Hardpan, brown	10	40
Gravel and boulders	5	45
Hardpan, brown	5	50
Sand, gravel, and boulders; water-bearing	11	61
Hardpan, brown	9	70
Sand and gravel; water-bearing*	25	95
22/23-27dca (cased to 162 ft; perforated from 120 to 162 ft)		
Clay, sandy, and rock fragments	7	7
Rock, decomposed, gray	33	40
Rock, red	57	97
Rock, red-brown, with some clay	51	148
Gravel and sand; water-bearing	10	158
Clay and gravel	4	162
22/24-13ac (cased to 315 ft; perforated from 250 to 310 ft)		
Boulders, large, and clay	215	215
Clay, sandy	45	260
Clay and gravel	27	287
Rock, crevassed	10	297
Rock, with vugs, and soft gray lava	13	310
Rock, hard	5	315
23/21-15bcc (cased to 191 ft)		
Fill, sandy	20	20
Decomposed granite(?)	25	45
Andesite, black, water-bearing	20	65
Sand, brown	40	105
Rock, broken, water-bearing	15	120
Rock, volcanic, gray, water-bearing*	67	187
Rock, broken	8	195
Andesite, gray	113	308
23/22-10cad (uncased)		
Clay and large boulders, yellow, hard	10	10
Boulders and clay, yellow, medium	26	36
Gravel and clay, yellow; small amount of water at 51 ft	21	57
Gravel and clay, green	18	75
Gravel and clay, green, soft	21	96
Rock, black, hard	9	105

Table 22.—Well logs—Continued

Material	Thickness (feet)	Depth (feet)
23/23-23bcb (cased to 136 ft; perforated from 126 to 136 ft)		
Sand and clay	8	8
Sand	4	12
Sand, volcanic; water-bearing	19	31
Mud, black, and decayed vegetation	10	41
Sand, black, volcanic, and decayed vegetation; water-bearing, but of poor quality	49	90
Clay, brown	10	100
Sand, black; water-bearing, but of poor quality	10	110
Hardpan, brown	10	120
Sand and gravel; water-bearing*	20	140
Bedrock(?)	—	140+
23/23-25cba (cased to 287 ft; perforated from 240 to 275 ft)		
Mud and gravel	24	24
Sand	10	34
Sand, muddy	11	45
Clay, black, water-bearing	15	60
Sand	20	80
Clay, gray	10	90
Sand, coarse, water-bearing	10	100
Clay and coarse sand	35	135
Sand	5	140
Clay and gravel	20	160
Sand	10	170
Clay and sand	20	190
Sand	35	225
Clay, green and gray	6	231
Pea-gravel	7	238
Clay and gravel	2	240
Sand, black, water-bearing*	2	242
Gravel, coarse, water-bearing*	11	253
Pea-gravel, water-bearing*	12	265
Gravel, coarse, water-bearing*	15	280
Mud and sand	7	287
23/23-26ddc (cased to 170 ft; perforated from 52 to 91 ft and from 160 to 170 ft)		
Clay, sandy	6	6
Sand, fine	6	12
Gravel, coarse	24	36
Clay, black	15	51
Clay, gray, with sand seams	2	53
Gravel with thin clay seams; water-bearing*	38	91
Clay, sandy	23	114
Sand, fine	46	160
Sand, coarse, water-bearing	10	170
24/21-15aca (cased to 212 ft; perforated from 160 to 210 ft)		
Sand and clay	46	46
Sand and some gravel; water-bearing at 53 ft	7	53
Sand and brown clay	20	73
Clay and rock	85	158
Sand and blue mud	15	173
Clay, blue, and large gravel; water-bearing	49	222
24/21-15cad (cased to 420 ft; perforated from 70 to 100 ft and from 150 to 390 ft)		
Sand and gravel	1	1
Clay, sandy, light	50	51
Clay, blue, and boulders	105	156
Rock, volcanic, red, broken	10	166
Clay, red, boulders, and some gravel	44	210
Clay, gravelly, and boulders	28	238
Clay, gravelly, brown, and boulders	90	328
Rock, green, soft	30	358
Rock, green, soft, with traces of clay	62	420

Material	Thickness (feet)	Depth (feet)
24/22-31ccc (cased to 226 ft; perforated from 76 to 226 ft)		
Sand, gray, soft	1	1
Hardpan	3	4
Clay, sandy, soft	4	8
Sand, loose, brown, soft	6	14
Clay and gravel, blue, with streaks of sand in lower 14 ft	78	92
Bedrock, gray, hard	134	226
24/23-25cca (cased to 120 ft; perforated from 40 to 120 ft)		
Clay, sandy	8	8
Sand and gravel	7	15
Gravel and streaks of sandy clay	37	52
Gravel and cobbles, clean; water-bearing	41	93
Sand, gravel, and clay streaks	17	110
Clay, dark brown	10	120
24/23-36cba (cased to 50 ft; perforated from 22 to 50 ft)		
Sand and rocks	12	12
Gravel, cemented	10	22
Gravel, coarse, water-bearing*	32	54
Clay, blue	2	56
Gravel, water-bearing	12	68
Clay, red	2	70
Gravel, water-bearing	3	73
25/21-18baa (cased to 112 ft; perforated from 87 to 107 ft)		
Sandy loam	16	16
Marsh mud, black, watery	33	49
Gravel, coarse, sandy, dark, water-bearing	63	112
25/21-32aaa (uncased)		
Boulders, sandy clay, and gravel; red	168	168
Same, with some red clay	101	269
Gravel, brown, with clay and boulders	39	308
Rock, volcanic, blue, medium at top grading to hard at bottom	89	397
26/20-26adb (cased to 204 ft)		
Gravel	38	38
Sand	20	58
Sand, black, and mud	45	103
Gravel	32	135
Boulders and gravel	10	145
Sand	27	172
Gravel and boulders	15	187
Boulders	17	204
26/21-6ccb (cased to 2,017 ft)		
Lakebed sedimentary deposits	350	350
Volcanic rocks, varying from highly altered rhyolitic tuffs to andesite flows of varying porosity; well was closed in for almost 1 year, after which down-hole temperatures were about 117°C, and flow was about 400 gpm	3,858	4,208
Rock (probably volcanic), extremely hard, with few permeable zones, but one zone of rather intense hydrothermal alteration; this interval was drilled 18 months after completion of top 4,208 ft; maximum bottom-hole temperature 113°C, flow about 7 gpm	1,722	5,930

Table 22.--Well logs--Continued

Material	Thickness (feet)	Depth (feet)
27/20-28bbc (cased to 135 ft; perforated from 100 to 135 ft)		
Clay, bentonitic	50	50
Clay, light brown	55	105
Clay, blue	10	115
Sand and gravel, water-bearing	14	129
Clay, blue	6	135
27/21-16abd (cased to about 44½ ft; screened from about 42½ to 44½ ft)		
Sand, medium-grained, with shells	3	3
Sand with wet clay content increasing to about 50 percent at 7 ft	4	7
Clay, brown and black, mottled	3	10
Clay, greenish black	2	12
Clay, black with greenish cast, high water content	20	32
Same as about, but greener	5	37
Same, but clay drier, more cohesive	10	47
28/21-33ccd (cased to about 60½ ft; screened from about 58½ to 60½ ft)		
Sand, medium-grained, with fine sand and silt	3	3
Clay, light brown, damp	19	22
Same as above, but mottled with dark green	5	27
Clay, dark green, damp	25	52
Same, but wetter	5	57
Clay, with medium sand and silt; water-bearing at about 60 ft	5	62
28/24-7cab (cased to 152 ft; perforated from 141½ to 152 ft)		
Decomposed granite, soft	122	122
Sand, granitic, cemented, hard	8	130
Gravel and clay, cemented, hard	15	145
Gravel and sand; soft, water-bearing	7	152
28/24-24bb (cased to 286 ft; perforated from 212 to 286 ft)		
Soil, soft, gray	4	4
Sand and gravel, cemented, hard	14	18
Silt, sandy, soft	22	40
Sand and gravel; cemented, hard; water-bearing below 275 ft	246	286

Table 23.--Water-level measurements in observation wells

[Water levels in feet below land-surface datum; highest and lowest levels for long-term records are indicated by underline and "H" or "L"]

16/19-10bbd (Washoe Valley)

3-18-68	5.79
4- 8-69	6.01
3-10-70	5.8
7- 7-70	6.47

18/19-12dbb (Truckee Meadows; monthly measurements during period of record; well unused)

Year	Low	Date	High	Date
1952	47.17L	4-23	39.66	10-22
1953	46.05	4-28	41.88	10-26
1954	47.89	4-29	42.25	11- 1
1955	47.92	4-29	18.87*	12- 1
1956	19.49	4- 4	15.94H	10-26
1957	20.24	3-26	16.37	9-30
1958	20.41	4-30	16.30	10-28
1959	20.48	3-25	16.87	10-29
1960	21.24	3-25	17.04	9-30
1961	21.76	3-31	18.98	7-20
1962	22.94	1-19	18.92	10- 1
1963	24.21	7-26	20.44	11- 6
1964	24.16	4-29	19.66	10-27
1965	23.43	4-29	19.95	10-28
1966	23.38	1-24	18.90	9-28
1967	22.28	4-25	19.77	8-29
1968	24.37	4-24	--	--

Well destroyed in 1968.

* Heavy pumping of adjacent well apparently ceased in August 1955.

19/19-22cda (Truckee Meadows)

1-30-51	217.10H
2-11-58	223.18
8-15-58	224.25
4-15-59	224.78
8-25-59	225.38
3-29-60	225.57
3-15-61	225.54
2-28-63	226.03
3-24-64	227.14
10-20-64	227.8L
3- 4-65	226.8
3-24-66	226.4
3- 8-67	226.0

Well abandoned in 1968.

19/19-24ccc and 19/20-8acc (Truckee Meadows)

See figure 2.

19/20-11abc (Truckee Meadows)

5-19-56	12.22
11-29-56	12.46
4-12-57	12.50
8- 9-57	10.90
12-13-57	12.30
4-14-58	11.50
8-14-58	9.26
12-30-58	11.39
4-14-59	12.43
8-26-59	9.02H
3-28-60	13.49
8-25-60	11.00
3-15-61	13.47
10-11-61	10.19
3- 1-62	10.80
2-28-63	11.54
9-11-63	10.29
3-18-64	13.65
9-16-64	12.34
3- 4-65	13.66
9-30-65	12.04
3-24-66	13.95L
9-28-66	12.67
3- 8-67	13.8
3-18-68	13.9
4- 8-69	13.64

Well destroyed in 1969.

Table 23.--Water-level measurements--Continued

20/20-19ad (Sun Valley)

6- 7-49	23.87
9-20-49	24.44
2- 1-50	24.20
8-28-50	24.54
2-27-51	24.08
8-27-51	24.50
3-21-52	23.56
6-24-52	22.97H
9-19-52	23.29
9-23-53	23.77
9-28-54	24.39
9-30-57	24.15
9-19-58	24.52
10- 5-59	25.13
8-29-61	26.33
2-28-63	26.49
3-17-64	26.38
9-16-64	27.87
3- 4-65	26.78
9-30-65	28.30
3-24-66	28.52
9-28-66	29.5 L
3- 8-67	29.2
3-18-68	27.6
4- 8-69	27.5

Well capped in 1969.

20/24-11ccc (Fernley Area)

Date	Water level (feet)	Field specific conductance (micromhos)
6- 3-53	12.8	--
7- 7-53	11.16	700
7-30-53	8.40	520
9- 2-53	8.42	490
11-10-53	8.25	550
1- 4-54	13.38	350
3- 3-54	15.50	340
5- 5-54	13.65	--
7- 8-54	9.27	--
9- 3-54	7.86H	--
11-16-54	9.81	--
1-28-55	14.01	--
3-10-55	15.96	--
7- 7-55	12.30	--
3-15-56	17.29L	--
2-25-60	17.26	--

Fernley Area

Date	20/25-18ccc1 (28 ft deep)	20/25-18ccc2 (155 ft deep)
6-15-53	3.19	9.00
9- 2-53	2.35	3.33H
11-10-53	2.26	4.96
1- 4-54	3.85	8.43
3- 3-54	4.48	10.63
5- 5-54	4.25	11.41
7- 8-54	2.17	5.33
9- 3-54	2.03	3.37
11-16-54	3.32	5.48
1-28-55	--	9.61
3-10-55	--	11.35
7- 7-55	1.96H	7.52
3-15-56	4.79	12.07
2-25-60	4.54	--
8- 8-60	3.80	--
2-20-70	5.53L	13.93L
7-14-70	4.40	12.83

21/20-26dc (Spanish Springs Valley)

10- -57	64.5
7-28-66	63.01
3-19-68	63.0
4- 9-69	62.8
3-10-70	62.6

22/20-12dbd (Warm Springs Valley)

3-19-68	38.1
4- 9-69	36.0
3-10-70	36.4
7-21-70	35.30

27/21-9bda (Pyramid Lake Valley)

7-28-67	5.90
3-31-69	6.68
8-22-69	6.79
1- 3-70	6.71
10-24-70	6.92

Date	27/21-16abd	28/21-33ccd
7-28-67	16.63	15.31
3-31-69	17.18	15.64
8-22-69	17.00	16.08
1- 3-70	17.51	15.82
10-24-70	17.39	16.31

Table 24.--Spring data

Location	Name	Approximate land-surface altitude (feet)	Date[2]	Flow (gpm)[3]	Temperature °F	Temperature °C	Field determinations[1]: Chloride (mg/l)	Hardness as $CaCO_3$ (mg/l)	Specific conductance (micromhos)[4]
16/19-3ba	Bowers	5,080	12- 4-59	70m	120	49	4.0d	12	254
-21a	--	5,200	6- 2-60	5	53	11½	.5d	43	120
18/19-10aa, -11bb	Lone Tree	4,950-5,025	12-23-57	50	60	15½	3.0d	72	237
-12db	Christman	4,597	1948-49	100±	62	16	11	--	--
18/20-17dc	Zollezzi	4,550	1-14-58	100-200	94	34½	94d	32	729
-28,33	Lane Steamboat	4,600-4,665	1945-52a	600±	89	31½	865d	16	3,210
19/18-8dca	--	4,840	--	1,100mf	--	--	--	--	--
-13ac	Lawton	4,650	2-11-58	250	120	49	57d	16	625
19/20-5bd	--	4,430	1-21-59	75-100	56	13½	--	--	--
-32aa	--	4,440±	5-14-58	50	60	15½	2.8d	119	301
19/23-29d	Biddleman	5,600	10-17-61b	½	--	--	30	200	500
19/24-9d	--	5,040	10-21-61b	--	--	--	130	320	520
20/24-35c	--	4,480	10-21-61b	--	--	--	40	180	370
21/23-29dca	--	5,470	2-20-70	20m	55	13	11d	279	610
23/21-1aac	--	4,000	7-10-70	5	--	--	201d	275	1,800
-15bbd	--	4,400	2-11-70	¼	54	12	16d	390	900
23/22-26c, -27d	--	5,100-5,600	10- 1-67c	10	--	--	3.6d	60	300e
24/20-13d	--	5,440-5,760	9-24-67c	125	--	--	2.6d	89	210e
24/24-1ada	Coyote	5,040	10-23-61b	15	57	14	50	170	420
-28add	Creel	4,560	10- 8-61b	small	54	12	50	50	510
25/20-3a	--	4,700	10- 1-67c	15	--	--	3.0d	83	230e
25/23-10bcd	Sevenmile	4,040-4,200	7-30-69	1-2	64	18	19d	110	410
25/24-15d	--	4,700	7-24-41	--	--	--	560d	2,020	4,500e
26/20-12bad	--	3,800	2-14-69	<10	132	55½	1,830d	446	6,300
26/23-10dba	--	3,980-4,000	7-30-69	2	65	18½	16d	28	420
26/24-7d	Goose	3,780	1959b	100	--	--	--	--	--
27/22-16ada	--	4,300-4,450	8-22-69	2-5	<77	<25	34d	231	640
27/23-10baa	Schell	4,170	10-10-61b	50±	57	14	40	50	290
			7-30-69	10	70	21	14	27	250

Table 24.--Spring data--Continued

Location	Name	Approximate land-surface altitude (feet)	Date[2/]	Flow (gpm)[3/]	Temperature °F	Temperature °C	Chloride (mg/l)	Hardness as $CaCO_3$ (mg/l)	Specific conductance (micromhos)[4/]
			Field determinations[1/]						
27/23-10cbc	Jackass	4,470	10-10-61b	20-40	57	14	20	50	230
-26d	--	3,885	6-22-59	5	--	--	775d	70	3,670
			10-10-61b	small	64	18	3,500	140	>10,000
-27bca	--	4,270	6-18-59	50	--	--	9.0d	44	241
27/25-8dd	Lower Stonehouse	5,100	10- 9-61b	4	60	15½	100	340	880
			9- 3-69	½	82	28	126d	330	1,100
-21b	--	5,730	10- 9-61b	6	--	--	--	--	--
28/23-27d	--	4,040-4,150	7-30-69	10-15	72	22	19d	25	300
29/21-35cbc	--	5,050-5,070	9- 4-69	1m	64	18	43d	198	530
29/24-9c	--	4,630	10-10-61b	5	60	15½	80	260	800
-10a	--	--	10-12-61b	1.0m	67	19½	40	220	670
30/24-33cad	--	5,080	10-10-61b	2	59	15	100	340	900

1. Laboratory determinations indicated by "d" following chloride value; more detailed analysis in table 18 for most "d" springs.

2. Data from U.S. Geol. Survey files except: a, flow quantity from White (1968, p. 83, includes thermal well discharge), analysis from U.S. Geol. Survey files; b, C. T. Snyder and R. E. Smith (U.S. Geol. Survey, written commun., 1970); c, Desert Research Institute (Wilsey & Ham, 1970, p. 42, 148).

3. Measured flow indicated by "m"; all others estimated.

4. Estimated values indicated by "e."

f. Information from M. V. Walberg (Viking Metallurgical Corp., oral commun., 1970).

LIST OF PREVIOUSLY PUBLISHED REPORTS IN THIS SERIES

(See fig. 1)

Report no.	Valley or area
1	Newark (out of print)
2	Pine (out of print)
3	Long (out of print)
4	Pine Forest (out of print)
5	Imlay area (out of print)
6	Diamond (out of print)
7	Desert (out of print)
8	Independence
9	Gabbs (out of print)
10	Sarcobatus and Oasis (out of print)
11	Hualapai Flat
12	Ralston and Stone Cabin
13	Cave
14	Amargosa Desert, Mercury, Rock, Fortymile Canyon, Crater Flat, and Oasis
15	Sage Hen, Guano, Swan Lake, Massacre Lake, Long, Macy Flat, Coleman, Mosquito, Warner, and Surprise
16	Dry Lake and Delamar
17	Duck Lake
18	Garden and Coal
19	Middle Reese and Antelope
20	Black Rock Desert, Granite Basin, High Rock Lake, Mud Meadow, and Summit Lake
21	Pahranagat and Pahroc
22	Pueblo, Continental Lake, Virgin, and Gridley Lake
23	Dixie, Stingaree, Fairview, Pleasant, Eastgate, Jersey, and Cowkick
24	Lake
25	Coyote Spring, Kane Springs, and Muddy River Springs
26	Edwards Creek
27	Lower Meadow, Patterson, Spring (near Panaca), Rose, Panaca, Eagle, Clover, and Dry
28	Smith Creek and Ione

Report no.	Valley or area
29	Grass (near Winnemucca)
30	Monitor, Antelope, Kobeh, and Stevens Basin (out of print)
31	Upper Reese
32	Lovelock
33	Spring (near Ely; out of print)
34	Snake, Hamlin, Antelope, Pleasant, and Ferguson Desert (out of print)
35	South Fork, Huntington, and Dixie Creek-Tenmile Creek (out of print)
36	Eldorado, Piute, and Colorado River (out of print)
37	Grass (near Austin) and Carico Lake (out of print)
38	Hot Creek, Little Smoky, and Little Fish Lake (out of print)
39	Eagle (Ormsby County)
40	Walker Lake and Rawhide Flats
41	Washoe
42	Steptoe
43	Honey Lake, Warm Springs, Newcomb Lake, Cold Spring, Dry, Lemmon, Red Rock, Spanish Springs, Bedell Flat, Sun, and Antelope
44	Smoke Creek Desert, San Emidio Desert, Pilgrim Flat, Painters Flat, Skedaddle Creek, Dry (near Sand Pass), and Sano
45	Clayton, Stonewall Flat, Alkali Spring, Oriental Wash, Lida, and Grapevine Canyon
46	Mesquite, Ivanpah, Jean Lake, and Hidden
47	Thousand Springs and Grouse Creek
48	Little Owyhee River, South Fork Owyhee River, Independence, Owyhee River, Bruneau River, Jarbidge River, Salmon Falls Creek, and Goose Creek

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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF THE TRUCKEE RIVER BASIN AND FERNLEY AREA, WESTERN NEVADA