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WATER RESOURCES - RECONNAISSANCE SERIES

REPORT 59

WATER-RESOURCES APPRAISAL OF THE CARSON RIVER BASIN, WESTERN NEVADA

By

Patrick A. Glancy
and
T. L. Katzer

Prepared cooperatively by the
U.S. Department of the Interior, Geological Survey

1976

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 59th report prepared by the staff of the Nevada District Office of the U.S. Geological Survey. These 59 reports describe the hydrology of 208 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 of the water resources.

Roland D. Westergard
State Engineer

1976

Division of Water Resources

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CONVERSION FACTORS

For those readers who may prefer to use metric units rather than English units, the conversion factors for terms in this report are listed below:

English unit	Metric unit	Multiplication factor to convert from English to metric quantity
Inches (in)	Millimetres (mm)	25.4
Feet (ft)	Metres (m)	0.305
Miles (mi)	Kilometres (km)	1.61
Acres	Square metres (m^2)	4,050
Square miles (mi^2)	Square kilometres (km^2)	2.59
Gallons (gal)	Litres (l)	3.78
Acre-feet (acre-ft)	Cubic metres (m^3)	1,230
Cubic feet per second (ft^3/s)	Litres per second (l/s)	28.3
Do.	Cubic metres per second (m^3/s)	0.0283
Gallons per minute (gal/min)	Litres per second (l/s)	0.0631

WATER RESOURCES APPRAISAL OF THE CARSON RIVER BASIN, WESTERN NEVADA

By P. A. Glancy and T. L. Katzer

SUMMARY

The study area lies at the western edge of the Great Basin, and encompasses six major hydrographic areas and one hydrographic subarea, but excludes most of the Carson River drainage in California. Five of the hydrographic areas are part of the Carson River drainage basin; the sixth, White Plains, is the terminus of the Humboldt River basin and connects that drainage to Carson Desert. Packard Valley is tributary to Carson Desert, but not directly to Carson River. Altitudes in the Carson River basin range from 11,005 feet in the Sierra Nevada to about 3,800 feet in Carson Sink. Precipitation averages less than 6 inches per year at low Carson Desert altitudes, and more than 30 inches at high Sierra Nevada altitudes. The study area is hydrologically dominated by Carson River, Lahontan Reservoir, and the Truckee Canal, which carries Truckee River water into the basin for irrigation use on the Newlands Irrigation Project.

Table 1 summarizes selected quantitative hydrologic estimates of the study area. Most of the data of table 1 are described and, more importantly, qualified in the body of the text.

Lithologic units delineated for their hydrologic characteristics include consolidated rocks, and valley-fill deposits made up of younger and older alluvium. The valley-fill deposits constitute the principal aquifer system, and the consolidated rocks form most of the hydrographic area boundaries.

Estimates of average annual water inflow to the study area during the 1919-69 reference period are as follows: (1) precipitation (about 1½ million acre-feet annually), (2) Carson River inflow (about 315,000 acre-feet annually), (3) Humboldt River tailwaste (about 6,000 acre-feet annually), (4) water imported from adjacent hydrographic areas (about 180,000 acre-feet annually), (5) natural subsurface inflow from adjacent hydrographic areas (about 8,200 acre-feet annually). Estimates of average annual water outflow from the study area during the reference period are as follows: (1) an undetermined quantity of precipitation that evaporates before it becomes salvable streamflow or ground-water recharge, (2) evapotranspiration losses from shallow ground-water discharge and consumptive crop use (about 300,000 acre-feet annually, or possibly more), (3) evaporation from surface-water bodies (about 250,000 acre-feet annually), and (4) subsurface outflow to adjacent areas (probably less than 1,000 acre-feet annually).

In contrast to the above long-term outflow estimates, the 1971 combined domestic, municipal, industrial, and livestock use was estimated at about 8,000 acre-feet, some of which was further available for additional uses.

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 (mi²)	Surface-water runoff at the mountain front	Potential ground-water recharge from precipitation	Inflow (I) and outflow (X) between areas via streams for reference period 1919-69	Imported water 1/	Subsurface inflow (I) and outflow (X) through alluvium	Ground water stored in upper 100 feet of saturated valley fill (acre-feet)
CARSON VALLEY (Nev. part only)	422	15,000	25,000	315,000 I 272,000 X	3,700	7,800 I 15 X	710,000
Eagle Valley 2/	71	13,000	8,700	none I 7,000 X	a 430	none I 2,200 X	200,000
DAYTON VALLEY	364	1,400	7,900	276,000 I b 268,000 X	a 220	1,600 I 70 X	440,000
CHURCHILL VALLEY	491	900	1,300	c 439,000 I 380,000 X	170,000	220 I unknown X	740,000
CARSON DESERT	2,016	2,300	1,300	d 391,000 I none X	10,000	1,200+I <1,000 X	8,000,000
Packard Valley	177	600	710	none I <100 X	none	none I 400 X	500,000
White Plains	158	100	<100	6,000 I 1,000 X	none	60 I 20 X	420,000

1. 1971 imports. There are no water exports from the study area.
2. Data from Worts and Malmberg (1966), except as noted.
a. Includes municipal imports as of 1971.
b. Includes 16,000 acre-feet per year through Buckland Ditch.
c. Includes 170,000 acre-feet per year through Truckee Canal.
d. Includes 10,000 acre-feet diversion from Truckee Canal in Hazen-Swingle Bench area and 1,000 acre-feet from White Plains.

Available data suggest that aside from riverflow, the Carson Valley ground-water reservoir is the best presently available source of large-quantity, high-quality water. In contrast, Carson Desert has a vast quantity of ground water in storage, but it is believed to be largely of unacceptable quality for most uses. Intervening hydrographic areas generally have significantly large quantities of stored ground water of intermediate quality. All hydrographic areas having generally good-to-high quality ground water also have localized areas of poor-quality water. All the presently imported sewage waste water, of varying quality, is being delivered to Carson Valley, the upstream hydrographic area of the river basin; also, much of the study area's rapidly increasing locally-generated sewage effluent is being injected into upper-basin hydrographic areas. Carson River water tends to deteriorate in quality downstream because of both natural and man-related effects. Reconnaissance data suggest abnormally high mercury concentrations in river-bottom sediments of Dayton and Churchill Valleys, which probably resulted from milling operations in the late 1800's.

The available ground-water supply of Carson Desert is unique in the study area and somewhat poorly understood. Fallon municipal and Naval Air Station supplies are obtained from a relatively deep basalt aquifer system, but the quantity of stored water and the replenishment mechanism of the system are not known. Most rural domestic supplies are obtained from a shallow aquifer system that may have originated mainly by infiltration of Newlands Reclamation Project irrigation water, in part imported from the Truckee River; however, that aquifer system is being increasingly threatened by sewage effluent from individual residences.

The rapid urban growth presently occurring in the Carson River basin not only stresses the natural hydrologic system, but, in turn, the natural system has great potential to stress the urbanizing environment. Principal geohydrologic hazards in the study area are seismic, flood, and mass earth-movement threats. The potentials for seismic and flood hazards are great throughout most of the area. Flood hazards consist of major river floods, generally restricted to the Carson River flood plain, and flash floods, which individually affect small areas but collectively are likely to occur over a large part of the area. Mass earth-movement hazards probably are common in some localized parts of the area. Unfortunately, all types of the above listed hazards might be expected to occur in varying combinations with each other, thereby further magnifying danger to lives and property through their cumulative and coincidental effects.

The Carson River basin is presently undergoing dramatic changes that depend on, and can be expected to influence, the hydrologic regime. Because of the dominance of the Carson River, stresses imposed on upper-basin hydrographic areas are very likely to be transmitted to lower-basin areas. Increased hydrologic knowledge is therefore a primary requisite to develop a needed understanding of the natural hydrologic system. A satisfactory understanding should be conducive to the efficient selection of planning alternatives that would aid in developing a compatible and beneficial symbiotic relationship between man and nature in the future.

INTRODUCTION

Purpose and Scope of the Study

Water-resource development in Nevada has increased substantially in recent years. Current increases relate strongly to urban and suburban population growth. The growing interest in ground-water development has created a substantial demand for information on ground-water resources throughout the State. Recognizing this need more than a decade ago, 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 59th report prepared as part of the reconnaissance series (fig. 1 and p. iii).

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

The general objectives of the reconnaissance reports during recent studies have been to (1) describe the hydrologic environment, (2) appraise the source, occurrence, movement, and chemical quality of water, (3) estimate the amount of average annual potential recharge to, discharge from, and yield of the ground-water reservoirs, (4) quantify the surface-water resources, (5) provide preliminary estimates of the amount of stored ground water, and (6) estimate the magnitude of the present water-resources development. This report encompasses most of these objectives, and because of recent hydrologic development in the Carson River basin, several additional objectives as described below.

The Carson River basin is presently undergoing extensive changes caused by rapid population growth and accompanying development. These changes are reflected in the increasing utilization of water resources, growing problems of sewage disposal, increased citizen concern for maintenance of the desirable aspects of the natural environment, including river quality, and increasing risks from geohydrologic hazards. Therefore, this study also evaluates (1) present trends of water use, compared to traditional historical uses, (2) inter- and intra-basin sewage disposal problems, (3) problems related to water quality, and (4) geohydrologic hazards.

Most of the hydrologic field work for this report was done in 1970, 1971, and the early part of 1972.

Although the river basin encompasses parts of two States, most quantitative estimates of the water resources are limited to Nevada. California segments are included where records of Carson River streamflow are provided by gages in California, several miles upstream from the State boundary (pl. 1).

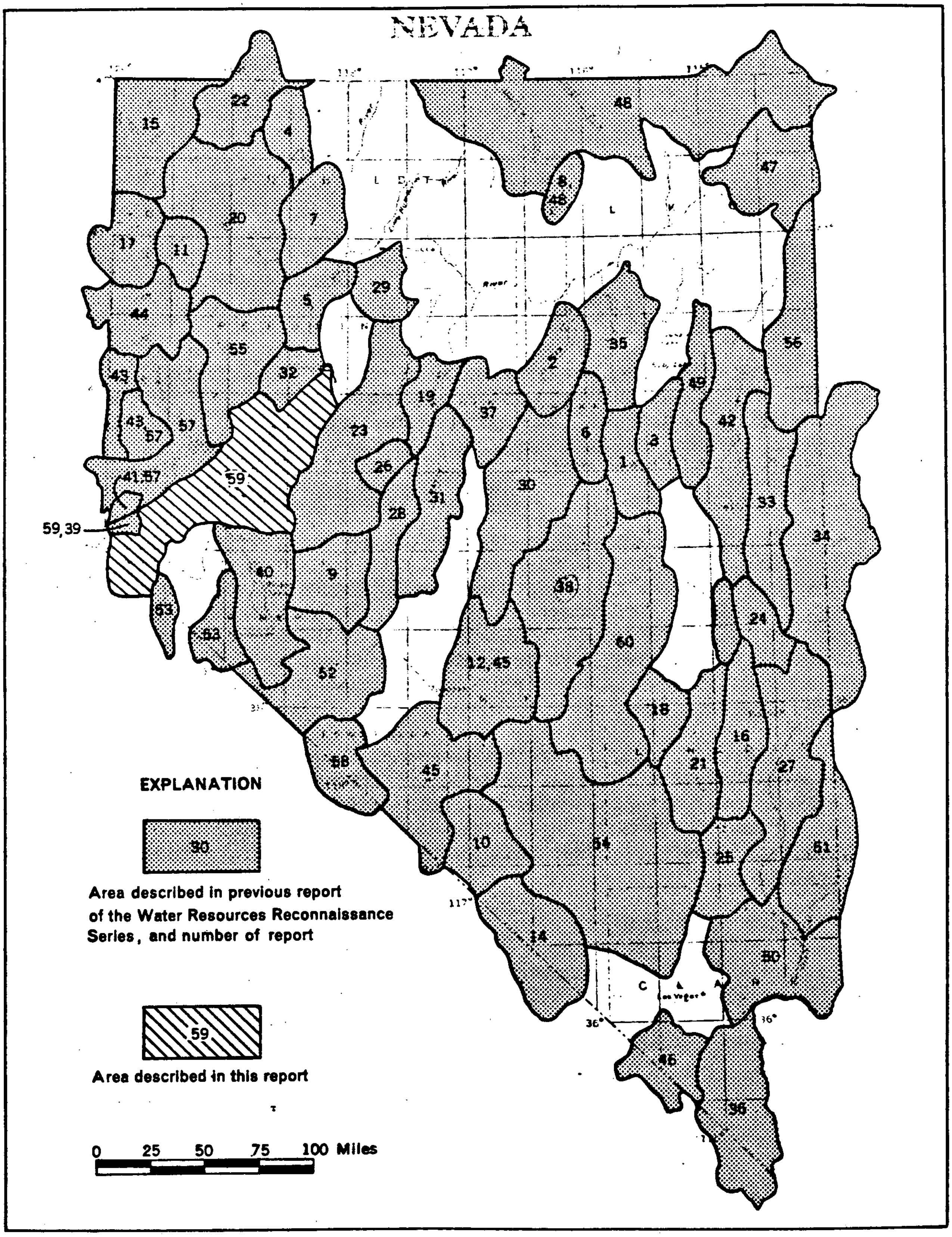

Figure 1.—Areas described in previous reports of this series, and the area described in this report

Location and General Geographic Features

The Carson River basin lies roughly between lat 38°32' and 40°16' N., and long 119°50' and 118°00' W. The basin, which together with Packard Valley and White Plains make up the study area, lies mostly in west-central Nevada, but includes some area in California. The river system consists of the East and West Forks and the mainstem of the Carson River. The basin comprises, in downstream order, five hydrographic areas in Nevada (Rush, 1968, p. 18-19): Carson Valley, Eagle Valley, Dayton Valley, Churchill Valley, and Carson Desert (less Packard Valley subarea, 177 mi^2), which total about 3,365 square miles in Nevada (fig. 1, pl. 1). White Plains hydrographic area, about 160 square miles in the lowest part of the Humboldt River basin, drains to the Carson Desert. The total area encompasses slightly more than 3,830 square miles including about 112 square miles in California.

Development has been intensive in recent years throughout the Carson River basin, with the primary emphasis on urbanization and a secondary interest in recreation. Principal towns within the area include Carson City, Gardnerville, Minden, Dayton, Virginia City, and Fallon--all in Nevada.

Other Studies and Data

The Carson River basin was one of the first settled and developed areas in Nevada. Continuous mining activity in the area, including the large-scale operations on the Comstock Lode, resulted in many geological studies during the past 100 years. Published results of these studies are numerous, but their relation to hydrology is not sufficient to justify mention in this report. However, several recently published geologic maps form the basis for the generalized geology shown on plate 1 of this study and these reports are identified in a later section.

U.S. Geological Survey hydrologic studies in the Carson River basin date back to the 19th century. Systematic streamflow measurements of Nevada streams began as early as 1889 when the U.S. Geological Survey began a streamflow measurement program on the Carson and Truckee Rivers (Chandler, 1905, p. 35). Results of most of these studies are referenced at appropriate places in this report.

Hydrologic data are also currently being collected in the area by other Federal and State agencies. Many hydrologic studies have also been made in areas immediately adjacent to the Carson River basin. A list of selected references is included following the main body of this report to provide a basic, but not exhaustive, list of published documents on local and regional hydrology that were not specifically cited in the text of this report.

Acknowledgments

Many individuals throughout the report area provided helpful information during this study. Critically important data were furnished by: Christopher Altemueller, Gardnerville-Minden Sewage Plant; Julio Alvas, Douglas County Water Reclamation Project; Leonard Anker, Buhel Heckathorn, Arlan Neal, William Dunning, and Duane Collins, U.S. Soil Conservation Service; J. Archambault, Lake Tahoe Area Council Lab.; Bill Berning and Walt Mandeville, Nevada State Prison; Roger Bialle, of Walters, Ball, Hibdon & Shaw, Consulting Engineers; Rob Roy Bittman, Twelfth Naval District, San Bruno, Calif.; Joseph D. Cushing and R. W. Rose, Naval Air Station, Fallon; James Dunn, Carson City Sewage Plant; J. D. Frank, Kennametals, Inc.; Clifford Girvan, Jr., Incline Village Improvement District; Dean S. Kingman, Kingman Engineers, Palo Alto, Calif.; Milton T. Lakey, Assistant City Engineer, Fallon; Pete Marshall, State Agricultural Extension Agent for Carson City and Storey Counties; Roger L. Mertens, U.S. Bureau of Land Management, Winnemucca; Richard Messier and Peter Stein, Lahontan National Fish Hatchery; William Mueller, City of Minden; Norman Murray, Mark Lawrence, and Kenneth Harrison, U.S. Bureau of Land Management; Mrs. Alton Park, Gardnerville Water Company; James Rankin, Carson City Engineer; John Schilling and Larry Garside, Nevada Bureau of Mines and Geology; James A. Smiley, U.S. Bureau of Indian Affairs; Thomas Sullivan, Edward King, and Robert Schriver, Carson Water Co.; L. A. Wolf, Lyon County Health Dept.; James Williams and Jack Sheehan, Nevada Division of Health; Hodges Transportation Corp.; employees of Nevada Division of Buildings and Grounds; J. Lyle Wightman and George Luke, Fallon area residents; and numerous other residents of the area. The help of all these people is greatly appreciated and enthusiastically acknowledged. The authors sincerely apologize to anyone who provided assistance, but whose name was inadvertently omitted from the foregoing list.

GENERAL HYDROLOGIC ENVIRONMENT

Physiographic Features

The Carson River basin is characterized by contrasting physiographic features; for example, rugged peaks and steep slopes of the Sierra Nevada contrast with the vast, flat playa surface of the Carson Sink; lush vegetated highlands of the Sierra Nevada contrast with the barren rocky peaks of the southern Stillwater Range; and the green, vegetated floor of Carson Valley contrasts with the barren, salt-encrusted valley floors of Eightmile and Fourmile Flats in Carson Desert.

The Carson River drainage begins in the high alpine zone of the Sierra Nevada in California. Many small perennial streams, most of which are outside the study area, flow into the East and West Forks of the Carson River. Ephemeral stream channels are numerous throughout the entire basin, and commonly transmit thundershower and snowmelt runoff. The two main Carson River forks in the upstream part of the basin flow generally northward and join in the northern part of Carson Valley. There, the river progressively changes to a more north-easterly course as it flows through downstream hydrographic areas to terminate in the Carson Sink.

The four hydrographic areas through which the Carson River flows are mainly bounded by mountain masses, as shown on plate 1. The major mountain ranges trend generally northward. However, some ranges also trend northeastward.

The Sierra Nevada is the dominant mountain range at the western margin of the basin, and it provides the bulk of the streamflow for the Carson River system. Other mountain ranges within the basin are the Pine Nut Mountains, Virginia Range, Desert Mountains, Hot Springs Mountains, Stillwater Range, and the West Humboldt Range (pl. 1).

The surface configurations of valley floors in the headward areas of the basin (Carson Valley and Eagle Valley) are affected greatly by streamflow processes. However, effects of ancient Lake Lahontan as a land-surface shaping agent become increasingly dominant on valley floors east of Dayton, particularly in the Carson Desert.

In the Carson Desert (including Packard Valley), alluvial fans, flood plains, and playas compose about 80 percent of the hydrographic areas. They are much less widespread in the upstream hydrographic areas of the river basin, as the following areal percentages indicate: Carson Valley, 25 percent; Eagle Valley, 30 percent; Dayton Valley, 25 percent; and Churchill Valley, 30 percent. These features also cover about a third of the White Plains hydrographic area. Additional quantitative characteristics of the physiography are summarized in table 2. Figure 2, a sketch map of the area, shows some of the main physiographic features.

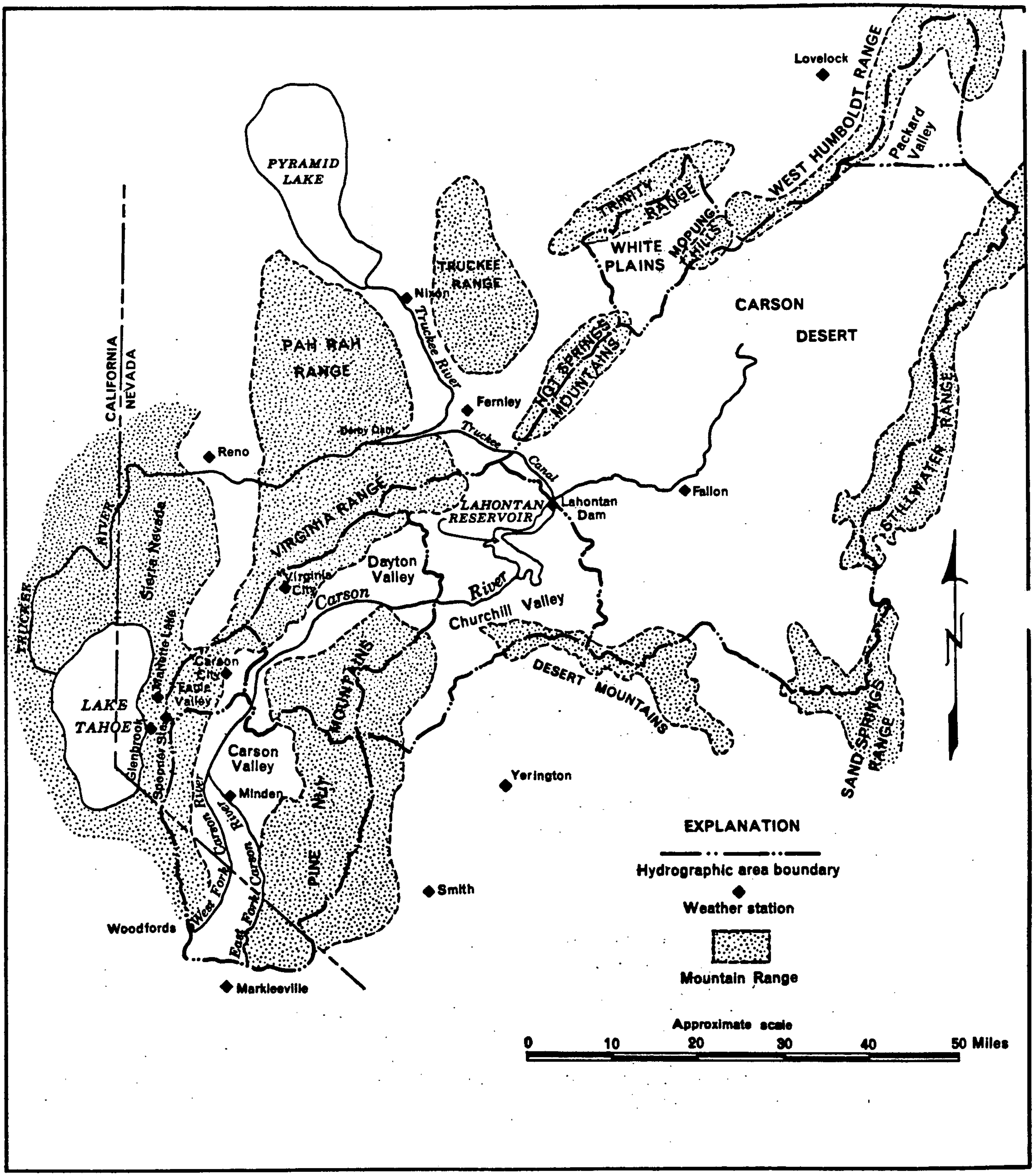

Figure 2.--Weather stations and general physiographic features in study area.

Table 2.--*Selected quantitative physiographic data*

Hydrographic area	Alluvial area (thousands of acres)	Consolidated rock area (thousands of acres)	Total area (square miles)	Percent of total study area	Approximate altitude (feet) highest	Approximate altitude (feet) lowest	Maximum relief (feet, rounded)
Carson Valley (Nev.)	88	182	422	11	11,005	4,620	6,400
Eagle Valley	a 13	32	71	2	9,214	4,600	4,600
Dayton Valley	55	178	364	10	7,856	4,215	3,650
Churchill Valley	92	222	401	13	8,763	4,080	4,700
Carson Desert 1/	1,010	280	2,016	55	8,790	3,800	5,000
Packard Valley	63	50	177	5	8,210	3,950	4,250
White Plains	52	49	158	4	5,520	3,870	1,650
Entire study area (rounded)	1,370	990	3,700	100	11,005	3,800	7,200

a. From Worts and Malmberg, 1966, p. 11.
1. Does not include Packard Valley.

Hydrogeologic Units

A great variety of rock types occur in the report area; however, for this reconnaissance study the rocks were grouped into three units on the basis of their general geohydrologic character. The three generalized units include younger and older alluvium (the valley-fill deposits), and consolidated rocks. The surficial distribution of the lithologic units is shown on plate 1, and their general character, extent, and water-bearing properties are summarized in table 3. The distribution of lithologic units as shown on plate 1 was derived mainly through synthesis and minor modification of existing geologic maps of the area as indicated on the plate. The Tertiary sedimentary-rock unit of Moore (1969) in Carson, Dayton, and Churchill Valleys is included in most places with the older alluvium for purposes of this report. The authors recognize that Moore's unit includes substantial areas of consolidated rocks, but the scope of this reconnaissance precludes further differentiation.

Plate 1 does not show geologic structural features (mainly faults) that are illustrated in the existing geologic maps. These features were omitted because many of the faults cutting consolidated rocks may not influence hydrologic interpretations in this area, and the authors believe that the structural deformation of valley fill has not been adequately investigated at present. Ground-water hydrology and the development of ground-water resources are strongly dependent on geologic structure in the valley fill, and therefore, additional investigation is needed to develop the necessary data.

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

Geologic age: Period	Geologic age: Epoch	Lithologic unit		Thickness (feet)	General characteristics and extent	Water-bearing properties
QUATERNARY	Holocene and Pleistocene	Valley fill	Younger alluvium	0-100±	Unconsolidated deposits of alluvium comprising silt, sand, gravel, and boulders derived primarily from mountain streams (perennial and ephemeral); flood-plain deposits from the Carson River, talus material, landslides, dune sand, and playa sediments. Source areas are mainly adjacent consolidated-rock uplands and older alluvium.	Younger and older alluvium together form the valley-fill reservoir, the principal source of water from wells in the area; the characteristics of recharge and the lithology of the deposits mainly control the quality and quantity of the contained ground water. Well yields range from a few gallons per minute to several thousand gallons per minute, and from very poor to excellent in quality.
TERTIARY TO QUATERNARY	Pleistocene to Miocene(?)	Valley fill	Older alluvium	0-several thousand(?)	Unconsolidated to semiconsolidated deposits of clay, silt, sand, and gravel exposed near mountain fronts and buried beneath younger alluvium elsewhere. Assumed thickest in valley troughs. Lacustrine deposits of Pleistocene Lake Lahontan are exposed throughout the lower Carson River basin below Dayton. Tertiary sedimentary rocks of Carson, Dayton, and Churchill Valleys are included, and contain in addition to the above material sandstone, marl, mudstone, shale, diatomite, limestone, calcareous tufa, interbedded tuffaceous rocks, lava flows, and breccias.	
PRE-JURASSIC TO QUATERNARY	--	Consolidated rocks		0-many thousand	Igneous, metamorphic, and sedimentary rocks; igneous rocks are mainly Cretaceous granitic intrusives and Quaternary and older volcanic rocks; metamorphic rocks include metavolcanics and metasedimentary rocks of Upper Jurassic age and older. Sedimentary rocks of lower Quaternary, upper Tertiary, and older units occur in about the same areal proportion as intrusive rocks. Volcanic rocks are slightly more prevalent.	Generally untested by wells except: in the Fallon area, a basalt of assumed Pliocene-Pleistocene age is the prime high-yielding water source for the city of Fallon and the Fallon Naval Air Station. Springs generally yield minor amounts of water throughout the area; in the Virginia Range above the Mound House area of Dayton Valley, they are the main s[illegible]ces of domestic suppl[illegible]

Valley-Fill Reservoirs

Extent and Boundaries

Younger and older alluvium (pl. 1) form the valley-fill reservoirs, which are the principal known sources of ground water in the area. The best known evidence of valley-fill thickness is contained in lithologic logs of wells drilled in the several valleys (table 40). The available evidence and resultant conclusions are as follows.

The deepest well in Carson Valley (1,268 ft) is at 13/19-22abb (see section describing numbering system for hydrologic sites) near Walley's Hot Springs (tables 39 and 40). It apparently did not fully penetrate alluvium, even though it was drilled less than one-tenth of a mile from the fault contact between alluvium and consolidated rock. However, the driller's lithologic log lacks detail (table 40). Numerous other wells, ranging from 300 to 800 feet deep, drilled a substantial distance from the valley-fill-consolidated-rock boundary, also bottom in valley-fill deposits. Therefore, the valley fill may be at least a thousand and perhaps several thousand feet thick in places.

Worts and Malmberg (1966, p. 9) concluded that valley-fill thickness in Eagle Valley is generally not more than 500 feet, although in some places it may exceed 600 feet. Recent data (1969) disclose an alluvial thickness greater than 800 feet at well 15/20-17dd (tables 39 and 40).

Dayton Valley includes several independent or semi-independent valley-fill reservoir systems (pl. 1). These systems, which are areally separated from each other by consolidated-rock divides, are as follows: (1) alluvium along the Carson River between the Carson River gage near Carson City (14/20-2bc) and the consolidated-rock river canyon just downstream from Empire; (2) alluvium in the Mound House area generally east of the Carson City-Lyon County border and west of Dayton; (3) alluvium generally north and south of the Carson River from just west of Dayton eastward to the bedrock divide bordering Stagecoach Valley subarea on the east; and (4) alluvium mainly north of the Carson River from the western bedrock boundary of Stagecoach Valley to the hydrographic area boundary of Churchill Valley on the east.

The two deepest wells in Dayton Valley (17/23-18dd, 822 feet, and 17/22-33ccbc, 633 feet) did not encounter bedrock; however, wells 16/23-3bd and 17/23-10bbb did at 178 feet and 234 feet, respectively. Valley-fill thickness may be as much as a thousand feet in some places but probably is thinner than 500 feet in most areas.

The principal areas of valley fill in Churchill Valley have not been deeply drilled, the greatest known well depth being 300 feet (18/24-27db) with no bedrock encountered. The thickness probably is at least several hundred feet throughout most of the area.

Carson Desert has the thickest known valley-fill deposits in the study area. Lithologic logs of several oil tests (17/29-18bd, 18/28-13ddc, 18/31-20c, and 22/30-14bbd) clearly show that alluvium is at least several thousand feet thick. One oil test (18/28-13aad) reportedly penetrated 8,001 feet with no evidence of bedrock (although the lithologic log lacks detail). Several other deep holes in the area (table 39) also apparently failed to reach bedrock. A test hole (16/32-19d) drilled for the U.S. Atomic Energy Commission near the playa at Fourmile Flat penetrated 780 feet of alluvium without encountering bedrock (table 40). Results of geological and geophysical studies suggest that the valley-fill deposits of Fourmile and Eightmile Flats are at least 1,950 feet thick in some parts of the valley (Nevada Bureau of Mines and others, 1962, p. 52). Therefore, valley-fill thickness over much of the Carson Desert probably is at least several thousand feet, and locally may exceed 8,000 feet.

No data are available to estimate valley-fill thickness in Packard Valley and White Plains.

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

Occurrence 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 Carson River basin, ground water moves from recharge areas in the mountains or on the adjacent alluvial slopes to the lowlands, where the water is either consumed by evapotranspiration and man's activities, or leaves the valley as stream and ground-water outflow. Carson Desert, which is a "sink" area, receives ground-water flow from upstream and from Packard Valley and White Plains. Any ground water reaching the sink is discharged by evapotranspiration.

Downgradient movement of ground water from one valley to the next occurs through alluvium and possibly consolidated rocks. There is no firm evidence that sizeable quantities of ground water move between valleys of the study area through consolidated rocks. However, downgradient intervalley movement by way of alluvium involves every valley of the study area. Estimates of these quantities are made in the report sections dealing with intervalley subsurface flow.

Availability of ground water in the several valleys is indicated in general by well drillers' reports of the depth at which water was first encountered during drilling, by reported well yields, and by the water levels in the completed wells (table 39).

The ground-water systems of the larger valleys in the report area are complex in that several aquifers may exist at varying depths and within localized geographic areas. These various aquifers, although collectively part of the valley-fill reservoirs, may act semi-independently of each other with regard to their individual hydraulic characteristics. For example, Walters, Ball, Hibdon, & Shaw (1970, p. 16 and 23) recognized two distinct zones, or aquifers, in Carson Valley alluvium, which they refer to as a shallow zone and a deep zone. They note a lack of any continuous confining strata between the two zones as indicated by well-drillers' logs, but recognize that partial confinement of the deep zone by an apparent overlapping of various clay lenses causes static water levels of the shallow and deep zones to differ. There are several flowing artesian wells in Carson Valley.

The ground-water reservoir of Carson Valley is believed to be the most important in the study area because it contains large quantities of good-quality water.

Occurrence and movement of ground water in Eagle Valley are discussed by Worts and Malmberg (1966).

The several valley-fill reservoirs unique to Dayton Valley have already been briefly described in the report section dealing with extent and boundaries of the valley-fill reservoir. Hydraulic heads in these valley-fill reservoirs generally range from a few feet above to several tens of feet below the land surface (table 39). Ground-water movement is generally toward the river in the three upstream systems. Movement of water through the valley-fill deposits that include the Stagecoach Valley subarea is less certain, because available data are inconclusive regarding hydraulic continuity between Stagecoach Valley alluvium and Carson River alluvium to the south. Natural phreatophyte discharge of ground water and existence of an alkali-flat playa in Stagecoach Valley, plus the presence of a gently sloping divide of subdued relief and possibly thin alluvial cover between that valley and the Carson River flood plain, suggest Stagecoach Valley may be hydraulically isolated from the Carson River. However, water-table altitudes beneath the playa and at the river are similar, suggesting a good possibility of hydraulic continuity between Stagecoach Valley and the Carson River. Resolution of this uncertainty is beyond the scope of this investigation.

No long-term records of static water levels are available for Churchill Valley; however, it is assumed that the filling of Lahontan Reservoir has caused a general rise in ground-water levels throughout much of the valley since 1915, when the dam was constructed. Ground-water levels measured in June 1970 in the vicinity of the reservoir were all within a few feet of the reservoir surface.

The regional ground-water flow system in the Carson River basin above Lahontan Dam is generally downstream toward the reservoir and is mainly controlled by the surface-water altitude. Katzer (1972) stated that some water probably is seeping from the reservoir through volcanic rocks and associated alluvial deposits that are present in the eastern subsurface of the reservoir in the vicinity of the dam. The magnitude of any subsurface leakage is unknown but probably is minor compared to surface-flow releases.

Static water levels of the shallow aquifer system in the Carson Desert indicate that ground-water flow is generally toward the major natural discharge areas, namely, Carson Sink, Carson Lake, and Fourmile and Eightmile Flats. The available static water levels (table 39) suggest that ground water in the Fourmile Flat area moves under gentle gradients from the peripheral mountain boundaries into the playa area (land-surface altitude about 3,890 feet, or lower) and is subsequently discharged naturally by evapotranspiration. Some ground water also may flow to Fourmile Flat from the northwest by way of the Turupah and Eightmile Flat areas, but water levels and flow data are presently too scanty to allow a confident estimate of water volumes involved.

Morrison (1964, p. 117) discussed ground water in the Carson Desert and related ground-water occurrence and yield to his detailed knowledge of Quaternary stratigraphy of the Carson Desert area.

About 150 shallow wells were drilled, dug, and driven by the U.S. Geological Survey in the Carson Desert in 1904 (before Newlands Reclamation Project irrigation began) to investigate natural water quality in the shallow aquifer system (Stabler, 1904, p. 33). Water levels in these and other wells suggest that ground water moved generally in the same directions as surface flow (Stabler, 1904, map no. 6046), and followed the natural distributary system of the Carson River. Rush (1972) stated that in 1906, when extensive irrigation began in the area, the levels of Big and Little Soda Lakes began to rise, continuing until about 1930. The total rise in stage for the period was about 60 feet. The principal cause of the rise was attributed to seepage losses from canals, which carried water from the Carson River to fields in the Fallon area as part of the Newlands Project of the U.S. Bureau of Reclamation (Lee and Clark, 1916, p. 672-675).

Basalt in the Fallon Area

Wells that supply the City of Fallon and the U.S. Naval Air Station extract water from a basalt aquifer that is apparently interbedded with the valley-fill deposits about 500 feet below land surface (wells 19/29-30cba, 30cdb1 and 2, 33cbb1, 2, and 3; tables 24, 39, and 40). These wells reportedly yield 1,000 to 2,000 gal/min. The nonpumping artesian water levels of these wells range from about 25 to 35 feet below land surface. The dissolved-solids concentration of the water from the basalt is greater than that of Carson River water but is generally much less than that of many nearby wells in valley-fill deposits. The extent of the basalt aquifer, its source of recharge, and its dependable supply are not known.

INFLOW TO THE HYDROGRAPHIC AREAS

Precipitation

The Sierra Nevada exerts the dominant control over precipitation within the Carson River basin. As storms move upslope from west to east across the Sierra Nevada, much of their moisture is depleted on west-facing slopes. This, in turn, causes lower precipitation on the east-facing slopes. Because the Sierra Nevada forms the western boundary of the Carson River basin, the study area lies mainly in a zone of diminished precipitation (a "rain shadow") with respect to east-moving storms. Table 4 summarizes the average annual precipitation at selected Weather Bureau stations in and near the report area. Figure 2 shows the location of precipitation measuring sites in and near the study area.

Snow accounts for the greatest percentage of precipitation within the basin over the long term; however, the amount of water that results from winter rains can be significant, especially in the eastern and lower parts of the basin where snowfall is usually light. Also, intense, generally unpredictable winter rains on snowpacks commonly cause severe flooding. The resulting early depletion of the snowpack occasionally results in a water shortage during the late summer growing season. Summer thunderstorms usually affect small areas, often less than a square mile, but commonly deliver large volumes of water relative to the size of drainage area in a very short time. They are a relatively unimportant water source in augmenting the available supply, but they commonly cause severe local floods, and are one of the main natural landforming agents.

Surface Water

The surface-water resources of the Carson River are well documented at a few key stations. Streamflow records at these sites are available for many years--some records date from as early as the 1890's. Definition of streamflow characteristics is possible even though the basin has undergone extensive agricultural development and small reservoirs are operated in the headwater area.

No surface water is exported from the Carson River basin, but a substantial amount is imported. Carson Valley receives treated sewage effluent from the Lake Tahoe Basin. Eagle and Dayton Valleys receive public water-supply imports from the Lake Tahoe Basin and Washoe Valley, and Churchill Valley receives a large amount of Truckee River water for irrigation use in Carson Desert. Churchill Valley also occasionally receives a minor amount of natural surface flow from the Walker River basin through Adrian Valley, and the Carson Desert receives overflow from the Humboldt River through White Plains.

Table 4.--*Average annual precipitation at weather stations*

Station	Approximate location	Altitude (feet)	Period of record (complete years)	Average annual precipitation (in inches)	
				For period of record used 1/	Adjusted to period 1930-69 (rounded)
Marlette Lake 2/	15/18-12	8,000	1930-44, 1948-52	28.5	29
Spooner's Station 2/	14/18-1	7,100	1940-42, 1954-67	27	26
Glenbrook 2/	14/18-15a	6,400	1945-69	19.1	19
Virginia City	17/21-29	6,002	1953-60, 1966	7.2	9.0
Woodfords	11/19-35	5,625	1938-69	20.3	20
Markleeville 3/	10/20-21	5,546	1931-36, 1944, 1947-48, 1953-60	17.8	20
Smith 2/	11/23-26	4,750	1930-43, 1945-65	7.3	6.5
Minden	13/20-32b	4,700	1930-38, 1940-69	8.7	8.6
Carson City	15/20-17	4,651	1930-69	11.2	a 11.2
Reno 2/	19/20-18d	4,404	1931-69	7.7	7.6
Yerington 2/	13/25-15d	4,375	1930-67, 1969	5.5	5.5
Lahontan Dam	19/26-33d	4,158	1930-34, 1936-50, 1952-69	4.4	4.4
Fernley 2/	20/24-11d	4,160	1955-69	6.1	6.6
Lovelock 2/	27/31-2bc	3,977	1930-35, 1937-66, 1968-69	5.7	5.7
Fallon Experiment Station	18/29-6b	3,965	1930-69	5.2	a 5.2
Nixon 2/	22/23-1	3,900	1930-47, 1949,1952, 1963-69	7.3	6.9

1. From published records of the U.S. Weather Bureau.
2. Outside of report area.
3. Record for 1961-68 estimated.
a. Index station used for estimating long-term data at other stations.

Records Available

Four long-term gaging stations on the Carson River system have recorded river flow since about the turn of the century. In addition, several stations with short-term records have been, or currently are being, operated on the mainstem, tributary streams, and diversions. Table 5 summarizes available streamflow records for the basin, and plate 1 shows the locations of the gaging stations. The annual flows of the Carson River at specific sites are presented in table 6, and maximum and minimum recorded discharges at the principal Carson River gaging stations are given in table 7. Table 8 gives the average annual flows at the six main Carson River stations for several different base periods. Table 9 presents the annual flow records for nonmainstem gaging stations upstream from Carson Desert. Table 10 lists the maximum discharge at partial-record stations and shows flow variability. Table 11 presents data for surface-water reservoirs, including information for headwater reservoirs in California, outside the report area. Additional surface-water data are available in various U.S. Geological Survey publications and files, and some are also available in reports and files of the U.S. Bureau of Reclamation, Federal Court Watermaster, Nevada State Engineer, Carson Water Subconservancy District, and the Truckee-Carson Irrigation District.

The variation of averages at a given streamflow measuring site for different base periods of record, shown in table 8, suggests that averages for different measurement sites are generally not comparable unless the same base periods are used. Therefore, this present study utilizes the base period 1919-69 of Van Denburgh and others (1973, p. 19), so that the hydrologic data, estimates, and budgets derived for the Carson River basin will be compatible with those of the adjacent Truckee River basin. No attempt has been made to adjust the flows to natural conditions because accurate adjustments are beyond the scope of this reconnaissance investigation. Natural flow conditions are discussed by Matthai (1975). Compatibility of the quantitative data derived for both river basins is desirable because the direct hydrologic interplay between the two river systems makes them dependent on each other.

Techniques of Runoff Determination

Measured runoff.--The average annual river inflow to the hydrographic areas was determined using the available streamflow records for a specific site and then adjusting the averages to the 1919-69 base period. The adjusted annual averages were determined by synthesizing missing record periods through graphic and statistical regression correlation methods. The resultant streamflow averages are shown in table 12.

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

Station number 1/	Station name (in downstream order)	Location (shown on pl. 1) 2/	Approximate drainage area (mi^2)	Period of record (calendar years) 3/	Refer to: Table	Refer to: Figure
10308200	East Fork Carson River below Markleeville Creek, near Markleeville, Calif.	10/20-15ac	276	1960-69+	6,8	
10308800	Bryant Creek near Gardnerville	11/21-30ba	31.5	1961-69++	9	
10309000	East Fork Carson River near Gardnerville	11/20-2ac	341	1890-93 1900-1906 a 1904-5 1908-10 a 1917 1925-28 a 1929 1935-37 1939-69+	6,7,8, 12,16	3a,4
10309005	Bodie Flat tributary near Gardnerville	11/21-9ab	0.46	1966-69+Θ	10	
10310000	West Fork Carson River at Woodfords, Calif.	11/19-34db	65.6	1891, a 1892 1901-20 1939-69+	6,7,8, 12,16	3a,4
10310400	Daggett Creek near Genoa	13/19-28ac	4.07	b 1964 c 1965 1965-69+	9	
10310500	Clear Creek near Carson City	14/19-1ba	15.5	1948-62++	9,10, 12	
10311000	Carson River near Carson City	14/20-2bc	876	d 1939-69+	6,7,8, 12,16	3a
10311450	Brunswick Canyon near New Empire	15/20-13ab	12.7	1966-69+Θ	10	
10311900	Buckland Ditch near Fort Churchill 4/	17/24-32db	(e)	1962-69+	9,12	
10312000	Carson River near Fort Churchill	17/24-32dc	1,450	f 1912-69+	6,7,8, 12,16	3b
10312012	Adrian Valley tributary near Wabuska	16/25-31da	5.75	1967-69+Θ	10	
10312015	Adrian Valley tributary near Weeks	16/25-30bb	0.12	1967-69+Θ	10	
10312050	Lahontan Reservoir tributary near Silver Springs	18/24-32cd	4.39	1962-69+Θ	10	

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

Station number 1/	Station name (in downstream order)	Location (shown on pl. 1) 2/	Approximate drainage area (mi^2)	Period of record (calendar years) 3/	Refer to: Table	Refer to: Figure
10351400	Truckee Canal near Hazen	19/26-4ca	(e)	1963-69+	9,12	
10313100	Lahontan Reservoir near Fallon	19/26-33dc	--	g 1917-69+		5,6
10312150	Carson River below Lahontan Reservoir	19/26-34dd	h 1,950	1917-69+	6,8, 12,15	6
10312210	Stillwater Diversion Canal near Fallon	19/30-34aa	(e)	1966-69+	15	
10312220	Stillwater Slough cutoff drain near Stillwater	20/31-32cd	(e)	1966-69+	15	
10312240	Paiute Diversion Drain near Stillwater	20/30-36bc	(e)	1966-69+	15	
10312260	Indian Lakes Canal near Fallon	20/29-26ab	(e)	1966-69+	15	
10312280	Carson River below Fallon	21/30-19cd	(i)	1966-69+	6,15	

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.

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, and in some instances only monthly discharges are available. Symbol "+" indicates stations still in operation following water year 1969, and symbol "++" indicates conversion from a continuous recording station to a partial record station (peak discharge only). Symbol "Θ" indicates a partial record station for the indicated period of record.

4. Station discontinued Sept. 30, 1971.

a. Gage heights only, some months.

b. Periodic measurements only in 1964.

c. Low-flow partial-record site in 1965.

d. For discontinued gage data see U.S. Geological Survey 1960, p. 355.

e. No drainage area listed for irrigation ditches.

f. Records for 1911-31 furnished by U.S. Bureau of Reclamation and those for 1931-50 furnished by Truckee-Carson Irrigation District.

g. Records furnished by Truckee-Carson Irrigation District.

h. Truckee River drainage not included.

i. No drainage figure due to diversions between the gage and the Carson River below Lahontan Dam.

Table 6.--*Annual flows of Carson River, water years 1891-1969, in thousands of acre-feet*

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

Water year 1/	East Fork near Markleeville, Calif. (10/20-15ac)	East Fork near Gardnerville (11/20-2ac)	West Fork at Woodfords, Calif. (11/19-34db)	Main stem near Carson City (14/20-2bc)	Main stem near Fort Churchill (17/24-32dc)	Main stem below Lahontan Dam 2/ (19/26-34dd)	Main stem below Fallon (21/30-19cd)
1891		445	95				
1892		400					
1893		654					
1894-1900	No record						
1901		379	104				
1902		242	99				
1903		324	85				
1904		a 396	129				
1905		a 254	79				
1906		a 509	164				
1907		a 651	210				
1908		a 200	72				
1909		383	141				
1910		308	103				
1911		a 467	144				
1912		a 179	73		174		
1913		a 183	74		161		
1914		a 450	108		617		
1915		a 312	87		297		
1916		a 367	a 114		550		
1917		a 333	95	a 493	467		
1918		a 242	56	a 243	223	316	
1919		a 262	73	a 273	256	306	
1920		a 217	53	a 164	145	293	
1921		a 290	a 81	a 314	298	328	
1922		a 343	a 103	a 475	460	509	
1923		a 276	a 80	a 348	329	431	
1924		a 118	a 29	a 115	91	286	
1925		a 277	69	a 285	267	307	
1926		143	a 53	a 131	114	284	
1927		320	a 94	a 360	341	a 360	
1928		187	79	a 190	170	a 360	
1929		a 149	39	a 112	92	a 260	
1930		192	a 52	a 168	149	310	

Table 6.--*Annual flows of Carson River, water years 1891-1969*--Continued

Water year 1/	East Fork near Markleeville, Calif. (10/20-15ac)	East Fork near Gardnerville (11/20-2ac)	West Fork at Woodfords, Calif. (11/19-34db)	Main stem near Carson City (14/20-2bc)	Main stem near Fort Churchill (17/24-32dc)	Main stem below Lahontan Dam 2/ (19/26-34dd)	Main stem below Fallon (21/30-19cd)
1931		a 121	a 31	a 86	65	162	
1932		a 292	a 82	a 326	307	284	
1933		a 163	a 43	a 142	122	287	
1934		a 128	a 39	a 98	76	140	
1935		a 254	a 69	a 230	210	241	
1936		252	a 82	a 296	275	274	
1937		228	a 74	a 281	262	321	
1938		a 460	a 127	a 592	580	541	
1939		a 163	39	a 163	140	311	
1940		273	76	285	279	331	
1941		250	78	263	244	330	
1942		355	106	428	403	456	
1943		331	90	425	403	474	
1944		177	47	177	169	365	
1945		307	76	332	310	399	
1946		255	76	287	262	415	
1947		181	48	180	165	348	
1948		190	56	170	152	273	
1949		196	51	187	167	354	
1950		254	77	263	260	333	
1951		349	99	434	423	555	
1952		459	127	576	587	534	
1953		256	78	286	240	511	
1954		200	53	197	177	488	
1955		160	49	134	114	390	
1956		436	124	550	533	573	
1957		228	69	243	224	557	
1958		340	98	376	341	583	
1959		147	42	128	108	453	
1960		128	38	90	60	268	
1961	115	120	31	75	44	160	
1962	234	233	63	239	218	252	
1963	297	320	92	369	338	442	
1964	168	171	50	158	136	422	
1965	360	372	120	434	382	505	

Table 6.--*Annual flows of Carson River, water years 1891-1969*--Continued

Water year 1/	East Fork near Markleeville, Calif. (10/20-15ac)	East Fork near Gardnerville (11/20-2ac)	West Fork at Woodfords, Calif. (11/19-34db)	Main stem near Carson City (14/20-2bc)	Main stem near Fort Churchill (17/24-32dc)	Main stem below Lahontan Dam 2/ (19/26-34dd)	Main stem below Fallon (21/30-19cd)
1966	183	192	55	188	171	571	
1967	417	408	99	482	449	470	81
1968	181	186	60	183	162	354	8.4
1969	452	489	124	588	561	526	130
Average for available period of record	267	284	81	276	264	377	--
Adjusted average for base period of this study, 1919-69	241	251	71	272	252	b 380	--

1. A water year is from October 1 through September 30. Thus, December 1968 is in the 1969 water year.

2. Flow figures prior to 1967 furnished by U.S. Bureau of Reclamation.

a. Record synthesized by U.S. Bureau of Reclamation, Lahontan Basin Office, Carson City, Nev. (Nathan Geering, oral commun., 1971). Correlations are based on nearby streamflow records and snow-survey data; in some years monthly-flow data were available from records of the Nevada State Engineer.

b. Rounded.

Table 7.--*Maximum and minimum recorded discharge at the principal Carson River measurement sites through 1969 water year*

Hydrologic site number	Station name	Maximum discharge 1/		Minimum discharge 1/	
		Date	Cubic feet per second	Date	Cubic feet per second
11/20-2ac	East Fork Carson River near Gardnerville	Dec. 23, 1955	17,600	Dec. 4-10, 19-23, 1904	8
11/19-34db	West Fork Carson River at Woodfords, Calif.	Feb. 1, 1963	4,890	Dec. 23, 1961	5
14/20-2bc	Carson River near Carson City	Dec. 24, 1955	a 30,000	Aug. 7, 1961	3
17/24-32dc	Carson River near Fort Churchill	Feb. 2, 1963	15,300	(b)	0

1. Instantaneous.

a. Probably exceeded during the flood of March 18, 1907, which washed out the gage (see flood section).

b. No flow during some periods in nearly every year since 1923; flow affected by Buckland Ditch, which diverts 400 feet upstream.

Table 8.--*Average annual streamflow at Carson River gaging stations, in thousands of acre-feet (rounded), for different reference periods*

Period (water years)	Average annual streamflow	Period (water years)	Average annual streamflow
10/20-15ac East Fork Carson River near Markleeville, Calif.			
a 1961-69	267	bc 1919-69	241
11/20-2ac East Fork Carson River near Gardnerville			
a 1891-93, 1901-3, 1909-10, 1926-28, 1930, 1936-37, 1940-69	282	c 1919-69	251
		d 1917-50	236
		e 1931-60	251
		f 1918-67	247
b 1891-93, 1901-69	284	g 1919-69	245
11/19-34db West Fork Carson River at Woodfords, Calif.			
a 1891, 1901-15, 1917-20, 1925 1928-29, 1939-69	84	d 1917-50	67
		e 1931-60	72
		f 1918-67	68
b 1891, 1901-69	81	g 1919-69	70
c 1919-69	71		
14/20-2bc Carson River near Carson City			
a 1940-69	279	c 1919-69	272
b 1917-69	276	d 1917-50	253
17/24-32dc Carson River near Fort Churchill			
a 1912-69	264	e 1913-60	255
c 1919-69	252	f 1918-67	246
d 1917-50	236		
19/26-34dd Carson River below Lahontan Reservoir, near Fallon			
a 1918-26, 1930-69	380	c 1919-69	378
		d 1917-50	343
b 1918-69	377		

a. Actual period of record.
b. Period of record including synthesized data.
c. Reference period used in this report.
d. U.S. Bureau of Reclamation, 1954, p. 38 of "Substantiating materials."
e. Pacific Southwest Inter-Agency Committee, 1972, p. 111, Flows modified for 1965 conditions.
f. Pyramid Lake Task Force, 1969, appended summary, p. 6.
g. Flows have been adjusted for conditions at the State line as follows; East Fork Carson River near Gardnerville: 250,000 acre-feet minus estimated 5,000 acre-feet inflow from Bryant Creek in California. West Fork Carson River at Woodfords: 71,000 acre-feet plus estimated 5,000 acre-feet inflow between gage and State line, and minus estimated 7,000 acre-feet consumptive use by vegetation between gage and State line (net State line total rounded).

Table 9.--*Annual flow at nonmainstem gaging stations, in thousands of acre-feet*

[Flows rounded to three significant figures]

Water year	Bryant Creek (11/21-30ba)	Daggett Creek (13/19-28ac)	Clear Creek (14/19-1ba)	Buckland Ditch (17/24-32db)	Truckee Canal near Hazen (19/26-4ca)
1949			2.89		
50			3.93		
1951			5.02		
52			8.14		
53			5.42		
54			3.45		
55			2.81		
1956			5.63		
57			3.53		
58			4.85		
59			2.98		
60			2.23		
1961			1.87		
62	4.25		2.27		
63	6.02			16.1	
64	2.67			14.8	a 262
65	5.00			16.5	a 250
1966	3.40	0.875		17.0	a 237
67	9.22	1.55		16.4	216
68	3.56	1.08		14.9	122
69	14.5	b 2.58		19.5	114
Average	6.08	--	3.93	16.5	200

a. Van Denburgh and others, 1973, p. 24.
b. Includes 400 acre-feet of imported sewage in 1969. See table 20.

Table 10.--*Maximum discharge at partial-record stations* 1/

Station name	Location 3/	Drainage area (mi²)	Maximum annual discharge 2/		
			Water year	Month	Cubic feet per second
Bodie Flat tributary near Gardnerville	11/21-9ab	0.46	1967	March	3
			1968	March	a 0.1
			1969	April	a 0.3
Clear Creek near Carson City	14/19-1ba	15.5	1963	January	170
			1964	--	35
			1965	--	58
			1966	April	9
			1967	March	110
			1968	February	130
			1969	April	87
Brunswick Canyon near New Empire	15/20-13ab	12.7	1966	August	a 4
			1967	March	63
			1968	May	a 0.1
			1969	January	60
Adrian Valley tributary near Wabuska	16/25-31da	5.75	1968	August	a 0.7
			1969	January	a 0.2
Adrian Valley tributary near Weeks	16/25-30bb	.12	1968	August	a 1
			1969	July	a 1
Lahontan Reservoir tributary near Silver Springs	18/24-32cd	4.39	1962	--	No flow
			1963	--	No flow
			1964	July	a 0.2
			1965	--	No flow
			1966	--	No flow
			1967	--	No flow
			1968	--	No flow
			1969	--	No flow

1. A partial-record station is operated to collect limited streamflow data on a systematic basis during high- and low-flow periods.
2. Discharge determined by indirect methods unless otherwise noted.
3. See report section describing hydrologic site numbering system.
a. Estimated.

Table 11.--*Data for reservoirs and lakes in the Carson River basin*

Name	Spillway location 1/	Spillway or maximum water-surface elevation above mean sea level (to nearest foot)	Maximum operating capacity 2/ (acre-feet)	Tributary to
		EAST FORK CARSON RIVER		
Upper Kinney Lake3/	8/20-7cb	8,536	328	Silver Creek
Lower Kinney Lake3/	8/20-7bd	8,442	920	Silver Creek
Kinney Reservoir3/	8/20-8cb	8,333	900	Silver Creek
Wet Meadows3/	9/19-27ad	8,030	450	Pleasant Valley Creek
Summit Lake3/	9/19-27db	8,022	31	Pleasant Valley Creek
Raymond Lake3/	9/19-25aa	a 8,980	50	Pleasant Valley Creek
Tamarack Lake3/	9/19-21cc	7,890	404	Pleasant Valley Creek
Upper Sunset3/	9/19-27ba	7,858	68	Pleasant Valley Creek
Lower Sunset3/	9/19-22dc	7,823	860	Pleasant Valley Creek
Heenan Lake3/	9/21-3cb	7,084	2,948	Heenan Lake Creek
Indian Creek Reservoir4/	10/20-4c	5,604	3,100	Indian Creek, a tributary to East Fork Carson River
Allerman no. 1 5/	13/20-26ca 13/20-35ba	4,856	437	Allerman Canal
Allerman no. 2	13/20-26cb	4,838	248	Allerman Canal
Allerman no. 4	13/20-14ba	4,836	867	Allerman Canal
		WEST FORK CARSON RIVER		
Upper or East Lost Lake 3/	9/18-12aa	8,598	92	Headwater of West Fork
Lower or West Lost Lake 3/	9/18-1dc	8,546	127	Headwater of West Fork
Crater Lake 3/	10/18-11ca	8,522	320	Crater Lake Creek
Scotts Lake 3/	10/18-2aa	8,001	736	Scott Creek
Red Lake 3/	10/18-23ac	7,867	1,103	Red Lake Creek
Mud Lake Reservoir	11/20-4ad	5,100	4,700	West Fork Carson River

Table 11.--*Data for reservoirs and lakes in the Carson River basin*--Continued

Name	Spillway location 1/	Spillway or maximum water-surface elevation above mean sea level (to nearest foot)	Maximum operating capacity 2/ (acre-feet)	Tributary to
		MAIN STEM CARSON RIVER		
Ambrosetti Pond	14/20-30cc	a 4,660	200	Carson River
Unnamed pond in gypsum quarry	16/20-25bb	--	--	No surface outflow
Lahontan Reservoir	19/26-33dd	4,164 (1917 datum)	b 322,000	Carson River
Soda Lake 6/	19/28-7,8	3,988	35,000	No surface outlet
Sheckler Reservoir 2/	18/27-13ab	3,990	11,000	AA Canal
S Line Reservoir2/	19/29-28ca	a 3,950	1,495	S Canal
Harmon Reservoir2/	19/30-32aa	3,926	1,700	S-2 Canal
Ole's Pond 2/	19/29-14bd	3,939 (1917 datum)	2,000	Ole's Pond outlet
Stillwater Point Reservoir 2/	19/31-16ba	3,906	7,000	Canal
Old River Reservoir 2/	19/29-7bd	3,958	1,100	Canal

1. See report section describing hydrologic site numbering system.
2. From Decree No. D-183 and U.S. Bureau of Reclamation (oral commun., 1971).
3. Outside of study area, not shown on plate 1.
4. Reservoir contents dominated by imported sewage from Tahoe Basin.
5. Dual outlets.
6. From Rush (1972).
a. Estimated.
b. From Katzer (1972).

Table 12.--*Estimates of average annual streamflow at hydrographic area boundaries, 1919-69 water years*

Inflow to	From	Name of stream or canal	Location	Acre-feet per year inflow (rounded)
Carson Valley (Nevada)	Carson Valley (Calif.)	East Fork Carson River at Stateline	11/20-25bc	a 245,000
		West Fork Carson River at Stateline	11/20-8bc	a 70,000
Carson Valley	Eagle Valley	Clear Creek near Carson City	14/19-1ba	3,000
		Carson Valley total		318,000
Dayton Valley	Carson Valley	Carson River near Carson City	14/20-2bc	272,000
Dayton Valley	Eagle Valley	Kings and Ash Canyon Creeks plus Carson City sewage effluent	--	b 4,000
		Dayton Valley total		276,000
Churchill Valley	Dayton Valley	Carson River near Fort Churchill	17/24-32dc	252,000
		Buckland Ditch near Fort Churchill	17/24-32db	16,000
Churchill Valley	Walker River basin	Adrian Valley	16/24-35bc	1,000
Churchill Valley	Truckee River	Truckee Canal near Hazen	19/26-4ca	170,000
		Churchill Valley total		439,000
Carson Desert	Churchill Valley	Carson River below Lahontan Reservoir near Fallon	19/26-34dd	380,000
Carson Desert	Truckee River	Truckee Canal at diversions to Hazen and Swingle Bench areas for irrigation	20/26-32, 19/26-4, and 19/26-22	10,000
Carson Desert	White Plains	Lower Humboldt Drain	23/28-24c	c 1,000
		Carson Desert total		391,000

1. Outside study area.
a. Flows were determined for nearest gaging stations near Gardnerville, Markleeville, and Woodfords (table 8), and were then adjusted for conditions at the State line.
b. Sewage effluent estimated to average 500 acre-feet per year for period 1919-69.
c. Estimated by channel-geometry methods developed by Moore (1968).

Estimated runoff.--Where stream-gaging records were not available, the ungaged runoff from tributary streams was estimated using the indirect methods developed by Moore (1968). The relationship between altitude, precipitation, and average annual runoff was defined for each hydrographic area at the mountain front. The resultant runoff estimate was refined using the channel-geometry technique (Moore, 1968). The accuracy of the runoff was checked by comparison with runoff estimates derived using actual streamflow measurements which were correlated for long-term average when such data were available. Data used in the checking process are shown in table 13. Table 14 summarizes the estimated runoff from tributary streams for the four mainstem hydrographic areas.

Local runoff into Carson Valley was estimated by Piper (1969, p. F7), who employed a statistical technique based on the relation between runoff and land-surface altitude, combined with coefficients for horizontal variations. For Carson Valley as a whole, the results of Piper's method and the methods used in this report to estimate runoff are compatible. However, there are minor disagreements in some of the subareas of Carson Valley, as might be expected when indirect techniques are used. Piper's water budget for Carson Valley is discussed in the Water Budget section of this report.

Streamflow Characteristics

The dominant hydrologic feature within the Carson River basin study area is the river. It generally flows perennially throughout most of its reaches. Many perennial tributaries in the river headwater areas drain the east slope of the Sierra Nevada, and although some other tributaries do not flow perennially in their lower reaches near confluence with the river, they do play a vital role in ground-water recharge. The number of perennial tributaries decreases in a downriver direction. Downstream from the head of Dayton Valley, all tributaries are ephemeral near their confluence with the river. Therefore, streamflow through these tributaries usually reaches the river as surface flow only during times of substantial runoff caused by large rainfall or snowmelt. The major source of water for the Carson River is the winter snowpack in the Sierra Nevada, but minor amounts of water are contributed locally by rainstorms. Streamflow characteristics for the various hydrographic areas are described below.

Carson Valley.--The time distribution of runoff within a given year at the stream-gaging stations above Lahontan Reservoir is, in general, believed to be very similar to that of the East Fork Carson River near Gardnerville (11/20-2ac, pl. 1). The streamflow records for this site are believed generally to typify natural runoff distribution from the headwaters of the river basin, because the East Fork Carson River is the largest tributary of the headwater drainage, and streamflow at this site is virtually unaffected by manmade diversions and impoundments.

Table 13.--*Instantaneous measured flow of several Carson River basin tributaries*

Stream	Location	Date	Discharge (ft^3/s)	Tributary to
Thompson Canyon near Gardnerville	12/22-31cb	Apr. 9, 1969	2.24	Pine Nut Creek
Pine Nut Creek near Gardnerville 1/	12/22-31cb	Apr. 9, 1969	5.85	Carson Valley
	12/21-25ab	Apr. 9, 1969	9.35	
	12/21-10cb	Apr. 9, 1969	9.39	
		Sept. 8, 1969	.56	
	12/21-5bc	Apr. 9, 1969	10.9	
	12/21-6bc	Apr. 9, 1969	10.0	
		Apr. 14, 1969	14.8	
	12/20-2ad	Apr. 9, 1969	8.12	
		Apr. 14, 1969	14.0	
Buckeye Creek near Gardnerville 1/	13/21-24ba	Apr. 14, 1969	7.60	Carson Valley
	13/21-19ac	Apr. 14, 1969	7.94	
	13/20-24cc	Apr. 14, 1969	4.99	
Mott Creek near Genoa	12/19-4cc	Sept. 11, 1969	3.48	West Fork Carson River
		Oct. 2, 1970	2.26	
		Nov. 9, 1970	2.75	
		Dec. 9, 1970	2.84	
		Feb. 9, 1971	3.25	
		Mar. 5, 1971	3.26	
		Mar. 10, 1971	3.13	
		Mar. 24, 1971	3.89	
Genoa Canyon near Genoa	13/19-9cd	Sept. 11, 1969	.94	Carson River
Sierra Canyon near Genoa	13/19-4db	Sept. 11, 1969	2.06	Carson River
		Aug. 5, 1971	a 340	
Unnamed tributary to Lahontan Reservoir	18/25-13ba	July 19, 1971	a 460	Lahontan Reservoir
Unnamed tributary to Lahontan Reservoir	17/24-10ab	July 20, 1971	a 1,700	Lahontan Reservoir

a. Peak discharge determined by indirect measurement methods, and rounded to two significant figures.
1. Listed in downstream order.

Table 14.--*Estimated average annual runoff at the mountain front from ungaged tributary streams in Nevada*

Hydrographic area	Runoff area (acres)	Percentage of total river basin runoff area	Acre-feet of runoff	Percentage of total runoff
Carson Valley (Nev. part only)	61,000	13	a 15,000	75
Dayton Valley	130,000	28	1,400	7
Churchill Valley	98,200	22	900	4
Carson Desert	173,000	37	b 3,000	15
Total (rounded)	462,000	100	20,000	100

a. Estimated Carson Valley runoff from combined Nevada and California segments, downstream from the Markleeville and Woodfords river gages, is 34,000 acre-feet per year.

b. Includes 600 acre-feet from Packard Valley and 100 acre-feet from White Plains.

Base flow is reached in late summer, and flow then increases slightly through the fall and winter months until the snowmelt season starts in early spring. Maximum annual flows can normally be expected in May and June. Surface-water runoff from April through July generally accounts for about 40 to 60 percent of the total annual flow. Figure 3a shows the monthly flow distribution for the East and West Forks of the Carson River, which together equal the total river inflow to Carson Valley. Also shown are similar data for the Carson River near Carson City (14/20-2bc), which document total river outflow from Carson Valley. The average annual flow of the East Fork Carson River near Gardnerville for the 1919-69 base period is 251,000 acre-feet, that of the West Fork Carson River at Woodfords (11/19-34db), 71,000 acre-feet, and Carson River near Carson City, 272,000 acre-feet. Outflow from Carson Valley generally exceeds inflow from November through March, mainly because of the combined effects of ground-water inflow, local runoff to the river, and reduced evapotranspiration losses. Usually, the irrigation season ends during late September or October; the weather at that time is considerably cooler, and evapotranspiration therefore decreases markedly. With the first warm weather of spring, generally in March, irrigation begins again, and river inflow to Carson Valley begins to exceed river outflow to Dayton Valley. This net reduction of streamflow is due mainly to the increase in evapotranspiration and ground-water recharge.

Carson Valley receives a small amount of surface flow from Eagle Valley via a diversion from Clear Creek at 14/19-4cab (site not shown on pl. 1). That diversion is estimated to average about 100 acre-feet annually and is used to irrigate pasture on the Schneider Ranch in northern Jack's Valley (Harry Schneider, oral commun., 1972).

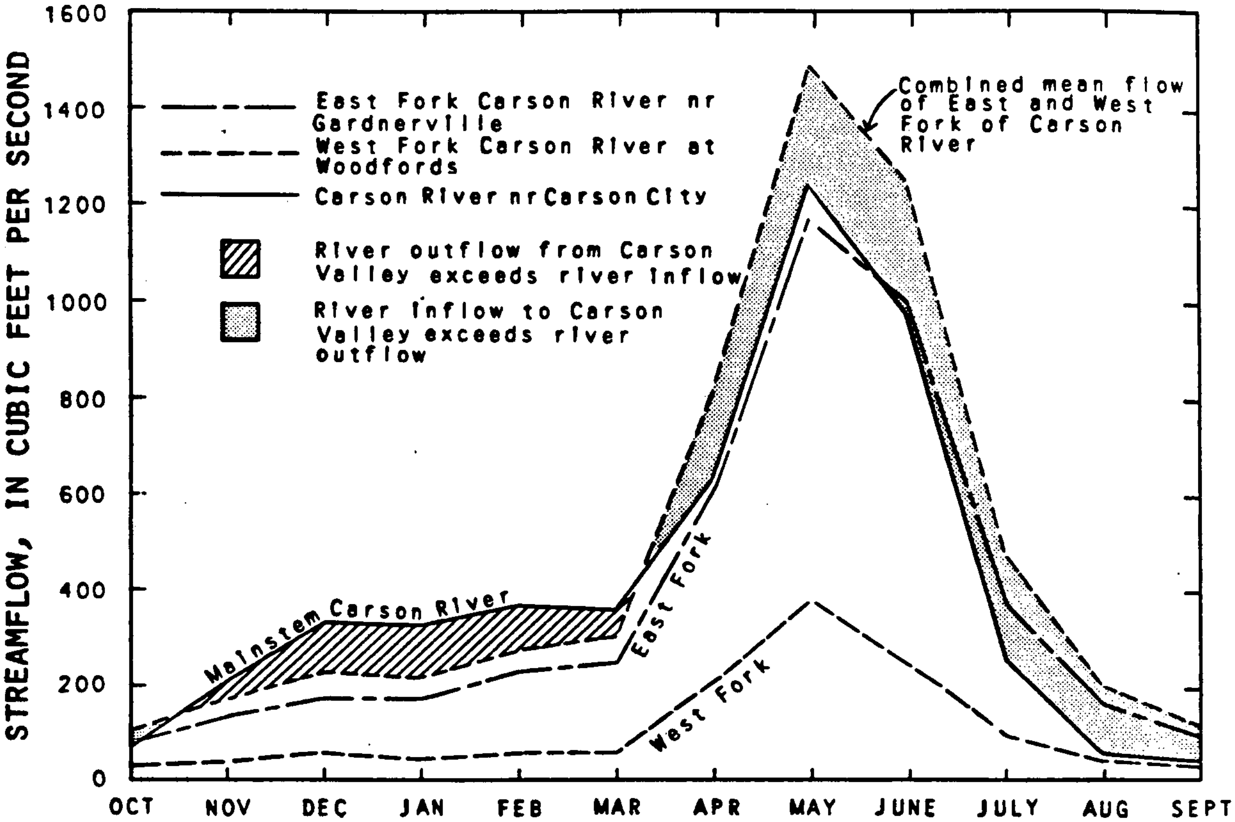

Figure 3a.—Mean monthly flow of Carson River into and out of Carson Valley, 1940-69 water years.

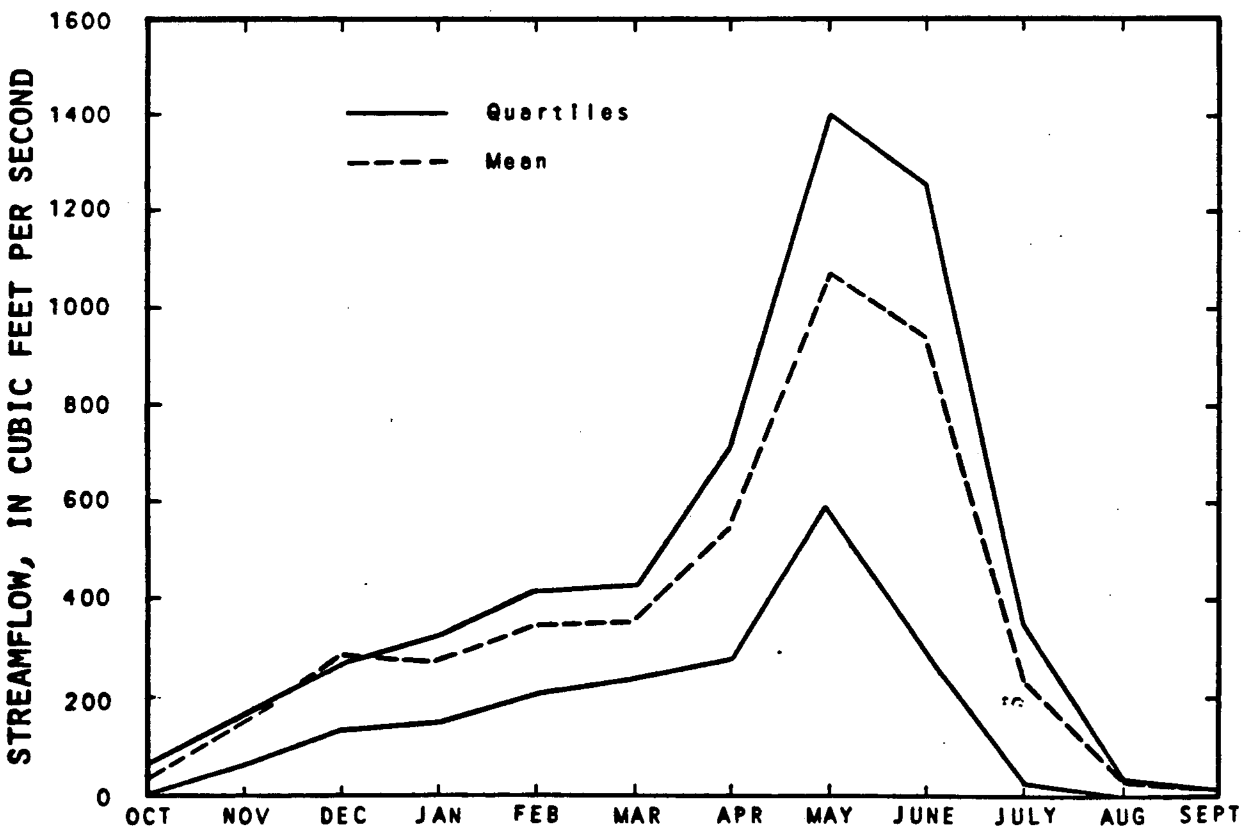

Figure 3b.--Average monthly flow distribution, Carson River near Fort Churchill, 1919-69 water years. Quartiles show 25 percent of the monthly flows were higher and lower than indicated.

Flow-duration curves for the East and West Forks are shown in figure 4. These curves show the amount of time a given flow was equaled or exceeded; for example, a flow of 100 ft^3/s on the West Fork has been equaled or exceeded 26 percent of the time during water years 1939-69. This does not mean that in any given year this flow will be reached 26 percent of the time; but over the years, this flow will average about this value if conditions are approximately equivalent to the 1939-69 period.

Eagle Valley.--Eagle Valley is not traversed by the Carson River, but is tributary to the river. According to Worts and Malmberg (1966, p. 19) the surface-flow quantities entering the Carson River are about 3,000 acre-feet per year from Clear Creek (enters the river upstream from the Carson City gage), and about 3,500 acre-feet per year from the remainder of Eagle Valley. In addition, for the period 1919-69, an estimated average of about 500 acre-feet per year of Carson City sewage effluent flowed to the river.

Dayton Valley.--The Carson River gage near Carson City (14/20-2bc) records river flow from Carson Valley to Dayton Valley. This flow averages about 272,000 acre-feet annually. The river furnishes the major part of streamflow entering Dayton Valley. Runoff from Eagle Valley, excluding Clear Creek, enters Carson River below the Carson City gage, as discussed in the previous report section. This inflow, principally from Kings and Ash Canyon Creeks and Carson City sewage effluent, is estimated to have averaged about 4,000 acre-feet per year. Therefore, the combined streamflow entering Dayton Valley from Carson and Eagle Valleys is about 276,000 acre-feet annually (table 12).

Churchill Valley.--The combined flow of Carson River (252,000 acre-feet annually) past the gage near Fort Churchill (17/24-32dc) plus Buckland Ditch (16,000 acre-feet annually, 17/24-32db) represent total surface-water outflow from Dayton Valley and are the major inflow components to Churchill Valley. Often during summer months, river reaches between the Carson City gage and the Fort Churchill gage are dry. River flow at the Fort Churchill gage also commonly ceases in late summer, as shown in figure 3b. The lack of flow at the Fort Churchill gage, however, is because the Buckland Ditch, which diverts just upstream from the Fort Churchill gage, often carries the entire river flow during late summer. The combined average annual flow of the river and ditch represents the cumulative flow at this hydrographic boundary; it averaged about 268,000 acre-feet annually for the 1919-69 base period.

Huxel (1969, p. 22) estimated an average annual flow of about 1,000 acre-feet per year from the Walker River in Mason Valley through Adrian Valley to the Carson River in Churchill Valley, downstream from the Fort Churchill gage. However, this quantity represents an estimated long-term average; flow occurs only during extremely wet years.

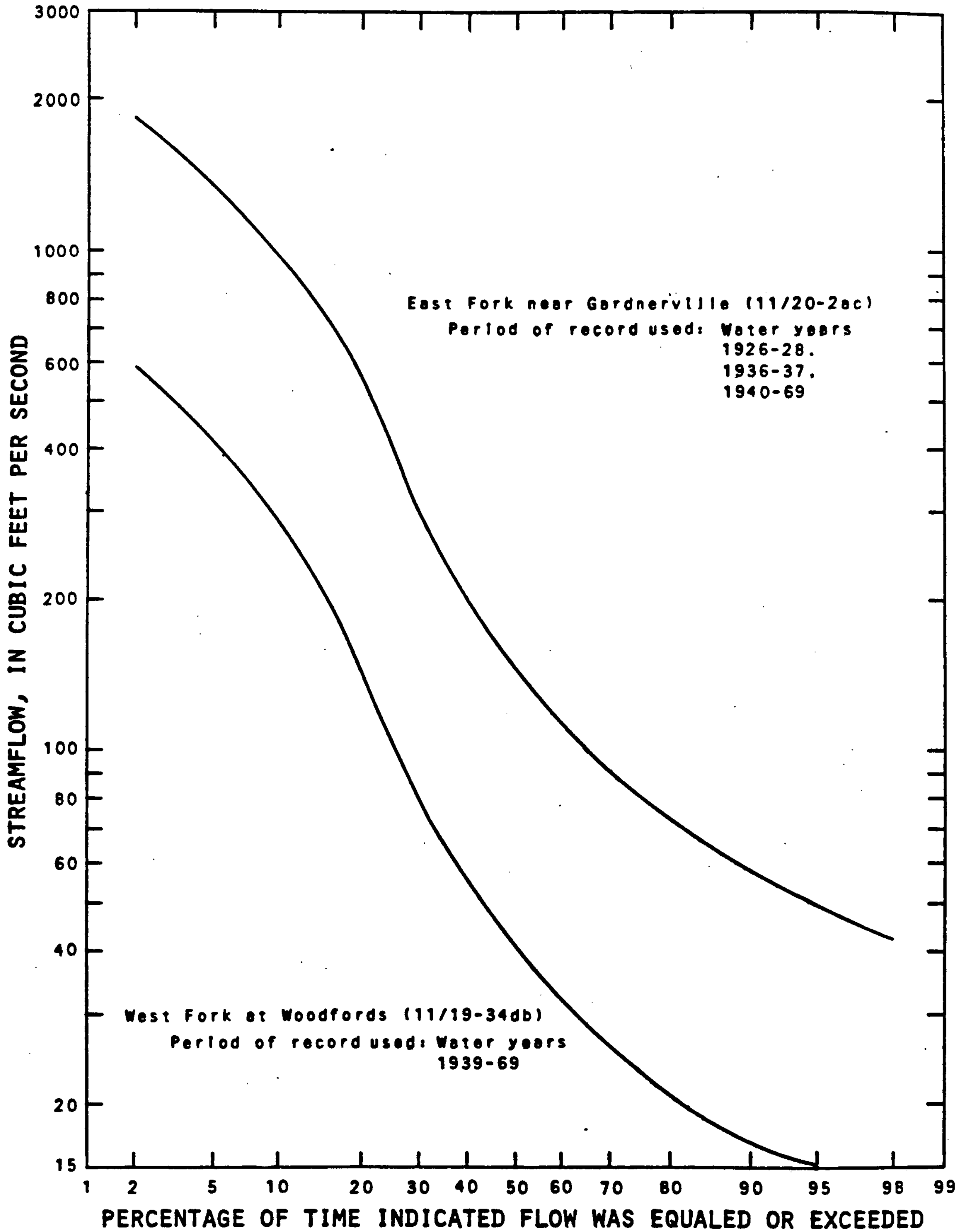

Figure 4.--Flow duration curves for East and West Forks Carson River.

Lahontan Reservoir is the largest surface-storage facility on the Carson River, and has a flashboard capacity of 322,000 acre-feet. Figure 5 shows the annual maximum and minimum stages of the reservoir for the period 1917-72 calendar years. Most of the Truckee Canal water diverted from the Truckee River at Derby Dam enters Lahontan Reservoir near Lahontan Dam. The amount of water reaching the study area was estimated by Van Denburgh and others (1973, p. 48, 57) to be 180,000 acre-feet per year for the base period 1919-69. Of this total, about 10,000 acre-feet was diverted to the Hazen-Swingle Bench area (in the Carson Desert hydrographic area), and the estimated amount entering Churchill Valley through the Truckee Canal (19/26-33dc) enroute to Lahontan Reservoir was 170,000 acre-feet per year.

Carson Desert.--The Carson River gage below Lahontan Dam (19/26-34dd) measures surface-water flow from Churchill Valley to Carson Desert. Streamflow at this site is controlled by reservoir releases, and averaged about 380,000 acre-feet annually for the base period. Figure 6 shows reservoir releases during the 1917-72 calendar years. This water is used primarily for irrigation in the Fallon area (pl. 1), but some also provides habitat for wildfowl in the Stillwater Wildlife Management area and adjoining areas. These uses are more fully discussed in later sections of this report.

As previously mentioned, during the 1919-69 base period, about 10,000 acre-feet per year was diverted from the Truckee Canal for irrigation in the Hazen-Swingle Bench area (pl. 1).

The surface-water outflow from the Newlands Irrigation Project is not completely accounted for by direct flow measurement. Since 1967, the Geological Survey has recorded Carson River flow just upstream from the Carson Sink (21/30-19cd), and also has recorded the flow of four canals tributary to the Stillwater Wildlife area (sites 19/30-34aa, 20/31-32cd, 20/30-36bc, and 20/29-26ab). Table 15 summarized available flow data for these five sites. Additional flow data for Carson Desert are available from the Truckee-Carson Irrigation District in Fallon and the U.S. Bureau of Reclamation in Carson City.

Packard Valley and White Plains.--Some streamflow reaches the Carson Sink of Carson Desert from Packard Valley and White Plains. The flow from Packard Valley probably is less than 100 acre-feet per year and generally occurs as the result of thunderstorms. The flow into White Plains, which represents terminal discharge of the Humboldt River, is estimated to average about 6,000 acre-feet per year. The flow from White Plains into Carson Sink is estimated to average about 1,000 acre-feet per year. The inflow-outflow quantities were estimated by a channel-geometry technique developed by Moore (1968, p. 36-68) and natural discharge evidence.

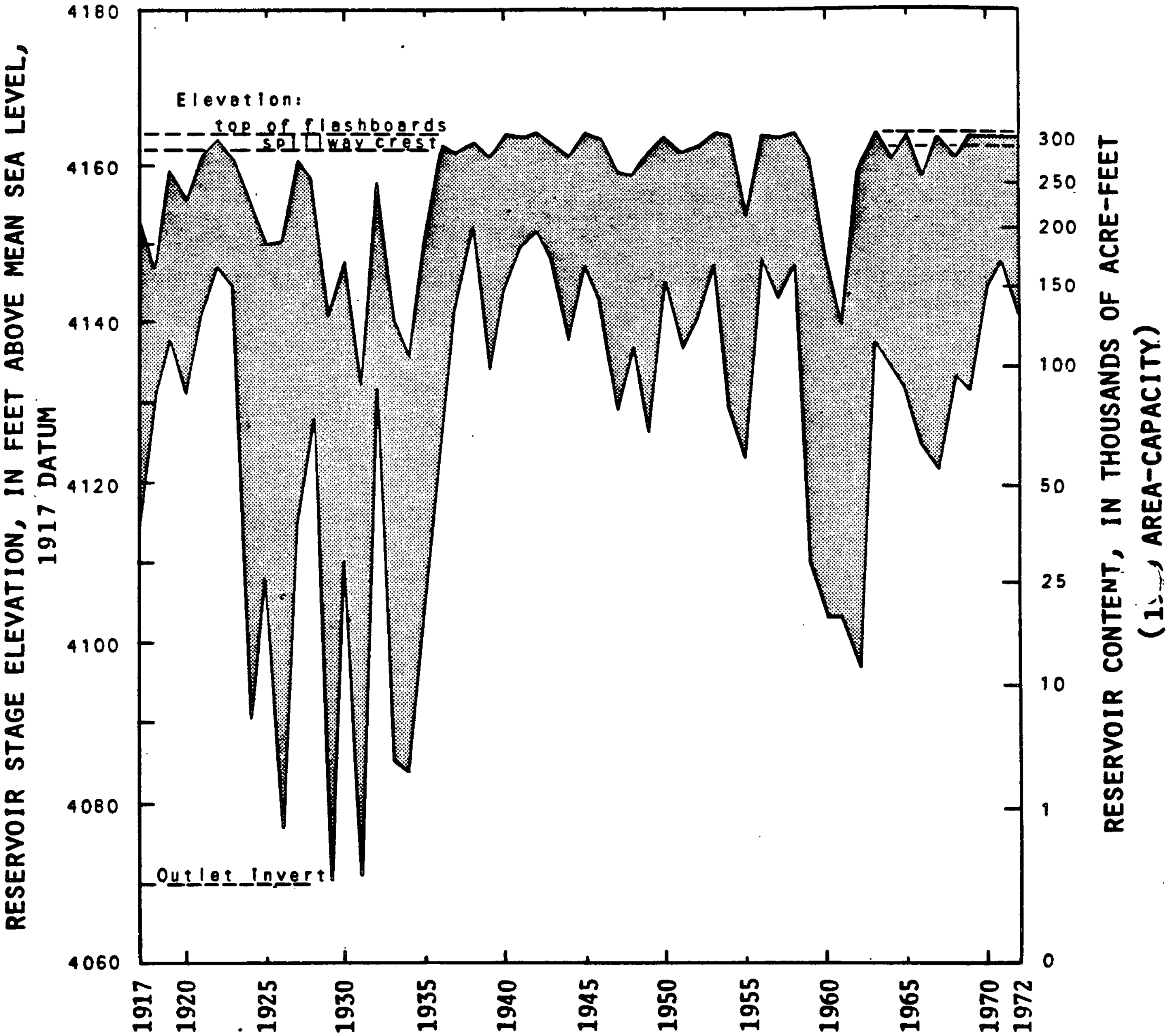

Figure 5.—Annual maximum and minimum stages and volume of stored water in Lahontan Reservoir, 1917-72 calendar years. (Data furnished by Truckee-Carson Irrigation District.)

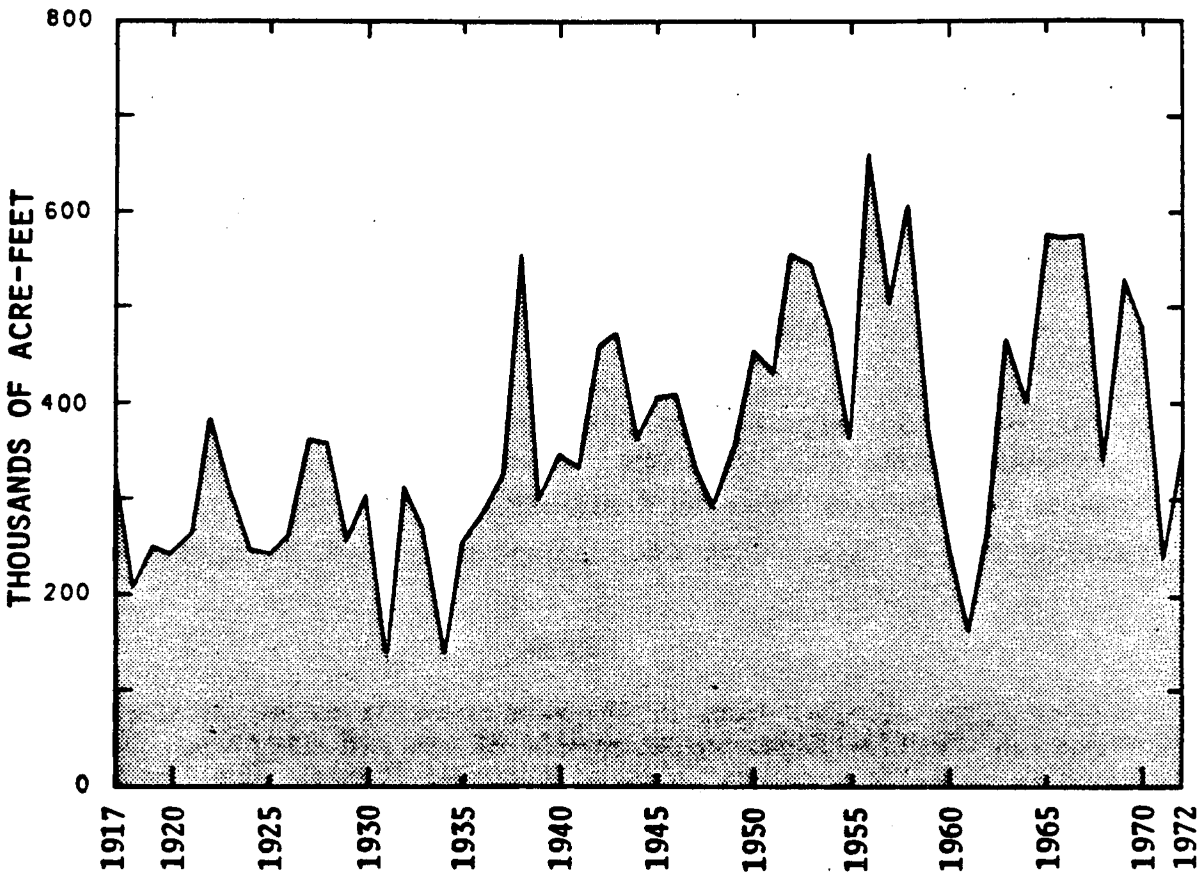

Figure 6.--Lahontan Reservoir releases to Carson River, 1917-72 calendar years. (Data furnished by Truckee-Carson Irrigation District.)

Table 15.--*Measured Carson Desert streamflow, return flow from irrigated lands, and flow from reservoir spills (thousands of acre-feet)* 1/

[Flows rounded to three significant figures]

Flow measurement site	Hydrologic site number	Water year						
		1967	1968	1969	1970	1971	1972	1973
Carson River below Lahontan Reservoir 2/	19/26-34dd	470	354	526	471	374	363	328
Carson River below Fallon 3/	21/30-19cd	81.1	8.41	130	68.3	74.9	6.03	6.66
Stillwater Diversion Canal near Fallon 3/	19/30-34aa	35.7	29.0	35.9	62.6	44.3	32.7	26.8
Stillwater Slough Cutoff Drain 3/	20/31-32cd	23.8	26.0	28.9	31.1	21.0	22.8	21.3
Paiute Diversion Drain near Stillwater 3/	20/30-36bc	7.45	5.25	7.22	9.59	6.45	6.35	6.44
Indian Lakes Canal near Fallon 3/	20/29-26ab	18.2	10.4	16.7	16.2	18.5	15.7	8.90

1. Records for other years and other stations are available from Truckee-Carson Irrigation District, Fallon and U.S. Bureau of Reclamation, Carson City.
2. Measures outflow from Lahontan Reservoir.
3. Measures flow to Carson Sink and Stillwater Wildlife Management area.

Floods

Carson River floods.--Many floods have occurred on the Carson River since settlement of the area began in the middle of the 19th century. Table 16 lists quantitative data for a select group of recorded floods. The floods listed in table 16 generally represent the major floods recorded at the various streamflow measurement sites in the river basin. The U.S. Department of Agriculture (1973) presents a more complete listing of specific floods and also describes interesting historical details of each individual flood. The data of table 16 and those of U.S. Department of Agriculture (1973) show that floods cannot be accurately predicted on the basis of a cyclic pattern of recurrence; for example, since 1890, the longest flood-free period (about 14 years) apparently occurred between January 1914 and March 1928, whereas more than one flood occurred during several individual years of record. The last major recorded flood occurred in 1964; therefore, the historical record suggests that statistical odds favor recurrent flooding in the not too distant future.

Nearly all known floods on the Carson River were caused by heavy rains falling on a substantially heavy snowpack, and the flooding resulted from the combined effects of rainfall, runoff, and snowmelt.

Table 16.--*Summary of quantitative streamflow data for selected historic floods of the Carson River*

Date of peak flow	Peak flows, in cubic feet per second 1/ East Fork near Gardnerville	West Fork at Woodfords	Mainstem near Carson City	Mainstem near Fort Churchill	Remarks
1890					
May 28	a 4,260 maximum observed		No record	No record	Snowmelt
June 9		b 1,280			Snowmelt
1892					
Dec. 25	a 5,540 maximum observed	No record	No record	No record	Rain on snow
1907					
Mar. 18	No record		d 4,000 maximum daily 2/	No record	Rain on snow
May 17		c 1,450 maximum daily			
1914					
Jan. 23	No record		e 5,160		Rain on snow
26				e 6,150 maximum daily	
May 2		e 1,050			
1937					
Dec. 11	f 10,300	g 3,500	No record		Rain on snow
14				f 5,500 maximum mean daily	
1943					
Jan. 21	g 5,420				Rain on snow
22			g 8,500		
24				g 6,300	
Apr. 28		g 1,290			
1950					
Nov. 20		h 4,730			Rain on snow
21	h 12,100				
22			h 15,500		
23				h 7,850 maximum daily	
Dec. 3	h 4,640 mean daily	h 1,880 mean daily			
4			h 7,280 mean daily		
5				h 7,100 mean daily	

Table 16.--*Summary of quantitative streamflow data for selected historic floods of the Carson River--Continued*

Date of peak flow	Peak flows, in cubic feet per second 1/ East Fork near Gardnerville	West Fork at Woodfords	Mainstem near Carson City	Mainstem near Fort Churchill	Remarks
1955					
Dec. 23	i 17,600	i 4,810			Rain on snow
24			i 30,000		
26				i 9,680 maximum daily	
1963					
Feb. 1	j 13,360	j 4,890	j 21,900		Rain on snow, ground frozen
2				j 15,300	
1964					
Dec. 23	j 8,230	j 3,100			Rain on snow
25			j 8,740		
26				j 7,220	

1. Momentary maximum discharge, except as noted.
2. Gage washed out after daily reading was taken.
a. From Newell, 1894, p. 116.
b. From Newell, 1891, p. 351.
c. From U.S. Geological Survey, 1913, p. 165.
d. From U.S. Geological Survey, 1910, p. 126.
e. From U.S. Geological Survey, 1917, p. 218 and 219.
f. From U.S. Geological Survey, 1939, p. 78 and 79.
g. From U.S. Geological Survey, 1945, p. 142, 155-157.
h. From U.S. Geological Survey, 1953, p. 186, 188, 190, 191.
i. From U.S. Geological Survey, 1958, p. 170, 171, 174, 175.
j. From U.S. Geological Survey, 1970, p. 714, 717, 722, 727.

Records are sketchy regarding floods prior to 1890 and quantitative flow data are unavailable. However, several qualitative summaries of early floods have been published. Thompson and West (1958, p. 34) provide a brief account of a very early flood:

> "On the twenty-fourth of December 1852, it commenced to snow in Carson Valley; in two days three feet of it was lying over the whole face of the country, and six days later the ground was bare. The sudden melting of the vast field of snow caused a greater flood in the Carson River to usher in the year 1853 than has since occurred [through about 1880]."

The flood of 1862 was apparently extreme, with disastrous consequences. Rain or snowfall occurred for 54 consecutive days after December 24, 1861. This caused intermittent flooding during the period, but the peak flow occurred between January 9 and 12, 1862, as a result of general rainfall. The towns of Empire (now an abandoned townsite northwest of the river just upstream from Brunswick Canyon) and Dayton were particularly hard hit. Several persons were reportedly drowned at Dayton, and a number of buildings were washed away. Parts of the Empire area were inundated by 6 to 8 feet of water during the flood peak (McGlashen and Briggs, 1939, p. 476). Bridges and other property belonging to settlers in Carson Valley were also seriously damaged (Grace Dangberg, oral commun., 1972). It was probably the greatest known flood up to that time in the area of Dayton and downstream. It may well have been greater than the floods of 1852 and 1955, but quantitative data are unavailable.

Thompson and West (1958, p. 364) also discussed the 1862 flood, but their description is limited to its effects in Carson Desert as follows:

> "The Carson River overflows annually. The most noted occurrence of the kind took place in January 1862. Before then, the waters of the Carson emptied directly into the Upper Sink, and passed thence through Carson Slough and Stillwater Slough, into Lower Sink. The dry river bed could be plainly seen in 1861, through which Old River now flows, carrying with it direct into the Lower Sink a great part of the waters of the Carson, instead of by the Upper Sink, and thence by the sloughs. The same flood cut a channel where New River now runs, and also changed the outlet of the Upper Sink into an inlet, taking some of the water from New River and emptying it into the Upper Sink. The remainder flows by Stillwater Slough into the Lower Sink thus flowing past the west side of the town of Stillwater."

The major channel changes apparently caused by this flood, as recounted above, reinforce the conclusion that the 1862 flood was indeed a major flood.

River flooding again damaged the towns of Dayton and Empire in 1867. Peak flow occurred on December 26, but the river remained at flood stage for several days. Peak flood stage at Empire was 2 feet lower than the 1862 peak (McGlashen and Briggs, 1939, p. 477).

U.S. Department of Agriculture (1973, p. 7-10) described interesting details of floods during 1874, 1875, and 1886.

Extensive flooding also occurred in January 1890. Again, flooding was caused by heavy rains on a thick snowpack. Although runoff was general throughout the upper Carson River basin because of the combined rain and snowmelt runoff, the flooding was locally intensified by ice-jam damming. Flooding recurred in early February after warm weather caused release of the ice jams and increased snowmelt runoff. Parts of Empire were flooded on February 6 and the gold mills along the river were put out of operation by the high water. More flooding occurred again during early May 1890, when the unusually heavy snowpack melted quickly in upper basin areas (McGlashen and Briggs, 1939, p. 477 and 478).

The flood of 1907 also resulted from rain on snowpack. Grace Dangberg (oral commun., 1972) witnessed the flooding in Carson Valley. She recalls that some of the local flooding in the Minden-Gardnerville area originated from the rains rapidly melting snowpack in the Pine Nut Mountains. Data of table 16 show only a 4,000 ft^3/s discharge at the gage near Carson City (gage was located about 8 miles downstream from present location). However, the gage washed out after the daily reading was taken, and therefore the peak flow was apparently not recorded. The magnitude of this flood may rank with the 1862 and 1955 floods. The greatest flood of record occurred in late December 1955; again heavy rains on a thick snowpack caused the flood.

Upper Carson River basin areas, particularly Carson, Dayton, and Eagle Valleys, are at a critical stage in planning history with regard to decisions involving Carson River flood hazards. If construction in such areas continues, flood-protection measures may be required.

The Carson River basin is now somewhat unusual, compared to many river basins of similar size, in that it has no major upstream flood-storage reservoirs above Lahontan Reservoir. In addition, much of the flood-plain area is not yet extensively developed. However, upstream storage facilities might be subject to earthquake hazards, a possibility that has yet to be adequately investigated.

Regardless of future changes in river-management policy, the historical record demonstrates that major river floods must be expected, but that their timing and magnitude cannot be predicted.

Local flash floods.--Flash flooding, although probably the most common geohydrologic hazard in the Carson River basin, is also probably the hazard least recognized by the general populace. Most flash floods in populated areas achieve a degree of short-term notoriety, but are quickly forgotten. Urban and other land-use planning, to date (1975), seems to have generally not addressed the problem of flash flooding in western Nevada.

Flash floods can result from winter rains and summer thundershowers. The winter floods frequently cover extensive areas, affect numerous small streams simultaneously, and usually contribute to major river floods. They generally result from moderate to heavy rains on a heavy snowpack or on frozen ground, and the rains commonly continue for a period of many hours or even days. In contrast, the flash floods associated with summer thundershowers, commonly referred to as "dry mantle floods" by the U.S. Department of Agriculture, usually result from extremely intense rainfall on a much smaller geographical area and for a much shorter time duration, often less than an hour. The resulting flood is frequently more intense and usually of a much shorter duration. It quickly mobilizes quantities of sediment and debris that combine with the water to form a mixture that moves as a potentially destructive flood wave. The crest of this flood wave frequently exceeds normal winter peak flood-flow quantities, and it therefore inundates areas not usually considered part of the stream's normal flood plain. Occasionally the water-sediment mixture completely abandons the normal stream channel and seeks a new route downhill. This redirected flow occurs because the moving debris commonly clogs normal channels and conveyance structures. Therefore, definition of flood plains and restrictive zoning of hazardous areas with regard to summer flash floods is normally much more difficult than that for winter floods. Risk to lives and property from the summer floods is just as real as that from winter floods--and possibly even greater, because victims are usually subjected to additional hazards from the debris, and because warning of an impending summer flood is usually much shorter than that of a winter flood.

Qualitative and quantitative data have been collected for several flash floods in the Carson River basin during recent years by the U.S. Geological Survey. These data and accompanying interpretations are planned for future publication in a special report on flash flooding in Nevada.

Ground-Water Recharge

Most recharge is provided by precipitation on 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 evaporates before infiltration, whereas some of the remainder adds to soil moisture, and some reaches already-saturated lowland areas. Thus, only a small percentage actually finds its way to the ground-water reservoir. On most valley floors in the study area, precipitation quantities are small, and 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 percentage of total precipitation potentially recharges the the ground-water reservoir, with that percentage depending on the average amount of precipitation within the zone. The term "potential recharge" is used because not all of the computed recharge (table 17) actually reaches the ground-water reservoirs in the hydrographic areas. Along the western side of Carson Valley, runoff from the Sierra Nevada, a part of which represents potential ground-water recharge, reaches the river, marshes, and bog areas before it can infiltrate to the ground-water reservoir. Similarly, in the upstream part of Dayton Valley, some potential ground-water recharge water (runoff from Eagle Valley and Brunswick Canyon) enters the Carson River before it can infiltrate into consolidated rocks or reach any valley-fill deposits. Likewise, a minor amount of peripheral streamflow enters Lahontan Reservoir in Churchill Valley before it can enter the ground-water system and therefore becomes a part of the surface-water system.

Table 17 lists the estimated potential recharge in the Carson River basin. The table shows an estimated 16,000 acre-feet of potential ground-water recharge in the Carson Valley part of California below the Markleeville and Woodfords river gages. An unknown part of this quantity probably is rejected as recharge because of the limited extent of valley-fill deposits in this area (pl. 1), or because the water is intercepted by the river before it reaches the valley fill.

Total precipitation and potential recharge for the entire Carson River basin in Nevada (not including White Plains) are about 1,300,000 and 36,000 acre-feet per year, respectively. Therefore, only about 3 percent of the overall precipitation is estimated to make up potential recharge. For the Nevada parts of the individual hydrographic areas, potential recharge estimates range from 0.2 to 9 percent of the total precipitation. The lowest percentages are for valleys in the eastern part of the area, where precipitation is small and catchment areas with potential recharge capability are limited in extent.

Table 17.—Estimated potential ground-water recharge

Precipitation zone (feet)	Area (acres)	Estimated precipitation: Range (inches)	Average: Feet	Average: Acre-feet	Estimated potential recharge: Percentage of total precipitation	Acre-feet per year
		CARSON VALLEY - CALIFORNIA				
		West Fork Carson River				
10,000-10,823	370	>40	3.3	1,200		300
9,000-10,000	3,060	30-40	3.0	9,200		2,300
8,000-9,000	4,260	27-30	2.4	10,000	25	2,500
7,000-8,000	4,180	25-27	2.2	9,200		2,300
6,000-7,000	3,880	20-25	1.9	7,400		1,800
5,000-6,000	9,920	12-20	1.3	13,000	10	1,300
4,820-5,000	2,320	8-12	.8	1,900	3	57
Subtotal (rounded)	28,000	—	—	52,000	20	10,600
		East Fork Carson River				
9,000-9,500	78	>24	2.0	160	25	40
8,000-9,000	4,180	20-24	1.8	7,500	20	1,500
7,000-8,000	11,620	15-20	1.5	17,000	15	2,600
6,000-7,000	11,000	12-15	1.1	12,000	7	840
5,150-6,000	17,000	8-12	.8	14,000	3	420
Subtotal (rounded)	43,900	—	—	51,000	11	5,400
Total, Calif. (rounded)	71,900	—	—	100,000	16	16,000
		CARSON VALLEY - NEVADA				
		East of Carson River				
9,000-9,450	791	>24	2.0	1,600	25	400
8,000-9,000	6,880	20-24	1.8	12,000	20	2,400
7,000-8,000	22,600	15-20	1.5	34,000	15	5,100
6,000-7,000	53,000	12-15	1.1	58,000	7	4,100
5,000-6,000	74,600	8-12	.8	60,000	3	1,800
4,620-5,000	41,400	<8	.5	21,000	minor	minor
Subtotal (rounded)	199,000	—	—	190,000	7	14,000
		West of Carson River				
9,000-9,591	481	>30	2.6	1,300		325
8,000-9,000	3,720	27-30	2.4	8,900	25	2,200
7,000-8,000	5,580	25-27	2.2	12,000		3,000
6,000-7,000	6,510	20-25	1.9	12,000		3,000
5,000-6,000	14,400	12-20	1.3	19,000	10	1,900
4,620-5,000	40,300	8-12	.8	32,000	3	960
Subtotal (rounded)	71,000	—	—	85,000	13	11,000
Total, Nevada (rounded)	270,000	—	—	270,000	9	25,000
Grand total, Carson Valley, Calif. and Nev.	342,000	—	—	370,000	11	41,000
		DAYTON VALLEY				
8,000-8,763	698	>20	1.8	1,300	20	260
7,000-8,000	10,600	15-20	1.5	16,000	15	2,400
6,000-7,000	43,900	12-15	1.1	48,000	7	3,400
5,000-6,000	74,900	8-12	.8	60,000	3	1,800
4,215-5,000	103,000	<8	.5	52,000	minor	minor
Total (rounded)	233,000	—	—	180,000	4	7,900
		CHURCHILL VALLEY				
8,000-8,763	775	>15	1.5	1,200	15	180
7,000-8,000	4,530	12-15	1.1	5,000	7	350
6,000-7,000	32,000	8-12	.8	26,000	3	780
4,070-6,000	277,000	<8	.5	138,000	minor	minor
Total (rounded)	314,000	—	—	170,000	0.8	1,300
		CARSON DESERT[1]				
8,000-8,790	450	>15	1.5	680	15	100
7,000-8,000	6,980	12-15	1.1	7,700	7	540
6,000-7,000	26,800	8-12	.8	21,000	3	630
3,845-6,000	1,260,000	<8	.5	630,000	minor	minor
Total (rounded)	1,290,000	—	—	660,000	0.2	1,300
		WHITE PLAINS				
5,500-6,000	125	>8	.8	100	3	<100
3,875-5,500	101,000	<8	.5	51,000	minor	
Total (rounded)	101,000	—	—	51,000	minor	<100
		PACKARD VALLEY				
7,500-8,206	930	>15	1.5	1,400	15	210
6,500-7,500	3,560	12-15	1.1	3,900	7	270
5,500-6,500	9,760	8-12	.8	7,800	3	230
3,950-5,500	98,800	<8	.5	49,000	minor	minor
Total (rounded)	113,000	—	—	62,000	1	710

1. Excluding Packard Valley.

A comparison of estimated mountain-front runoff with estimated potential recharge for other hydrographic areas in Nevada discloses that runoff averages about twice the potential recharge. Considerable variation occurs in individual hydrographic areas throughout the State, with presently available ratios of runoff to recharge ranging from about 0.04 to about 8. Ratios computed for the Carson River basin are as follows: Carson Valley (Calif. and Nev. parts combined), 0.8; Eagle Valley, 1.5; Dayton Valley, 0.2; Churchill Valley, 0.7; and Carson Desert (excluding Packard Valley), 2.7. The overall ratio for the river system is 0.9, which is considerably below the statewide average. The overall ratio reflects the dominance of the wetter upstream hydrographic areas of the Carson River basin. The generally low runoff-recharge ratios of the upper Carson River basin are similar to those for most of the upstream hydrographic areas of the Walker and Truckee River drainages (Glancy, 1971, and Van Denburgh and others, 1973).

The trend of lower-than-average runoff-recharge ratios generally common to contiguous hydrographic areas along the front of the Sierra Nevada has several possible explanations: (1) the estimates of recharge, runoff, or both may be in error because of inaccuracies inherent in the presently used estimating techniques, (2) the lack of high-altitude precipitation data may have caused overestimates of precipitation, and hence excessive recharge estimates, in areas immediately adjacent to the Sierra mountain front, or (3) the geologic character of the consolidated-rock uplands may induce above-average recharge in the consolidated rocks, accompanied by reduced runoff quantities at the mountain fronts, thereby reducing the runoff-recharge ratio. Thus, users of these estimates should be aware of their limitations.

Natural Subsurface Inflow

Natural subsurface inflow to the valley-fill reservoirs can be of three general types: (1) inflow from the surrounding consolidated rocks within a valley watershed, which originates as infiltrated precipitation and runoff; (2) underflow from an adjacent watershed mainly through surficially exposed consolidated rocks, with subsequent subsurface leakage into the valley-fill reservoir; and (3) inflow from an adjacent upgradient valley through valley-fill deposits (alluvium) and (or) through consolidated rocks buried by the valley fill.

The first type of inflow is included in the estimates of recharge in table 17; the proportionate amount recharged in this manner is unknown. The second type of inflow may occur more frequently than originally assumed in the Great Basin Region. However, the evidence is generally indirect; for example, a notable imbalance in the hydrologic budget of an adjacent valley, and (or) favorable flow gradients between the valley-fill reservoirs of adjacent valleys. Favorable gradients in themselves are only suggestive; however, combined with obvious hydrologic budget imbalances, they become stronger evidence for leakage. Although no inflow of this type to the Carson River basin is known or suspected on the basis of available evidence, some outflow may occur in Rawhide Flats (p. 55).

The third type of ground-water inflow, through alluvium (valley fill), can be computed using a form of Darcy's law:

$$Q = 0.00112\ TIW$$

in which Q is the quantity of flow, in acre-feet per year; T is the transmissivity, in gallons per day per foot; I is the hydraulic gradient, in feet per mile, W is the width of the flow section, in miles; and the factor 0.00112 converts gallons per day to acre-feet per year. Table 18 summarizes this type of ground-water inflow to valleys of the study area.

Imported Water

The Carson River basin receives water imports for irrigation and municipal supply. It also receives sewage effluent from the Lake Tahoe basin.

Irrigation water enters the basin from the Truckee River by way of the Truckee Canal. This import is one of the main irrigation supplies to the Newlands Irrigation Project lands of the Fallon area. Average annual import by way of the canal has been an estimated 180,000 acre-feet for the period 1919-69 (Van Denburgh and others, 1973, p. 48, 57). About 10,000 acre-feet is diverted from the Truckee Canal to irrigate about 1,400 acres of Carson Desert land in the Hazen and Swingle Bench area. Therefore, about 170,000 acre-feet per year reaches Lahontan Reservoir in Churchill Valley.

Imports for municipal use come to Eagle Valley and Virginia City areas by way of the Marlette-Hobart component of the State-owned Marlette Water System. Presently (1971), the imports are mainly from the Hobart Reservoir watershed which is tributary to Washoe Valley, but during the past century significant amounts were imported to the Virginia City area from Marlette Lake (not shown on pl. 1), which is part of the Lake Tahoe drainage basin. Table 19 lists quantities of water imported from the Marlette Water System during recent years. Several estimates of the average annual yield of the system are as follows (rounded to the nearest hundred acre-feet):

(1) 5,200 acre-feet (Montgomery Engineers of Nevada, 1965, p. V-3 and appendix III).
(2) 8,100 acre-feet (Nevada Legislative Commission, 1969, p. 24).
(3) 7,100 to 7,400 acre-feet (Creegan and D'Angelo, Consulting Engineers, and Christoph J. Altemueller, Consulting Engineer, *in* Nevada Legislative Commission, 1971, p. IV-3).

The average imports from that system to the Carson River basin (Eagle Valley and Virginia City areas combined) during recent years (table 19) range from about 440 to 760 acre-feet, annually. Therefore, based on the above estimates, the Marlette Water System is currently (1971) utilizing only about one-tenth of the estimated average annual water supply.

Sewage wat.r has been exported to Carson Valley from the Lake Tahoe basin for several years. A planned program of total sewage export from the Tahoe Basin to protect its unique environment is well underway; as a result, Carson Valley since 1968 has become the recipient of effluent from three major sewage treatment plants located around the east and south shores of the lake. The

Table 18.--*Estimated ground-water inflow to valleys of the study area through alluvium*

Inflow to: (in downstream order)	From:	Location of flow section	Assumed transmissivity [(gal/d)/ft] (T)	Estimated hydraulic gradient (feet per mile) (I)	Approximate width of section (miles) (W)	Estimated subsurface flow (ac-ft/yr, rounded) (Q)
Carson Valley (East Fork)	California	East Fork Carson River channel at Stateline	50,000	27	0.1	150
Carson Valley (West Fork)	California	West Fork Carson River at Stateline	50,000	85	1.5	7,000
Carson Valley	Eagle Valley	Clear Creek underflow[2/]	30,000	40	0.50	600
Dayton Valley	Carson Valley	Carson River channel at Carson City gage	25,000	10	0.05	15
Dayton Valley	Eagle Valley	Two separate sections[2/]	20,000 and 50,000	70 and 25	1.0 and 0.05	1,600
Churchill Valley	Dayton Valley	Carson River channel at gage	50,000	5	0.25	70
Churchill Valley	Mason Valley	Adrian Valley (15/25-18)[3/]	50,000	15	0.2	150
Carson Desert	Churchill Valley	Seepage from Lahontan Reservoir	--	--	--	Unknown
Carson Desert	Fernley Area	Alluvium near Hazen[4/]	50,000	7	2	800
Carson Desert	Packard Valley	Alluvium	5,000	20	4	400
White Plains	Lovelock Valley (Humboldt Sink)	Beneath Humboldt drain	5,000	2.5	4	60
Carson Desert	White Plains	Alluvium	5,000	1	3	20

1. River channel is on or very close to bedrock.
2. Data from Worts and Malmberg, 1966, table 9, p. 29.
3. Data from Huxel, 1969, table 13, p. 29.
4. Data from Van Denburgh and others, 1973, p. 47.

Table 19.--*Water imported from the Marlette Water System* 1/

	Imports to Carson River basin (acre-feet)				
Water year	State distribution system	Purchased by Carson Water Co.	Purchased by Virginia City	Purchased by Lakeview development	Total
1966	253	331	166		750
1967	182	124	136		442
1968	278	400	160		838
1969	256	340	164		760
1970	255	212	191	3	661
1971	253	168	220	5	646

1. Data from records of Nevada Division of Buildings and Grounds. The data update table 5 of Worts and Malmberg (1966).

South Tahoe Public Utility District began exporting its treated effluent by pipeline to Indian Creek Reservoir (table 11) in 1968. The Douglas County Water Reclamation Project began to export treated effluent from its Round Hill treatment plant to Carson Valley by way of Daggett Creek in 1969. In January 1972, the Douglas County facility discontinued use of Daggett Creek and began exporting its treated effluent directly to the Carson River through a new pipeline system (Julio Alvas, Plant Manager, oral commun., 1972). According to Mr. Alvas, some future diversion of the treated effluent from the pipeline for irrigation in Carson Valley is probable. The Incline Village General Improvement District plant began export of its treated effluent to Carson Valley in 1971. The District had, as of December 1971, delivered at least 98 percent of its effluent to the U.S. Bureau of Land Management and the Harry Schneider Ranch in Jacks Valley for stockwatering and irrigation. However, a pipeline allows effluent to be discharged directly to the river.

The combined import of sewage effluent from all three sources in 1971 was about 3,700 acre-feet (table 20). The maximum capacity of the present Incline system is 3.5 million gallons daily, or about 3,900 acre-feet per year (Cliff Girbon, Jr., oral commun., 1972). That of the Douglas County Water Reclamation Project is 6 million gallons daily, or about 6,700 acre-feet per year (Julio Alvas, oral commun., 1972). The South Tahoe Public Utility District may be exporting nearly 14,000 acre-feet annually by the year 2006 (Lake Tahoe Area Council, 1970, p. 5). This means that within just a few decades Carson Valley could be receiving about 25,000 acre-feet of imported sewage effluent annually from the Lake Tahoe basin.

Table 20.--*Estimated imports of waste water to Carson River basin*

Import system	Inflow per water year (acre-feet)			
	1968	1969	1970	1971
South Tahoe Public Utility District via Luther Pass to Indian Creek reservoir 1/	a 1,280	2,470	2,640	2,930
Douglas County Water Reclamation Project via Daggett Creek to Carson River 2/	0	a 400+	550	520
Incline Village General Improvement District via Spooner's Summit to Carson River basin 3/	0	0	0	a 290
Total (rounded)	1,300	2,900+	3,200	3,740

1. Data from Lake Tahoe Area Council (1970, p. 23) and Jack Archambault of Lake Tahoe Area Council Laboratory (oral commun., 1971).

2. Data from Julio Alvas, plant manager, Douglas County Water Reclamation Project (oral commun., 1971).

3. Data from Cliff Girbon, Jr., plant manager, Incline General Improvement District Treatment Plant (oral commun., 1971).

a. First year of system operation; therefore, imports took place only part of the year.

OUTFLOW FROM THE HYDROGRAPHIC AREAS

Surface and Subsurface Outflow

All surface-water flow between hydrographic areas within the Carson River basin is listed in table 12. No surface water flows from the Carson River basin to adjacent areas, as all water not percolated or discharged by evapotranspiration flows to the Stillwater Wildlife Management area or to the sink areas.

Subsurface flow between areas is discussed mainly in the section titled "Subsurface inflow" (see table 18). Possible subsurface leakage from the Carson Lake area of Carson Desert to Rawhide Flats in the Walker River drainage (not shown on pl. 1) was postulated by Everett and Rush (1967, p. 17), because the estimated annual discharge from Rawhide Flats was about five times greater than the estimated recharge. This imbalance resulted in an apparent water deficiency in Rawhide Flat of about 650 acre-feet per year. Two shallow wells were drilled in 1971 in the Bass Flats area, near Carson Lake in Carson Desert; this area is separated from Rawhide Flats by the Blow Sand Mountains. The static water-table surface inferred from water levels in these and nearby wells in Carson Desert suggests that ground-water movement in the shallow aquifer system is toward Carson Lake rather than toward Rawhide Flats. However, the water table in Rawhide Flats is about 20 feet lower than that in southern Carson Desert. Therefore, although available evidence refutes interbasin ground-water movement from Carson Desert to Rawhide Flats through shallow aquifers, the possibility of leakage through deeper aquifers still exists. The leakage requirement to satisfy estimated budget deficiencies in Rawhide Flats, only about 650 acre-feet per year, is completely masked by the great natural discharge in the Carson Desert.

Public, Domestic, and Industrial Supplies

Most of the residents in the study area, as well as industrial and commercial enterprises in the cities and most communities, are served by public water supplies. Table 21 gives estimates of public, domestic, and industrial water use during the 1971 water year in the Carson River basin. Where possible, annual estimates were made on the basis of records of water diverted or delivered to consumers. These records were not adjusted to reflect true consumptive use. When no records were available, consumptive use was estimated through population estimates and application of an average use rate of 110 gallons per day per person in most instances. For Minden and Gardnerville, a higher use rate of 120 gallons per day per person was applied to compensate for increased water consumption by a tourist population assumed greater than that of other unmetered rural communities.

Table 22 gives a summary of estimated ground-water pumpage for public supply, domestic, and industrial purposes during 1971. Tables 23 and 24 document the municipal water-supply histories of Carson City and Fallon, respectively, during recent years.

Table 21.--*Estimates of public, domestic, and industrial water use during 1971 water year*

Population group or facility served	Source of supply	Estimated 1971 use (acre-feet)	Basis of estimate
	Carson Valley		
Gardnerville Ranchos 1/	2 wells	160	Estimated population of 1,000. Golf course of about 20 acres at use rate of 2 feet annually.
Gardnerville	4 wells	110	Estimated population of 820.
Minden	2 wells	70	Estimated population of 500.
Genoa	Flow of Genoa Canyon 1/, springs in Schoolhouse Canyon 1/, some piped water from Sierra Canyon 1/, and individual wells.	20	Estimated population of 135 plus unknown number of livestock.
Carson Valley (rural)	Individual wells	180	Estimated population of 1,500.
Nevada Medium Security Prison 1/	2 wells at Medium Security Prison	50	Estimated population of 380.
Subtotal (rounded)		590	
	Eagle Valley		
Stewart	1 active well	100	Estimated population 1,000, about ½ of which reside only 3/4 of each year.
	Diversions from Clear Creek to water lawns and grounds	50	Worts and Malmberg, 1966, p. 23.
Carson Water Co.	5 wells in Eagle Valley; 2 wells in Jack's Valley; Eagle Valley spring and streamflow; imported water from Marlette water system	a 2,920	Records of Carson Water Co. and Nevada Division of Buildings and Grounds (see table 23).
Rural	Individual wells	400	Estimated population of 3,000+.
State system	Eagle Valley spring and streamflow	a 150	Records of State Division of Buildings and Grounds (table 19), and Worts and Malmberg (1966, table 6).
	Imported water from Marlette water system	a 253	
Subtotal (rounded)		3,870	
	Dayton Valley		
Virginia City (includes Gold Hill and Silver City)	Imports from Washoe Valley and Tahoe basin via Marlette water system.	a 220	Records of State Division of Buildings and Grounds (table 19).
Residences in Mound House area	Springs in the Virginia Range	12	Estimated population of 100.
Area near junction of U.S. Highway 50 and Nevada Highway 17	Individual wells	5	Estimated population of 25-50.
Dayton	Individual wells	30	Estimated population of 250 and several commercial establishments
Rural	Individual wells	30	Estimated population of 250.
Subtotal (rounded)		300	
	Churchill Valley		
Silver Springs	2 community wells	30	Estimated population of 225 and 8 commercial establishments.
Rural	Individual wells	25	Estimated population of 200.
Subtotal (rounded)		55	
	Carson Desert		
Hazen	Diversions from Truckee Canal	10	Estimated population of 50-100.
Fallon	2 wells	a 1,030	City pumpage records.
U.S. Naval Air Station	3 wells	a 438	Navy pumpage records.
Rural	Individual wells	1,000	Estimated population of 8,000+.
Kennametal, Inc. 1/	1 well	50	Information from J. D. Frank, Manager
Subtotal (rounded)		2,530	
Total (rounded)		7,300	

1. Location not shown on plate 1.

a. Estimate of water delivered to consumers, but not adjusted to reflect true consumptive use.

Table 22.--*Summary of estimated ground-water pumpage for public supply, domestic, and industrial purposes, 1971 water year*

Hydrographic area	Pumpage estimates (acre-feet)
Carson Valley	580
Eagle Valley	1,360
Dayton Valley	65
Churchill Valley	55
Carson Desert	2,500
Packard Valley	minor
White Plains	none
Total (rounded)	4,600

Table 23.--*Water input to the Carson Water Company distribution system during the 1970 and 1971 calendar years*

	INPUT			
	1970		1971	
Source	Acre-feet	Percentage of annual subtotal	Acre-feet	Percentage of annual subtotal
Pumpage from Eagle Valley wells 1/	1,264	45	1,357	47
Stream and springflow from Eagle Valley drainages 1/	1,340	48	1,363	47
Imports from the State distribution system 2/	212	7	174	6
Eagle Valley system subtotal	2,816	100	2,894	100
Jack's Valley system 1/	23	--	25	--
Water Company combined system total (rounded)	2,840	--	2,920	--

1. Data from Carson Water Co. records.
2. Data from Nevada Division of Buildings and Grounds.

Table 24.--*Pumpage of Fallon city wells and Fallon Naval Air Station wells during the 1966-71 water years*

Water year	Pumpage (acre-feet per year)		
	Fallon wells 1/	Navy wells 2/	Total
1967	784	457	1,241
1968	853	486	1,339
1969	911	438	1,349
1970	874	438	1,312
1971	1,029	438	1,467

1. Data furnished by Milton Lakey, Assistant City Engineer of Fallon.

2. Data furnished by Lt. P. A. Faletti, Public Works Officer, U.S. Naval Air Station, Fallon.

A few small industrial concerns in the larger municipalities generally satisfied their limited water needs as of 1971 from the municipal-supply systems. Kennametal, Inc., operates a plant about 10 miles north of Fallon. They obtain part of their water supply from a well at the plant site which produced about 50 acre-feet of water in 1971. They supplemented this water with about 6 acre-feet purchased from the city of Fallon (J. D. Frank, Mgr., oral commun., 1972).

Water is used for power generation at Lahontan Dam by Sierra Pacific Power Co., and at a small powerplant on the V-canal by the Truckee-Carson Irrigation District. However, since 1967, no water has been used for power generation alone, because the plants use water only when it is being released for irrigation purposes.

Irrigation Pumpage

Cropland within the report area is irrigated primarily with surface water. Most ground-water pumpage for irrigation in areas upstream from Lahontan Reservoir, particularly in Carson and Dayton Valleys, is supplemental to surface-water irrigation. In other words, most irrigators supply their crops with ground water only when surface-water supplies are inadequate. As a result, pumpage is largest during years of deficient surface-water supply, and smallest during years of abundant runoff. Table 25 shows the estimated maximum, minimum, and average irrigation pumpage under current (1971) conditions of agricultural development.

Pumpage estimates for Carson Valley were made during a recent ground-water investigation (Walters, Ball, Hibdon, & Shaw, 1970, p. 42). The estimate for 1968 was 10,000 acre-feet, when the combined river flow was about 70 percent of the 1905-69 average. The estimate for 1969 was 3,000 acre-feet, when combined river flow was about 176 percent of the 64-year average. This suggests that the average annual pumpage rate during years of normal river flow is about 5,000 acre-feet.

Irrigation pumpage in Eagle Valley is estimated at less than 100 acre-feet per year, because the only known pumpage not accounted for as domestic and municipal use is that for the local golf course and cemetery.

Table 25.--*Estimated annual irrigation pumpage*

Hydrographic area	Pumpage estimates (acre-feet)		
	Small runoff years	Average runoff years	Large runoff years
Carson Valley 1/	10,000	5,000	3,000
Eagle Valley	less than 100	less than 100	less than 100
Dayton Valley 2/	7,000	3,500	1,200
Churchill Valley 3/	50	50	50
Carson Desert 4/	minor	minor	minor
Packard Valley 3/	none	none	none
White Plains 3/	none	none	none
Total (rounded)	about 17,000	about 9,000	about 4,000

1. Modified from data of Walters, Ball, Hibdon, & Shaw, 1970, p. 42.
2. Based on field data collected during this study and water-rights data of Nevada State Engineer's office.
3. Based on field data collected during this study.
4. Oral communication with Truckee-Carson Irrigation District staff, 1971.

Irrigation pumpage in Dayton Valley is also mainly supplemental to surface-water irrigation. The exceptions are in the Stagecoach area (17/23-10) and the area southeast of the Carson River a few miles downstream from Dayton (16/22-4 and 9), where farmers cumulatively irrigated about 400 acres exclusively by ground-water pumpage in 1971-72.

The only known irrigation pumpage in Churchill Valley during 1971-72 was for an alfalfa field of about 15 acres at the west edge of Silver Springs. The annual pumpage is estimated at about 50 acre-feet, and is supplied by well 18/24-25bda (pl. 1 and table 39).

The Carson Desert probably has only a minor amount of irrigation pumpage because the Truckee-Carson Irrigation District does not permit ground-water irrigation of areas greater than one acre by any individual farm. Therefore, each farm does not irrigate more than a small garden or lawn with ground water, and the total cumulative pumpage for this purpose probably is accounted for in estimates of rural domestic water use (table 21).

A comparison of tables 21 and 25 shows: (1) irrigation pumpage is somewhat more than all other pumpage in Carson and Dayton Valleys, (2) irrigation pumpage is about equal to other pumpage in Churchill Valley, (3) public, domestic, and industrial pumpage is much greater than irrigation pumpage in Eagle Valley and Carson Desert, and (4) combined pumpage for all purposes in Packard Valley and White Plains is negligible.

Surface-Water Diversions

Irrigation by surface-water diversions was not determined directly because this reconnaissance did not include detailed mapping of irrigated lands according to crop type; in fact, irrigated lands and phreatophyte areas have been field-mapped as a single unit (pl. 1). Estimates of irrigated acreages for the various hydrographic areas shown in table 28 were generally obtained from other sources, as credited in the table. Total evapotranspiration of crops and phreatophytes is approximated by difference in the water budget (table 30).

Livestock Use

Water for livestock comes from wells, springs, streams, and irrigation ditches. The amounts consumed are small compared to other types of water use. Table 26 lists the estimated average annual consumption by livestock from all water sources as of 1971. Total use of water by livestock throughout the study area in 1971 was about 700 acre-feet.

Table 26.--*Estimated annual consumption of water by livestock, 1971 calendar year*

Hydrographic area	Population estimates 1/					Total consumption (acre-feet, rounded)
	Range cattle	Milk cows	Hogs	Sheep	Horses	
Carson Valley	23,000	1,500	500	7,000	1,000	220
Eagle Valley	1,100	100	minor	1,300	700	20
Dayton and Churchill Valleys	2,000	minor	minor	1,000	200	18
Carson Desert	50,000	3,200	1,000	15,000	3,500	480
White Plains 2/	minor	none	none	minor	minor	minor
Packard Valley 2/	200	none	none	minor	minor	2
Total (rounded)	76,000	4,800	1,500	24,000	5,400	700

1. Population estimates based on U.S. Dept. of Commerce (1971) and modified with assistance of County Extension Agent's staffs, except as noted. Animal per-capita use rates as follows (Nevada State Engineer, 1971, p. 16):
   - Range cattle - 6 gal/d (gallons per day)
   - Milk cows - 20 gal/d
   - Hogs - 2 gal/d
   - Sheep - 2 gal/d
   - Horses - 10 gal/d
2. Population estimates by P. A. Glancy.

Recreation Use

Recreation is one of the fastest growing water uses in the Carson River basin. This reconnaissance does not allow an analysis of the present use or future potential of the river system for recreation purposes, because the use is generally nonconsumptive. Two principal areas of recreation use are Lahontan Reservoir, for boating and fishing, and Stillwater Wildlife Management Area, for wildfowl.

Springs

Numerous small springs occur in the consolidated rocks of the mountains. Some springs also discharge from the valley fill (pl. 1). Although these springs furnish water for stock and wildlife, the cumulative water quantities involved are minimal compared to pumpage and streamflow in the area. The springflow typically supports growth of meadowgrass, saltgrass, rabbitbrush, greasewood, willow, and aspen over very limited areas. Some of the flow probably seeps back into the ground. Doud Spring (11/21-20cd) and Saratoga Spring (14/20-21cdd) in Carson Valley have much higher discharges than most springs visited during this investigation (table 27). The table indicates that several of the springs are thermal. Worts and Malmberg (1966, p. 30) discussed springs in Eagle Valley, and Morrison (1964, p. 117) discussed springs in the Carson Desert.

Table 27.--*Spring data*

Location	Name	Approximate land-surface altitude (feet)	Date	Estimated flow (gal/min)	Temperature °F	Temperature °C
11/21-20cd	Doud Spring	5,750	5- 7-70	180	70	21.0
-26ba	Double Spring	5,930	5- 6-70	<10	52	11.0
13/19-22abc	Walleys Hot Spring	4,670	11-10-59	10-15	146	63.0
14/19-23dd	Hobo Hot Spring	4,760	5- 3-60	10-15	114	45.5
14/20-21cdd	Saratoga Hot Springs	4,700	5-14-70	350	122	50.0
16/21-2daa	Sutro Tunnel	4,480	6- 1-70	25-50	83	28.5
-22cb	Dove Spring	4,620	6- 1-70	5	59	15.0
16/24-15bcd	--	4,275	6- 8-70	3	61	16.0
16/29-34bc	Lee Hot Springs	4,020	8-18-70	10	boiling	boiling
17/22-8cad	Sutro Springs	5,590	7-23-72	10	69	20.5
17/31-31ab	Rock Spring	3,915	8-19-70	1	68	20.0
-31ba	--	3,920	8-19-70	1	66	19.0
18/22-25da	Cooney Spring	5,330	6- 3-70	<1	69	20.5
18/23-33ccb	Corral Spring	4,395	12- 7-71	1	58	14.5
28/34-31db	--	5,035	10- 8-70	5	62	16.5

Natural Evapotranspiration

In areas of shallow ground water, natural discharge occurs by evaporation from surface-water bodies and bare-soil areas, and by transpiration from naturally growing plants called phreatophytes, whose roots tap the ground-water reservoir. Large amounts of water are naturally discharged to the atmosphere by these evapotranspiration processes in the Carson River basin. However, as mentioned in the section on "Irrigation pumpage," no estimates of crop or natural losses are made in this report. They are shown by difference in table 30. Evapotranspiration areas are listed in table 28 and are shown in combination with irrigated areas on plate 1.

Estimates of average net evaporation from surface-water bodies in individual hydrographic areas of the Carson River basin are shown in table 29. Acreage estimates were based on the following assumptions and criteria: Carson Valley acreage includes ponds, lakes, and major stream channels; Dayton Valley acreage is almost all river-surface area; Churchill Valley acreage is largely Lahontan Reservoir and a small amount of river surface; Carson Desert acreage includes a reasonably firm estimate of about 35,000 acres of lakes, ponds, and reservoirs; a somewhat less confident estimate of about 10,000 acres in Carson Lake; and a very crude estimate of about 20,000 acres of flooded playa in the Carson Sink and Fourmile Flat areas.

Evaporative discharge from bare soil (table 28) involves water losses from the ground-water reservoir, but not losses associated with playa-surface flooding, which are accounted for in estimates of evaporation from surface-water bodies. Significant areas of bare-soil ground-water discharge exist only in Carson Desert and White Plains. The probability of ground-water discharge from the playa areas of Turupah Flat, southeast of the Fallon Naval Air Station, and Bass Flats, at the southern edge of Carson Lake, is very uncertain. Recently drilled shallow wells in these playas suggest static water levels in Turupah Flat and Bass Flats are about 11 feet and 14 to 25 feet below land surface, respectively (table 39); the amount of ground-water discharge under these conditions is considered minor.

Water losses from large areas in the Carson Lake and Stillwater Wildlife Management segment of Carson Desert are dominated from time to time by either water-surface evaporation, bare-soil ground-water discharge, phreatophyte discharge, or various combinations of these three types of discharge, depending on prevailing water supplies and water-management practices. These areas of variable discharge, therefore, are listed in several special discharge categories in table 28.

Packard Valley has practically no water-surface evaporation. Transpiration from about 1,700 acres of phreatophytes is estimated to be about 340 acre-feet per year.

Table 28.--*Estimated acreage of irrigated lands, phreatophytes, surface-water bodies, and discharging playas* 1/

(All figures rounded)

	Carson Valley (Nevada)	Eagle Valley	Dayton Valley	Churchill Valley	Carson Desert	Packard Valley	White Plains	Total
Irrigated lands	a 48,000	b 700	a 6,300	a 1,300	c 56,000	(d)	(d)	112,000
Phreatophytes[2]	6,000	b 5,100	6,700	22,000	e 300,000	1,700	13,000	e 350,000
Surface-water bodies (lakes, ponds, and streams)	1,100	minor	300	>7,000	65,000	minor	500	74,000
Discharging playa	none	none	none	none	276,000	none	12,000	290,000
Playa of uncertain ground-water discharge	none	none	none	none	5,500	none	(d)	5,500
Mixed marsh grass, greasewood, bare soil, and surface water	(d)	(d)	(d)	(d)	4,200	(d)	(d)	4,200
Mixed bare soil and a few phreatophytes	(d)	(d)	(d)	(d)	32,000	(d)	(d)	32,000
Mainly surface water with some pasture, marsh grass, and phreatophytes	(d)	(d)	(d)	(d)	4,200	(d)	(d)	4,200
Total (rounded)	55,000	5,800	13,000	30,000	740,000	1,700	25,000	870,000

1. Values determined during period of study. Some areas may vary substantially during periods of varying wetness.
2. Numerical difference between combined reconnaissance-field-mapped acreage of phreatophytes and irrigation, and reported irrigated acreage.
a. Acreage from U.S. Soil Conservation Service (Joe VanMullem, oral and written commun., 1974).
b. From Worts and Malmberg (1966, p. 24 and table 8).
c. From U.S. Bureau of Reclamation (Nathan Geering, oral commun., 1971).
d. No acreage determined in given category.
e. Includes about 250,000 acres where phreatophytes may be spotty or in some places absent.

Table 29.--*Estimated average annual evaporation from surface-water bodies for mainstem hydrographic areas, 1919-69*

Hydrographic area	Estimated average area (acres)	Net evaporation rate 1/ (feet per year)		Average annual discharge (acre-feet per year)
Carson Valley	1,100	2½		2,800
Dayton Valley	300	3		900
Churchill Valley	>7,000	>3½		30,000
Carson Desert	a 45,000	4	180,000	220,000
	b 20,000	a 2	40,000	

1. Average annual lake evaporation (Kohler and others, 1959, pl. 2) minus average annual precipitation (table 4).

a. Perennial lakes and ponds as determined by 1971 field studies. During periods of deficient water supply, such as 1920-35 and 1958-61, many of these areas reportedly decrease markedly (Harold Soule, Truckee-Carson Irrigation District, and George Luke, Stillwater resident, oral commun., 1974).

b. Mainly playa areas that are partly flooded on a very irregular basis. Therefore evaporation rate assumes water coverage only half of each year on the average.

Part of White Plains is flooded about twice per decade, on the average, during years of large runoff in the Humboldt River basin. The ponded flood water generally evaporates and (or) drains to Carson Desert, and the flooded areas become dry within a few months. Water-surface evaporation probably averages less than 500 acre-feet per year. Phreatophytes (mainly greasewood) occupy about 13,000 acres in a generally sparse pattern, and consume an estimated 1,300 acre-feet per year. Ground-water discharge from bare soil is an estimated 1,200 acre-feet per year from about 12,000 acres of playa surface. Total evapotranspiration, then, may be about 3,000 acre-feet per year for White Plains.

WATER BUDGETS

Water budgets for the mainstem hydrographic areas are dominated by the Carson River, because river-flow quantities generally are much larger than other budget elements. Water budgets for hydrographic areas are shown in table 30. The various budget elements are determined for the 51-year base period 1919-69, and therefore, the recent sharp increases in water imports as well as domestic and municipal use have little effect on the long-term budget averages.

Mainstem Areas

Carson Valley (Nevada)

In Carson Valley, most mountain-front runoff (table 14) and most of the ground water recharged through consolidated rocks reach the river or the valley-fill ground-water reservoir. The net average quantity annually entering the system by these two processes is assumed to be about 30,000 acre-feet (table 30).

The annual net depletion, or consumptive use, within the valley is computed by difference to be about 80,000 acre-feet. This estimate compares favorably with the 77,000 acre-feet of Piper (1969, p. F7), although Piper relied on a different period of record (1909-60) and also included the area in California below the Woodfords gage.

Dayton Valley

Most of the mountain-front runoff in Dayton Valley (averaging 1,400 acre-feet annually, table 14) is assumed to be either dissipated by evapotranspiration or infiltrated to the ground-water reservoir before reaching the river. As a result, potential ground-water recharge (7,900 acre-feet annually, table 17) is considered the local input to the Dayton Valley hydrographic areas.

Churchill Valley

The hydrologic budget of Churchill Valley is dominated not only by natural river flow, as are upstream valleys, but also by inflow of the Truckee Canal, evaporation from Lahontan Reservoir, and man-controlled releases from Lahontan Reservoir. Therefore, man-controlled activities dominate the outflow elements and also strongly influence inflow totals. Natural local input (mountain-front runoff, 900 acre-feet, plus potential ground-water recharge, 1,300 acre-feet) is insignificant when compared to most other budget elements. The budget of table 30 shows 30,000 acre-feet per year of "other outflow quantities" (by difference), which includes crop, phreatophyte, municipal, and domestic consumptive use. However, the total seems to be about 10,000 acre-feet more than the apparent water requirements indicated according to crop and phreatophyte acreages. Therefore, the apparent excess of 10,000 acre-feet presumably is either the product of errors in the estimation of inflow and outflow elements, or it represents a quantity of water escaping the valley via some undefined route.

Table 30.—Reconnaissance water budgets, in acre-feet per year, for mainstem hydrographic areas, 1919-69

	Carson Valley (Nev.)	Dayton Valley	Churchill Valley	Carson Desert	Total (rounded)
INFLOW					
Mainstem inflow:					
Streamflow (table 12)	315,000	272,000	a 268,000	b 380,000	315,000
Ground water (table 18)	7,200	15	70	unknown	7,200
Imported water (tables 19 and 20)	c minor	d 150	e 170,000	e 10,000	180,000
Inflow from nonmainstem (adjacent) hydrographic areas:					
Streamflow	f 3,100	g 3,500	h 1,000	i 1,400	8,500
Ground water (table 17)	g 600	g 1,600	h 150	j 1,200	3,600
Input to system from within mainstem hydrographic area	k 30,000	ℓ 7,900	ℓ 1,300	ℓ 1,300	40,000
TOTAL INFLOW (rounded)	355,000	285,000	440,000	390,000	550,000
OUTFLOW					
Mainstem outflow:					
Streamflow (table 12)	272,000	a 268,000	b 380,000	0	0
Ground water (table 18. and p.)	minor	70	minor	<1,000	<1,000
Evaporation from surface-water bodies (table 29)	2,800	900	30,000	220,000	250,000
Other outflow quantities[1/]	m 80,000	n 16,000	o 30,000	p 170,000	300,000
TOTAL OUTFLOW (rounded)	355,000	285,000	440,000	390,000	550,000

1. Computed by difference: total inflow minus all other outflow elements. Includes water consumptively used for municipal, industrial, domestic, and agricultural purposes, plus evapotranspiration from phreatophytes and playas.

a. Carson River, 252,000 acre-feet (table 12) plus Buckland Ditch, 16,000 acre-feet.

b. U.S. Bureau of Reclamation records.

c. Average import from Lake Tahoe basin minor for period 1919-69.

d. For Virginia City area; estimated long-term average on basis of data in table 19).

e. Truckee Canal (quantity for Carson Desert is net import).

f. Clear Creek (Worts and Malmberg, 1966, p. 19, plus 100 acre-feet diversion from Clear Creek to Jacks Valley).

g. From Eagle Valley (Worts and Malmberg, 1966, p. 19 and 29).

h. Inflow from Adrian Valley (Huxel, 1969, p. 22).

i. Inflow from White Plains (1,000 acre-ft per yr) and Packard Valley (400 acre-ft per yr).

j. Inflow from White Plains (20 acre-ft per year), Packard Valley (400 acre-ft per yr), and Fernley area (800 acre-ft per yr, Van Denburgh and others, 1973, p. 47).

k. Net annual average input of 30,000 acre-feet assumed on the basis of 15,000 acre-feet estimated mountain-front runoff (table 14) and 25,000 acre-feet estimated potential ground-water recharge (table 17).

ℓ. Assumed equal to estimated potential ground-water recharge (table 17).

m. Agrees reasonably well with 77,000 acre-feet of Piper (1969, p. F7). Includes water consumed by about 54,000 acres of crops and phreatophytes.

n. Includes minor pumpage for stock and domestic use, plus water for 13,000 acres of crops and phreatophytes.

o. Includes pumpage for stock and domestic and water for about 20,000 acres of crops and phreatophytes; may include substantial ground-water outflow to Carson Desert (see text).

p. Includes water consumed by 56,000 acres of crops and up to about 620,000 acres of phreatophytes and discharging playas.

Carson Desert

Carson Desert hydrology is dominated by man-controlled releases from Lahontan Reservoir. The "other outflow quantities" determined by difference suggest that only 170,000 acre-feet of water is consumed annually by domestic, municipal, and agricultural consumptive use and natural evapotranspiration. The crops, phreatophytes, and naturally discharging bare playas (table 28) alone probably would consume or discharge considerably more than 170,000 acre-feet annually. Therefore, the outflow of water from Carson Desert seems greater than is accountable through the combined inflow elements. Reconciliation of this critical problem, unfortunately was beyond the scope of this reconnaissance.

Another budget element not considered in this reconnaissance is the amount of irrigation water that went into ground-water storage from canals, distribution ditches, and fields following the start of the Newlands Project in about 1905. Water levels locally rose as much as 50 to 60 feet during the period 1905-30 (Rush, 1972). This additional water loss, if known, would increase the losses under the "outflow" section of the budget (table 30).

Nonmainstem Areas

Eagle Valley

The water budget of Eagle Valley used in this study is that of Worts and Malmberg for conditions as of 1965 (1966, p. 33 and table 11). Their budget indicates a near balance between inflow and outflow of about 15,000 acre-feet annually; of that quantity, about 8,800 acre-feet ultimately reaches the mainstem Carson River (table 30), and the residual, 6,200 acre-feet is assumed dissipated within Eagle Valley.

Packard Valley

Packard Valley is tributary to Carson Desert (though it is not tributary to the Carson River). Subsurface leakage to Carson Desert from Packard Valley is considered as the arithmetic difference between estimates of recharge and natural discharge in Packard Valley. Estimated recharge (table 17) is 710 acre-feet and natural discharge from about 1,700 acres of phreatophytes (table 28) is estimated at about 340 acre-feet. Subsurface leakage is therefore assumed to be about 400 acre-feet. Average annual surface-water runoff to Carson Desert from Packard Valley probably is less than 100 acre-feet per year.

White Plains

Average annual outflow from the White Plains hydrographic area is estimated at about 6,000 acre-feet, and consists of about 1,000 acre-feet of surface-water flow (p. 38); an estimate of 20 acre-feet of ground-water underflow to Carson Desert (table 18); about 2,600 acre-feet of natural discharge by 13,000 acres of phreatophytes (table 28); 1,200 acre-feet of bare-soil evaporation from 12,000 acres (table 28); and roughly 1,000 acre-feet of estimated water-surface evaporation from about 500 acres (table 28).

Average annual inflow estimates are as follows: a minor amount of ground-water recharge within the hydrographic area (table 17); and ground-water inflow from the Humboldt Sink of about 60 acre-feet (table 18). Surface inflow from the Humboldt Sink is assumed to equal the difference between the other elements of inflow and outflow, or about 6,000 acre-feet per year, on the average (p. 38).

Entire Carson River Basin

For the entire report area, including mainstem and nonmainstem hydrographic areas, the estimated total water supply has averaged about 560,000 acre-feet per year during the base period 1919-69. The total includes 550,000 acre-feet in mainstem areas (table 30), 6,200 acre-feet dissipated in Eagle Valley (p. 67), 710 acre-feet in Packard Valley (p. 67), and 6,000 acre-feet in White Plains (p. 67). Of this approximate 560,000 acre-feet total supply, 322,000 acre-feet enter the report area from the Carson River drainage in California (table 30), 180,000 acre-feet are imported from the Truckee River via the Truckee Canal (table 30), 6,000 acre-feet are supplied from the Humboldt River drainage via White Plains (p. 67), and 1,000 acre-feet enter from the Walker River basin via Adrian Gap (table 30). Thus, the combined total inflow from outside the report area is roughly 510,000 acre-feet. Therefore, only about 50,000 acre-feet, or slightly less than 10 percent, of the total area supply is generated within the study area which was confined to Nevada.

The estimated total outflow also has averaged about 560,000 acre-feet per year, including 250,000 acre-feet of evaporation from surface-water bodies (table 29) and 310,000 acre-feet (calculated by difference) of evapotranspiration from phreatophytes, bare playas, and agricultural lands plus water consumed for municipal, industrial, and domestic purposes.

WATER QUALITY

The water quality of the Carson River basin is best in the headwater areas and tends to deteriorate in a downstream direction as a result of both natural processes and man-caused effects. The quality involves, and is determined by, a complex interrelationship of at least four general components: (1) physical characteristics of the water, such as temperature and rate and path of movement, (2) dissolved chemical constituents in the water, (3) particulate matter carried by, or in contact with, the water, and (4) the biologic community of plants and animals, including man, that live partly or wholly in this hydrologic environment. The complex interrelationship of the above components requires detailed knowledge of Carson River basin hydrology both to understand present water-quality characteristics and to predict successfully specific future changes in water quality. This required knowledge is presently inadequate, mainly because of a shortage of hydrologic data. Therefore, this study is concerned mainly with a summary presentation of some of the available data and preliminary interpretations of these data, where feasible.

General Chemical Character

Table 31 shows chemical analyses of representative water samples collected within the report area. Although the interpretations of chemical quality in the study area rely largely on the data of table 31, they are also based in part on data of Miller and others (1953), University of Nevada (1944), Walters, Ball, Hibdon, & Shaw (1970), Guyton & Associates (1967), and Worts and Malmberg (1966). Data from these reports generally are not repeated in table 31. Many unpublished analyses from the files of the Nevada Division of Health were also utilized in the interpretations. Some of these data are included in table 31.

The specific conductances in table 31 can be used as a preliminary indication of general chemical character, because the concentration of dissolved solids in a water, expressed in milligrams per litre (mg/l), is generally 55 to 70 percent of the specific conductance, in micromhos per centimetre at 25°C (hereafter abbreviated "micromhos"). Milligrams per litre are equivalent to parts per million in most waters; see footnote 1, table 31.

Criteria for Suitability

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 supplies; these standards have been adopted by the Nevada Bureau of Environmental Health for public supplies in the State. The standards, as they apply to data listed in table 31, are as follows:

Table 31.—Chemical analyses of well, spring, stream, and lake waters

Part A.—Routine analytical determinations

Milligrams per litre (upper number) and milliequivalents per litre (lower number).[1/]

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[2/]	SAR[2/]	Sodium hazard[2/]	RSC[2/]
										CARSON VALLEY												
11/19-12ad	Fredricksburg Canyon Creek (a)	12-10-56	R	—	—	—	6 0.30	1.3 0.11	(a)	34 0.56	0 0.00	1.9 0.04	0.4 0.01	—	53	21	70	7.9	L	0.3	L	S
11/21-20cd	Doud Spring	5- 7-70	G	—	—	—	32 1.60	16 1.30	18 0.79	169 2.77	0 0.00	39 0.81	4 0.11	—	—	145	330	8.2	L	.7	L	S
-26ba	Double Spring	5- 6-70	G	52	11.0	—	52 2.59	20 1.65	33 1.44	194 3.18	0 0.00	112 2.33	6 0.17	—	—	212	540	8.1	L	1.0	L	S
-30ba	Bryant Creek	9-22-69	G	—	—	—	46 2.30	14 1.12	19 0.83	0 0.00	0 0.00	199 4.14	4 0.11	—	—	171	480	4.3	L	.6	L	S
12/19-3ca	Mott Canyon Creek (a)	12-11-56	R	—	—	—	8.8 0.44	1.3 0.11	(a)	45 0.74	0 0.00	1.9 0.04	0.7 0.02	—	61	28	82	8.1	L	.4	L	S
-14cb	Sheridan Creek (a)	12- 7-56	R	—	—	—	7.2 0.36	1.1 0.09	(a)	34 0.56	0 0.00	4.3 0.09	0.4 0.01	—	51	23	68	8.0	L	.4	L	S
-26dad	Luther Creek (a)	12- 7-56	R	—	—	—	4 0.20	0.5 0.04	(a)	31 0.51	0 0.00	0 0.00	0.7 0.02	—	36	12	57	8.0	L	.4	L	S
12/20-4baad	Well (343 ft) (a)	5-11-70	H	—	—	0.00	58 2.89	16 1.32	21 0.91	266 4.36	0 0.00	17 0.35	8 0.23	7.2 0.12	274	208	—	7.6	L	.6	L	S
-4bbad	Well (a)	2- 3-69	H	—	—	0.02	40 2.00	11 0.90	20 0.87	176 2.88	0 0.00	27 0.56	5 0.14	10 0.16	174	144	—	7.2	L	.7	L	S
-10dccb	Well (445 ft) (a)	4-29-70	H	—	—	0.02	22 1.10	5 0.41	15 0.65	110 1.80	0 0.00	11 0.23	5 0.14	0.8 0.01	141	76	—	7.9	L	.8	L	S
-14addc	Well (497 ft) (a)	1- 4-65	G	54	12.0	0.03	58 2.89	14 1.18	(a)	253 4.15	0 0.00	21 0.44	10 0.28	19 0.31	307c	204	485	7.3	L	.7	L	S
-15aaba	Well (450 ft) (a)	4-28-70	H	—	—	0.00	24 1.20	4 0.33	13 0.56	105 1.72	0 0.00	11 0.23	5 0.14	0.8 0.01	146	76	—	7.8	L	.6	L	S
12/21-24bc	Pine Nut Creek (a)	12-22-56	R	—	—	—	50 2.50	9.5 0.78	(a)	194 3.18	11 0.37	25 0.52	3.9 0.11	—	234	164	395	8.6	L	.7	L	S
13/19-3ca	Sierra Canyon Creek (a)	12-13-56	R	—	—	—	20 1.00	2.7 0.22	(a)	92 1.51	0 0.00	2.4 0.05	0.7 0.02	—	103	61	160	8.4	L	.9	L	S
-9db	Genoa Canyon Creek (a)	12-13-56	R	—	—	—	16 0.80	2.9 0.24	(a)	75 1.23	2 0.06	6.7 0.14	0 0.00	—	110	52	146	8.7	L	.5	L	S
-22abc	Walley's Hot Spring (a)	11-10-59	G	146	63.5	0.01	9.6 0.48	0.5 0.04	(a)	12 0.20	24 0.80	200 4.16	46 1.30	0.3 0.00	492c	26	730	9.1	L	12	M	S
-27bbc	Daggett Creek (a)	12-12-56	R	—	—	—	11 0.55	2.6 0.21	(a)	68 1.12	0 0.00	1.0 0.02	0.4 0.01	—	92	39	121	8.2	L	.5	L	S
13/20-29cdcd	Well (398 ft) (a)	2- 3-69	H	—	—	1.4	22 1.10	3.9 0.32	12 0.52	93 1.52	0 0.00	16 0.33	5 0.14	2.2 0.04	123	72	—	8.1	L	.6	L	S
-32babc	Well (301 ft) (a)	2- 3-69	H	—	—	0.70	21 1.05	3.9 0.32	13 0.57	90 1.48	0 0.00	15 0.31	4 0.11	3.3 0.05	108	68	—	8.3	L	.7	L	S
13/21-28ccb	Well (95 ft)	5-14-70	G	58	14.5	—	29 1.45	9 0.73	35 1.53	140 2.30	0 0.00	57 1.19	8 0.23	—	—	109	360	7.8	L	1.5	L	S
13/22-29aa	Buckeye Creek (a)	17-21-56	R	—	—	—	27 1.35	9.5 0.78	(a)	142 2.33	0 0.00	42 0.87	3.9 0.11	—	253	106	330	8.3	L	1.0	L	S
14/19-23dd	Hobo Hot Spring (a)	5- 3-60	G	114	45.5	0.03	6 0.30	0.7 0.06	(a)	51 0.84	17 0.57	109 2.27	74 2.09	0 0.00	415c	18	662	8.9	L	13	H	S
14/20-21cdd	Saratoga Hot Spring	5-14-70	G	122	50.0	—	172 8.58	0 0.00	160 6.94	4 0.07	7 0.23	678 14.12	39 1.10	—	—	429	1,500	9.0	H	3.4	L	S
										EAGLE VALLEY												
15/19-13	Ash Canyon Creek (a)	11- 2-70	H	—	—	0.07	10 0.50	1 0.08	17 0.74	76 1.24	0 0.00	tr.	2 0.06	0.1 0.00	67	28	—	7.9	L	1.4	L	S
-13	Kings Canyon Creek (a)	11- 2-70	H	—	—	0.05	11 0.55	1 0.08	8 0.35	56 0.92	0 0.00	1 0.02	2 0.06	0.1 0.00	57	32	—	8.0	L	.6	L	S
15/20-7ddb	Well (515 ft) (a)	3-13-72	H	—	—	0.52	26 1.30	4 0.33	9 0.39	115 1.88	0 0.00	3 0.06	2 0.06	1.8 0.03	122	80	—	7.9	L	.4	L	S
-9acbal	Well (69 ft)	9-18-62	H	—	—	4+	54 2.70	20 1.64	494 21.48	717 11.75	0 0.00	312 6.50	272 7.67	0 0.00	2,700	216	—	7.9	H	15	VH	U
-17dd	Well (604 ft) (a)	11- 2-70	H	—	—	0.40	24 1.20	1 0.08	25 1.09	112 1.84	0 0.00	18 0.38	5 0.14	0.1 0.00	150	64	—	7.9	L	1.6	L	S
-32dcab	Well (375 ft) (a)	12-14-71	H	—	—	0.37	21 1.05	7 0.58	6 0.26	105 1.72	0 0.00	4 0.08	3 0.08	0 0.00	129	80	—	7.3	L	.3	L	S

Table 31.—Chemical analyses of well, spring, stream, and lake waters—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 litre (upper number) and milliequivalents per litre (lower number) 1/												Factors affecting suitability for irrigation 2/			
									DAYTON VALLEY													
15/20-1aa	Well (256 ft)	5-28-70	G	—	—	—	23 1.15	6 0.47	15 0.66	62 1.02	0 0.00	37 0.77	8 0.23	16 0.26	—	81	240	7.1	L	0.7	L	S
16/20-14,23, 24;and 16/21-18	Springs supplying J & R Game Ranch (combined flow)	12- 7-71	G	—	—	—	97 4.84	7 0.55	17 0.73	116 1.90	0 0.00	200 4.16	2 0.06	—	—	270	588	7.9	L	.4	L	S
16/20-25bb	Pond in Gypsum Quarry	5-28-70	G	60	15.5	—	651 32.48	98 8.08	0 0.00	81 1.33	0 0.00	1,810 37.68	55 1.55	—	—	2,030	3,400	8.0	VH	.0	L	S
16/21-24aa	Sutro Tunnel (a)	4-16-59	G	81	27.0	3.3	267 13.32	53 4.36	(a)	312 5.11	0 0.00	732 15.24	8.2 0.23	0 0.00	1,320c	884	1,650	7.6	H	1.0	L	S
-12acd	Well (265 ft)	7-11-72	G	95	35.0	—	120 5.99	0 0.00	170 7.52	49 0.80	0 0.00	570 11.87	30 0.84	—	—	300	1,280	7.8	H	4.3	L	S
-13bbb	Well (264 ft)	7-11-72	G	67	19.5	—	72 3.59	19 1.60	41 1.79	161 2.64	0 0.00	180 3.75	21 0.59	—	—	260	657	7.8	M	1.1	L	S
-22cb	Spring	6- 1-70	G	59	15.0	—	110 5.49	27 2.26	35 1.50	259 4.25	0 0.00	206 4.29	25 0.71	—	—	388	850	8.2	M	.8	L	S
-23acd	Well (250 ft*) (a)	3-13-69	N	—	—	0.13	67 3.34	17 1.48	64 2.78	193 3.16	0 0.00	170 3.54	19 0.54	22	435	240	—	7.4	M	1.8	L	S
-24bd	Well (135 ft) (a)	2-14-72	N	—	—	0.31	37 1.85	12 0.99	34 1.48	173 2.84	0 0.00	56 1.17	8 0.23	4.4 0.07	275	140	—	7.5	L	1.2	L	S
-29ab	Well (135 ft)	12- 6-71	G	—	—	—	132 6.59	22 1.80	44 1.91	250 4.10	0 0.00	280 5.83	13 0.37	—	—	420	911	8.2	M	.9	L	S
-29cd	Well (79 ft) (a)	7-10-69	N	—	—	0.04	413 20.61	26 2.14	52 2.26	154 2.52	0 0.00	1,060 22.07	16 0.45	1.7 0.03	1,810	1,140	—	7.6	H	.7	L	S
-29db	Well (85 ft)	5-28-70	G	—	—	—	448 22.36	39 3.21	5 0.21	208 3.41	0 0.00	995 20.72	35 0.99	41 0.66	—	1,280	2,200	7.6	H	.0	L	S
16/22-7bdb	Well (100 ft)	10- 6-67	N	80	26.5	0.13	102 5.09	1 0.08	42 1.83	149 2.44	0 0.00	192 4.00	21 0.59	0 0.00	583	260	—	7.7	L	1.1	L	S
-9ab	Well (145 ft) (a)	6- 5-72	N	—	—	0.03	35 1.75	13 1.07	49 2.13	166 2.72	0 0.00	80 1.67	16 0.45	5.2 0.08	320	140	—	7.8	L	2.2	L	S
-9bc	Well (600 ft)	6- 1-70	G	66	19.0	—	52 2.59	14 1.13	27 1.18	164 2.69	0 0.00	90 1.87	12 0.34	—	—	186	490	8.2	L	.9	L	S
-18ccc	Well (a)	3-20-72	N	—	—	0.01	72 3.59	16 1.32	67 2.91	195 3.20	0 0.00	187 3.89	15 0.42	22 0.36	471	248	—	7.8	M	1.9	L	S
-31cc	Eldorado Canyon Creek	2-19-72	G	52	11.0	—	40 2.00	12 1.02	46 1.98	218 3.57	2 0.07	52 1.08	10 0.28	—	—	151	467	8.4	M	1.6	L	S
17/22-28dba	Well (122 ft) (a)	1- 7-72	N	—	—	0.00	29 1.45	18 1.48	7 0.30	154 2.52	0 0.00	17 0.35	8 0.23	6.1 0.10	238	144	—	7.6	L	.2	L	S
-28dbd	Well (123 ft) (a)	1- 7-72	N	—	—	0.10	26 1.30	21 1.73	1 0.04	151 2.48	0 0.00	16 0.33	8 0.23	6.2 0.10	228	156	—	7.6	L	.0	L	S
-30ddb	Well (177 ft)	6- 3-70	G	—	—	—	139 6.94	36 2.93	27 1.18	161 2.64	0 0.00	369 7.68	26 0.73	—	—	494	1,000	7.6	M	.5	L	S
-32cd	Sixmile Canyon Creek	5-25-69	G	56	13.5	—	130 6.49	38 3.16	47 2.03	112 1.84	0 0.00	459 9.56	10 0.28	—	—	483	1,000	8.2	M	.9	L	S
-33ccbc	Well (633 ft)	7-13-72	G	69	20.5	—	48 2.40	19 1.60	42 1.81	136 2.23	0 0.00	160 3.33	9 0.25	—	—	200	566	7.9	M	1.3	L	S
-34bca	Well (500 ft)	7-20-72	G	67	19.5	—	52 2.59	24 2.01	36 1.56	195 3.20	0 0.00	130 2.71	9 0.25	—	—	230	587	8.1	M	1.0	L	S
-35bc	Well	7-21-72	G	64	18.0	—	32 1.60	12 1.00	30 1.31	174 2.85	0 0.00	40 0.83	8 0.23	—	—	130	393	8.1	M	1.1	L	S
17/23-2bd	Well (252 ft) (a)	3-16-72	N	—	—	0.02	45 2.25	14 1.15	42 1.83	173 2.84	0 0.00	63 1.31	30 0.85	12 0.19	341	168	—	8.1	L	1.4	L	S
-2bc	Well (305 ft) (a)	2- 2-72	N	—	—	0.69	6 0.30	0 0.00	42 1.83	24 0.39	8 0.27	49 1.02	13 0.37	2.8 0.04	152	16	—	9.0	L	4.7	L	S
-2bd	Well (300 ft) (a)	3-16-72	N	—	—	0.01	50 2.50	10 0.82	25 1.09	146 2.39	6 0.20	53 1.10	14 0.40	14 0.22	299	164	—	8.3	L	.8	L	S
-3bbb	Well (120 ft) (a)	9-12-71	N	—	—	0.00	32 1.60	15 1.23	54 2.35	156 2.56	0 0.00	83 1.73	30 0.85	1.1 0.02	335	140	—	8.2	L	2.0	L	S
-10baa	Well (300 ft) (a)	8-17-71	N	—	—	0.01	34 1.70	13 1.07	50 2.17	171 2.80	0 0.00	73 1.52	16 0.45	6.5 0.10	325	136	—	8.0	L	1.8	L	S
-10bcc	Well (198 ft) (a)	8-17-71	N	—	—	0.02	79 3.94	20 1.64	41 1.78	158 2.59	0 0.00	204 4.25	14 0.40	3.5 0.06	506	276	—	7.8	L	1.0	L	S
-11acc	Well (70 ft) (a)	8- 3-71	N	—	—	0.01	56 2.79	11 0.90	97 4.22	167 2.74	0 0.00	201 4.18	31 0.87	5.5 0.09	438	184	—	7.9	M	3.1	L	S
-11dcb	Well (165 ft*) (a)	6- 3-70	G	57	14.0	—	43 2.15	10 0.81	113 4.92	146 2.39	0 0.00	193 4.02	52 1.47	—	—	148	830	8.0	M	4.0	L	S
-27aba	Well (220 ft) (a)	9-12-71	N	—	—	0.00	43 2.15	29 2.38	122 5.30	107 1.75	0 0.00	179 3.73	155 4.37	0 0.00	597	288	—	8.1	M	3.5	L	S
-30baa	Well (510 ft) (a)	5-24-71	N	—	—	0.12	67 3.34	22 1.81	90 3.91	210 3.44	0 0.00	123 2.56	75 2.12	62 1.00	530	260	—	—	M	2.4	L	S
18/22-25da	Cooney Spring (a)	7-30-71	N	—	—	0.04	40 2.00	11 0.90	30 1.30	188 3.08	0 0.00	40 0.83	8 0.23	2.3 0.06	253	144	—	8.1	L	1.1	L	
18/23-33ccb	Corral Spring (a)	7-30-71	N	—	—	0.00	35 1.75	14 1.15	30 1.30	176 2.88	0 0.00	48 1.00	9 0.25	2.5 0.04	282	144	—	7.8	L	1.1	L	

Part A (continued)

Table 31.—Chemical analyses of well, spring, stream, and lake waters—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[2]	SAR[2]	Sodium hazard[2]	RSC[2]
							Milligrams per litre (upper number) and milliequivalents per litre (lower number)[1]												Factors affecting suitability for irrigation[2]			
CHURCHILL VALLEY																						
16/24-15bcd	Spring	6- 8-70	C	61	16.0	—	40 2.00	16 1.30	52 2.24	151 2.47	0 0.00	134 2.79	10 0.28	—	—	165	560	7.9	L	1.7	L	S
17/24-1cba	Well (200 ft) (a)	3- 3-70	N	—	—	0.30	37 1.85	4 0.33	68 2.96	162 2.66	0 0.00	89 1.85	21 0.59	0.4 0.01	352	108	—	7.7	L	2.8	L	S
-36aa	Well (63 ft) (a)	11-22-70	N	42	5.5	0.23	42 2.10	18 1.48	54 2.35	251 4.11	0 0.00	69 1.44	11 0.31	0 0.00	331	176	—	7.8	L	1.8	L	S
17/25-6dbb	Well (105 ft) (a)	4- 1-69	N	—	—	0.52	21 1.05	6.8 0.56	26 1.13	110 1.80	0 0.00	36 0.75	7 0.20	1.3 0.02	209	80	—	7.5	L	1.3	L	S
-18dddd	Well (150 ft) (a)	6-11-70	N	—	—	0.33	27 1.35	10 0.82	15 0.65	110 1.80	0 0.00	31 0.64	10 0.28	0 0.00	193	104	—	7.9	L	.6	L	S
18/24-25adb	Well (260 ft) (a)	6-12-69	N	—	—	0.00	43 2.15	16 1.30	56 2.44	142 2.33	0 0.00	124 2.58	27 0.76	14 0.23	412	172	—	7.7	L	1.9	L	S
-27cac	Well (300 ft*) (a)	8-17-71	N	—	—	0.02	47 2.34	11 0.90	49 2.13	134 2.20	0 0.00	107 2.23	26 0.73	10 0.16	364	160	—	7.9	L	1.7	L	S
-28dbc	Well (a)	8-17-71	N	—	—	0.01	56 2.79	11 0.90	25 1.09	127 2.08	0 0.00	110 2.29	8 0.23	11 0.18	354	184	—	7.9	L	.8	L	S
-32abc	Well (315 ft) (a)	9-12-71	N	—	—	0.06	88 4.39	20 1.64	39 1.70	158 2.59	0 0.00	227 4.73	12 0.34	3.5 0.06	526	300	—	7.8	M	1.0	L	S
18/25-4a	Well (380 ft)	6-12-67	N	—	—	2.4	157 7.83	1.6 0.13	49 2.13	561 9.20	0 0.00	4.8 0.10	32 0.90	0 0.00	860	400	—	6.6	M	1.1	L	M
-19cdc	Well (290 ft) (a)	6-12-69	N	—	—	0.13	40 2.00	15 1.23	36 1.56	151 2.48	0 0.00	65 1.35	24 0.68	12 0.19	346	160	—	8.0	L	1.2	L	S
CARSON DESERT																						
17/31-31ab	Rock Spring	8-19-70	C	68	20.0	—	—	—	—	394 6.46	0 0.00	—	1,300 36.67	—	—	—	5,340	8.2	VH	—	—	—
18/29-4bac	Kingman well (776 ft)	10- -58	(?)	82	28.0	—	8 0.40	1 0.08	350 15.18	480 7.87	12 0.40	43 0.90	230 6.49	—	950	24	1,850	8.0	H	31	VH	U
-23ccc	Truckee-Carson Irrigation Canal (a)	10- 2-56	G	70	21.0	1.4	21 1.05	4.4 0.36	(a)	84 1.38	0 0.00	29 0.60	6.8 0.19	1.8 0.03	145c	70	229	7.1	L	.9	L	S
18/30-12aca	Well (a)	8-15-63	G	60	15.5	—	6.8 0.34	0.5 0.04	(a)	784 12.85	47 1.57	876 18.24	5,420 152.90	37 0.60	11,200c	19	17,500	8.5	U	420	VH	U
-35dc	Well (100 ft)	8-19-70	G	—	—	—	—	—	—	—	—	—	1,400 39.49	—	—	—	5,680	—	VH	—	—	—
18/31-4da	Well (140 ft)	8-19-70	G	66	19.0	—	13 0.65	31 2.55	2,500 108.51	519 8.51	0 0.00	940 19.57	3,000 84.63	—	—	160	10,900	7.6	U	86	VH	U
-31ccc	Well (300 ft) (a)	1961(?)	N	—	—	3	1 0.05	1 0.08	(a)	423 6.93	12 0.40	495 0.10	2,155 60.79	—	4,820	6	—	8.7	VH	270	VH	U
19/27-12dc	Well (150 ft)	6-16-71	G	—	—	—	300 14.97	110 9.01	1,100 49.52	212 3.47	0 0.00	2,700 56.21	490 13.82	—	—	1,200	6,380	7.7	VH	14	VH	S
19/28-7dd	Soda Lake (a)	8-28-58	G	—	—	0.10	7.9 0.39	194 16.04	(a)	1,250 20.49	1,360 45.33	6,220 129.50	7,570 213.47	2.2 0.04	24,700c	822	31,800	9.6	U	130	VH	U
-22daa	Well (41 ft)	2-25-64	N	—	—	0.10	53 2.64	23 1.89	117 5.09	307 5.03	0 0.00	144 3.00	52 1.47	10 0.16	605	228	—	8.0	M	3.4	L	S
-22dab	Well (1,155+ft) (a)	12- 9-71	G	—	—	—	5 0.25	1 0.11	54 2.35	118 1.93	4 0.13	23 0.48	6 0.17	—	—	18	276	8.6	L	5.5	L	M
19/29-30cdb 1,2	Wells (combined flow; 506 and 521 ft)	9-29-69	N	—	—	0.10	—	—	(a)	356 5.84	23 0.77	164 3.41	84 2.37	0.6 0.01	424	28	—	9.3	M	21	VH	U
-30cdb1	Well (506 ft) (a)	5- 8-58	G	68	20.0	0.02	2 0.10	1.4 0.12	(a)	231 3.79	20 0.67	75 1.56	67 1.89	0.8 0.01	498c	11	821	8.8	M	23	VH	U
-31babc	Well (444 ft)	12- 9-71	G	—	—	—	8 0.40	1 0.08	58 2.51	124 2.03	0 0.00	38 0.79	6 0.17	—	—	24	316	8.0	L	5.1	L	M
-33cbb1	Well (540 ft) (a)	1-26-67	C	—	—	0.37	0.8 0.04	1.5 0.12	216 9.39	283 4.64	26 0.87	66 1.37	94 2.65	0.4 0.01	580	8	906	9.1	M	33	VH	U
19/30-30ccb	Well (15-19 ft) (a)	6- 9-69	N	—	—	0.18	35 1.75	18 1.48	350 15.22	237 3.88	0 0.00	129 2.69	420 11.85	0 0.00	1,110	160	—	8.1	H	12	M	S
-30ccc	Well (37 ft) (a)	1-15-69	N	—	—	0.10	1.6 0.08	42 3.45	7,840 341.04	1,650 27.04	24 0.80	7,750 161.36	5,500 155.16	30 0.48	21,400	176	—	8.2	U	260	VH	U
19/31-7dc	Well (204 ft)	11-23-71	G	Boiling		—	91 4.54	1 0.08	1,400 59.74	104 1.70	0 0.00	190 3.96	2,080 58.68	—	—	230	7,420	7.5	VH	39	VH	S
-11a	Well	10- 8-70	G	65	18.5	—	34 1.70	52 4.29	2,300 100.87	377 6.18	0 0.00	93 1.94	3,500 98.74	—	—	300	12,600	7.8	U	58	VH	S
20/28-1bd	Well (627 ft) (a)	2-26-69	N	—	—	12	78 3.89	24 1.96	(a)	372 6.10	0 0.00	340 7.08	2,720 76.73	7 0.11	5,320	293	—	8.1	U	47	VH	S
21/30-19cd	Carson River	10-18-71	G	37	3.0	—	32 1.60	10 0.80	78 3.41	178 2.92	0 0.00	91 1.90	35 0.99	—	—	120	615	8.3	L	3.1	L	S
-30ac	Well (985 ft)	10-13-71	G	63	17.0	—	4 0.20	1 0.10	600 26.19	554 9.08	37 1.23	100 2.08	500 14.10	—	—	15	2,930	8.7	H	68	VH	U
21/32-25cbc	Well	10- 8-70	G	—	—	—	170 8.48	33 2.71	130 5.77	111 1.82	0 0.00	470 9.78	190 5.36	—	—	560	1,820	7.6	H	2.4	L	S
22/33-15b	Well	10- 8-70	G	—	—	—	14 0.70	4 0.30	430 18.59	293 4.80	44 1.47	220 4.58	310 8.74	—	—	50	2,130	9.0	H	26	VH	U

Part A (continued)

Table 31.—Chemical analyses of well, spring, stream, and lake waters—Continued

Location	Source (with well depth where appropriate)	Date sampled	Analyst 3/	Temperature °F	Temperature °C	Milligrams per litre (upper number) and milliequivalents per litre (lower number) 1/: 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	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Factors affecting suitability for irrigation 2/: Salinity hazard	SAR	Sodium hazard	RSC
									PACKARD VALLEY AND WHITE PLAINS													
23/28-29dc	Well (44 ft)	10- 7-70	G	58	14.5	—	140 6.99	15 1.20	4,200 182.39	207 3.39	0 0.00	48 1.00	6,600 186.19	—	—	410	20,500	7.6	U	90	VH	S
24/29-26cd	Humboldt River drain	5- 1-72	G	58	14.5	—	50 2.50	30 2.50	370 16.05	361 5.92	5 0.17	220 4.58	370 10.38	—	—	250	2,090	8.5	H	10	H	S
		6-20-72	G	64	18.0	—	48 2.40	63 5.19	740 32.08	388 6.36	0 0.00	440 9.16	860 24.15	—	—	380	3,990	8.3	VH	20	VH	S
		2-28-73	G	50	10.0	—	82 4.09	110 8.70	1,700 75.16	202 3.31	12 0.40	930 19.36	2,300 64.88	—	—	640	8,000	8.6	U	30	VH	S
27/33-24ccd	Well	10- 8-70	G	—	—	—	110 5.49	40 3.30	100 4.50	189 3.10	0 0.00	110 2.29	280 7.90	—	—	440	1,450	7.9	H	2.1	L	S
28/34-31db	Spring	10- 8-70	G	63	17.0	—	66 3.29	14 1.11	50 2.18	134 2.20	0 0.00	75 1.56	100 2.82	—	—	220	692	7.6	L	1.5	L	S

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; C, Cook Research Lab.; H, Abbot A. Hanks, Inc.; M, Morse Laboratories; N, Nevada State Health Div.; R, U.S. Bur. Reclamation.

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 B of this table.

Table 31.—Chemical analyses of well, spring, stream, and lake waters—Continued

Part B.—Additional determinations from detailed chemical analyses

Location	Silica (SiO_2)	Manganese (Mn)	Arsenic (As)[6]	Sodium (Na)	Potassium (K)	Fluoride (F)[6]	Phosphate (PO_4)	Boron (B)
	Milligrams per litre (upper number) and milliequivalents per litre (lower number)[1]							
CARSON VALLEY								
11/19-12ad	—	—	—	3.5 0.15	2 0.05	—	—	0.00
12/19-3ca	—	—	—	4.6 0.20	2 0.05	—	—	0.04
-14cb	—	—	—	4.4 0.19	0.4 0.01	—	—	0.03
-26dad	—	—	—	3.2 0.14	1.6 0.04	—	—	0.01
12/20-4baad	—	—	0.00	—	—	0.1 0.01	—	—
-4bbad	—	—	0.00	—	—	0.1 0.00	—	—
-10dccb	—	—	0.00	—	—	0.1 0.00	—	—
-14addc	33	0.00	—	24 1.04	3 0.08	0.1 0.01	—	0.30
-15aaba	—	—	tr.	—	—	 0.00	—	—
12/21-24bc	—	—	—	20 0.87	2.3 0.06	—	—	0.17
13/19-3ca	—	—	—	7.1 0.31	1.6 0.04	—	—	0.00
-9db	—	—	—	8.3 0.36	2 0.05	—	—	0.14
-22abc	61	—	—	137 5.96	2.9 0.07	5.0 0.26	0.06	—
-27bbc	—	—	—	7.1 0.31	2.7 0.07	—	—	0
13/20-29cdcd	—	—	0.005	—	—	0.1 0.01	—	—
-32babc	—	—	0.01	—	—	0.1 0.01	—	—
13/22-29aa	—	—	—	25 1.09	4.3 0.11	—	—	0.13
14/19-23dd	47	0.00	0.00	125 5.44	1.7 0.04	7.1 0.37	0.01	1.5
14/20-21cdd	20	—	—	—	—	—	—	—
EAGLE VALLEY								
15/19-13 Ash Canyon Creek	—	—	0.00	—	—	0.1 0.01	—	—
15/19-13 Kings Canyon Creek	—	—	0.00	—	—	0.1 0.01	—	—
15/20-7ddb	—	—	0.00	—	—	0.1 0.01	—	—
-17dd	—	—	0.015	—	—	0.5 0.03	—	—
-32dcab	—	—	tr.	—	—	0.2 0.01	—	—
DAYTON VALLEY								
16/21-24aa	34	1.2	—	67 2.91	4.6 0.12	0.6 0.03	0.00	0.03
-23acd	—	—	0.00	—	—	0.1 0.01	—	—
-24bd	—	—	0.005	—	—	0.2 0.01	—	—
-29cd	—	—	0.00	—	—	0.4 0.02	—	—
16/22-9ab	—	—	0.00	—	—	0.3 0.02	—	—
-18ccc	—	—	0.005	—	—	0.3 0.02	—	—
17/22-28dba	—	—	0.00	—	—	0.1 0.01	—	—
DAYTON VALLEY—Continued								
17/22-28dbd	—	—	0.00	—	—	0.1 0.01	—	—
17/23-1bd	—	—	0.01	—	—	0.2 0.01	—	—
-2bc	—	—	tr.	—	—	0.2 0.01	—	—
-2bd	—	—	0.01	—	—	0.1 0.01	—	—
-3bbb	—	—	0.00	—	—	0.3 0.02	—	—
-10baa	—	—	0.01	—	—	0.1 0.01	—	—
-10bcc	—	—	0.01	—	—	0.2 0.01	—	—
-11acc	—	—	0.005	—	—	0.2 0.01	—	—
-27aba	—	—	0.005	—	—	0.1 0.01	—	—
-36baa	—	—	0.005	—	—	0.2 0.01	—	—
18/22-25da	—	—	0.005	—	—	0.1 0.01	—	—
18/23-33ccb	—	—	0.02	—	—	0.2 0.01	—	—
CHURCHILL VALLEY								
17/24-1cba	—	—	0.025	—	—	0.4 0.02	—	—
-36aa	—	—	0.00	—	—	0.3 0.02	—	—
17/25-6dbb	—	—	tr.	—	—	0.3 0.02	—	—
-18dddd	—	—	tr.	—	—	0.2 0.01	—	—
18/24-25adb	—	—	0.005	—	—	0.2 0.01	—	-
-27cac	—	—	0.01	—	—	0.1 0.01	—	—
-28dbc	—	—	tr.	—	—	0.1 0.01	—	—
-32abc	—	—	0.015	—	—	0.5 0.03	—	—
18/25-19cdc	—	—	0.00	—	—	tr.	—	—
CARSON DESERT								
18/29-23ccc	20	0.00	—	18 0.78	2.4 0.06	0.5 0.03	—	—
18/30-12aca	35	—	—	4,180 181.83	154 3.94	5.2 0.27	—	36
18/31-31ccc	46	—	—	2,020 87.65	95 2.43	—	—	—
19/28-7dd	3.3	0.00	0.00	8,610 374.54	39 1.00	7.9 0.42	12	51
19/29-30cdb1,2	—	0.00	0.04	250 10.88	8.8 0.22	0.6 0.03	—	—
-30cdb1	31	0.00	—	175 7.57	8.4 0.21	0.8 0.04	0.9	0.04
-33cbb1	18	0.00	0.07	—	—	0.8 0.04	—	—
19/30-30ccb	—	—	0.01	—	—	0.6 0.03	—	—
-30ccc	—	—	>1.0	—	—	—	—	—
20/28-1bd	—	0.00	0.021	1,840 80.04	112 2.86	1.2 0.06	—	—

1. See footnote 1, p. 73.

6. Concentrations reported as "trace amount" are indicated by "tr."

Constituent	Recommended maximum concentration (milligrams per litre)
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	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 fixtures 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 and to cause bone changes, especially those of children, and a large amount of nitrate is dangerous during pregnancy and infancy because it may increase the susceptibility to "blue-baby" disease.

The arsenic concentration of drinking water is particularly important because of the possibility of long-term poisoning. The U.S. Public Health Service standards (1962, p. 8), state that arsenic should not exceed 0.05 mg/l in drinking water.

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. The rating scale below commonly is used for hardness.

Hardness, as $CaCO_3$ (milligrams per litre)	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 31 show that suitable water is available in all the valleys, but that problem areas do exist. The individual problems are discussed in later sections dealing with the specific hydrographic areas.

Suitability for Agricultural Use

In evaluating the suitability of a water for irrigation, the most critical considerations include dissolved-solids concentration, the relative proportion of sodium to calcium plus magnesium, and the abundance 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 31, and are discussed briefly in footnote 2 of that table. Minor amounts of boron (as much as 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).

Most animals are more tolerant of poor water than man. Although available data are somewhat conflicting, a dissolved-solids concentration 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.

Specific problems relating to suitability of water for agricultural use are discussed later by hydrographic areas.

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 Advisory Committee (1968, p. 185-215) discuss the subject in detail. Much of the water of the Carson River basin is acceptable for most industrial uses, but other waters probably are not, on the basis of particular water-quality problems discussed below.

Sewage

Sewage effluent is rapidly becoming a significant part of the hydrologic environment of the Carson River basin. Recent accelerated urbanization within the basin with its accompanying increases in sewage wastes (table 32), as well as recent dramatic increases in sewage effluent imports from the Lake Tahoe basin (table 20) emphasize the increasing importance of sewage to this study area, particularly regarding its effects on water quality.

Sewage is generally collected for treatment and disposal in the major municipalities. In some small communities, some suburban areas, and all rural areas, individual dwellings and establishments dispose of their own individual sewage. In a minority of the individual disposal systems, untreated sewage is directly discharged to the Carson River or its major tributaries. In most places, individual discharge involves injection of untreated sewage into septic tanks, the effluent from which then percolates to ground water and, depending on a variety of circumstances, may ultimately discharge to streams. The degree to which contaminants are removed from ground water prior to its discharge to streams depends on the type of contaminants, the specific nature of the ground-water reservoir materials, the hydraulics of the flow system, the quantity of contaminants, and the rate and duration of injection.

The collected sewage is generally delivered to a treatment plant where, prior to final discharge, it receives different degrees of treatment depending on each plant's designed capability. The several treatment plants in the Carson River basin utilize at least primary and in many facilities secondary treatment techniques.

Data necessary but generally unavailable to evaluate the short- and long-term effects of sewage discharge on the environment throughout the basin are (1) continuous records of quantities of discharge from municipal plants, (2) continuous records of discharge of sewage imports to the river and to other sources, (3) continuous records of detailed chemical and biological makeup of sewage discharge, and (4) various types of hydrologic data on the components of the hydrologic system that are involved in the disposal of sewage.

Estimated sewage totals for 1971 in tables 20 and 32 show that the volume processed by seven treatment plants in the Carson basin was about equal to the amount of treated effluent imported from the Lake Tahoe basin.

Table 32.--*Estimated quantities of sewage processed by treatment plants within the Carson River basin*

Treatment system	Disposition of treated effluent[1]	Quantity of water processed (acre-feet)				
		1967	1968	1969	1970	1971
Gardnerville-Minden[2]	Evaporation plus seepage, and discharge to Carson River	—	—	—	—	560
Stewart[3]	Evaporation plus seepage, and discharge to Clear Creek	70	70	70	70	70
Nevada Medium Security Prison[4]	Evaporation plus seepage, and discharge to Clear Creek	—	—	—	—	32
Carson City[5]	Evaporation plus seepage, and discharge to Carson River	1,570	1,480	1,870	2,010	2,100
Virginia City[6]	Evaporation plus seepage, and discharge to Sixmile Canyon	—	—	—	—	56
Fallon[7]	Evaporation plus seepage, and discharge to Carson Desert alluvium	—	—	—	420	480
U.S. Naval Air Station, Fallon[8]	Evaporation plus seepage, and discharge to Carson Desert alluvium.	320	340	300	300	300
Total (rounded)		—	—	—	—	3,600

1. Some unknown quantity probably enters ground-water system in all systems.

2. C. A. Altemueller (Minden-Gardnerville Sanitation Dist. Engineer, oral commun., 1971) estimates that an average of 500,000 gallons per day is processed; he also estimates that about 30 percent of this is ground water that leaks into sewer mains.

3. Quantity from Worts and Malmberg (1966, p. 26) because population and water use apparently have not changed appreciably since that time.

4. Quantity based on an average population of 375 (Walter Mandeville, Prison employee, oral commun., 1971) and 70 percent of water supplied.

5. Flow into plant is metered. James Dunn (City employee, oral commun., 1971) stated that these metered quantities are conservative estimates because during peak-load periods the maximum inflow meter rate is exceeded. Quantities include an unknown amount of ground water that leaks into sewer mains.

6. Estimated quantity based on estimated average resident and tourist populations of 450 and 200. Collection system does not include communities of Gold Hill or Silver City.

7. Quantities are metered inflow to treatment plant.

8. Quantities based on Public Works office estimate that an average of 70 percent of utilized water supply is processed as sewage.

Table 32 suggests that during 1971 nearly 2,800 acre-feet of varyingly treated sewage was discharged into the Carson River from treatment plants within the basin. The greatest quantity of imported sewage effluent reaching the river during 1971 from any single source probably was that from the Douglas County Water Reclamation Project plant which discharged about 520 acre-feet to Daggett Creek. However, a substantial amount of that 520 acre-feet may have been consumed by evapotranspiration before reaching the river, because an unknown amount of Daggett Creek flow is used for irrigation during the growing season. According to Cliff Girbon, Jr., an employee at the Incline Village General Improvement District treatment plant (oral commun., Dec. 1971), more than 97 percent of the treated effluent transported through that system was utilized by the U.S. Bureau of Land Management for stockwatering, and by the Harry Schneider ranch for irrigation in Jacks Valley. The South Tahoe Public Utility District delivers its tertiary-treated effluent to Indian Creek reservoir (table 11) and some is used for irrigation of nearby agricultural lands (Record-Courier, 1972).

An unknown amount of the sewage effluent generated within and imported to the basin percolates into the ground-water reservoir from storage facilities and irrigation systems.

Specific effects of sewage effluent on surface-water quality within the report area are discussed below.

Carson River

Mainstem

Table 33 is a summary of selected chemical data collected at five locations along the Carson River from 1966 through 1971 by the Nevada Bureau of Environmental Health. The tabulation is based on about 55 monthly samples from each station.

Several trends suggested by the data are (1) average water temperatures gradually increase downstream, and temperature maxima are roughly equal at the three mainstem sites but are appreciably higher than the maxima at the two tributary sites; (2) average nitrate concentrations at the three mainstem sites are similar, and at least twice as great as those of the two tributary sites; (3) average orthophosphate concentrations at the mainstem sites far exceed those of the upstream tributary sites; (4) average dissolved-solids concentrations progressively increase downstream; (5) pH values vary little from site to site; and (6) minimum dissolved-oxygen concentrations generally decrease downstream to New Empire.

The marked increases in nutrient (nitrate and orthophosphate) concentrations between the tributary forks and New Empire are probably the result of (1) agriculture-related input (fertilizers and animal wastes) mainly in Carson Valley, and (2) the inflow of sewage effluent in Carson Valley and from the Carson City sewage treatment plant. The marked decrease in orthophosphate concentrations between New Empire and Weeks may be the result of biologic and nonbiologic assimilation. The general downstream decrease in dissolved-oxygen minima to New Empire probably is a rough indication of increased biochemical oxygen demand caused by agricultural and sewage inflows.

Table 33.--*Summarized water-quality data for sites on Carson River, July 1966 to December 1971* 1/

[Data from Nevada Bureau of Environmental Health]

Site (approximate location in downstream order; not shown on plate 1)	Temperature °F	Temperature °C	Chloride (Cl)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved solids (residue at 105°C)	pH	Dissolved oxygen
	Maximum, minimum, and average values for samples collected about monthly (in milligrams per litre, except for temperature and pH)							
West Fork	66	19.0	8	3.7	0.21	120	8.2	12.1
Carson River	32	0.0	1	.0	.00	25	7.4	7.5
near Highway 88	47	8.5	2	.3	.06	59		9.8
(11/20-19ab)								
East Fork	71	21.5	12	12	0.33	173	8.9	12.9
Carson River at	32	0.0	1	.0	.00	54	7.4	7.6
Lahontan Fish	50	10.0	5	.6	.09	112		10.4
Hatchery (12/20-23dd)								
Carson River at	85	29.5	19	9.6	1.1	275	8.1	11.4
Cradlebaugh	32	0.0	1	.0	.15	67	7.2	5.8
Bridge	52	11.0	7	1.2	.43	164		8.7
(14/20-30db)								
Carson River	85	29.5	28	7.7	9.2	582	8.6	17.5
near New	32	0.0	1	.0	.27	82	7.4	4.1
Empire	54	12.5	11	1.5	1.3	228		9.7
(15/20-12bc)								
Carson River	81	27.0	18	14	1.7	416	8.3	11.9
at Weeks	32	0.0	1	.0	.10	92	7.4	6.5
(17/24-35da)	56	13.5	10	1.4	.45	237		9.7

1. Samples collected on a once-a-month basis with frequency distribution of sampling generally as follows: July-October 1966; July-December 1967; 1968, monthly; 1969, monthly; January-October 1970; and 1971, monthly.

The U.S. Geological Survey has analyzed numerous samples of Carson River water collected near Fort Churchill (17/24-32dc) as part of its irrigation network sampling program. These data have been collected for about 10 years and are published annually in the Geological Survey's publication titled "Water Resources Data for Nevada."

Some early (1906-7) chemical data on Carson River water were obtained just downstream from the confluence of the Truckee Canal and the river, near the present site of Lahontan Dam (Stabler, 1911, p. 23-25). These data represent the combined flow of the Truckee Canal and the Carson River, and provide some insight to the quality of Newlands Irrigation Project water supply at an early period of the project's history.

Carson River water is temporarily stored in Lahontan Reservoir. Its dissolved chemical load may be slightly concentrated during storage, according to Rollins (1965, p. 10) and Clyde-Criddle-Woodward, Inc. (1971, p. 26). However, summary data of table 34 suggest a decrease in dissolved-solids concentration of reservoir water compared to that of the inflow at Weeks (table 33). This apparent decrease may exist because sampling of reservoir water was restricted to spring and summer months when the effects of fresh seasonal inflow would most likely dominate near the reservoir surface, whereas summary data for the inflow more nearly reflects the average of varying conditions throughout the year. The increased chemical concentration of water within the main body of the reservoir, if such is indeed the case, is at least partly offset near Lahontan Dam by the inflow of characteristically more dilute water from the Truckee Canal (Rollins, 1965, p. 10).

Below Lahontan Dam, the dissolved-solids concentration of the Carson River increases markedly downstream mainly because of inflowing irrigation drainage (Rollins, 1965, p. 16, and Clyde-Criddle-Woodward, Inc., 1971, App. A, table 6). However, some of the increase during periods of low river stage may also be from inflow of shallow saline ground water, plentiful in the Carson Desert area.

Mercury, normally a trace constituent of stream waters, is of special concern in the Carson River. Before 1900, about a dozen mills along the river used mercury in the so-called "Washoe Process" for the milling of silver and gold ore from the Comstock Lode. During that time, almost 15 million pounds of the mercury escaped recovery (Smith, 1943, p. 257), much of it being incorporated in the mill tailings. Today, downstream from the millsites, measured concentrations of mercury are as much as 200 times the normal "background" level in shallow, fine-grained sediment from the bottom of streams, canals, and Lahontan Reservoir (Van Denburgh, 1973, p. 3). The greatest concentrations have been encountered in sediments of the Carson River, within and immediately upstream from the reservoir. Data for the river near Fort Churchill suggest that most of the shallow mercury may be present as mercuric sulfide or as a component of non-methyl organic compounds.

Table 34.--*Summarized water-quality data for Lahontan Reservoir, July 1966 to July 1971* 1/

[Data from Nevada Bureau of Environmental Health]

Site (approximate location in downstream order; not shown on plate 1)	Maximum, minimum, and average values for samples collected occasionally during spring and summer months 2/ (in milligrams per litre, except for temperature and pH)							
	Temperature °F	°C	Chloride (Cl)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved solids (residue at 105°C)	pH	Dissolved oxygen
17/25-22	82	28.0	12	1.7	0.76	200	8.8	16.0
	50	10.0	1	.0	.28	118	7.5	5.4
	70	21.0	6	.7	.44	165		9.2
18/25-20	77	25.0	12	4.8	0.85	223	8.6	9.6
	54	12.5	1	.0	.20	118	7.6	6.1
	65	18.5	6	1.4	.48	164		7.8
18/25-24	77	25.0	16	4.8	1.0	238	8.9	10.6
	50	10.0	1	.0	.13	116	7.6	6.4
	66	19.0	8	1.6	.47	163		7.9
19/26-33	74	23.5	17	10	1.6	183	8.7	9.2
	52	11.0	1	.0	.30	119	7.5	5.0
	66	19.0	10	2.2	.79	151		7.5

1. This summary updates the tabulation of Katzer (1972) with the addition of 1970 and 1971 data.
2. Data based on about 14 samples collected only during spring and summer months as follows: 2 in 1966; 2 in 1967; 4 in 1968; 4 in 1969; 1 in 1970; and 1 in 1971. Samples collected from boat; sample depth 0-1 foot.

Among stream waters sampled in 1971-72, about 70 percent contained less than 1 μg/l (microgram per litre) of total mercury (Van Denburgh, 1973, table 2). The maximum measured quantity was 6.3 μg/l, for the Carson River near Fort Churchill during the spring snowmelt runoff. (The interim limit for drinking water, established by the U.S. Environmental Protection Agency (1975, p. 11994), is 2 μg/l of mercury.) At the highest concentrations, most of the mercury was associated with suspended sediment in the stream, rather than being dissolved. In areas of mercury-rich stream-bottom sediment, peak discharges in May 1973 that were greater than the relatively low flows of 1971-72 produced greater total-mercury concentrations in the streamflow (A. S. Van Denburgh, U.S. Geol. Survey, oral commun., 1973). A recent investigation by the College of Agriculture, University of Nevada, shows no evidence of mercury accumulation ("magnification") in terrestrial plants or animals from the Carson River basin (Dr. H. G. Smith, written commun., 1972). In contrast, a similar study by the Nevada Department of Fish and Game has shown that fish in the mercury-affected lakes and streams contain greater-than-background concentrations (R. C. Sumner, oral commun., 1972).

In the future, increased nutrient contributions to the river from sewage treatment plants may in turn increase the "accessibility" of the mercury now present in the bottom sediments, through chemical transformations associated with biologic activity. The presence of mercury in the river-bottom sediments raises the question of whether toxic amounts might thus enter the food chain of high-order organisms.

Tributaries

Table 31 includes data from several small tributary streams in Carson Valley. The dissolved-solids concentrations of 7 streams draining the Sierra Nevada on the west side of the valley range from 36 to 110 mg/l, whereas samples from two streams draining the Pine Nut Mountains on the east side have concentrations of 234 and 253 mg/l.

The Bryant Creek basin, mainly in California but tributary to the East Fork Carson River in the upstream part of Carson Valley in Nevada, has been a source of concern regarding pollution. Bryant Creek and some of its tributaries are reportedly polluted by acid mine drainage from the Leviathan Sulfur Mine (California Water Resources Control Board, written commun., 1970). As a Carson River tributary, any localized pollution problems of Bryant Creek are subsequently transmitted in some degree to the Carson River. Bryant Creek normally furnishes only a minor part of the total flow of East Fork Carson River; therefore pollutants transported by Bryant Creek are generally subject to substantial dilution by river flow. Localized flooding of Bryant Creek at a time of low river flow might pose a downriver pollution hazard because of insufficient dilution of Bryant Creek runoff.

Tables 35 and 36 summarize available data on the quality of tributary inflow to the Carson River where treated sewage effluent is a component of the inflow. Table 35 shows the changes in the quality of Daggett Creek when treated sewage effluent from the Douglas County Water Reclamation Project was added in the 1969 water year (table 20). The concentrations of chloride, nitrate, orthophosphate, and dissolved solids all increased after sewage effluent was introduced. However, the lack of great change in the minimum concentrations of some of these constituents reflects the intermittent manner in which the treated effluent is introduced into the creek. The general chemical character of Daggett Creek about a decade before introduction of treated sewage effluent is shown in table 31.

Table 35.--*Summarized water-quality data for Daggett Creek, August 1966 to December 1971* 1/

Sampling period	Temperature °F	Temperature °C	Chloride (Cl)	Nitrate (NO_3)	Ortho-phosphate (PO_4)	Dissolved solids (residue at 105°C)	pH	Dissolved oxygen
	Maximum, minimum, and average values for samples collected about monthly (in milligrams per litre, except for temperature and pH)							
August 1966 - September 1968 2/	60	15.5	12	8.7	0.10	100	8.2	11.8
	34	1.0	3	.0	.00	63	7.5	7.3
	49	9.5	5	.9	.04	87		9.1
October 1968 - December 1971 3/	64	17.5	77	27	24	283	8.2	11.9
	32	.0	1	.0	.46	67	7.5	8.1
	47	9.0	15	5.5	6.0	126		9.6

1. Sampling site not shown on plate 1 (13/19-27bbd). Data furnished by Nevada Bureau of Environmental Health.

2. Data based on 18 samples collected as follows: 2 in 1966, in August and October; 7 in 1967, monthly from June to December; 9 in 1968, monthly.

3. Data based on 37 samples collected as follows: 3 in 1968, monthly; 12 in 1969, monthly; 10 in 1970, monthly from January to October; 12 in 1971, monthly.

A few data, not included in table 31, collected on streamflow of Gold Canyon and Sixmile Canyon Creeks in Dayton Valley during brief periods of rainfall and snowmelt runoff, suggest that the dissolved-solids concentration of these streams is frequently greater than the average of those in the Carson River basin. The data show that the water is very hard and occasionally contains appreciable quantities of sulfate. In these respects, the streamflow is chemically similar to ground water in Dayton Valley, as discussed in a later section of this report.

The final vestiges of Humboldt River flow dominate surface drainage in White Plains. Sample data of this water are included in table 31. However, the two samples may not be representative of average water quality. Humboldt River water that survives evaporation during its transit through White Plains flows into the Carson Sink and merges with any residual of Carson River flow. It then becomes more chemically concentrated through solution of playa salts in the Carson Desert and by evaporation.

The Packard Valley area has no perennial streams that reach the valley fill. No known data are available to characterize the chemical quality of ephemeral runoff in the area.

Table 36.--*Summarized water-quality data for some Carson River tributaries that convey treated sewage* 1/

Tributary and sampling site (location not shown on pl. 1)	Maximum, minimum, and average values for samples collected about monthly (in milligrams per litre, except for temperature and pH)							
	Temperature °F	Temperature °C	Chloride (Cl)	Nitrate (NO_3)	Ortho-phosphate (PO_4)	Dissolved solids (residue at 105°C)	pH	Dissolved oxygen
Ditch to East Fork Carson River from Gardnerville-Minden sewage treatment plant (13/19-24cdd) 2/	83	28.5	18	5.1	8.5	316	8.5	13.7
	45	7.0	2	.2	.88	127	7.4	2.9
	61	16.0	9	1.7	2.0	233		8.8
Clear Creek at mouth (14/20-10bbb) 3/	81	27.0	17	0.8	1.7	339	8.2	10.3
	36	2.0	1	.0	.35	86	7.6	5.6
	56	13.5	10	.3	.72	155		8.8
Sewage effluent ditch below Carson City sewage treatment plant (15/20-15cbb) 4/	60	15.5	31	2.6	25	398	8.0	7.5
	38	3.5	24	1.1	12	321	7.6	5.4
	48	9.0	27	1.7	18	361		6.7
Mexican Ditch, including Carson City effluent, at confluence with Carson River (15/20-11bdc) 5/	79	26.0	26	1.6	13	343	8.0	12.8
	45	7.0	8	.7	.40	186	7.4	5.1
	59	15.0	16	1.2	5.5	251		8.3

1. Data furnished by Nevada Bureau of Environmental Health.
2. Data based on 11 samples collected as follows: 1 in November 1970; 10 on a monthly basis from January to October 1971.
3. Data based on 11 samples collected monthly from January to November 1971.
4. Data based on 3 samples collected in October, November, and December 1971.
5. Data based on 10 samples collected as follows: 1 in November 1970; 9 on a monthly basis from January to September 1971.

Newlands Reclamation Project Irrigation Water

Rollins (1965) described the water quality of the Newlands Reclamation Project as of 1960. Although the study was done in a restricted time period (1959-61) during which the river flows were below average (Rollins, 1965, p. 6), the results and conclusions of the study also may be valid for years of average or above average water-supply conditions. A brief summary of Rollins' conclusions are as follows (1965, p. 17 and 18): (1) The irrigation water is of good chemical quality, having a medium salinity hazard and practically no sodium hazard; (2) the drainage waters are higher in dissolved solids and percent sodium than the irrigation water; (3) drainage waters further increase in salt concentration as they flow downstream; (4) drains in the center of the project, particularly south of the Carson River, are free from excessive salt but pick up salt rapidly as they approach the Carson Lake and Carson Sink areas; (5) conversely, drains immediately north of the Carson River carry high salt concentrations; (6) seasonal water-quality changes are more pronounced in the drainage water than in the irrigation supply; (7) some drainage is of an acceptable quality for further use as an irrigation supply, whereas other drainage is unacceptable; (8) reduction in the quantity of the irrigation supply would be expected to increase the concentrations of dissolved solids and sodium in drainage waters; (9) irrigation waters now being used in the project area probably would not harm most canal liners being used, although some of the drainage waters with highest dissolved-solids concentrations could shorten the life of some liners; (10) soil salinity and alkalinity are nearly stabilized under the existing (1960) irrigation and drainage systems; (11) over-irrigation should be prevented to avoid excessive rises in ground-water levels; and (12) chemical quality of the irrigation water supply probably has not changed since the project began (1905), but the quality of drainage water has probably improved over the long term (that is, greater quantities of salt were removed by drainage water during early years of the project than are being removed now).

A considerable amount of data on chemical quality of Newlands Project irrigation water and drainage has also been collected during the last several decades by the U.S. Bureau of Reclamation (J. Gallagher, oral commun., 1971), and is available in the files of the Bureau of Reclamation office in Carson City. A salt-balance study of irrigation water and lands by the U.S. Bureau of Reclamation (unpublished report, 1967) suggests that more salts left the irrigated area by drainage return flow than entered the area in the irrigation supply. Therefore, irrigation practice was leaching salts from the soils.

Ground Water

Carson Valley

The valley-fill deposits of Carson Valley form the major storage reservoir of high-quality ground water in the Carson River basin (table 31). The water stored in these deposits may well be the major future source of supply for a large urban populace in this part of western Nevada. Walters, Ball, Hibdon, & Shaw (1970) discussed the quality of ground water in Carson Valley as part of their study for the Carson Water Company. Their report indicates (p. 10) that the ground water is generally excellent. They also concluded (p. 34) that the central and western parts of the valley apparently contain the best quality ground water.

Wells in the Hot Springs Mountain area, 8 miles north of Minden (pl. 1), particularly deep wells, generally produce the poorest-quality water known in the valley. This localized area of poor-quality water may be related to deeply circulating, high temperature, minerallized water from sources associated with Saratoga Hot Springs (14/20-21cdd, pl. 1).

The Stewart area historically has had problems with excess iron in the ground-water supply. The problem is spotty, though, and not all wells yield water containing high concentrations of iron.

Eagle Valley

Worts and Malmberg (1966, p. 35) categorized Eagle Valley water as "generally satisfactory for irrigation, domestic, and most common uses." Guyton & Associates (1967, p. ii) rated Eagle Valley water quality as "generally good." However, Carson Water Co. well 15/20-17dd, drilled in 1969, yields water that apparently contains a small amount of hydrogen sulfide, which imparts an objectionable taste and smell.

Analyses of water from well 15/20-9da in Worts and Malmberg (1966, table 12) and well 15/20-9acbal (table 31, this report) suggest that poor-quality ground water occurs in the New Empire area of northeast Carson City.

Dayton Valley

Ground-water quality in Dayton Valley varies greatly from place to place (table 31). Miller and others (1953, p. 34) published a small amount of Dayton Valley water-quality data.

Several acute water-quality problem areas exist in Dayton Valley. Ground water in the Pinion Hills suburban area just east of the Carson River near Carson City is of very poor quality. A January 7, 1971, memorandum from the Nevada Bureau of Environmental Health to Pinion Hills residents categorized most of the ground water in the area as "hot mineralized water in a cemented gravel strata," and having the following general chemical composition:

Constituent or property	mg/l
Iron	0.4
Calcium	280
Sodium	200
Sulfate	900
Fluoride	4.2
Total dissolved solids	1,500
Total hardness	600

The mineralized and thermal character of this water suggests that is is associated with a deeply circulating ground-water system. The surface venting of this hot water (about 45°C) probably is related to geologic structure. However, several wells in the southwest part of the subdivision produce cool water with a dissolved-solids concentration of only about 300 mg/l. This cool water (about 18°-20°C) is of generally acceptable quality for most uses on the basis of presently available information. These wells probably produce from aquifers more closely associated with the Carson River flow system than with the deep-circulation system described above.

Poor-quality ground water also occurs north of the Carson River from the Mound House area eastward to the junction of Nevada State Route 17 and U.S. Highway 50 (pl. 1). This water is characterized mainly by high concentrations of calcium (100 to at least 600 mg/l), sulfate (500 to at least 2,000 mg/l), and dissolved solids (1,000 to at least 3,000 mg/l), which apparently are related to gypsum-rich rocks and alluvial deposits in the immediate area. Geology of these gypsum deposits was discussed by Lincoln (1923, p. 129) and Archbold in Moore (1969, p. 34). Many of the residents in the Mound House area are supplied by a community water system fed by springs of better-quality water from the Virginia Range to the north (Mrs. Julius Bunkowski, oral commun., 1971).

Much of the water used for domestic purposes in the community of Dayton comes from shallow wells in town. The chemical character of water from one well serving several homes and the community center building is shown by analysis 16/21-23acd in table 31. These and other data show that the water is high in dissolved solids (400 to at least 500 mg/l) and sulfate (150 to at least 250 mg/l), and is hard (200 to 300 mg/l).

Ground waters within Dayton Valley east of Dayton and north-northwest of the Carson River, although locally variable in quality, are also commonly characterized by moderately high dissolved solids (as much as 600 mg/l), sulfate (as much as 300 mg/l), and hardness (as much as 300 mg/l). This condition is prevalent not only near Sixmile Canyon but also in the Stagecoach subarea about 15 miles northeast of Dayton. The character of this ground water strongly suggests that mineralization in the Virginia Range is a dominant chemical influence. The Virginia Range probably is the main recharge area for most of the ground water.

Chemical data are scanty south and southwest of the Carson River in Dayton Valley. The few available analyses are restricted to wells east of Dayton in T. 16 N., Rs. 21 and 22 E., and suggest that ground water may generally be somewhat more dilute than that across the river. If so, the difference may reflect a contrast in geochemical control of ground water in the Pine Nut Mountain recharge province compared to that of the Virginia Range.

A somewhat anomalous situation exists with regard to nitrate concentrations in the ground water of Dayton Valley. About one-third of Dayton Valley ground-water analyses examined (most of which are by the Nevada Bureau of Environmental Health) show nitrate concentrations in excess of 10 mg/l, with a maximum (analysis 17/23-36baa, table 31) of 62 mg/l. Although nitrate concentrations locally exceed 10 mg/l in Carson Desert, the normal concentrations for ground water in most of the Carson River basin are somewhat less than 10 mg/l. The above-average nitrate concentrations in Dayton Valley also apparently extend to ground water in the Silver Springs area of Churchill Valley (table 31).

Churchill Valley

Ground water from community wells supplying Silver Springs is generally of good chemical quality (table 31). Although the water is hard, the dissolved-solids and sulfate concentrations are not excessive. The numerous domestic wells in the area may not yield water with the same chemical characteristics as water from the Silver Springs community wells.

Water from the only known well in White Sage Flat (not labeled on pl. 1) of northern Churchill Valley (18/23-4a) is of much poorer quality than the Silver Springs community wells (table 31). It is extremely hard and has excessive amounts of iron, calcium, and bicarbonate.

Carson Desert

Ground water in the Carson Desert is abundant, but much of it is of poor to very poor chemical quality for most uses. The Carson Desert is the terminus of the Carson River hydrologic system. It is therefore the final discharge area for water that has moved downbasin and, as such, becomes the final receiving area for soluble chemicals transported by the water. As water evaporates from the desert, it leaves behind its dissolved chemical load. A substantial part of this load remains highly soluble and therefore tends to progressively enrich the remaining and incoming water supply. The residual waters therefore are considerably more saline than the composite inflow. Available data suggest that the ground water can be grouped into five general categories according to chemical characteristics, as follows: (1) large quantities of moderately saline to very saline water fill most of the valley-fill deposits from relatively shallow to great depths; (2) an unknown quantity of moderately dilute water occurs within a basalt aquifer of apparently local areal extent generally about 500 feet below land surface in the Fallon area; (3) unknown quantities of dilute to moderately dilute water are found within, or associated with, recent fluvial sediments generally near present or relatively contemporary Carson River channels, from shallow to unknown maximum depths; (4) dilute to moderately dilute water occurs within shallow valley-fill deposits, probably resulting from infiltration of irrigation water beneath or near lands of the Newlands Reclamation Project; and (5) unknown amounts of water of variable chemical quality lie within consolidated rocks.

Domestic water demands are supplied mainly by (1) public-supply systems for the city of Fallon and the Naval Air Station, which tap water from the basalt aquifer, and (2) individual domestic wells that tap the shallow and generally thin lens of relatively dilute water overlying the vast saline reservoir that occupies most of the valley-fill deposits. Water from the basalt aquifer has been utilized as a public supply for more than two decades. The water is soft and generally suitable for most uses. Thus far, only the arsenic concentration (characteristically 0.05-0.10 mg/l) has caused any concern regarding suitability for consumption by humans. Arsenic concentrations slightly exceed the limit for drinking water (p. 75). Public-supply systems continue to rely on the basalt aquifer, owing to (1) the lack of any evidence of long-term adverse effect attributable to the arsenic, and (2) the probable great expense involved in developing an alternate source of supply.

The shallow ground water tapped by most individual domestic wells in the Carson Desert area has an uncertain future as an acceptable supply because of the risk of contamination. This risk is further increased by the fact that most of the people extracting the water from shallow domestic wells also use septic tanks that discharge at shallow depths within, or very close to, the water-supply zone. Future replenishment of this domestic supply is also uncertain because the amount and quality of replenishment depends on irrigation practices and conditions. Current emphasis on increasingly frugal use of water for irrigation suggests that future replenishment may differ somewhat from past replenishment. Lawrence Wolf, Churchill County Health Department (oral commun., 1972), stated that water quality of the shallow aquifer apparently deteriorates during periods of nonirrigation and no canal flow.

Salinity of Carson Desert ground water and the water's mineral precipitates have from time to time been exploited commercially. The salt deposits associated with Soda Lakes were mined extensively during the latter half of the 19th and early 20th centuries. However, rising lake levels associated with infiltration of irrigation water after the establishment of the Newlands Reclamation Project (Lee and Clark, 1916, p. 679 and 680) flooded the salt works and diluted the saline lake water. The unique hydrologic and chemical character of Soda Lakes was discussed by Rush (1972), Breese (1968), Lincoln (1923), Lee and Clark (1916), Stabler (1904), Russell (1885), and others. The geologic origin of Soda Lakes has been most recently discussed by Morrison (1964, p. 71-72).

The U.S. Geological Survey prospected for salt deposits associated with the valley fill during the early part of the 20th century (Gale, 1913, p. 303-311). Other explorations probably were made from time to time throughout the Carson Desert. Sodium chloride is presently harvested on the Fourmile Flat playa (pl. 1) by the Huck Salt Company of Fallon. This company, since 1938, has been harvesting salt that becomes concentrated on the playa surface through the interaction of the ground- and surface-water flow systems (Elmer Huckaby, oral commun., 1971). Earlier exploitation of saline playa deposits in the study area was described by Russell (1885, p. 234 and 235) and Lincoln (1923, p. 7-9 and 14).

White Plains and Packard Valley

Very few water-chemistry data are available for the White Plains and Packard Valley areas (table 31). One sample (well 23/28-29dc) suggests that the valley-fill deposits of White Plains are saturated with saline, sodium chloride-rich water similar to much of the very saline ground water of Carson Desert. This similarity is to be expected because both areas are the sinks of their respective large drainage systems. Salt has been harvested along the west side of White Plains playa in the past, as evidenced by the remains of abandoned salt evaporation pans visible from U.S. Interstate Highway 80. Salt harvesting was described by Lincoln (1923, p. 7 and 14).

Two chemical analyses (27/33-24ccd and 28/34-31db; table 31) suggest that ground water of the Packard Valley area is of the calcium sodium chloride type, and varies in dissolved-solids concentration from place to place. The chemical quality doubtless deteriorates as the ground water moves downgradient toward the Carson Sink. The end product is the highly saline water that saturates the valley-fill deposits of the sink.

Thermal Water

Thermal water, for purposes of this discussion, is arbitrarily defined as ground water warmer than the mean annual air temperature at the site.

Data in tables 27 and 31 suggest that several localized areas of deep-seated ground-water circulation exist. The flows of Walleys, Hobo, and Saratoga Hot Springs in Carson Valley (table 27) are thermal. Worts and Malmberg (1966, p. 30, and table 12) described Carson Hot Springs in Eagle Valley. The urbanizing area east of the Carson River at the base of Pinion Hills between Mexican Dam and New Empire (location about 15/20-35c; locally referred to as the Pinion Hills subdivision) has a number of wells with thermal water. Sutro Tunnel in Dayton Valley discharges warm water from the consolidated rocks.

The major known thermal ground-water area of Carson Desert is a generalized zone extending from Soda Lakes to Stillwater that recently was classified by the U.S. Geological Survey (Godwin and others, 1971, p. 2 and 4) as a "known geothermal resource area." Morrison (1964, p. 117) briefly discussed the thermal ground water in this area. This possibly extensive geothermal system is widely recognized, but published information regarding its ground-water flow system is scanty. The basic nature of such an extensive geothermal system inherently guarantees some influence on the quality of the involved ground water, but the extent of influence in this case is virtually unknown.

Principal Water-Quality Problems

Table 37 summarizes the presently recognized water-quality problems in the Carson River basin. It also summarizes some possible future problems that might be anticipated on the basis of present developments, limited knowledge of water quality, and the hydrologic flow system of the basin.

Table 37.--*Summary of presently recognized and possible future water-quality problems*

Area	Present problem	Possible future problem
Bryant Creek, East Fork Carson, and Carson River below confluence with Bryant Creek	Chemically contaminated streamflow originating in vicinity of Leviathan sulfur mine may adversely affect Carson River water under certain hydrologic conditions.	Pollution threat could continue, subside, or possibly worsen, depending on hydrologic and other circumstances.
Do.	Massive landslide in area of Leviathan sulfur mine tightly encroaching on tributary to Bryant Creek. Hydrologic circumstances could result in serious sediment-pollution problem downstream, and (or) potential downstream flash-flood danger.	Same potential for future as at present. Threat depends on future movement of slide and flow conditions in streams tributary to slide area.
Carson River and tributaries	Periods of highly turbid streamflow caused by both natural and man-accelerated influences. Results in problems to surface-water irrigation systems. Also causes unknown amount of damage to fish habitat. Diminishes esthetic value of streamflow to unknown degree. Magnitude of problem not presently known because of lack of data.	Same as present, with possible additional problems also to future municipal and industrial use of river water, and reduced capacity of present and future streamflow-storage reservoirs. Could also seriously hamper attempts to utilize streamflow for artificial recharge of diminishing ground-water supplies.
Do.	Discharge of sewage effluent of a quality poorer than natural streamflow causes several problems to river environment that vary in intensity depending on hydrologic circumstances at time of discharge.	Same as present problems: severity will increase if quantity of effluent increases without counterbalance by upgrading of effluent quality.

Table 37.--*Summary of presently recognized and possible future water-quality problems--Continued*

Area	Present problem	Possible future problem
Carson River and tributaries	--	Ground water contaminated by septic-tank effluent and sewage-effluent spreading; could also seep to river and degrade streamflow quality.
Do.	--	Improperly located or unprotected land-fill deposits could furnish leachate pollutant that would degrade stream quality and ground water
Carson Valley: Saratoga Hot Springs area	High dissolved-solids and sulfate concentrations in ground water.	Same as present.
Carson Valley-Eagle Valley: Stewart area	Excessive iron concentrations in water.	Same as present.
Eagle Valley	Foul-smelling water from one municipal supply well.	Unknown.
Carson River below Carson City	Mercury in shallow fine-grained bottom sediments of river, canals, and Lahontan Reservoir. Excessive mercury in river water near Fort Churchill during periods of high flow. Above-normal mercury in fish associated with the mercury-affected surface waters and bottom sediments.	Increased nutrient contributions from sewage treatment plants may in turn increase the "accessibility" of the mercury through chemical transformations associated with biologic activity.
Dayton Valley: Pinion Hills area	Poor-quality ground water: high concentrations of dissolved solids, sulfate, fluoride, iron, calcium, and sodium, and excessive hardness.	Same as present.

Table 37.--*Summary of presently recognized and possible future water-quality problems--Continued*

Area	Present problem	Possible future problem
Dayton Valley: Mound House area	Poor-quality ground water: high concentrations of dissolved solids, calcium, and sulfate, and excessive hardness.	Same as present.
Dayton Valley: north of river downstream from Dayton	Ground water commonly hard to very hard with high concentrations of dissolved solids and sulfate.	Same as present.
Dayton Valley-Churchill Valley	Ground waters in a substantial number of wells in the valley downstream from Dayton may have nitrate concentrations somewhat above average, compared to the total river basin.	Increasing disposal of sewage through septic tanks and incompletely treated sewage may foul the ground-water reservoir; risk is increased because nitrate concentrations appear to be above average at present.
Churchill Valley: Silver Springs area	Ground water very hard.	Same as present.
Churchill Valley: White Sage Flat	Ground water is apparently extremely hard and has excessive concentrations of iron, calcium, and bicarbonate.	Same as present.
Lahontan Reservoir and possible future large storage reservoirs	--	Increased sewage effluent may result in nutrient enrichment of reservoir water, causing problems of excessive algae.
Carson Desert	Saline water throughout most of the valley-fill reservoir.	Same as present.

Table 37.--*Summary of presently recognized and possible future water-quality problems--Continued*

Area	Present problem	Possible future problem
Carson Desert: Fallon area	Large quantities of saline water throughout most of the ground-water system.	Excessive pumping of the basalt aquifer supplying Fallon and Naval municipal supplies may promote saline-water intrusion into this aquifer system.
Carson Desert	Same as above.	Increasing septic disposal of sewage may degrade the quality of the shallow, fresh ground-water supply to a point of unacceptability. Decrease in amount of irrigation infiltration, related to probable reduction in application of water, may accelerate deterioration of water quality of shallow ground-water system.

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 saturated thickness (in this study, 100 ft), and the specific yield of the deposits (assumed to average 10 percent for the study area). The estimates are listed in table 38.

Table 38.--*Estimated quantity of ground water stored in the upper 100 feet of saturated valley fill* 1/

Hydrographic area (in downstream order)	Area probably underlain by 100 feet or more of saturated valley fill 2/ (acres, rounded)	Estimated quantity of stored ground water 3/ (acre-feet, rounded)
Carson Valley (Nev.)	70,000	700,000
Eagle Valley 4/	13,000	200,000
Dayton Valley	44,000	440,000
Churchill Valley	a 74,000	a 740,000
Carson Desert	b 800,000	c 8,000,000
Entire Carson River basin in Nevada	b 1,000,000	c 10,000,000
Packard Valley	50,000	500,000
White Plains	b 42,000	c 420,000

1. Data developed mainly by A. S. Van Denburgh, U.S. Geological Survey.
2. Assumed to be about 80 percent of the alluvial areas listed in table 2, because of inward-sloping contact between valley fill and consolidated rocks. (Does not apply to Eagle Valley.)
3. Assuming a specific yield of 0.10.
4. Data from Worts and Malmberg (1966, p. 11).

a. Includes ground water underlying Lahontan Reservoir.
b. Includes areas where ground water is too saline for most common uses.
c. Much of this water is probably of an unacceptable quality for most common uses.

Although the estimates of stored ground water are large, the amount available in areas where the depth to water is within economic pumping lift 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 the water-bearing deposits, the permeability and specific yield 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. Also, large withdrawals of ground water along the flood plains of perennial streams can affect the flow of surface water and therefore might legally infringe on previously decreed surface-water rights.

Available Supply, Mainstem Areas

The available water supply in mainstem areas of the Carson River basin in Nevada during the base period 1919-69 consisted principally of about 320,000 acre-feet per year of combined river flow and ground-water underflow at the California State line; 50,000 acre-feet per year of local surface- and ground-water inflow to the system, for a total of 370,000 acre-feet between the State line and the Carson Sink; and about 180,000 acre-feet of water imported from the Truckee River basin through the Truckee Canal; for a grand total of about 550,000 acre-feet per year (table 30). In addition, more than 10 million acre-feet of ground water is presently stored in the upper 100 feet of saturated valley-fill deposits of the study area (table 38). Most of the surface water but little of the ground water has been developed, as described in this report. However, much of the stored ground water, particularly in the Carson Desert, may be of unacceptable chemical quality for most uses.

Activities are underway to determine the most efficient legal, economic, and physical solutions to the problems of the combined Truckee and Carson River basins. One principal problem relates to use and diversion of the water supply of the two river basins, which has contributed to the declining stage of Pyramid Lake, the terminal sink of the Truckee River basin. Traditionally, the Carson River basin has been geared to a mining and agricultural economy and its needs. However, if the present trends of population growth and urbanization continue, many new hydrologic problems should be expected.

Available Supply, Nonmainstem Areas

The available supply of Eagle Valley was described by Worts and Malmberg (1966, p. 39) as the system yield, and was estimated at 10,000 acre-feet per year.

Packard Valley and White Plains are tributary to the sink area of Carson Desert but are not tributary to the river mainstem. White Plains receives surface inflow on a generally irregular basis from the Humboldt River, and discharges part of that flow to the Carson Sink. Very little ground-water underflow enters or leaves White Plains (table 18) and only a minor amount of ground-water recharge originates within the White Plains hydrographic area (table 17). Most stored ground water may be of very poor quality, and surface inflow from the Humboldt Sink is of variable and possibly poor quality much of the time. Therefore, the amount of water reaching White Plains depends on the degree of upstream utilization of Humboldt River, which is subject to changing practices of man, and consequently, the residual is of undependable quantity and quality. Thus, the dependable, usable, and therefore available water supply, including the largely saline stored water (table 38), of White Plains can be considered small at best.

Packard Valley does not receive inflow from other hydrographic areas but precipitation within its own area generates a potential for significant recharge. Packard Valley discharges water to the Carson Sink by intermittent streamflow and ground-water underflow. Because of intermittent flow characteristics, the average annual streamflow is too unpredictable to be considered a dependable water supply. A well field probably could be developed that would salvage some of the phreatophyte discharge (about 300 acre-feet) and some of the ground-water underflow to Carson Desert. Assuming effective salvage of about half the underflow (about 200 acre-feet), the available supply of the valley would be about 500 acre-feet per year, plus a substantial part of the 500,000 acre-feet of stored water (table 38).

GEOHYDROLOGIC HAZARDS

Geohydrologic hazards probably are as critical in the Carson River basin as they are in almost any area of the world. Among these hazards, flooding of the Carson River itself may be the most noticeable, because of its widespread effect. Other water-related hazards of a generally more localized nature include flash floods in small-drainage basins, snow avalanches, and landslides. Earthquakes also must be considered because, though generally not hydrologic in origin, they nonetheless could be direct forerunners of hydrologic hazards.

None of these hazards should be considered independently. For example: (1) landslides can become more active during earthquakes and during times of intense, flood-causing rains; (2) collapse of flood-control dams, with subsequent major flooding, might well occur during an intense earthquake; (3) snow avalanches could well be triggered by heavy rains or earthquakes; and (4) landslides might cause major floods on relatively small tributary streams by ponding large quantities of water that might then suddenly be released as the impounding landslide is overtopped and quickly eroded.

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 14/19-15bcc is in SW¼SW¼NW¼ sec. 15, T. 14 N., R. 19 E. In this report, most sites identified with three and occasionally four letters are in areas where detailed U.S. Geological Survey topographic maps (scale, 1:62,500 and 1:24,000) are 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, Lakewood, Colo. 80225.

Because of space limitation, wells are shown on plate 1 by a map number which is referenced to a location number in table 39. Springs and other hydrologic sites are identified on plate 1 only by the above described site numbering system. Township and range numbers are shown along the margins of the plate.

Use: D, domestic; E, exploratory; FH, fish hatchery; I, industrial; Ir, irrigation; OT, oil test; P, public supply; S, stock; U, unused or abandoned (intended use in parentheses); L, landfill.

Water level: Measurements recorded to tenths or hundredths of a foot were generally 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 31; F, depth, in feet, at which water was first encountered during drilling; L(+), driller's log in table 40; L(E), electric log available; L, driller's or lithologic log available but not included in table 40; O, U.S. Geological Survey observation well; P, period of water-level observations; S, log in files of State Engineer (State log number is indicated); T, length of time between start of pump test and measurement of yield and drawdown, in hours.

Map no.	Location	Owner	Year drilled	Depth (feet)	Casing diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement: Depth (feet)	Water-level measurement: Date measured	Remarks
							CARSON VALLEY				
1	12/20-4aadd	City of Gardnerville Well no. 4	1970	313	12	P	1,125/58	4,782	20	4- -70	L(+); S=11,006; T=48; not yet in production as of 8-19-71
2	-4baad	City of Gardnerville Well no. 3	1965	343	12	P	1,020/--	4,760	11	2- -65	F=10; L(+); S=8488; T=20.5; C
3	-4bbad	City of Gardnerville Well no. 1	pre-1925	--	--	P	--	4,753	--	--	C
4	-10dccb	Gardnerville Ranchos Well no. 2	1967	445	12	P	1,150/--	4,818	23	9- -67	F=4; L(+); S=9699; T=24; C
5	-14aaba	U.S. Bureau of Sport Fisheries, Well no. 5	1965	800	16	FH	1,420/--	4,882	40.5	8- -65	L(+); S=8665; T=12
6	-14addc	U.S. Bureau of Sport Fisheries, Well no. 4	1961	497	16-10	FH	--	4,876	--	--	L; S=5842; C
7	-15aaba	Gardnerville Ranchos Well no. 1	1965	450	18	P	2,250/--	4,828	18	10- -65	F=5; L; S=9832; C
8	-17ba	J. Hellwinkel	--	165	18	Ir	1,175/--	4,750	10.19	5-11-48	O; P=1951-56, 1959-present
9	-23aaca	U.S. Bureau of Sport Fisheries, Well no. 3	1964	650	12	FH	1,500/275.5	4,895	26.2	12-14-64	F=9; L(+); L(E); S=8264; T=9.7; Pump test data from Desert Research Institute
10	-23bdac	U.S. Bureau of Sport Fisheries, Well no. 6	1965	803	16	FH	2,000/--	4,874	40	9- -65	F=6; L; S=8666; T=10
11	-23daca	U.S. Bureau of Sport Fisheries, Well no. 2	--	--	--	FH	--	4,895	--	--	
12	-23dacd	U.S. Bureau of Sport Fisheries, Well no. 1	1964	200	8	FH	36/--	4,895	14	4- -64	F=12; S=8219; T=24
13	13/19-22abb	U.S. Steel Corporation	1962	1,268	10-7	E	--	4,665	--	--	L(+); S=9313; another well nearby encountered bedrock at 280 ft. This well log shows no bedrock
14	13/20-6ad	R. W. Hopkins	1963	404	14	Ir	about 3,000/--	4,676	--	--	F=90; L; S=7386; T=about 4 hrs.
15	-7ac	Andre and Bernard Aldax	1963	400	14	Ir	about 1,800/--	4,682	--	--	F=21; L; S=7132; T=about 4 hrs.
16	-7dad	E. L. Marshall	1965	441	16	Ir	3,400/--	4,684	flowing	6- -65	F=8; L(+); S=8588
17	-8cad	C. W. Godecke	1928	300	18-12	Ir	2,000/--	4,700	1.98	5-12-48	O; P=1951-52, 1954-present
18	*-29cdcd*	*City of Minden, Well no. 1*	1925±	398	--	P	1,800/15	4,722	--	--	C
19	-31ca	Dangberg Land & Livestock Co.	1945	413	16	Ir	3,800/37	4,712	6	6- -48	L; S=566
20	-32babc	City of Minden, Well no. 2	1947	301	12	P	1,350/--	4,722	8	4- -47	F=8; L(+); S=34; C
21	-32caa	Mack Land & Cattle Co.	1927	420	18	Ir	2,600/--	4,733	7.99	5-12-48	O; P=1951-62, 1964-present
22	-32daab	City of Gardnerville Well no. 2	1947	301	12	P	1,000/72	4,737	16.6	9- -47	F=16; L(+); S=108
23	13/21-15bad	U.S. Bureau of Land Management, "Uhalde Ranch Well"	1941	500	8	U(S)	--	5,365	96.30	5-14-70	L
24	-19cbb	U.S. Bureau of Land Management, "Buckeye Creek Well"	1941	140	8	U(S)	--	5,000	102.38	5-14-70	L
25	-28ccb	U.S. Bureau of Land Management, "Fish Spring Flat Well"	1941	95	8	S	--	5,170	56	8- -41	C, L
26	14/19-15bcc	John Ascuaga	1948	302	12	Ir	500/--	5,160	1	11- -48	F=20; L(+); S=734; bedrock at 295 ft
27	-15cc	John Ascuaga	1953	252	12	U(Ir)	780/--	5,150	20	10- -53	F=12; L; S=2410
28	-25ba	U.S. Bureau of Indian Affairs	--	240±	12	Ir	350/81+	4,680	10.49	5-10-46	O; P=1951-present
29	14/20-4bdb	Nevada State Medium Security Prison, Well no. 3	1968	a 519	8	P(E)	100/167	4,685	37	1970(?)	L(+); S=10,298; bedrock at 490 ft
30	-28cdd	Unknown	--	--	6	U(D)	--	4,710	11.2	5-14-70	
31	-32cc	M. Johnson	1969	436	16	Ir	2,800/92	4,675	flowing	5- -69	L; S=10,579; T=24
							EAGLE VALLEY				
32	14/20-6cb1	Sierra Estates Gen. Imp. Dist. (1973), formerly Carson Water Co., Well no. 5	1960	300	14	P	520/--	4,860	35	10- -60	F=52; L(+); S=5566; T=108; granite bedrock at 198 ft
32	-6cb2	Sierra Estates Gen. Imp. Dist. (1973), formerly Carson Water Co., Well no. 5A	1962	150	10	P	30-40/--	4,860	20	11- -62	F=36; L; S=7012
33	15/19-12ada	Carson Water Co., Well no. 6	1972	500	16-12	P	1,200/80.6	4,860	93.3	7- 9-72	L; S=12,430; T=25.8
34	-33dd	U.S. Forest Service	1966	305	16	P	31/--	5,780	125	12- -66	F=155; L; S=9539; T=48; granite bedrock at 187 ft
35	-34cc	U.S. Forest Service	1966	290	10	P	70/20	5,750	65	8- -66	F=60; L; S=9540; T=1
36	15/20-7ddb	Carson Water Co., Well no. 5	1970	515	14-12	P	40/164	4,730	16	9- -70	L(+); S=11,262; C
37	-9acba1	J. L. Bliss	--	69±	6	U(D)	--	4,650	--	--	C
37	-9acba2	J. L. Bliss	1963±	132	6	D	--	4,650	--	--	
38	-17dd	Carson Water Co., Well no. 4	1969	b 807	14	P	500+/116.75	4,640	flowing	1- -69	C; L(+); S=10,564; T=48
39	-32dcab	Nevada Indian Agency, Well no. 4	1969	375	10	P	250/58.5	4,715	26.5	7-23-69	C; L(+); L(E); S=10,670; T=24; no bedrock encountered
40	-32ddcc	Nevada Indian Agency, Well no. 3	1967	247	10	P	--	4,705	20.86	11- 4-71	L(+); S=10,351; bedrock at 243 ft

a. Originally drilled at 8-inch diameter to 519 feet for test purposes; later re-drilled at 10-inch diameter to 330 feet for production purposes.

b. Plugged back to 604 feet.

Table 39.—Well data—Continued

Map no.	Location	Owner	Year drilled	Depth (feet)	Casing diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement: Depth (feet)	Water-level measurement: Date measured	Remarks
						DAYTON VALLEY					
41	15/20-1aa	Carson City	1969	256	8	L	8/27	4,860	222	10- -69	C; L; S=10,763; bedrock at 136 ft
42	16/21-12acd	W. W. Eitel	1968	265	16	Ir	3,250/74	4,310	10	6- -68	P=5; L(+); S=10,144; T=8; bedrock at 222 feet; C
43	-13bbb	Allran, Inc., Well no. 6	1948	264	16	Ir	960/—	4,320	15	2- -48	P=30; L; S=446; C
44	-13bdd	Quilici Ranch	1920±	120	14	Ir	1,000/—	4,330	—	—	
45	-23acd	C. C. Barton	1938±	e 250	—	P	—	4,355	—	—	C
46	-23ddd	J. Ricci	1948	75	6	D	30/—	4,360	11	11- -48	L; S=749; P=20
47	-24bd	Dayton Elementary School	1971	135	8	P	150/25	4,370	73	4- -71	L; S=11,529; C; T=16
48	-26bcba	Anchor Trailer Court	1957	108	—	P	—	4,370	—	—	
49	-29ab	Nevada Craft Guild	1969	135	6	D	2/100±	4,760	30	10- -69	L; S=10,837; C
50	-29cd	Fred Winkler	1967	79	6	D	30/—	4,770	45	1- -67	C; P=55; L; S=9403
51	-29db	R. J. Sarroille	—	85	—	D	—	4,770	—	—	C
52	-29dc	R. C. Brown	—	80	6	D	—	4,770	—	—	
53	16/22-4cbc	Allran, Inc., Well no. 5	1961	460	16	Ir	4,000/36	4,290	20	7- -61	P=50; L; S=6087
54	-4db	Dayton Valley Ranchos	1955	260	14-12	P	—	4,345	57.82	2-18-72	L; S=2999; P=60
55	-7bdb	W. W. Eitel	—	100	8	D	—	4,305	—	—	C
56	-7cd	Gene Minor	—	197	12	U(Ir)	3,000/—	4,310	7	1949	S=1003
57	-8ab	Marvin Pickles	1971	145	8	D	30/20	4,335	64	9- -71	L; S=11,951; T=4; C
58	-9ba	R. L. Biedebach	1968	373	16	Ir	2,400/51	4,350	54	6- -68	L; S=10,114; T=6
59	-9bc	R. L. Biedebach	1963	600	14	Ir	2,800/—	4,350	55	7- -63	C; L(+); S=7314
60	-9daa	Unknown	—	—	6	D	—	4,410	123.22	6- 1-70	
61	-18ab	Gene Minor	1960	300	14	Ir	2,800/—	4,358	53.24	2-15-72	L; S=5336
62	-18ccc	W. E. Herrmann	—	—	6	D	—	4,375	—	—	C
63	-18dddd	W. E. Herrmann	1956	292	16	Ir	1,750/—	4,375	55	6- -56	L; S=3465
64	-19aad	W. E. Herrmann	1956	235	16	U(Ir)	1,500/—	4,375	66.06	7-20-72	L, S=3435; P=60
62	-19bbb	W. E. Herrmann	1928	372±	16	Ir	3,000/—	4,375	51.04	7-20-72	
65	-19bbc1	W. E. Herrmann	1956	192	16	U(Ir)	—	4,375	52.81	7-12-72	L; S=3436; P=67
65	-19bbc2	W. E. Herrmann	1956	197	16	U(Ir)	—	4,375	53.02	7-12-72	
66	16/23-3bd	Hodges Transportation Co.	1947	315	16-12	U(Ir)	—	4,250	20	12- -47	P=20; L(+); S=328; bedrock at 178 ft
67	17/22-20dddd	Mark Twain Estates	1971	227	6	U(D)	16/14	4,440	138.29	7-22-72	L; S=11,768; bedrock at 47 feet
68	-28dba	E. P. O'Neill	1970	122	8	D	—	4,345	—	—	C
68	-28dbd	Ralph Hicks	1970	123	6	D	—	4,340	53.32	7-22-72	P=65; L; S=11,630; C
69	-30acb	Glen S. Kunkel	1971	215	6	D	9/2	4,500	182.6	7-22-72	P=180; L; S=11,825; T=1.5
70	-30ddb	Sagebrush Ranch	1967	177	8	D	—	4,415	117	6- -67	C; P=145; L; S=9568
71	-31ad	Six-Mile Quarry Products	1971	185	10	I	—	4,405	103.72	7-22-72	P=60; S=12,180
72	-32db	G. Smith	—	—	8	U(D)	—	4,350	53.6	6- 3-70	
73	-33ccac	Allran, Inc., Well no. 2	1961	500	8	U(Ir)	200/29	4,320	28.35	2-12-72	P=50; L; S=6088
73	-33ccbc	Allran, Inc., Well no. 1	1961	633	16	Ir	1,300/145	4,3'C	60	7- -61	P=35; L(+); S=6086; C
74	-33dbc	Allran, Inc., Well no. 3	1961	504	16	Ir	2,370/—	4,310	—	—	P=105; L; S=6643
75	-34bca	Allran, Inc., Well no. 4	1961	500	16	Ir	2,500/96	4,305	35	6- -61	P=15; L; S=6085; C
76	-35bc	Joseph Chaves	1948	—	16	Ir	840/42.5	4,300	24.20	1-31-69	C; O; P=1952-55, 1958-65, 1967-present
77	17/23-1bd	Stagecoach Land Co. Well no. 1	1970	252	8	P	—	4,370	145.70	6- 3-70	L; S=10,878; P=150; C
78	-1db	Stagecoach Land Co.	1970	280	8	U(P)	20/16	4,460	224.19	7-14-72	L; S=11,159; P=236
79	-2bc	Stagecoach Land Co. Well no. 3	1971	305	8	P	30+/—	4,325	79.05	7- 1-72	L; S=11,863; T=8; C
80	-2bd	Stagecoach Land Co. Well no. 2	1970	300	10	P	—	4,325	—	—	L; S=11,349; P=96; C
81	-3aaa	Vestus Calico	1971	164	8	D	30/—	4,350	—	—	L; S=11,501
82	-3adb	H. Wixson	1969	350	12	D(Ir)	—	4,290	59.13	6- 3-70	P=162
83	-3bbb	Ben Rollison	1971	120	8	D	15/—	4,350	82.27	7-14-72	L; S=11,734; T=4; C; P=60
84	-7ddd	Utah Construction & Mining Co.	1961	386	12	U	—	4,335	74.00 73.98 74.14 74.16	6- 5-70 8- 5-70 12- 7-71 3- 5-72	L; S=6554
85	-10baa	H. C. Phillips	1969	300	12	Ir	900/112	4,285	48 49.45 48.71	4- -69 12- 7-71 3- 5-72	C; L(+); S=10,523; P=89
86	-10bbb	W. M. Boyer	1959	320	10	Ir	1,239/23	4,295	59	8- -59	P=59; L(+); S=8812; T=30; bedrock at 234 feet
87	-10bcb	W. M. Boyer	—	204	6	D	—	4,290	—	—	
87	-10bcc	P. I. Augustine	1969	198	6	D	—	4,280	45	5- -69	C; L; S=10,846
88	-10bdd	Weatherman	—	—	—	D	—	4,275	—	—	
89	-11ab	Master	—	—	6	D	—	4,300	—	—	
90	-11acc	Dooley	1971	70±	6	D	—	4,280	—	—	C
91	-11dcb	Unknown	—	—	48±	S	—	4,270	45.79 46.13 44.50	6- 5-70 8- 5-70 12- 7-71	C
92	-18dd	Utah Construction & Mining Co.	1962	822	16	U(I)	900/—	4,285	35.85	6- 3-70	P=68; L(+); S=6553
93	-27aba	S. Holman	1963	220	8	U(Ir,D)	140/—	4,280	51.14 51.34	6- 5-70 3- 5-72	P=80; L; S=8230; T=6; C
94	-36baa	Hodges Transportation Co.	1971	510	—	I	—	4,250	—	—	L; S=11,750; C
95	18/23-34dc	John Baril	1972	18C	6	D	—	4,360	128.62	7-14-72	

e. Estimated.

Table 39.—Well data—Continued

Map no.	Location	Owner	Year drilled	Depth (feet)	Casing diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement: Depth (feet)	Water-level measurement: Date measured	Remarks
						CHURCHILL VALLEY					
96	16/25-5dc	U.S. Bureau of Land Management	1963(?)	127±	6	S	—	4,230	65.16	6- 9-70	
97	-12bc	U.S. Bureau of Land Management "Lahontan Well"	1944	126	6	S	—	4,215	43.5	6- 9-70	P=82; L
98	16/26-3da	U.S. Bureau of Land Management "Hooten Well"	—	—	—	S	—	4,195	—	—	
99	17/24-1dcd	Unknown	—	—	8	U(D)	—	4,200	49.62	6- 8-70	Abandoned homesite
100	-1cba	Edwin McPherson	1969	200	8	D	—	4,250	100	11- -69	L; S=10,793; C
101	-35da	Frank Ghiglia	1966	64	8	U(D)	50/5	4,205	28	4- -66	P=40; L; S=8994
102	-36aa	Frank Ghiglia	1970	63	10	D	—	4,215	—	—	C
103	17/25-6dbb	Richard Spooner	1966	105	6	D	—	4,185	32.81	7-11-72	C
104	-10cd	Unknown	—	—	8	D	—	4,195	34.08	6-10-70	
105	-16cbc	Meinert	—	—	6-8	—	—	4,190	32.30	2-11-69	
106	-18dddd	Marnell Davis	1970	150	8	D	—	4,205	—	—	C
107	-19bab	J. Stephenson	—	103	6	D	—	4,195	39.20	2-11-69	
108	-29cbc	Unknown	—	—	—	D	—	4,185	36	2-11-69	
109	18/24-25adb	Community of Silver Springs	1954	260	14	P	—	4,202	64	4- -54	P=64; L(+); S=2543; C
110	-25bda	J. A. Powell	1960	285	12	Ir	—	4,210	70	1960	P=58; L; S=5137
111	-27cac	Mark Morgan	—	300±	—	D	—	4,340	—	—	C
112	-27db	Eugene Black	1956	300	10	D	25+/—	4,315	160	11- -56	P=175; L(+); S=3568
113	-28ac	U.S. Bureau of Land Management "Stockton Flat Well"	1942	281	6	U(S)	—	4,380	221 216.45	11-15-42 6- 5-70	P=220; L
114	-28dbc	James Geurts	—	—	—	D	—	4,380	—	—	C
115	-32abc	J. A. Key	1971	315	8	D	—	4,420	262.8	7-14-72	C
116	-36add	Unknown	—	—	6	U(D)	—	4,195	46.30	6-10-70	
117	18/25-4a	U.S. Bureau of Land Management "White Sage Flat Well"	—	380	6	S	—	4,355	332.85	6-10-70	P=348; L; C
118	-19cdc	Community of Silver Springs	1951	290	8	P	—	4,185	—	—	L; S=1691; C
						CARSON DESERT					
119	16/30-7daa	U.S. Geological Survey	1971	64	1.5	E	—	3,930	25.06	10-13-71	
120	-9c	U.S. Bureau of Land Management "Bass Flat Well"	1943	—	6	S	—	3,934	21.45 21.66	4-17-62 8-18-70	1962 water-level measurement by DRI personnel
121	-17bca	U.S. Geological Survey	1971	43	1.5	E	—	3,930	14.13	10-13-71	
122	-30aa	U.S. Bureal of Land Management "Diamond Wash Well"	1946	—	6	S	—	3,995	70.49	8-18-70	
123	16/31-36cad	U.S. Bureau of Land Management "Wightman Well"	1946	350	6	S	—	4,193	285.0 284	6- 1-62 —	1962 water-level measurement by DRI personnel
124	16/32-5bcd	P. Cushman	—	27	6	S	e 0.5-1/—	3,904	3.19 3.2	4-10-62 7-30-62	1962 water-level measurement by DRI personnel
125	-5cdd	B. Mathews	—	—	6	U(D)	e 20-23/—	3,961	29.1 29.25	4-13-62 7-30-62	1962 water-level measurement by DRI personnel
126	-5ddb	F. Bennett	—	162	6	U(I)	—	3,974	65.2 65.87	4-10-62 7-30-62	1962 water-level measurement by DRI personnel
127	-6b	Dodge Construction Co.	—	190	4	U	e 0.2/—	3,893	flowing	5-22-62	1962 water-level measurement by DRI personnel
128	-19b	P. Cushman	—	—	4	S	e 3-5/—	3,900	flowing	6- 1-62	1962 water-level measurement by DRI personnel
129	-19d	U.S. Atomic Energy Commission	1962	780	8	E	e 66/—	4,017	110.88	7-30-62	L(+); water-level measurement by DRI personnel; log from Nevada Bureau of Mines and others (1962, p. 107)
130	-29adc	U.S. Atomic Energy Commission	1962	480	8	E	e 5-10/—	4,232	328.3	7-31-62	L(+); L(E); water-level measurement by DRI personnel; granite bedrock at 310 feet; log from Nevada Bureau of Mines and others (1962, p. 114)
131	17/28-13d	G. Dalton	1947	448	3	U	e 15/—	3,915	flowing	11- -47	S=281
132	17/29-18bd	Jones and Jewell Ranch	1921-23	3,300	—	OT	—	3,915	—	—	L(+); log from Morrison (1964, p. 149)
133	17/30-3ca	U.S. Geological Survey	1971	22	1.5	E	—	3,936	11.62	10-13-71	
134	-4caa	U.S. Geological Survey	1971	22	1.5	E	—	3,936	11.31	10-13-71	
135	17/31-15d	U.S. Bureau of Land Management(?)	—	—	6	S	—	4,050	117.76	8-19-70	
136	7/32-22b	U.S. Bureau of Land Management "Sand Mountain Well"	1964	180	6	S	—	-4,600	156	1964	P=165; L
137	18/28-3bcb	Churchill Drilling Corp. "Lima no. 1"	1960	1,256±	—	OT	—	3,978	—	—	Reportedly no bedrock encountered
138	-13aad	Churchill Drilling Corp. "Reggie no. 1"	1959	8,001	—	OT	—	3,958	—	—	Reportedly no bedrock encountered
139	-13ddc	Churchill Drilling Corp. "Williams no. 1"	1961	4,750	—	OT	—	3,952	—	—	Reportedly no bedrock encountered
140	18/29-4bac	U.S. Navy	1958	776	8-12	U(E)	—	3,947	20	10-28-58	C; L(+); well sanded in during pump test; log from Kingman (1959)
141	-5aaa	U.S. Navy	1958	623	14	U(E)	—	3,950	—	—	L(+); log from Kingman (1959)
142	-10bbb	U.S. Navy	1958	602	14	U(E)	—	3,940	—	—	L(+); L(E); log from Kingman (1959)
143	-23cac	U.S. Navy	1944	1,700±	—	U(P)	—	3,935	—	—	L(+); log from Morrison (1964, p. 149)

e. Estimated.

Table 39.--Well data--Continued

Map no.	Location	Owner	Year drilled	Depth (feet)	Casing diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement: Depth (feet)	Water-level measurement: Date measured	Remarks
						CARSON DESERT--Continued					
144	18/30-12aca	Unknown	—	—	6	S	—	3,941	—	—	C
145	-35dc	L. Reeve, "Salt Wells"	1957(?)	100	6	D	—	3,957	—	—	C
146	18/31-4da	U.S. Bureau of Land Management "Kent Well"	1941	140	6	S	—	4,027	125.80	8-20-70	C
147	-20c	Lahontan Nevada Oil Co.	1921-23	2,015-2,060±	—	OT	—	4,215	—	—	L(+); log from Morrison (1959, p. 237)
148	-27d	U.S. Bureau of Land Management "Diamond Canyon Well"	1952	343	6	S	—	4,226	300	5-29-62	Water-level measurement by DRI personnel
149	-31ccc	U.S. Bureau of Land Management	—	300	6	S	—	3,976	32.4 31.96 39.27	4-13-62 7-30-62 8-19-70	C; 1962 water-level measurements by DRI personnel
150	19/26-23bb	Unknown	—	—	6	U	—	4,115	63.84	6-11-70	
151	19/27-12dc	U.S. Geological Survey	1971	150	1.5	E	—	4,008	—	—	C
152	-18bc	Unknown	—	—	6	U	—	4,075	42.00	8- 5-70	
153	19/28-21cc	Unknown	1970(?)	—	8	U(D)	—	3,995	3.75	8- 6-70	
154	-22daa	Clyde Gummow, Sr.	—	41	8	U(D)	—	3,972	—	—	C
155	-22dab	Clyde Gummow, Sr.	1921	1,155+	—	D(OT)	—	3,972	—	—	L(+); C; basalt at 1,050 feet; log from Morrison (1959, p. 125)
156	-24acc	City of Fallon	1934	387	—	U(P)	—	3,970	—	—	L(+); abandoned and unused; log from Morrison (1959, p. 127)
157	-36aba	City of Fallon	1969	813	14	U(P)	230/81	3,962	38.42	11-15-71	T=12; L(+): S=10,789; basalt at 520 feet
158	-36daa	City of Fallon	1965	558	14	U(P)	1,000/—	3,965	30.4	11- -65	P=13; L(+); S=8724; basalt at 510 ft
159	19/29-30cba	City of Fallon, Well no. 3	1970	484	—	P	2,100/—	3,960	33	12- -70	L(+); S=11,374; basalt at 404 feet
160	-30cdb1	City of Fallon, Well no. 1	1941	506	16±	P	1,600/6	3,958	33	1941	L(+); basalt at 448 feet; C
160	-30cdb2	City of Fallon, Well no. 2	1948	521	12-14-18	P	1,000/<1	3,958	33	1948	L(+); basalt at 455 feet; C
161	-31babc	I. E. Kent Co.	1960	444	6-8	D	200+/—	3,965	35	2- -60	L(+); S=5928; P=15; C; basalt at 418 feet
162	-33cbb1	U.S. Navy, Well no. 1	1962	540	10-16-24	P	1,000/—	3,948	29.4	5- -62	L(+); S=6628; C; basalt at 496 feet
162	-33cbb2	U.S. Navy, Well no. 2	1961	530	16	P	1,400/—	3,948	22	2- -61	L(+); S=6822; basalt at 500 feet
162	-33cbb3	U.S. Navy, Well no. 3	1962	531	16-24	P	2,000/—	3,948	29.4	4- -62	L(+); S=6629: T=72; basalt at 500 feet
163	19/30-30ccb	L. W. Mason	1969	15-19	8	D	—	3,928	6	1969	C
164	-30ccc	T. L. Sherman	—	37	8	U(D)	—	3,928	—	—	C
165	19/31-7dc	John Bell	—	204	3	heating	flowing/—	3,897	21 ft above lsd	reported	C; reported boiling
166	-11a	U.S. Bureau of Land Management "Stillwater Point Well"	1954(?)	—	6	S	—	3,950	40.56	8-20-70	C
167	-32cc	Calneva Trust Co. and Last Chance Oil Co.	1922-24	1,472	—	OT	—	3,935	—	—	L
168	20/26-26cc	Southern Pacific Railroad	1907	1,323	10	U(I)	—	4,005	29	7-27-07	L(+)
169	20/28-1bd	Kennametals, Inc.	1968	627	8-16	I	70/105	3,982	52	1968	C; L(+); S=10,044; T=24
170	-28ccb	Unknown	—	60	—	U	—	3,985	—	—	Drilled at site of extinct hot spring (Morrison, 1964, p. 117)
171	20/29-30ccc	U.S. Corps of Engineers	1959	692	8	U(E)	—	3,980	—	—	L(+); L(E)
172	20/32-28c	U.S. Bureau of Land Management "Flat Well"	—	—	8	S	—	3,925	37.65	8-20-70	
173	21/27-22bd	Unknown	—	—	8	S	—	4,080	147.68	8-21-70	
174	21/30-30ac	U.S. Geological Survey "Timber Lake Well"	1911-12	985	12	E	25-30/—	3,882	flowing	10-13-71	C; log in Gale, 1913, p. 306
175	21/32-25cbc	U.S. Bureau of Land Management "Desert Well"	—	—	8	S	—	3,932	32.95	8-20-70	C
176	22/30-14bbd	Churchill Drilling Corp. "T.C.I.D. no. 1"	1961	3,758±	—	OT	—	3,850±	—	—	Reportedly no bedrock encountered; saltwater and gas, 3,125-3,150 ft
177	-19bbd	H. B. Thorpe Co. "Carson Sink no. 1"	1964	2,805	—	OT	—	3,850±	—	—	Reportedly no bedrock encountered
178	22/33-15b	U.S. Bureau of Land Management "Fisk Well"	—	—	6	S	—	3,950	35.26	10- 8-70	C
179	23/33-12bb	U.S. Bureau of Land Management "Copper Kettle Well"	1969(?)	—	6	S	12/—	3,990	81.98	8-20-70	
180	24/33-14dc	Unknown	—	—	12	U	—	3,958	52.09	10- 8-70	
						PACKARD VALLEY					
181	26/33-10aa	U.S. Bureau of Land Management "Nettleberry Well"	1936	115	6	S	—	4,255	97.53	8-20-70	L(+)
182	27/33-24ccd	U.S. Bureau of Land Management "Relief Well no. 2"	1939	120	6	S	—	4,515	99.06	8-20-70	C
						WHITE PLAINS					
183	23/28-29dc	Unknown	—	44	48x48	U	—	3,930	42.67	10- 7-70	C

Table 40.--Selected well logs

Material	Thickness (feet)	Depth (feet)
12/20-4aadd		
Topsoil, sandy	3	3
Clay, brown, sandy	4	7
Sand, brown, silty	7	14
Sand, coarse, with semirounded gravels to 2 inches, some cobbles and clay lenses, water	24	38
Clay, yellow, sandy	8	46
Sand, fine to coarse with semirounded gravels to 1 inch, water	7	53
Sand, coarse, clean	7	60
Sand, coarse, silty, with yellow clay streaks, water	30	90
Sand, coarse, clean, with some gravels to 2 inches, water	7	97
Clay, yellow, soft	3	100
Sand, yellow, silty, with clay lenses, water	21	121
Clay, yellow, hard	5	126
Clay, yellow, hard, with sand lenses	4	130
Sand, coarse, with 2-inch gravels and clay streaks, water	33	163
Silt, brown, with rounded gravels to 3/4 inch, water	4	167
Clay, gray, sandy	5	172
Sand, coarse, with gravels to 1½ inches mixed-clay lenses	14	186
Sand, coarse, with rounded gravels to 1½ inches mixed-very clean, water	20	206
Clay, yellow, sandy	9	215
Sand, coarse, with angular gravels to 2 inches mixed	35	250
Clay, yellow, hard, with cobbles to 5 inches mixed	6	256
Sand, coarse, with small cobbles to 3 inches mixed, water	34	290
Sand, silty	4	294
Sand, coarse, with semirounded gravels to 1½ inches mixed, water	14	308
Clay, yellow, hard, with occasional gravel to 2 inches	5	313
12/20-4baad		
Topsoil	10	10
Boulders, with sand	12	22
Sand	12	34
Silt, gray	12	46
Sand, medium-grained	8	54
Sand, hard, and boulders soft streaks	18	72
Clay, sandy, few boulders	5	77
Sand, silty	13	90
Sand, large-grain, small gravel	12	102
Sand, soft, large-grain with brown clay	20	122
Sand, hard, with tight shells	33	155
Quartz, hard, sandy gravel	33	188
Sand, large-grain conglomerate	45	233
Sand with boulders, some brown clay	47	280
Sand, large-grain to small gravel	16	296
Sand and gravel packed in clay	8	304
Sand, gravel, and boulders	22	326
Clay, yellow, sandy, and gravel	17	343
12/20-10dccb		
Topsoil, loamy, with rounded cobbles to 8 inches	4	4
Sand, fine to coarse, with silt and rounded cobbles to 8-inch diameter	6	10
Sand, fine to coarse, with rounded gravels to 3 inches and cobbles to 8 inches. Silt and some soft, sandy, yellow clay, odoriferous	50	60
12/20-10dccb--Continued		
Boulder, hard, with fine to coarse sand and silt	1½	61½
Sand, fine to coarse with rounded gravels, cobbles to 8 inches, some sandy yellow clay, mixed	5½	67
Sand, fine to coarse, with rounded gravels to 1½ inches, some sandy yellow clay mixed	5	72
Boulder, very hard	1	73
Sand, fine to coarse, with silt and rounded gravels to 2 inches, clean in streaks, some cobbles and yellow clay mixed	35	108
Boulder, very hard, probably granite	1	109
Sand, fine to coarse, with silt and rounded gravels to 3 inches	1½	110½
Boulder, very hard, probably granite	1½	112
Sand, fine to coarse, with rounded gravels to 3 inches, probably water-bearing	3	115
Clay, sandy, yellow, with fine to coarse sand and rounded gravels to 1 inch, all mixed	16	131
Sand, fine to coarse, with silt and large rounded cobbles to 10 inches, some yellow clay mixed	16	147
Sand, fine to coarse, with rounded cobbles to 10 inches and boulders to 18 inches appears to be a very good aquifer	9	156
Clay, yellow, hard, sticky	5	161
Sand, fine to coarse, with rounded gravels to 2 inches, and small boulders to 12 inches, occasional streak of hard sticky yellow clay mixed	21	182
Clay, yellow, hard and soft, sandy, with rounded gravels to 1 inch	15	197
Sand, fine to coarse, with rounded gravels to 2 inches and cobbles to 10 inches, some yellow clay	48	245
Sand, fine to coarse, with rounded gravels to 3 inches, very clean, some yellow clay and silt mixed	37	282
Sand, fine to coarse, with cobbles to 10 inches	2	284
Sand, fine to coarse, with rounded gravels to 4 inches and occasional cobbles to 10 inches, some silt mixed	22	306
Clay, yellow, hard and soft, sandy	23	329
Sand, fine to coarse, with rounded gravels to ¼ inch	6	335
Clay, yellow, hard, sticky	4	339
Sand, fine to coarse, with semirounded gravels to 3/4 inch mixed	9	348
Clay, yellow, hard and soft, sandy, sometimes sticky	6	354
Sand, fine to coarse, with rounded gravels to ¼ inch, some silt	14	368
Clay, yellow, hard and soft, sandy	6	374
Sand, fine to coarse, with semirounded gravels to 3/4 inch some silt	12	386
Clay, yellow, very soft, sandy	7	393
Sand, fine to coarse, with silt and rounded gravels to 3/8 inch mixed	17	410
12/20-10dccb--Continued		
Clay, yellow, hard and soft, sandy, and coarse sand mixed with small rounded gravels to ¼ inch, possibly water-bearing	11	421
Sand, fine to coarse, with small semi-rounded gravels to ¼ inch, very silty	4	425
Clay, yellow, soft, sandy	3	428
Clay, yellow, hard, sticky, some rounded gravels to ¼ inch imbedded	6	434
Sand, fine to coarse, with small rounded gravels to ¼ inch	8	442
Clay, yellow, hard, sticky, with some gravels to 3/8 inch mixed	3	445
12/20-14aaba		
Clay, streaks of gravel	35	35
Granite, decomposed	32	67
Gravel, coarse, and rock	32	99
Gravel, coarse	21	120
Sand and boulders	15	135
Sand and coarse gravel	31	166
Sand, cobbles, and boulders	29	195
Sand, gravel, and rock	15	210
Gravel	30	240
Shale and gravel	15	255
Gravel, ¼ inch	90	345
Gravel, rock, and boulders	155	500
Sand and boulders	30	530
Clay, sandy, and boulders	45	575
Gravel	15	590
Gravel and shale	60	650
Gravel, streaks of sand	30	680
Sand, fine to coarse, mixed	60	740
Sand and gravel	60	800
12/20-23aaca		
Topsoil	4	4
Sand, coarse to very coarse. 70-80% angular basalt fragments, 20% subangular to sub-rounded quartz and chert. Some biotite. Much gray-brown drilling mud but no clay lumps.	10	14
Sand, very coarse to gravel. 70-80% angular brownish-black basalt fragments (may be iron stains). Angular light yellow-brown chert, 10% subrounded to angular quartz. Trace of muscorite and biotite. Clean sample, no clay lumps.	20	34
Gravel, some very coarse sand. 80% subrounded to angular basalt pebbles and fragments, black with brownish stains. Subrounded to subangular quartz and chert. One calcite fragment noted	10	44
Sand, coarse, 60% gravel sizes. Some basalt pebbles. 80-90% angular basalt fragments, with brown stains. Subrounded to angular quartz and chert.	10	54
Gravel to pebble sizes to 15 mm. 70% pebble-sized angular fragments of black basalt. 20% subangular quartz and chert. 10% red-brown clay.	27	81
Gravel with 20% pebble sizes. 70-80% angular basalt fragments. 15% subrounded to angular quartz and chert. 10% red-brown clay.	15	96
Sand, coarse, and gravel. 80-90% angular to sub-rounded basalt. 10-20% angular quartz and chert. Clean sample, no clay.	12	108
12/20-23aaca--Continued		
Gravel, uniform, about 4 mm. diameter. 95% subrounded volcanics, mainly basalt. 5% subrounded quartz and chert. Clean sample, no clay.	17	125
Gravel, uniform. 90% subrounded to angular basalt. 5% sub-rounded quartz and chert. 5% red-brown clay.	10	135
Sand, coarse, 30%, and gravel, 70%. 90% basalt in rounded to angular grains. Less than 15% chips. 5% quartz and chert in sand-sized grains. Some lumps of yellow clay.	4	139
Sand, coarse, 20%, and gravel, 80%. 90% basalt, rounded to angular grains. 20% chips. 5% quartz and chalcedony. 5% brown clay.	8	147
Same as above, lump of yellow clay.	8	155
Clay, 50%, and gravel. 50% rounded to angular basalt as gravel and chips, 70%. 50% yellow clay and brown silty clay.	8	163
Sand, coarse, 50%, clay, 30%, and gravel, 20%. 60% basalt to sub-rounded, 20% chips. 10% quartz and chert. 30% clay. Yellow and brown lumps noted.	8	171
Sand, coarse, 30%, and gravel, 70%. 80% basalt, subrounded to angular. 20% chips. 20% quartz and chert.	7	178
Clay, 40%, and gravel. 60%. 60% basalt, sub-rounded to angular. 40% clay. Gray, brown, and yellow clay lumps.	17	195
Sand, coarse, 20%, and gravel, 80%. 80% basalt rounded to angular. 20% quartz, chert, granite. 50% of sample in chips.	9	204
Sand, coarse, 40%, gravel, 50%, and clay, 10%. 80% basalt, angular. 10% chert and quartz. 10% brown and yellow clay. Lumps of yellow clay. 50% of sample as chips.	9	213
As above but more clay, about 30%. Lumps of brown and yellow clay.	10	223
Gravel (fines probably washed from sample). 90% basalt, slightly iron stained. 10% quartz and chert. Some lumps of brown clay. 40-50% chips.	17	240
As above but with about 30% brown clay.	17	257
Sand, coarse, 20%, and gravel. 80%. 90% basalt, rounded to angular, 10% quartz and chert. Clean sample, no clay. 40-50% chips.	6	263
Clay, 50%, coarse sand, 10%, and gravel, 40%. 50% brown clay with few lumps yellow clay. 45% basalt, angular 5% quartz and chert. 40-50% chips.	26	289
As above but no clay and less chips. 20-30% chips.	8	297
Sand, coarse, 40%, gravel 50%, clay, 10%. 90% basalt, angular 10% brown clay, no lumps. 20-30% chips.	16	313
Sand, medium, 30%, to gravel, 70%. 90% basalt subrounded to angular. 10% quartz and chert. 20-30% chips.	10	323

(Continued)

Table 40.--Selected well logs--Continued

Material	Thickness (feet)	Depth (feet)
12/20-23aaca--Continued		
Sand, coarse, 30%, to gravel, 70%. 90% basalt subrounded to angular. 10% quartz and chert. 20-30% chips.	10	333
Sand, coarse, 20%, clay, 10%, and gravel, 70%. 90% basalt, well rounded to angular. 10% brown clay with no lumps. 20-30% chips.	20	353
As above, clay more sandy.	21	374
Sand, coarse, 40%, sandy clay, 10%, gravel, 50%. Brown clay, no lumps. Well rounded to angular, 20-30% chips.	12	386
Sand, medium to coarse, 95%, clay, 5%, rounded to angular 45% basalt. 50% quartz, chert, hornblende. 50% brown clay (as drilling mud) few chips.	8	394
Sand, coarse, 95%, to gravel, 5%. 70% basalt. 30% quartz, chert, etc. rounded to angular. Few chips.	8	402
As above, but 20% brown clay.	8	410
As above, 40% clay.	8	418
As above, 20% clay.	8	426
Sand, medium to coarse, 60%, and gravel, 20%, with 20% brown clay.	8	434
As above, 5% clay.	8	442
As above, 20% clay.	24	466
As above, but with 40% brown clay.	8	474
Missing	8	482
Sand, medium to coarse, 60%, and gravel, 20%, with 40% brown clay.	8	490
As above, 30% clay.	8	498
As above, 50% clay.	8	506
As above, 60% clay.	8	514
As above, 70-80% clay.	8	522
Clay, 20%, 60% coarse sand, 20% gravel, lithology unchanged.	5	527
Clay, brown, 90%. Dark gray clay, 10%.	32	559
As above with no gray clay and some coarse sand.	8	567
Clay, brown, 90%, coarse sand, 10%.	16	583
As above, 5% coarse sand	8	591
Clay, brown, 80%, coarse sand, 20%.	32	623
As above, 50% coarse sand and gravel.	8	631
As above, 15% coarse sand and gravel.	19	650
13/19-22abb		
Alluvium; granitic composition	1,268	1,268
13/20-7dad		
Topsoil	4	4
Gravel, coarse	6	10
Sand and gravel	8	18
Clay, blue	2	20
Sand and gravel	4	24
Clay, sand, and gravel	12	36
Sand, coarse, and gravel	12	48
Clay, brown	4	52
Sand and gravel	22	74
Cobbles	5	79
Sand, medium	46	125
Sand and gravel	44	169
Sand, clay, and cobbles	45	214
Sand and gravel	36	250
Sand and clay	28	278
Cobbles and clay	2	280
Clay, sandy	55	335
Clay, sandy, and gravel	60	395
Sand and gravel	10	405
Sand, gravel, and clay	15	420
Clay	7	427
Sand, gravel, and clay streaks	14	441
13/20-32babc		
Topsoil	2	2
Gravel, large, and cobbles	6	8
Gravel, cemented	7	15
Sand, coarse, and cobbles	11	26
Sand, loose	9	35
Gravel, tight	5	40
Gravel, loose	5	45
Sand, tight	8	53
Cobbles, cemented	4	57
Clay, gravel, very soft	4	61
Cobbles, cemented	7	68
Gravel, loose; tight streaks	10	78
Sand, tight	7	85
Clay, hard	5	90
Gravel, loose; tight streak	104	194
Gravel, tight, and cobbles	13	207
Gravel, firm, and cobbles	48	255
Clay	3	258
Gravel, large, loose	19	277
Clay and gravel	3	280
Gravel, loose	16	296
Clay	5	301
13/20-32daab		
Topsoil	3	3
Gravel, large, cemented	9	12
Gravel, cemented	18	30
Gravel with tight streaks	66	96
Clay	16	112
Gravel, loose	9	121
Clay and gravel	3	124
Gravel, loose	11	135
Clay	6	141
Gravel, loose	21	162
Gravel, cemented	21	183
Cobbles	19	202
Clay	3	205
Gravel, loose	9	214
Clay	3	217
Granite, tight, decomposed	13	230
Sand	13	243
Clay	29	272
Gravel	25	297
Clay	4	301
14/19-15bcc		
Loam, dark, sandy	10	10
Sand, yellow	15	25
Hardpan	3	28
Sand, gravel, yellow muck	24	52
Granite, decomposed	3	55
Sand, gravel, and muck, water	5	60
Granite, decomposed	5	65
Sand, gravel, and muck, hard	5	70
Gravel, large, water	4	74
Cemented	9	83
Granite, decomposed	10	93
Boulders	5	98
Sand, dark, hard	3	101
Granite, decomposed	6	107
Granite, gravel, and sand	13	120
Rock, hard, solid, sharp	4	124
Rock, dark, hard	2	126
Sand and gravel, hard	4	130
Gravel and sand, hard	4	134
Granite and gravel	11	145
Clay	15	160
Sand, gravel, water	23	183
Clay, yellow	3	186
Sand, gravel, water	14	200
Rock, dark, hard	4	204
Clay, yellow, and boulders	6	210
Sand and gravel	10	220
Granite boulders, decomposed	7	227
Sand, gravel, and boulders	11	238
Sand, gravel, and boulders mixed with clay	12	250
Sand and gravel	13	263
Gravel and boulders	10	273
Sand, gravel, and boulders	12	285
Sand, water	6	291
Granite gravel, decomposed	4	295
Rock, hard	7	302
14/20-4bdb		
Sand, gravel, and clay	67	67
Boulder	3	70
Sand, gravel, and clay	90	160
Clay	5	165
Sand and gravel	5	170
Clay	5	175
Sand, gravel, and thin streaks of clay	72	247
Clay	3	250
Sand and gravel	15	265
Clay	3	268
Sand and gravel	10	278
Clay	4	282
Sand and gravel	2	284
Clay	2	286
Sand and gravel	6	292
Clay	4	296
Sand, gravel, and thin streaks of clay	38	334
Granite boulder	2	336
Sand, gravel, and clay	128	464
Clay with some gravel and sand	26	490
Granite	29	519
14/20-6cbl		
Sand	3	3
Sand and clay	12	15
Clay	5	20
Clay, hard	11	31
Clay and sand	31	62
Sand and boulders	33	95
Clay	20	115
Sand and rock	38	153
Sand, coarse and fine	45	198
Granite, solid	102	300
15/20-7ddb		
Sand, hardpan at 4 feet	12	12
Sand, coarse	50	62
Clay and gravel	6	68
Clay and sand	12	80
Gravel and sand	10	90
Clay and sand	13	103
Clay and gravel	45	148
Sand and clay	20	168
Clay, soft, and sand	22	190
Sand and clay	37	227
Sand, hard, cemented	3	230
Sand and gravel, cemented, and clay	30	260
Sand and clay, cemented	22	282
Sandstone with rocks, cemented	21	303
Sandstone, cemented streaks of pebbles	87	390
Granite, decomposed	43	433
Basalt streaks in decomposed granite	3	436
Granite, decomposed and clay streaks	63	499
Quartz and imbedded quartzite	11	510
Quartz and granite	5	515
15/20-17dd		
Clay, sandy	6	6
Sand, coarse, and gravel	18	24
Silt, black, hard	5	29
Clay, sand, and gravel	18	47
Clay, streak of gravel	22	69
Gravel, sand, and streak of clay	13	82
Sand and gravel	6	88
Clay, streak of sand and gravel	16	104
Sand and gravel	2	106
Clay, streak of sand and gravel	16	122
Sand and gravel	8	130
Clay, streak of sand and gravel	7	137
Sand, gravel, and clay, broken	52	189
Clay	10	199
Sand, gravel, and clay streak	8	207
Clay, streak of sand and gravel	13	220
Sand, gravel, and clay streak	10	230
Sand, gravel, and clay, broken	15	245
Clay, streak of sand and gravel	7	252
Sand, gravel, and clay, broken	45	297
Clay, streak of sand	10	307
Sand, gravel, and clay, broken	3	310
Clay, few hard streaks	27	337
Sand	12	349
15/20-17dd--Continued		
Clay, streak of sand, hard streaks	25	374
Clay and sand, broken	8	382
Sand and gravel	5	387
Clay, sandy	10	397
Sand and gravel	9	406
Clay, hard streaks	5	411
Sand and clay streaks	5	416
Clay, streak of sand	16	432
Sand, gravel, clay streak	6	438
Clay, streak of sand	15	453
Sand, gravel, and clay, broken	28	481
Sand, gravel, streak of clay	30	511
Clay, sandy	11	522
Sand, gravel, streak of clay	12	534
Clay, sandy	25	559
Sand and clay, broken	20	579
Sand and gravel	7	586
Clay, sandy	30	616
Sand and gravel	8	624
Clay, sandy	33	657
Sand and gravel	5	662
Clay, sandy	18	680
Clay and sand, broken	20	700
Clay	14	714
Sand and gravel	5	719
Clay and sandy clay	18	737
Sand and gravel	4	741
Clay and sandy clay	17	758
Sand and gravel	3	761
Clay and streak of sand	42	803
15/20-32dcab		
Topsoil	1	1
Sand	7	8
Clay, sandy	4	12
Sand, coarse	10	22
Sand, clay, and firm decomposed granite	28	50
Sand, medium	25	75
Sand, firm decomposed granite	43	118
Sand, medium	2	120
Sand, firm decomposed granite	50	170
Sand, medium to coarse	29	199
Sand, fine	10	209
Sand and clay in alternating layers	166	375
15/20-32ddcc		
Topsoil (silty and sandy)	12	12
Sand, silt. Water at 14 feet, came up to 10 feet	8	20
Sand, gravel to 1 inch	4	24
Sand, some silt; very clean	16	40
Silt, green; some clay	6	46
Sand, silt; rust color	23	69
Sand, silt; some small gravel; rust color	36	105
Sand, silt; some small gravel and clay; rust color	15	120
Clay, blue, sandy	10	130
Sand, some clay, brown	16	146
Clay, sandy	4	150
Sand, some clay, brown	24	174
Sand, some clay, gravel	7	181
Clay, sandy	14	195
Sand, some clay	13	208
Clay, sandy	19	227
Granite, rotten	16	243
Granite, hard, solid	4	247
16/21-12acd		
Topsoil	5	5
Gravel, decomposed granite, water	55	60
Gravel, cemented	15	75
Gravel and rock, water	31	106
Sand and gravel, water	19	125
Gravel, cemented	8	133
Sand and gravel, water	8	141
Gravel and small ledges, water	42	183
Clay, blue	3	186
Gravel, water	11	197
Granite, decomposed	17	214
Gravel, water	8	222
Granite, blue	43	265

Table 40.--Selected well logs--Continued

Material	Thickness (feet)	Depth (feet)
X 16/22-9bc		
Sand	18	18
Clay	7	25
Clay, streaks of sand	10	35
Sand, thin streaks of clay	55	90
Clay, blue, streaks of fine gravel	10	100
Gravel, loose, and cobblestones	24	124
Clay, brown, streaks of sand	8	132
Gravel and sand, thin streaks of sandy clay	118	250
Sand and fine gravel, some clay	60	310
Sand and fine gravel	170	480
Sand and gravel, thin streaks of sandy clay	100	580
Gravel and cobblestones, streaks of gray clay	20	600
16/23-3bd		
Sand, fine	4	4
Sand and clay	14	18
Clay, sandy	2	20
Sand, fine	34	54
Gravel, coarse	6	60
Gravel, coarse, going into clay	12	72
Clay, yellow	4	76
Clay, yellow, mixed with gravel	44	120
Clay, hard, mixed with gravel	12	132
Clay, yellow, very hard	8	140
Clay, very hard, mixed with gravel	15	155
Clay and gravel	7	162
Clay and broken rock	7	169
Rock, broken, and clay, malapai	9	178
Lava	77	255
Lava with brown sandy clay	28	283
Lava, very hard	7	290
Lava, hard	11	301
Lava and brown sandy clay	14	315
16/32-19d (Nev. Bur. Mines and others, 1962, p. 106)		
Sand, light-brown, with some green; 100% very fine- to fine-grained sand, with medium grains, predominantly subrounded; non-frosted grains	15	15
As above, but predominantly fine- to medium-grained sand; up to 40% of sand grains nonquartzose, including olivine, biotite mica, hornblende, fine-grained acid and basic volcanics, zircon	10	25
Sand, 90-95% very fine- to very coarse-grained sand, predominantly fine- to medium-grained; up to 30% nonquartzose; slightly plastic at 45-50 feet; 5-10% gravel, including some with ellipsoidal shape; possibly a beach or near-shore deposit of Lake Lahontan	25	50
Sand, 100% very fine- to medium-grained sand, predominantly subrounded; less than 10% nonquartzose; some gravel toward bottom; microfossils present at 50-55 feet	10	60
As above, but light-green-brown; 30-40% nonquartzose	5	65
As above, but subangular to subrounded; 25% nonquartzose	10	75
16/32-19d--Continued		
Sand, 90% very fine- to very coarse-grained sand predominantly subrounded; 25% nonquartzose; 10% subrounded to ellipsoidal gravel; possibly a beach or near-shore deposit of Lake Lahontan	10	85
Sand, 100% very fine- to medium-grained sand, predominantly fine-grained, getting coarser-grained toward the bottom of the interval; up to 25% nonquartzose; few gravels	20	105
Sand, 90-95% very fine- to very coarse-grained sand, predominantly subangular; up to 25% nonquartzose; 5-10% silt, increasing toward the bottom; 5% subangular gravel; alluvium	10	115
As above, but more rounded sand and gravel; possibly beach or near-shore deposit of Lake Lahontan	5	120
Sand, olive green-brown; 100% very fine- to very coarse-grained sand, predominantly medium- to coarse-grained and subrounded; 25-30% nonquartzose; water encountered at 128 feet and subsequently rose to 111 feet; 128-140: 5% silt, slightly to moderately plastic, possibly contaminated by drilling mud; microfossils from 130-140 feet	20	140
Sand, light-brown; 95% very fine- to medium-grained; 20 percent nonquartzose; microfossils	5	145
Sand, gravelly, gray-green-brown; 80-85% very fine- to very coarse-grained sand, angular to subrounded; 40% nonquartzose; up to 5% silt; 10-15% angular to subrounded gravel	15	160
Sand, gray-green-brown; 90-100% very fine- to very coarse-grained sand, becoming very fine- to medium-grained and angular to subrounded at 165 feet; 25-30% nonquartzose; 5% silt from 160 to 165 feet; slightly plastic from 170 to 180 feet, possibly contaminated; 5% gravel from 160-165; alluvium	20	180
Sand, light-gray-brown; 95-100% very fine- to medium-grained sand; 20% nonquartzose, increasing to 40% at 195 feet; up to 5% silt	20	200
Sand, gray-light-brown; 95% very fine- to very coarse-grained sand, angular to subrounded; 40% nonquartzose; 5% silt; rock fragments, subrounded to ellipsoidal gravel from 205-210.	10	210
16/32-19d--Continued		
Sand, gray-green-light-brown; 95-100% very fine- to very coarse-grained sand, predominantly very fine- to medium-grained from 210 to 215 feet; 30-40% nonquartzose; 5% silt; few gravels; microfossils present at 210 to 220 and 235 to 242 feet	32	242
Sand, gravelly, gray-green-brown; 85% very fine- to very coarse-grained sand; 40% nonquartzose; 15% gravel	3	245
Sand, gray-green-brown; 95% very fine- to coarse-grained sand, predominantly fine- to medium-grained; 15-20% nonquartzose; 5% gravel; microfossils present	15	260
Sand, gray-green-brown; 95% very fine- to coarse-grained sand, predominantly very fine- to medium-grained; 15-25% nonquartzose; 5% silt; few gravels; very slightly plastic, may be apparent cohesion; microfossils present at 285-290 feet	30	290
Sand, gray-light-brown; 90% very fine- to very coarse-grained sand, predominantly very fine- to medium-grained; 15% nonquartzose; 10% silt; slightly to moderately plastic; microfossils at 300-305 feet	25	315
As above, but up to 20% nonquartzose, 5% silt; nonplastic to slightly plastic; some gravel and rock fragments	35	350
As above, but 100% sand, microfossils present	10	360
Sand, gray-green-brown; 95-100% very fine- to very coarse-grained sand, predominantly very fine- to medium-grained from 360 to 445 feet; 20% nonquartzose, becoming 25-30% at 450 feet; nonplastic to slightly plastic; up to 5% gravel from 445 feet; microfossils present at 445 to 450 feet	95	455
Sand, gravelly, brown-green-gray; 80-85% very fine- to very coarse-grained sand, predominantly medium- to very coarse-grained; 50-60% nonquartzose; 15-20% gravel and rock fragments, gravels increase in size and become more subrounded to ellipsoidal-shaped at 465 feet, some show a calcareous and siliceous cement adhering to their surface; some slightly to moderately plastic clay lumps present at 470 to 485; possibly a cemented beach or near-shore deposit of Lake Lahontan	40	495
Sand, gray-green-brown; 95-100% very fine- to very coarse-grained sand, predominantly very fine- to medium-grained; 15% nonquartzose; slightly plastic	5	500
16/32-19d--Continued		
Sand, gravelly, olive-green; 85% very fine- to very coarse-grained sand, becoming 90-95% sand at 505 feet; 25% nonquartzose; slightly plastic; 15% gravel and rock fragments, some cement present on larger fragments	15	515
Sand, olive-green-brown; 95-100% very fine- to coarse-grained sand, predominantly very fine- to medium-grained; 20-25% nonquartzose; slightly to moderately plastic	10	525
As above, but plastic to very plastic; still predominantly a sand lithology	20	545
Sand, gray-brown; 90-95% very fine- to medium-grained sand, becoming coarser-grained toward the bottom, predominantly subangular; 20-25% nonquartzose; 5% silt; up to 5% gravel	15	560
Sand, gray-green-brown; 100% very fine- to very coarse-grained sand, predominantly very fine- to medium-grained, becoming coarser-grained toward the bottom of interval; 15-20% nonquartzose; nonplastic to slightly plastic; up to 5% angular to subrounded gravel toward the bottom of the interval	65	625
Sand, gravelly, gray-green-brown; 85% very fine- to very coarse-grained sand, becoming 60% at 630 feet; 25% nonquartzose, becoming 25-50% at 630 feet, 15% gravel becoming 40% gravel at 630 feet, some of gravels are ellipsoidal; possible beach or near-shore deposit of Lake Lahontan	15	640
As above, but 15-20% nonquartzose, 15% gravel	25	665
Sand, gray-green-brown; 95-100% very fine- to very coarse-grained sand, predominantly very fine- to medium-grained toward the bottom of interval; 15-20% nonquartzose; slightly to moderately plastic; up to 5% gravel	15	680
Sand, gravelly, brown-gray; 85-90% very fine- to very coarse-grained sand; 20-25% nonquartzose; moderately plastic from 695 to 705 feet; 10-15% gravel	25	705
Sand, brown-gray; 90-100% very fine- to very coarse-grained sand, angular to subrounded; 15-25% nonquartzose; up to 5% silt; nonplastic to slightly plastic; 5% gravel	45	750
Sand, gravelly, gray-brown; 80% very fine- to very coarse-grained sand; 40-50% nonquartzose; slightly plastic to plastic, decreasing in plasticity above and below the 760 to 775 foot interval	30	780

Table 40.--Selected well logs--Continued

Material	Thickness (feet)	Depth (feet)
16/32-29adc		
Sand, 95-100% very fine- to very coarse-grained sand; up to 5% silt; some gravel and rock fragments; subaerial sediments	15	15
Sand, gravelly, 85% very fine- to very coarse-grained sand; less than 5% silt; 10-15% gravel, subrounded and ellipsoidal-shaped; possible Lake Lahontan beach or near-shore deposit	15	30
Sand, green-gray-brown; 95-100% very fine- to medium-grained sand, a few coarse-grains, predominantly subrounded, ellipsoidal; very calcareous; beach or near-shore deposit of Lake Lahontan	15	45
As above, but brown again; more coarse-grained; some angular rock fragments; noncalcareous to slightly calcareous	25	70
Sand, 95% very fine- to very coarse-garined sand; less than 5% silt; up to 5% gravel and rock fragments; subaerial sediments	10	80
Sand and sand-sized particles, 90-95% very fine- to very coarse-grained sand-sized particles angular to subrounded; up to 10% silt-sized particles; 5-10% rock fragments up to one inch in diameter; sample becomes finer toward the bottom of interval; at 80 to 101 feet a boulder field was encountered	21	101
Sand, 80-90% very fine- to very coarse-grained sand, predominantly very fine- to medium-grained; up to 10% silt; 10% gravel, with suggestions of reworking by waves; many basic rock fragments; trace of water encountered at 101 feet, but possibly was drilling water	6	107
Sand, 90-95% very fine- to very coarse-grained sand, predominantly very fine- to medium-grained, not all quartzose; 5% silt; up to 5% gravel and some rock fragments; becomes coarser toward the bottom of the interval	33	140
Sand, 85-90% very fine- to medium-grained sand, some coarser grains; 10-15% silt; some gravels and rock fragments; more rock fragments toward the bottom of the interval	65	205
16/32-29adc--Continued		
Sand, 85-90% very fine- to very coarse-grained, angular to subrounded; 5-10% silt; 5-10% gravel and rock fragments of both acid and basic igneous origin; many dark, heavy minerals	25	230
Clayey sand, 85-90% very fine- to very coarse-grained sand; up to 5% silt; slightly plastic to plastic; up to 5% gravel	16	246
Sand, same as above, becoming slightly plastic to moderately plastic at 270 feet	44	290
Silty sand, 85-90% very fine- to very coarse-grained sand, angular to subrounded; 10-15% silt; 5% gravel and rock fragments, angular to subrounded, including much basic igneous material; sample becomes slightly to moderately plastic and color becomes more yellow-brown at 295 feet	20	310
Clayey, silty, sand-sized particles, yellow-brown; 85% very fine- to fine-grained sand-sized particles, some coarser materials, angular to subrounded, predominantly angular; up to 15% silt or silt-sized particles; moderately plastic to plastic; apparently a weathered bedrock surface was encountered at 310 feet, with some alluvial material present (possibly as contamination from above); much limonite staining; biotite present in larger amounts than previously; becomes less plastic toward bottom of interval	45	355
Similar to above interval, but only slightly weathered bedrock; a make-shift core barrel brought up a 3-inch core of acidic, coarse-textured igneous material; core has limonite and clay streaks; feldspars are all plagioclases; water was encountered at 361 feet; below the ground and subsequently rose to 329 feet; a possible fractured zone occurs at 361 feet as the drilling tool was caught there; differences in percentage of fine to coarse fragments may be due to differences in degree of hardness of bedrock	20	375
Sand-sized particles, 100% very fine- to very coarse-grained sand-sized particles, angular to subangular; noncalcareous; sample clean and fresh, becoming slightly to moderately plastic toward bottom of interval	70	445
16/32-29adc--Continued		
Clayey sand-sized particles, gray; very fine- to very coarse-sized, angular to subangular; 5% silt-sized particles; plastic; slightly calcareous; probably a clay streak in weathered bedrock	2	447
Sand-sized particles, very fine- to very coarse-sized, angular to subangular; 5-10% silt-sized particles; moderately plastic toward the bottom of the interval	33	480
17/22-33ccbc		
Sand and pea gravel	118	118
Clay, gray	27	145
Sand, white, fine	15	160
Clay, gray	40	200
Clay, sandy	20	220
Pea gravel	20	240
Clay, blue-gray	45	285
Pea gravel	15	300
Clay, red	20	320
Gravel, fine	9	329
Clay, gray	28	357
Clay, sandy	18	375
Pea gravel, fine	14	389
Clay, blue-gray	33	422
Clay, red, sandy	18	440
Sand, dark red, fine	12	452
Clay, blue-gray	28	480
Sand, coarse	24	504
Clay, gray, sandy	16	520
Pea gravel	29	549
Sand, fine; streaks of gravel	51	600
Sand, black	33	633
17/23-10baa		
Topsoil	4	4
Sand, brown, hard-pack	50	54
Sand, coarse, and gravel	35	89
Sand, soft, and gravel	50	139
Gravel, cemented	23	162
Gravel, hard-pack	66	228
Sand, soft, and gravel	72	300
17/23-10bbb		
Gravel	30	30
Gravel and sand	10	40
Sand, clay, and boulders	25	65
Gravel; water	169	234
Bedrock	86	320
17/23-18dd		
Clay, sandy	5	5
Clay, sandy, and gravel	19	24
Sand and gravel	11	35
Sand, gravel, and clay	7	42
Clay, sandy, and gravel	26	68
Sand, gravel, and clay in streaks	15	83
Clay, sandy, and gravel	70	153
Sand, fine	2	155
Clay, sandy	20	175
Sand, clay, and trace of smooth gravel	5	180
Clay, sandy, and gravel	33	213
Sand streak, fine	2	215
Clay, sandy, and gravel	4	219
Sand streak, fine	2	221
Clay, sandy	4	225
Sand streak	2	227
Clay, sandy, and gravel	11	238
Sand streak	6	244
Clay, sandy, and gravel	51	295
Clay, some gravel	25	320
Clay, some trace of sand	7	327
Clay, white, or bentonite	8	335
Clay, sandy, some gravel	10	345
Bentonite	15	360
Clay, sandy	25	385
Clay and some gravel	5	390
Clay, sandy, and some gravel	25	415
Clay, sandy	45	460
Sand and clay streaks	5	465
Clay, sandy, and gravel	10	475
Clay	120	595
Clay and some gravel	23	618
Clay, soft	2	620
Clay, sandy	30	650
Clay, sandy, trace of gravel	55	705
Clay, sandy	80	785
Clay, hard	37	822
17/29-18bd (Morrison, R. B., 1964,169)		
Fallon Formation:		
Surface	20	20
Sehoo Formation:		
Clay, sticky, yellow	25	45
Wyemaha Formation:		
Sand and gravel	30	75
Clay, blue	15	90
Gravel	25	115
Gumbo, black, gas showing	15	130
Gumbo, black	64	194
Correlation uncertain:		
Shale(?)	2	196
Gumbo and sand	54	250
Sand	85	335
Sand, hard	3	338
Shale, soft, gray	10	348
Sand, fine	20	368
Sand, coarse	13	381
Shale, hard, sandy	16	397
Sand, hard	34	431
Sand, fine	10	441
Sand, hard	4	445
Crevice	1	446
Sand, fine	7	453
Sand, hard	10	463
Shale, rotten (smelling?), black; turns gray on exposure to air	10	473
Sand, fine	7	480
Sand, very hard; small crevices and thick hard "shells"	8	488
Sand, fine	12	500
Shale, sandy, gray	11	511
Sand, hard, some shale	17	526
Shale, gray	6	532
Shale, sandy, gas showing at 544 ft	14	546
Shale, gray; crevice	9	555
Shale, sand streaks	10	565
Shale, sandy	5	570
Shale, hard	13	583
Clay, tough, blue	8	591
Sand	6	597
Shale, hard	21	618
Clay, tough, blue	5	623
Sand, hard	14	637
Clay, tough, blue	6	643
Clay	7	650
Sand, very hard	2	652
Shale, very hard	0.7	652.7
Clay and shale	15.3	668
Sand and shale	3	671
Shale, sandy	13	684
Shale, gray	7	691
Shale, sandy	12	703
Sand, coarse	3	706
Shale, sandy	6	712
Shale, blue	9	721
Sand, coarse, water at 725 ft	5	726
Sand, hard	4	730
Shale, hard	9	739
Shale, gray, and sand	9	748
Sand, hard	7	755
Shale with sand streaks	8	763
Shale	9	772
Shale, sandy	6	778
Shale	12	790
Sand	7	797
Shale, hard	1	798
Shale, soft	6	804
Sand, coarse, hard	10	814
Shale, sandy	8	822
Shale	7	829
Shale, hard	1	830
Sand, hard	7	837
Clay, sticky	13	850
Sand, fine	10	860
Shale, tough, gray	42	902
Shale, tough, gray, with sand streaks	20	922
Shale, tough, gray	8	930
Sand, fine	12	942
Sand, hard, and clay	17	959
Sand, fine; and shale	20	979
Shale with sand streaks	25	1,004
Shale, sandy	19	1,023
Shale	34	1,057
Sand, hard	5	1,062
Shale	12	1,074
Sand, hard	6	1,080
Shale	17	1,097
Shale, hard	7	1,104
Shale	10	1,114
Sand, hard	13	1,127
Shale, sandy	7	1,134
Sand, coarse	21	1,155
Sand, hard	3	1,158
Shale, sandy	42	1,200
Sand, hard	3	1,203
Shale, hard	1	1,204
Shale, hard, sandy, slow drilling	4	1,208
Shale, hard	2	1,210
Shale and streaks of hard sand	9	1,219
Shale, sandy	3	1,222
Shale, sandy, gray	28	1,250

(Continued)

Table 40.--Selected well logs--Continued

17/29-18bd--Continued

Material	Thickness (feet)	Depth (feet)
Shale	16	1,266
Limestone shale, hard	.5	1,266.5
Shale, sandy	9.5	1,276
Limestone shale, hard	1	1,277
Shale, blue, with limestone streaks	11	1,288
Sand	2	1,290
Limestone shale	2	1,292
Shale, blue	16	1,308
Shale, blue, and limy shale beds	54	1,362
Shale, blue	4	1,366
Sand, hard	2	1,368
Rock	1	1,369
"Quartz"	5	1,374
Conglomerate(?), very hard	3	1,377
Conglomerate(?), extra hard	4	1,381
Conglomerate(?) extremely hard	1	1,382
"Lime," blue, with thin shale streaks; very hard; gas showing	59	1,441
Shale, soft, blue	5	1,446
Shale, hard	4	1,450
Shale, blue	7	1,457
Shale, hard	3	1,460
Shale, blue	3	1,463
Sand	7	1,470
Shale, hard	4	1,474
Shale and sand, strong gas showing	8	1,482
Shale	4	1,486
Shale and sand	18	1,504
Shale, gray	14	1,518
Rock	.5	1,518.5
Shale and "oil" sand	1.5	1,520
Shale	28	1,548
Sand, hard	4	1,552
Sand and shale	13	1,565
Sand, hard, and shale	22	1,587
Shale	31	1,618
Shale, very hard	8	1,626
Sand and shale	36	1,662
Rock	5	1,667
Shale	11	1,678
Sand and shale	12	1,690
Sand, hard	5	1,695
Shale	25	1,720
Sand	11	1,731
Sand, hard	2	1,733
Sand and shale; crevice, lost circulation	21	1,754
Shale	26	1,780
Shale, hard, gas showing	1	1,781
Sand, shaly; crevice, lost circulation	13	1,794
Shale	4	1,798
Shale, hard, sandy	1	1,799
Shale, lost circulation	4	1,803
Shale, soft, blue	33	1,836
Shale, sticky, gooey	24	1,860
Sand, fine	5	1,865
Shale, gray	14	1,879
Sand, hard	2	1,881
Shale, gray	35	1,916
Sand, hard	5	1,921
Shale	17	1,938
Sand and shale	32	1,970
Shale, hard	4	1,974
Sand and shale	21	1,995
Shale	35	2,030
Sand, hard	5	2,035
Shale	25	2,060
Sand, hard	6	2,066
Shale	20	2,086
Shale, brown	14	2,090
Sand, hard	6	2,096
Sand and shale	24	2,120
Sand, running	14	2,134
Shale	19	2,153
Sand, hard	7	2,160
Shale	32	2,192
Sand, hard, and shale	20	2,212
Quicksand	16	2,228
Sand and shale	30	2,258
Lime, blue	2	2,260
Shale, sticky, blue	12	2,272
Sand and shale	22	2,294
Shale, sticky, blue	44	2,338
Sand, hard	3	2,341
Lime, white	6.5	2,347.5
Sand, hard	3.5	2,351
Shale, sticky	43	2,394
Clay, sticky	15	2,409
Shale, nonsandy	10	2,419
Shale, sticky	12	2,431
Shale and sand	73	2,504
Sand	40	2,544
Shale, sticky	60	2,604
Sand, fine	16	2,620
Shale, hard	16	2,636
Shale	48	2,684
Sand, hard	14	2,698
Sand, fine, gas showing	11	2,709
Shale	26	2,735

17/29-18bd--Continued

NOTE.--D. F. Hewett, of the U.S. Geological Survey, visited this well in May 1922, when it was 2,845 feet deep. He reported (U.S. Geol. Survey open-file report, 1922): water level stood 300 feet below surface, gas bubbled up from outside the casing and was under slight pressure in casing; cuttings were "largely greenish shaly clay, probably derived from finely divided water laid tuff, and no volcanic flow or breccia material was recognized. Cuttings contained minute shells, which in field were considered to be gastropods and bivalves. Specimens were submitted to the National Museum, but the only fossils found were simple ostracods considered to be derived from fresh water Tertiary rocks." R. W. Richards (U.S. Geol. Survey open-file report, 1947) mentioned that various items in the Churchill County *Eagle* between June 10, 1922, and October 1923 stated that the well reached 3,036 feet with rotary equipment, then was deepened either 96 or possibly 264 feet by cable-tool, between September 1922 and October 1923. In June 1922, 6¼-inch casing was set at 2,590 feet; later this casing was pulled and 4-inch casing was run to 3,035 feet and 3-inch to 3,128 feet; 70 feet of hard sandstone with "oil and gas showing" is reported below about 2,875 feet, and below 3,128 feet, very hard sandstone, with drilling rates from 1 to 3 feet a day, and a "strong gas show" between 3,147 and 3,152 feet. Richards reported, however, that C. D. Murray, who did most of the cable-tool drilling, recollected in 1946 that most of the section was soft shale.

18/24-25adb

Material	Thickness (feet)	Depth (feet)
Topsoil	20	20
Clay	26	46
Clay, blue	18	64
Sand, fine; first water-bearing sand	8	72
Gravel, cemented	9	81
Sand, packed	4	85
Pea gravel, clay	7	92
Pea gravel, sand; second water-bearing sand	2	94
Lava formations	48	142
Pea gravel	83	225
Clay with small rocks	25	250
Gravel, cemented	10	260

18/24-27db

Material	Thickness (feet)	Depth (feet)
Clay and rock	110	110
Boulders	10	120
Clay and rock	55	175
Rock with water	82	257
Clay	43	300

18/29-4bac (Kingman, D. S., 1959, fols. p. 15)

Material	Thickness (feet)	Depth (feet)
Sand, coarse, free, subangular, quartz and country sand	17	17
Clay, gray with rounded gravel	10	27
Clay, gray, some sand	18	45
Sand, brown, fine to medium grained, rounded to subangular	3	48
Clay, black and gray, little sand	14	62
Sand, medium to coarse, tight	8	70
Basalt gravel cemented with fine sand	2	72
Sand, fine, tight	15	87
Clay, gray, soft and sticky, grass roots	5	92
Sand, fine grained with basalt grains, tight	10	102
Sand, rounded to subangular, medium to coarse grained, free, quartz and country sand	40	142
Gravel, small, subangular; brown clay to sandy gravel and brown clay	20	162
Clay, gray with some pea-sized gravel	25	187
Clay, gray	10	197
Clay, black and gray, sticky	37	234
Clay, gray, sandy	71	305
Sand, fine to medium grained, subangular; gray clay	7	312
Sandy gray clay with streaks of gray clay, trace of pea-sized gravel	68	380

18/29-4bac--Continued

Material	Thickness (feet)	Depth (feet)
Sand, fine grained, subangular	5	385
Clay, gray, hard	5	390
Clay, gray, sandy, trace of lime	25	415
Clay, gray, trace of sand	5	420
Clay, gray, more sand	10	430
Clay, gray, sticky, trace of sand	27	457
Clay, gray with subangular fine sand	60	517
Clay, gray with trace of sand	20	537
Clay, gray, sticky	39	576
Sand, fine, free	5	581
Clay, gray with trace of fine to coarse sand	55	636
Sand and gravel, subangular, trace of gray clay	6	642
Sand and dark gray clay, fine to medium subangular sand	19	661
Sand, medium to coarse grained and gray clay, trace of gravel, tight formation	4	665
Clay, sandy gray	33	698
Clay, dark blue	3	701
Clay, gray, soft	2	703
Basalt gravel and volcanic dust well cemented	1	704
Basalt gravel and cinders cemented with quartz sand or glass (volcanic tuff); very little country sand; marine shells, 710 to 714	13	717
Basalt sand and volcanic dust loosely cemented; small basalt grain size	2	719
Basalt cinder rock and volcanic sand well cemented	11	730
Basalt gravel and volcanic sand, loose	4	734
Basalt gravel and volcanic sand, cemented	3	737
Basalt gravel and volcanic sand cemented, little gray clay	5	742
Basalt gravel and sand with gray clay; streaks cemented and loose	9	751
Gray sand, fine to medium subangular grained, and gray clay; little basalt rock, cemented	25	776

18/29-5aaa (Kingman, D. S., 1959, fols. p. 15)

Material	Thickness (feet)	Depth (feet)
Sand, gray, poorly sorted fine (50%) to pea gravel (2%), round to subangular, marine shells, some basalt chips	17	17
Sand, coarse, brown, fairly well sorted, rounded, 99% quartz	10	27
Sand, fine, free, well sorted, gray 99% quartz	10	37
Sand, coarse, gray, fairly well sorted, rounded, 99% quartz, little gray clay	28	65
Sand, dark gray, poorly sorted, quartz 95%, basalt 5%, free, poorly sorted fine to medium	15	80
Sand, medium to coarse, light brown, free, multicolored grains other than quartz	22	102
Sand with gravel, sand well sorted coarse, rounded; gravel country rock to ¼ inch, subangular, some brown clay	23	125
Gravel, to 3/8 inch, free, rounded to subangular, poorly sorted, quartz, basalt and sandstone, some brown clay	22	147
Gravel and sand, poorly sorted up to ¼ inch round to subangular, free, lot of basalt pebbles	23	170

18/29-5aaa--Continued

Material	Thickness (feet)	Depth (feet)
Sand, brown, poorly sorted fine to coarse, little rounded basalt gravel, grass roots, little clay, loose	12	182
Sand, brown, poorly sorted, round to subangular, loose	5	187
Sand, brown, poorly sorted, subangular, loose, green and gray clay	35	222
Sand, dark brown, poorly sorted fine to coarse, round to subangular; quartz and basalt grains, less clay than above, loose mud	20	242
Clay and sand, poorly sorted silt to fine sand, clay green and black, sand grains subangular	7	249
Sand, poorly sorted to medium grain, subangular, little green clay; formation tight	18	267
Sand and clay, sand poorly sorted, subangular; clay green and black, formation tight, grass roots	10	277
Sand, brown, rounded to subangular, poorly sorted mostly coarse grains; little clay green, gray and black; formation loose	30	307
Sand, poorly sorted fine to coarse, subangular, little clay	14	321
Sand, brown, poorly sorted medium to coarse, round to subangular; some clay, green, gray and black; formation loose	31	352
Clay, gray with fine subangular sand; formation hard	10	362
Clay, gray and green with fine grained sand, grass roots, few pebbles of white rock; formation soft; little mica	34	396
Clay, gray and green with fine grained round to subangular sand, grass roots; formation hard	7	403
Clay, same as above with very little sand; formation is soft	37	440
Sand, brown, poorly sorted fine to pea gravel, some clay green, gray and black. Lower 12 feet has more clay and more coarse sand; some basalt grains	45	485
Clay, gray with poorly sorted sand, grass roots, some mica; formation soft	23	508
Clay, same as above with more sand, finer grained, little brown clay	34	542
Sand, gray, poorly sorted fine to small gravel, few grains of basalt pebbles; some mica and gray clay	41	583
Cemented sand and gravel, rounded medium sorted sand; lot of porous basalt grains, dark color; formation hard; more basalt and less sand near bottom of formation	7	590
Cemented basalt gravel with sand and clay matrix	11	601
Cemented basalt gravel, very few porous cuttings; fine grained sand near top, harder formation in middle; some clay near bottom; very hard	8	609
Basalt pea gravel, loose, reddish brown, little clay	2	611

(continued)

Material	Thickness (feet)	Depth (feet)
18/29-5aaa--Continued		
Cemented basalt gravel and boulders, little clay and sand	5	616
Same with more porous grains, some clay, grass roots	7	623
Lost mud rapidly after 6 inches into clay formation at 623 feet		
18/29-10bbb (Kingman, D. S., 1959, fold. p. 15)		
Sand, fine grained surface material	9	9
Clay, green with nodules of gray clay, little sand	16	25
Clay, green, hard and tight	8	33
Clay, very fine grained sandy gray, some mica and country grains of sand	41	74
Clay, same with lenses of black clay	9	83
Clay, same with more sand	22	105
Sand, gray, poorly sorted, fine to medium rounded grains - eolian	38	143
Clay	11	154
Sand, poorly sorted fine to coarse rounded grains	10	164
Clay, black and gray, some fine sand	6	170
Clay, soft, black, some fine sand	7	177
Clay, green, tight	10	187
Clay, gray with nodules of black clay, very little sand; swamp odor from lower ¼ of formation	86	273
Clay, gray and green with fine grained sand	32	305
Sand, medium to coarse, green clay, few grains of fine gravel	16	321
Clay, green, hard	45	366
Shaly clay, swamp gas	11	377
Clay, blue green	36	413
Shaly clay	6	419
Clay, gray and green, some medium grained sand; gas at 447 feet and 495 feet	76	495
Clay, gray soft, some sand	38	533
Clay, gray, green and black, little sand	22	555
Clay, gray, sandy, lenses of shaly clay; gas at 575 feet	34	589
Clay, sandy, gray, green and brown, nodules of lime, grass roots	13	602
18/29-23cac (Morrison, R. B., 1964, p. 149)		
Fallon Formation:		
Sand	11	11
Sehoo Formation:		
Clay, gray	36	47
Wyemaha Formation:		
Clay, black	101	148
Correlation uncertain:		
Clay, gray	67	215
Clay, soft, black	55	270
Clay, gray	72	342
Clay, gray, and fine sand	14	356
Clay, black	52	408
Clay, greenish-gray	142	550
Clay, gray-green	50	600
Clay, gray	155	755
Clay, green	25	780
Clay, gray	80	860
Clay, green-gray	26	886
Clay, gray, and streaks of sand	76	962
Clay, gray	94	1,056
Clay, gray, and sandy grit	24	1,080
Clay, gray	176	1,256
Sand, fine	2	1,258
Clay, gray	52	1,310
Clay, sandy, gray	17	1,327
Clay, gray	3	1,330
Clay, sandy, gray	32	1,362
Clay, gray	27	1,389
Sandstone	1	1,390
Clay, gray	27	1,417
Clay, soft, gray	9	1,426
Clay, hard, gray, and sand	2	1,428
Clay, soft, gray	12	1,440
Clay, gray	4	1,444
Clay, gray, some sand streaks	28	1,472
Clay, grimy, green	From	1,472
Total depth reported to be		1,700
18/31-20c (Morrison, R. B., 1959, p. 237)		
Sand and gravel	20	20
Clay, red	10	30
Sand	15	45
Clay	75	120
Gravel	10	130
Clay	35	165
Sand	5	170
Clay	85	255
Sandstone	70	325
Gravel; salt water	35	360
Sand	20	380
Gravel	6	386
Sandstone	14	400
Sand, dry	3	403
Sandstone	17	420
Gravel	10	430
Clay	90	520
Shale, blue	80	600
Shale, brown	20	620
Shale, blue	50	670
"Shale", brown	155	825
"Shale", blue	60	885
"Shale", gray	40	925
"Shale", brown	125	1,050
"Shale", gray	15	1,065
"Shale", brown	40	1,105
"Lime", gray	30	1,135
"Shale", brown	85	1,220
"Conglomerate"	15	1,235
"Lime", gray; "iron" at 1,370 feet	210	1,445
"Lime", black	15	1,460
"Shale", gray	30	1,490
"Sand", gray, carries water	10	1,500
"Lime", gray	135	1,635
"Lime", black	20	1,655
"Lime", blue	10	1,665
"Lime", black	10	1,675
"Lime", gray	65	1,740
"Lime", black	60	1,800
"Lime", gray	120	1,920
"Lime", black	60	1,980
Total depth reported to be or 2,060 feet		2,015
19/28-22dab (Morrison, R. B., 1959, p. 125-126)		
Sand	60	60
Clay, blue	9	69
Sand	3	72
Hard streak	1	73
Sand, coarse	32	105
Clay, gray and brown	15	120
Clay and streaks of sand	138	258
Gravel, cemented	20	278
"Metamorphosed rock"	5	283
Conglomerate, black	1	284
Rock, hard	2	286
Conglomerate	119	405
Sandstone	4	409
Clay, yellow	3	412
"Blue strata"	71	483
Sandstone	7	490
Shale	140	630
Sand, fine	5	635
Sandstone	7	642
Sandstone, soft, and sand	118	760
Shale	24	784
Lime and fine green sand	6	790
Sand, hard	35	825
Shale, blue	46	871
Sandstone	3	874
Shale, blue; hard streak at base	124	998
Shale, gray	13	1,011
Sandstone	24	1,035
Shale, blue and green	15	1,050
Hard vesicular basalt breccia, cemented by greenish $CaCO_3$	26	1,076
19/28-24acc (Morrison, R. B., 1959, p. 127)		
Surface soil	5	5
Clay, soft	11	16
Sand	3	19
Clay, soft	16	35
Clay, hard	3	38
Clay, soft	2	40
Sand	5	45
Clay, sandy	35	80
Clay, hard, sandy	2	82
Sand	16	98
Clay, sandy	9	107
Silt, black	17	124
Sand, fine	4	128
Clay, soft	17	145
Clay, sandy	5	150
Sand, very fine	10	160
Clay	4	164
Sand	1	165
Clay	15	180
Sand with streaks of clay	16	196
Sand	2	198
Clay, sandy	10	208
Sand, fine	13	221
Clay, yellow	17	238
Gravel, fine	4	242
Clay, green	15	257
Sand	13	270
Sand, water-bearing	17	287
Clay	1	288
Sand and gravel, water-bearing	45	333
Clay	54	387
19/28-36abe		
Sand, fine grain	60	60
Clay, blue with sand stringers	37	97
Clay, gray, with sand stringers	45	142
Clay, gray, hard, with sand stringers	59	201
Sand, hard, large grain to small gravel	11	212
Clay, gray, sandy with sand stringers	58	270
Clay, gray, sandy	20	290
Sand	6	296
Clay, gray, sandy, and gravel	22	318
Clay, blue, sandy	52	370
Clay, gray, sandy, with sand stringers	85	455
Clay, blue, sandy	25	480
Clay, yellow, tan sticky clay, black mucky mud (gas)	40	520
Basalt	44	564
Basalt, black, hard	17	581
Basalt, black, extra hard	8	589
Basalt with quartz, some sand, real loose	25	614
Sand, loose, with gray sandy clay	59	673
Sand, hard	5	678
Sand with sandy clay	37	715
Sand, hard	2	717
Sand, silty, and sandy clay	23	740
Sand streaks with blue clay and sandy clay	73	813
19/28-36daa		
Topsoil and sand	4	4
Clay and sand	9	13
Sand, coarse	4	17
Clay, blue, and sand in streaks	19	36
Clay, brown, sandy	14	50
Clay, black	3	53
Clay streaks, dark, sand and gravel	147	200
Clay, dark, sandy	90	290
Clay, blue	60	350
Gravel, coarse	7	357
Clay streaks, sand, and gravel	133	490
Clay, blue	20	510
Rock, porous	48	558
19/29-30cba		
Topsoil	5	5
Sand, yellow, and gravel, soft	21	26
Clay, blue	8	34
Sand, blue	26	60
Clay, sandy, soft	31	91
Sand, streak of clay	30	121
Clay streaks, blue, yellow clay, blue sand	61	182
Clay, blue, 10 feet; 20 feet hard sand	30	212
Sand, blue	60	272
Sand, blue, some yellow clay	61	333
Clay, blue, yellow clay, streaks of sand; basalt 404 to 423 feet	90	423
Basalt	61	484
19/29-30cdb1		
Topsoil	5	5
Sand, fine	7	12
Sand and gravel	4	16
Clay, sandy	4	20
Sand, fine, and soft clay	13	33
Clay, blue, hard	1	34
Sand, fine, and soft clay	3	37
Tule sand, fine, odor very bad	32	69
Sand, coarse, and gravel, bad water due to tule water above	10	79
Tule sand, very fine	4	83
Sand, coarse, and gravel, tule water	8	91
Clay, brown	1	92
Sand, fine	8	100
Sand, fine, and gravel	9	109
Clay, brown	1	110
Sand, fine	13	123
Clay, brown	2	125
Clay, brown, sandy	2	127
Tule clay, black, soft	23	150
Tule clay, brown, soft, sandy	15	165
Sand, coarse, and gravel	2	167
Clay, black, hard	3	170
Clay, fine, sandy, and mud	138	308
Clay, brown, soft	5	313
Clay, fine, sandy, and mud	17	330
Clay, light, sandy	2	332
Clay, brown, hard	2	334
19/29-30cdb1--Continued		
Sandstone, brown	2	336
Clay, soft, mud, and silt	56	392
Clay, sandy, soft	36	428
Rocks, 2 inches	1	429
Clay, brown, soft	3	432
Sand, fine	1	433
Clay, brown, hard; cut-off point for 22-inch casing	11	444
Point of water	4	448
Water static 33 feet	2	450
Rock, very large, hard and soft, water good	10	460
Rock, very large, hard and soft	35	495
Setting of 14-inch water column	--	495
End of hole. Eight-inch drill left in hole, 495 feet to 506 feet. This hole is still in large rock, no sand, silt, or mud below 448 feet. Good water.		506
19/29-30cdb2		
Fallon Formation:		
Surface soil	5	5
Sand, fine	7	12
Sand and gravel, water-bearing	4	16
Wyemaha Formation:		
Clay, sandy	4	20
Sand, fine, and soft clay	13	33
Clay, hard, blue	1	34
Sand, fine and soft clay	3	37
"Tule" sand, fine, (with dark-colored organic matter), very bad odor	32	69
Sand, coarse, and gravel; bad-smelling water	10	79
"Tule" sand, very fine	4	83
Sand, coarse, and gravel; "tule" (swamp) water	8	91
Clay, brown	1	92
Sand, fine	8	100
Sand, fine, and gravel, water-bearing	9	109
Clay, brown	1	110
Sand, fine	13	123
Clay, brown	2	125
Clay, brown, sandy	2	127
"Tule" (organic) clay, black, soft	23	150
"Tule" (organic) clay, brown, soft, sandy	15	165
Sand, coarse, and gravel	2	167
Clay, hard, black	3	170
Unit unknown:		
Clay, fine-sandy, and mud	138	308
Clay, soft, brown	5	313
Sand, fine, clay and mud	17	330
Clay, light, sandy	2	332
Clay, hard, brown	2	334
Clay, gray	2	336
Clay, soft, and mud	56	392
Sand	63	455
Probably basalt of Rattlesnake Hill or Bunejug Formation:		
Basalt, hard, black	3	458
Lava, porous	2	460
Lava, porous, slightly harder	15	475
Lava, porous	40	515
Lava, very hard	6	521
19/29-31babc		
Clay and sand	15	15
Clay, blue, and sand	20	35
Sand, blue, fine	46	81
Sand	24	105
Clay, gray	30	135
Sand	3	138
Clay, blue	57	195
Sand	5	200
Clay, blue	15	215
Gravel, fine	15	230
Clay, gray	25	255
Sand and gravel	45	300
Clay, brown	98	398
Gravel, cemented	11	409
Clay, blue, and rocks	9	418
Volcanic rock - either boulders or shattered rock	17	435
Cinders, porous black rock, softer than above	9	444

Table 40.--Selected well logs--Continued

Material	Thickness (feet)	Depth (feet)
19/29-33cbb1		
Sand	20	20
Clay, gray	5	25
Sand	10	35
Clay, blue	55	90
Sand	25	115
Clay	35	150
Sand, cemented	22	172
Clay, sandy	13	185
Clay, blue, and silt	66	251
Clay, blue, and sand	29	280
Clay, blue, and coarser sand	50	330
Sand	63	393
Sand, cemented	8	401
Clay, thin layers, and sand	28	429
Sand	11	440
Clay and sand	30	470
Sand, cemented	10	480
Sand, cemented, with soft spots	16	496
Basalt, black	9	505
Same with soft spots	7	512
Rock, black, extremely hard	5	517
Softer, probably sandstone	6	523
Rock, black and red, fractured	17	540
19/29-33cbb2		
Alluvial topsoil	18	18
Hardpan	11	29
Clay, sandy	81	110
Sand rock, soft	13	123
Clay, blue and green	377	500
Lava rock	30	530
19/29-33cbb3		
Sand	20	20
Clay, sandy	20	40
Sand	15	55
Clay	5	60
Silt, blue	15	75
Clay	10	85
Clay, sandy	45	130
Clay with some sand	10	140
Sand, hard	10	150
Sandstone?	10	160
Sand, loose	4	164
Sand and some clay	52	216
Clay, blue, silty	7	223
Sand	10	233
Clay and sand (very thin layers)	107	340
Sand, hard	10	350
Sandstone, soft	20	370
Sand and clay	38	408
Sand	50	458
Clay, blue, and sand	24	482
Clay, blue	8	490
Sand, cemented	10	500
Basalt	17	517
Basalt, fractured and porous	14	531
20/26-26cc		
Clay, white	32	32
Gravel	18	50
Shale	52	102
Sandstone	18	120
Shale	3	123
Sandstone	23	146
Shale	8	154
Lava rock	23	177
Shale	20	197
Sandstone	7	204
Shale	91	295
Sandstone	60	355
Sand rock, hard	14	369
Clay and sand	2	371
Clay	15	386
Shale	45	431
Shale and sand	9	440
Shale	88	528
Shale and rock	8	536
Shale	39	575
Clay	5	580
Rock	2	582
Sand, dry	8	590
Clay and sand	2	592
Sand, dry	23	615
Shale	4	619
Rock	3	622
Shale	118	740
Shale and sand	12	752
Shale	17	769
Shale and sand	5	774
Shale and rock	4	778
Shale	14	792
Sand	14	806
Shale, black, sticky	13	819
Shale, black, and gravel	7	826
Shale, brown, and gravel	5	831
20/26-26cc--Continued		
Shale, black	9	840
Sand and shale	6	846
Shale, brown and black	11	857
Shale, black	13	870
Shale and slate	3	873
Slate	4	877
Slate and sandy blue clay	4	881
Clay, blue, sandy	23	904
Sandstone	6	910
Sandstone and blue clay	19	929
Sandstone	20	949
Sandstone and blue clay	8	957
Sandstone	6	963
Sandstone and blue clay	15	978
Clay, blue, sticky	7	985
Clay, blue	10	995
Clay, blue, and sand	8	1,003
Clay, blue	17	1,020
Clay, blue, and sand rock	5	1,025
Sandstone	10	1,035
Clay, blue	12	1,047
Clay, blue, and sandstone	9	1,056
Clay, blue	7	1,063
Clay, blue, and sand	11	1,074
Clay, blue	6	1,080
Clay, sandy	6	1,086
Sandstone and clay	8	1,094
Shale, sandy	8	1,102
Sand	2	1,104
Clay, sandy	5	1,109
Sand	15	1,124
Clay, blue	11	1,135
Slate, blue	4	1,139
Sandstone	4	1,143
Clay, blue	7	1,150
Shale, blue	14	1,164
Sandstone	6	1,170
Shale, blue	10	1,180
Sandstone, gray, hard	3	1,183
Sandstone	3	1,186
Clay, white	9	1,195
Chalk rock	8	1,203
Clay, white	17	1,220
Sand rock, blue	10	1,230
Shale, blue	6	1,236
Sand rock, blue	10	1,246
Sandstone	4	1,250
Clay, blue	3	1,253
Clay, blue, and gravel	9	1,262
Slate, blue, and clay	8	1,270
Clay, blue	42	1,312
Sand rock, hard	4	1,316
Clay and sandstone	7	1,323
20/28-1bd		
Clay	2	2
Sand	1	3
Clay, sandy	107	110
Sand, medium	10	120
Clay, sandy	75	195
Sand, medium	5	200
Clay, sandy	145	345
Sand and gravel	12	357
Basalt rock	25	382
Gravel, cemented	158	540
Rock, broken	37	577
Unconsolidated rock, conglomerate	50	627
20/29-30ccc		
Dune sand, gray, mostly very fine to fine-grained, small percent medium grained, rounded to subangular particles mostly quartz with 10 to 15% lithic fragments, black, brown, red (probably basalt and rhyolite) contains a small amount of silt	18.0	18.0
Silt, brown, low plasticity, fairly dense; contains a low plasticity, fairly dense; contains a low percent of very fine, micaceous sand	4.2	22
Clay, gray, firm, moderately to highly plastic, moderately consolidated; contains less than 5% very fine black sand	14.4	36.4
Sand, very fine to medium-grained, 75% quartz and 25% lithic fragments (volcanics), rounded to subrounded particles, loose, drills fast	3	39.4
20/29-30ccc--Continued		
Clay, gray, highly plastic	.6	40
Sand as described from 36.4 to 39.4	2.4	42.4
Clay, brown at upper contact with streaks of iron oxide changing to gray, moderately to highly plastic, soft	4.9	47.3
Organic clay, bluish black, very soft, plastic, has slight odor of decaying organic matter	8	55.3
Sand, fine to medium-grained, quartz and volcanic fragments in about equal proportions; particles rounded to subrounded	1.7	57
Clay, dark gray, highly plastic, slightly organic; contains a large percent of coarse sand from 62.0 to 63.0	6	63
Sand, medium to coarse-grained with occasional pea gravel; particles subangular to rounded, about equal proportions of quartz and black volcanic fragments; from 67.0 becomes medium-grained, well sorted	20.7	83.7
Organic clay, very soft, black tule deposit, has slight odor	1	84.7
Sand, medium-grained, as described from 67.0 to 83.7	7	91.7
Clay, greenish-gray, very dense, slightly to moderately plastic	2	93.7
Sand, medium-grained as described from 67.0 to 83.7	4.3	98
Clay, greenish-gray as described from 91.7 to 93.7	1	99
Sand, medium-grained as described from 67.0 to 83.7	1	100
Sand, medium-grained, fairly well-sorted, rounded to subangular particles of quartz and volcanic fragments	1.7	101.7
Clay, greenish-gray, dense, slight to moderate plasticity; changing to light brown clay, firm moderately plastic	3	104.7
Sand, medium to coarse-grained, same composition as sand from 99.0 to 101.7	2.3	107
Clay, light brown, dense moderately plastic; contains low percent of fine sand	6	113
Sand, light brown, black, red, white translucent particles, medium to coarse-grained, mostly coarse-grained, rounded to subangular particles of quartz and lithic fragments in about equal proportions. Thin clay interbed at 115.0 about 1-foot thick	16.2	129.2
Clay, brown, lean, slight to moderate plasticity, firm; contains about 5% fine sand. Changes to gray and becomes sandy from 135.0 to 138.7	9.5	138.7
Fat clay, light gray, highly plastic, firm, moderately consolidated. Becomes tight, dense, well consolidated from 145.0 to 147.0	8.3	147
Clay, dark gray to black, dense, well consolidated, slightly organis, highly plastic	2	149
Clay, dark greenish-gray, moderately plastic, moderately consolidated; contains 10 to 15% fine-grained sand	5	154
Sand, fine to medium-grained, few coarse grains, fairly well graded in fine and medium sizes; composed of estimated 60% quartz, 25% black fragments (basalt), 15% green, brown, red lithic fragments; particles are subrounded to angular	15	175
Sand, fine to coarse-grained, well graded; particles are subrounded to subangular, composition as above	7.5	182.5
Clayey sand, green gray, grading quickly to fat clay, moderately consolidated	1.5	184
Fat clay, gray, moderately consolidated, highly plastic. Becomes tight, drier, well consolidated from 186.0 to 189.0. Contains 5 to 10% fine-grained sand from 189.0 to 194.0	10	194
Sand, fine to coarse-grained with occasional pea gravel, predominantly medium-grained, particles rounded to angular, estimated 50% quartz with red, brown, tan, green lithic fragments, few black basalt particles. This sand has different appearance than previous sands.	6	200
Sand, poorly-graded, fine to coarse-grained with occasional pea gravel; particles rounded to angular, composition as above. From 216.0 to 221.8 becomes well-sorted, medium-grained	20	220
Sand, mostly medium-grained, fairly well sorted, composition as above	1.8	221.8
Sandy clay, gray, low to moderate plasticity, contains an estimated 25% fine sand	2.2	224
Sand, fine to medium-grained, composition as from 194.0 to 221.8	1	225
Clay, gray, moderate plasticity, contains low percent of fine sand	1	226
Sand, fine to medium-grained at upper contact becoming fine to coarse-grained with about 10% pea gravel; red, green, black lithic fragments, 50% quartz; particles rounded to subangular	7.8	233.8
Clay as from 225.0 to 226.0 alternating with fine to medium-grained sand, apparently occurring as thin beds of clay and sand; clay is moderately plastic	2.8	236.6
Sand, fine to medium-grained, 70% quartz, 30% red, brown, black, tan lithic fragments; particles rounded to subangular	3.4	240
Sand, fine to medium-grained to 245.0, 70% quartz, 30% lithic fragments, mostly volcanics, rounded to subangular, gradually becoming coarse grained below 245.0. About equal proportions of medium and coarse grains at 250. Predominantly coarse-grained at 253.0 and below with 5 to 10% pea gravel	25.7	265.7
Clay, brown, moderately plastic; contains 10 to 15% fine to medium-grained sand	1.8	267.5

(Continued)

Table 40.--Selected well logs--Continued

Material	Thickness (feet)	Depth (feet)
20/29-30ccc--Continued		
Sand, fine to medium-grained, 40% quartz, 60% lithic fragments; particles rounded to subangular	2.5	270
Clay and sand, thinly bedded. Clay, gray, moderately plastic, firm; contains 10 to 15% fine sand. Sand, fine to medium-grained, composition as from 267.5 to 270.0	6.9	276.9
Sand, fine to medium-grained, poorly graded, predominantly medium-grained, subrounded to angular particles, 50 to 60% quartz, 40 to 50% black, brown, red, green lithic fragments, maximum particle size, 0.1-inch diameter. This sand is probably partly cemented although there is no indication of cementation in the cuttings	20.5	297.4
Sand with thin clay interbeds; sand is fine to medium-grained as above; clay is gray, highly plastic, firm	2.6	300
Sand with thin clay interbeds as above	9	309
Sandy clay, dark gray, moderately plastic, moderately consolidated, firm, becoming softer with depth and slightly organic	10	319
Clay, very soft, dark gray to black, slightly organic; no odor	2	321
Sand, fine to medium-grained, approximately equal proportions of quartz and lithic fragments, maximum particle size 0.1 inch	7	328
Clay or silt, dark bluish-gray, very soft, slightly organic	2	330
Sand, fine to medium-grained as from 321.0 to 328.0	2	332
Clay, dark bluish-gray, or silt as from 328.0 to 330.0	4	336
Sand, fine to medium-grained as from 321.0 to 328.0	6	342
Clay, dark bluish-gray as from 328.0 to 330.0	1	343
Sand, fine to medium-grained as from 321.0 to 328.0	1	344
Clayey sand, blue-gray, fine-grained quartz sand with 10 to 15% blue-gray clay	1	345
Sand, fine to medium-grained, subangular to rounded particles of quartz and red, brown, green, black lithic fragments, maximum particle size 0.1 inch. Thin interbed of gray clay from 347.0 to 348.	10	355
Clay, light gray, soft, moderately plastic; contains low percent of fine to medium-grained sand	4	359
Sand, fine to medium-grained, mostly medium grained, quartz, green, brown, black fragments	1	360
Clay, light brown, soft, low plasticity, contains a low percent of fine sand	14	374
Clay, dark gray, soft, slightly organic, contains estimated 5% fine to medium-grained sand	6	380
Clay, black, soft, slightly organic becoming more organic with depth, highly organic at about 385.0; contains 10 to 15% very fine sand; has slight organic odor, silty	12	392
Sand, fine to medium-grained, poorly-graded, quartz, green, brown, black fragments	1	393
Silt and clay, black, organic, very soft; same as described above from 380.0 to 392.0	2	395
Sand, fine to medium-grained, predominantly medium-grained, subangular to rounded particles of quartz and lithic fragments	1.5	396.5
Clay and silt, dark gray to bluish-black, plastic, soft to very soft, organic; contains a low percent of very fine sand	10.5	407
Sand, as described from 395.0 to 396.5	1	408
Clay and silt, dark gray to bluish-black, plastic, soft, organic; contains a low percent of very fine sand	3	411
Sand, fine to medium-grained as described from 395.0 to 396.5	1	412
Clay, grayish-green, dense, slightly plastic	4	416
Silt and clay, dark gray to black, organic	3	419
Sand, as from 395.0 to 396.5	.5	419.5
Organic silt and clay as above	2.5	422
Sand, medium-grained becoming medium to coarse-grained from 425.0 to 427.0, rounded to subangular particles, 30% quartz, 70% black, green, gray, lithic fragments. Sand appears to be clean but is underlain and overlain by organic deposits	10	432
Clay, dark gray, moderately soft, moderately plastic, slightly organic, very slight odor	4	436
Sand, predominantly medium-grained, some fine grained, composition as above	4	440
Cuttings are sandy clay; 60% clay, 40% sand. Formation is probably thin beds of clay and sand. Clay is dark gray, slightly organic, slight odor as before. Sand is predominantly medium-grained, 60% quartz, 40% tan, red, black, light green gray fragments, few mica flakes; particles are angular to subrounded	11	451
Interbedded clay and sand. Clay is gray, soft, inorganic. Sand, medium-grained, composition as above	5	456
Sand, fine to medium-grained, angular to rounded particles of quartz and lithic fragments	3	459
Interbedded soft gray clay and medium-grained sand	5	464
Sand, medium to coarse-grained, average particle size, 0.1 inch, maximum size, ¼ inch, angular to rounded	5	469
Clay, light brown, moderately plastic, soft to firm	2	471
Sand as from 464.0 to 469.0	3.5	474.5
Sandy clay, light gray, slightly plastic; contains 25 to 30% very fine quartz and black sand	3	477.5
Sand, poorly-graded, fine to medium-grained, angular to subrounded particles, most are angular, 30% quartz with red, brown, black, green, gray lithic fragments, few dark mica flakes	3.5	481
Clay, gray, soft, moderately plastic, slightly sandy	9	490
Clay, brown, moderately plastic, firm, moderately consolidated, contains 5 to 10% fine sand	4	494
Clay, very soft, gray; contains 25 to 30% fine sand which probably occurs as thin interbeds, occasional streak of black decomposed organic material present	6	500
Clay, very soft, gray, contains 25 to 30% fine sand which probably occurs as thin interbeds, occasional streak of black, decomposed organic matter	8	508
Clayey sand gradually changing to sandy clay; 20% clay, 80% sand at upper contact with clay content gradually increasing to 60%, grayish-green, nonplastic; sand is fine-grained	3	511
Clay and silt, dark gray to black, organic, soft	2	513
Clay, light gray, soft contains a low percent of sand	4	517
Clay and silt, dark gray to black, soft, organic	1	518
Clay as from 513.0 to 517.0, sandy, probably contains thin interbeds of sand	2	520
Clay, gray, soft, sandy; probably contains thin beds of sand	5	525
Interbedded clay and sand. Clay, gray, soft, moderately plastic as above. Sand fine to medium-grained, predominantly medium-grained	9	534
Clay, gray, soft, moderately plastic, slightly organic	9	543
Sand, predominantly medium-grained, particles are angular to subrounded, quartz and red, brown, black, green lithic fragments, cuttings contain 20 to 25% soft gray clay, probably thin clay interbeds	11.3	554.3
Sand, medium-grained, particles mostly angular to subrounded, few well rounded, estimated 60 to 70% quartz, small amount of chert, remainder black (basalt), green, gray, red, brown lithic fragments, few mica flakes	7.7	562
Clay, brown, dense, moderately well consolidated, moderately plastic, slightly sandy	1	563
Sand, fine to medium-grained, predominantly medium-grained, few coarse grains; particles are mostly angular to subrounded, few well rounded; estimated 60 to 70% quartz, small amount of chert and few mica flakes; remainder is black (basalt) green, gray, red, brown lithic fragments	18	580
Sand, fine to medium-grained. Mostly medium grained, few coarse grains; particles are mostly angular to subrounded; few are well rounded; composed of 50 to 60% quartz, 40 to 50% black, gray, brown, red, green lithic fragments, few mica flakes. Cuttings at 583.0 and 588.0 are clayey sand, brown, fine-grained, mostly quartz grains with 25 to 30% clay	20	600
Sandy clay, light rust brown, dense, moderately well consolidated, slightly to moderately plastic; sand content variable from 10 to 30%	4	604
Sand, medium grained with few fine and coarse grains as from 563.0 to 600.0. Several thin beds of sandy clay are present	15	619
Sandy clay from 619.0 to 620.0, light brown, slightly plastic, contains 15 to 20% fine sand	1	620
Sand, predominantly medium-grained, few fine and coarse grains, particles mostly angular to subrounded, few well rounded; estimated 60 to 70% quartz with 30 to 40% black (basalt), green, gray, red, brown lithic fragments, few mica flakes. Thin beds of sandy clay at 622.0 and 626.0, brown, moderately consolidated, nonplastic; contains 25 to 35% fine sand	16	636
Clay, brown, dense, moderately to highly plastic; contains less than 5% fine sand	4	640
Sand, fine to medium-grained, composition as from 604.0 to 636.0	6	646
Clay, brown, moderately plastic, firm	1	647
Sand, fine to medium-grained as from 604.0 to 636.0. Cuttings contain from 10 to 25% clay from 650.0 to 665.0, brown to gray, firm, moderately plastic; probably occurs as thin clay interbeds. Thin clay layer at 668.0	24	671
Clay, medium gray, firm, moderately consolidated, moderately to highly plastic	3	674
Sandy clay with thin sand interbeds. Clay is gray, moderately consolidated; contains 10 to 25% fine sand. Sand is fine to medium grained as above	7	681
Clay, medium-gray, dense, moderately well consolidated, moderately to highly plastic, contains a low percent of fine sand	11.3	692.3
25/33-10aa		
Silt, soft	9	9
Gravel, coarse	3	12
Gravel and silt, medium soft	6	18
Sand, hard	4	22
Gravel, coarse	8	30
Gravel, hard, coarse	10	40
Silt and sand, soft	5	45
Gravel, hard, coarse	15	60
Silt and sand, soft	15	75
Gravel, hard, coarse	10	85
Silt and sand, soft	5	90
Gravel, hard, coarse	13	103
Gravel, hard, coarse, water	12	115

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Water year	Number	Year of pub.
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1916	390	1917
1938	860	1939
1943	980	1945
1951	1214	1953
1956	1444	1958
1961-65	1927	1970

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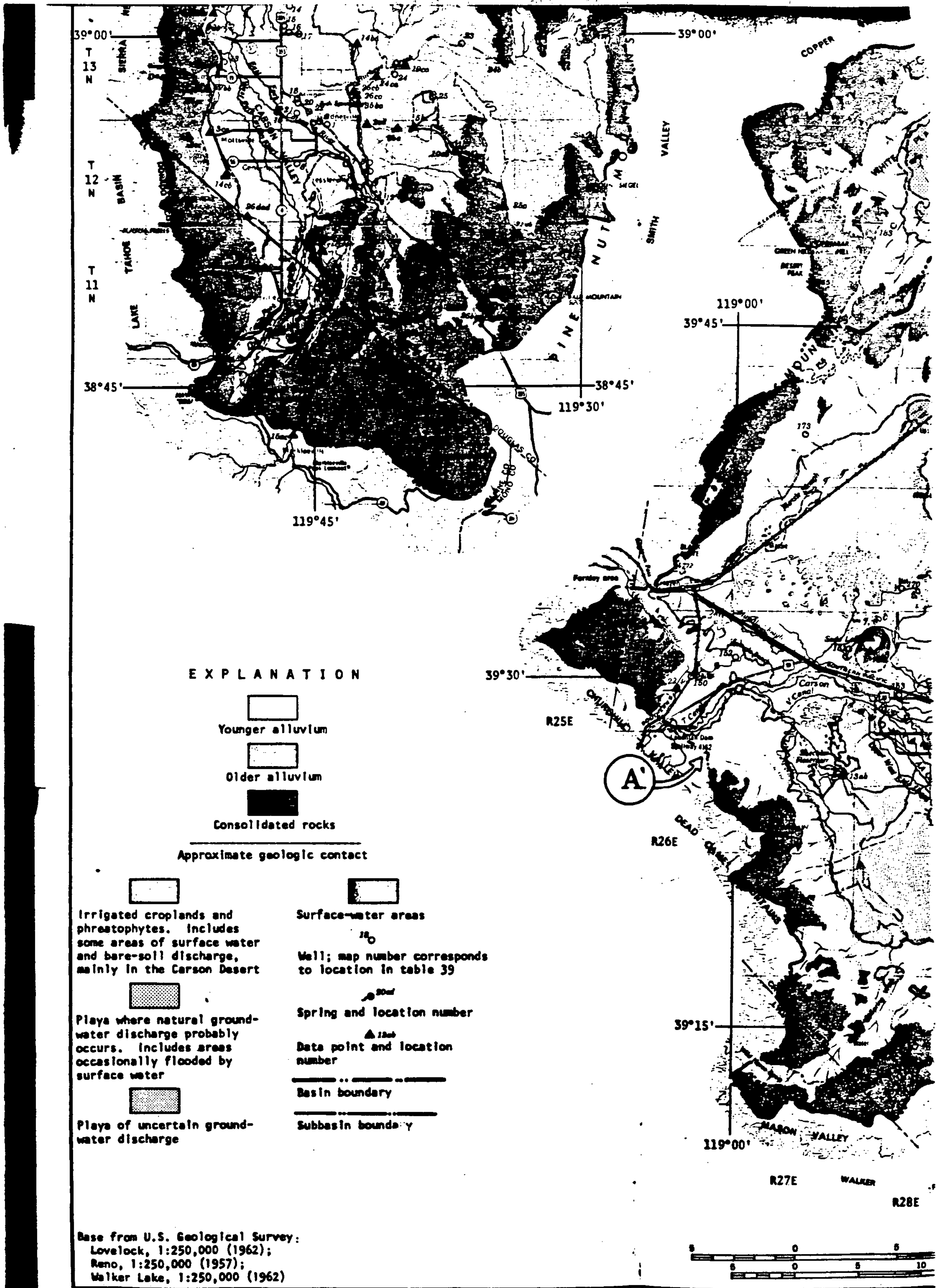
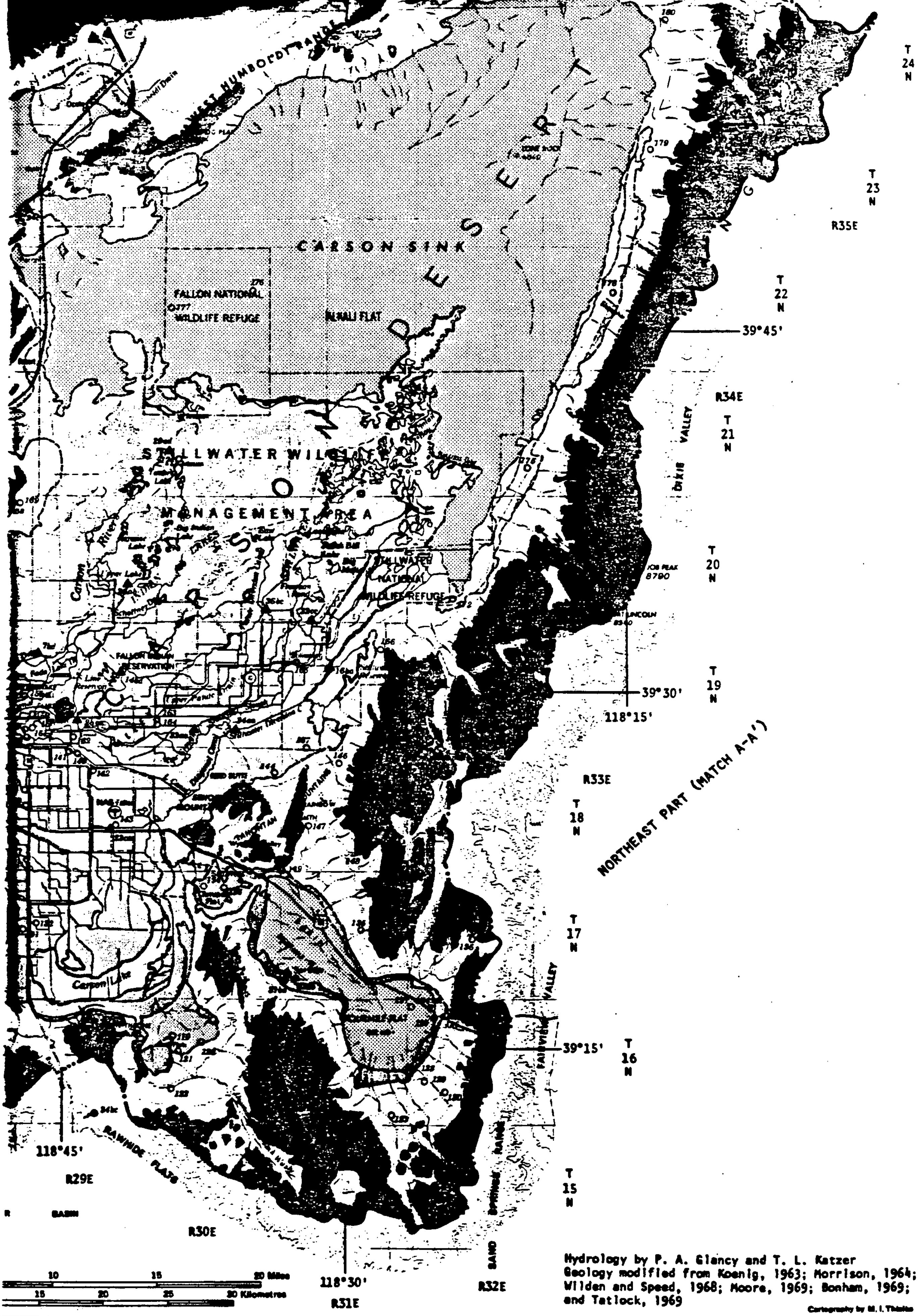


PLATE 1.—GENERALIZED HYDROGEOLO



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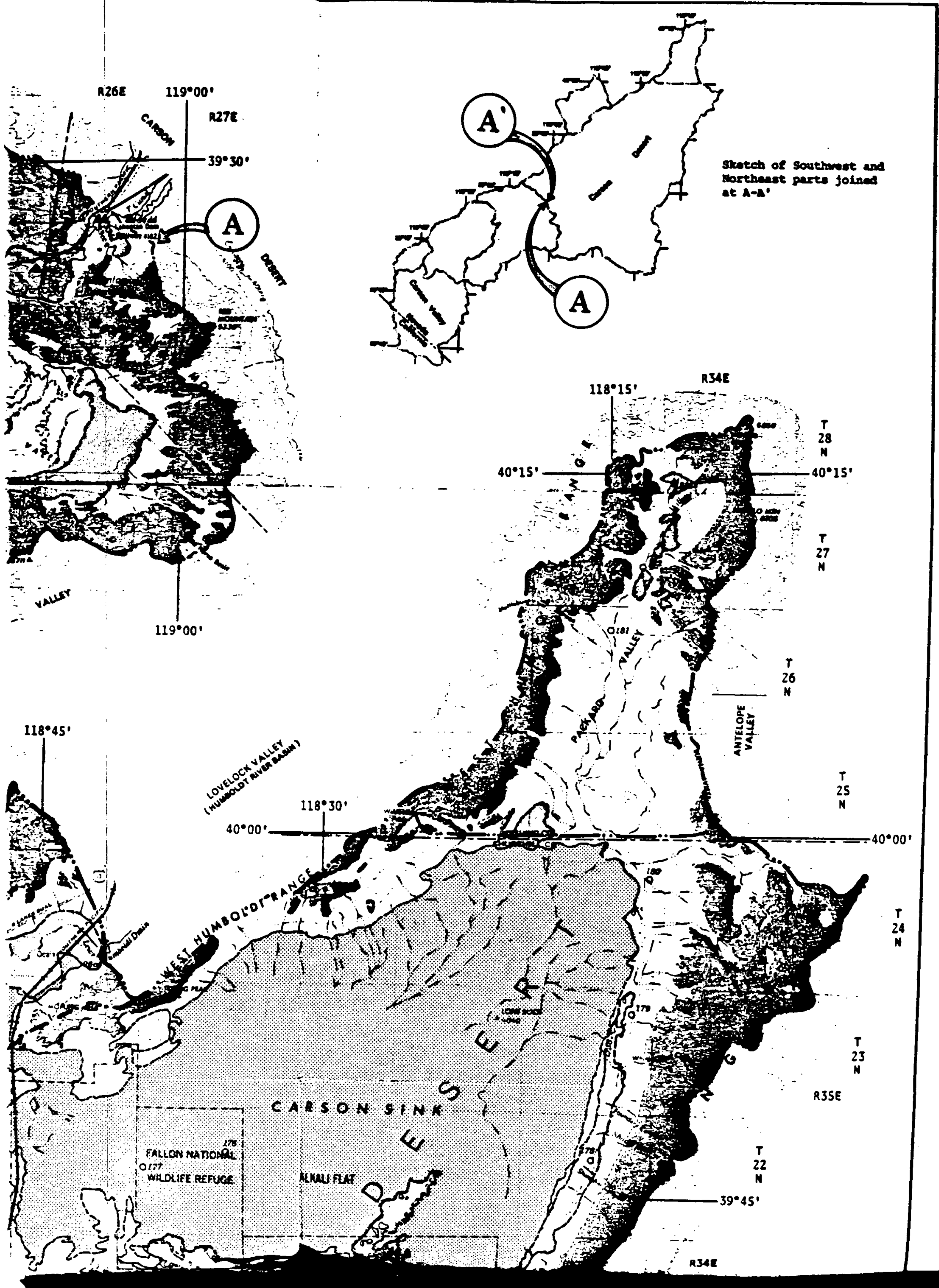

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