STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DIVISION OF WATER RESOURCES

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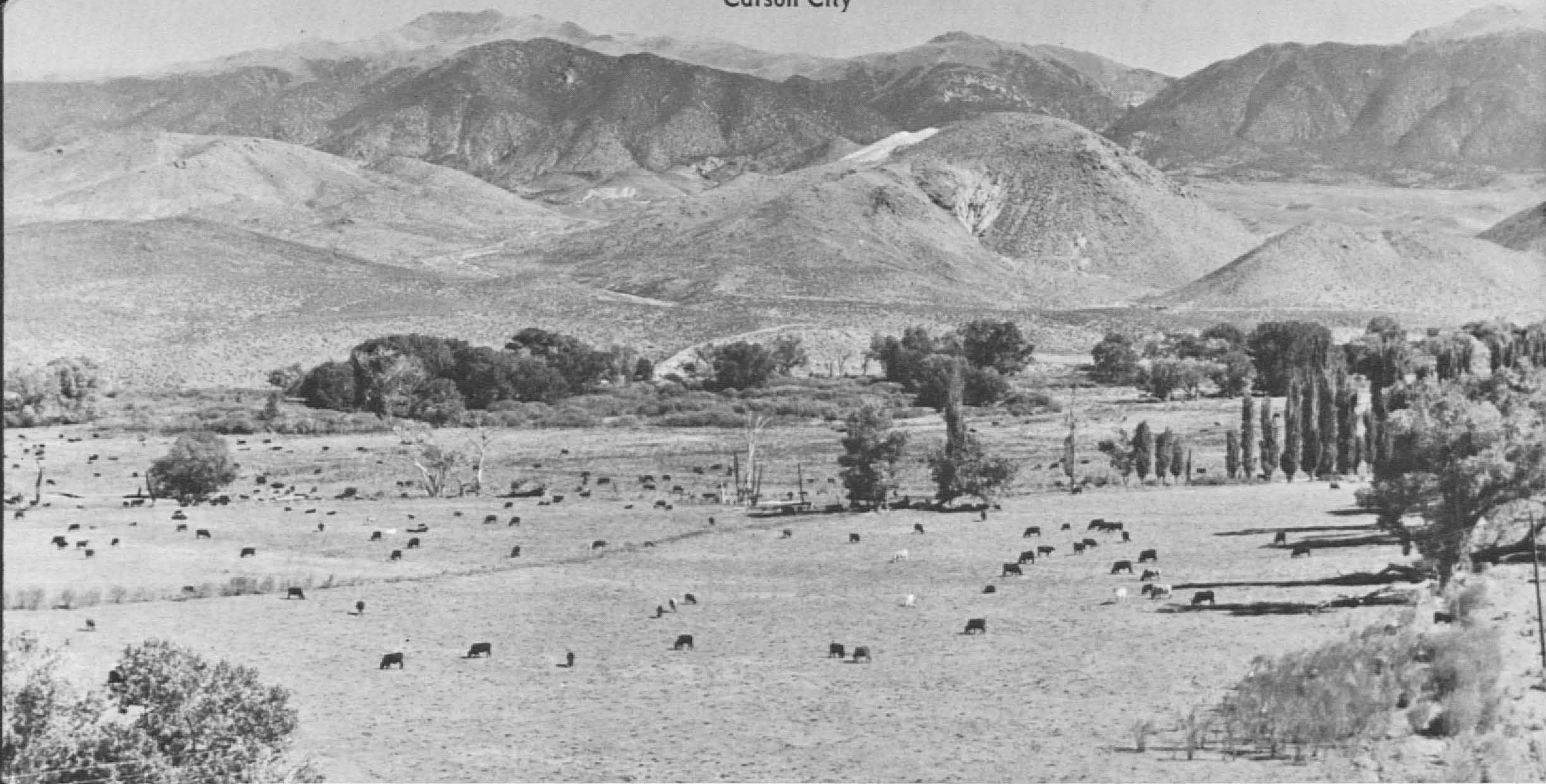

Livestock grazing on the floodplain of the East Walker River.

WATER RESOURCES–RECONNAISSANCE SERIES

REPORT 53

WATER–RESOURCES APPRAISAL OF ANTELOPE VALLEY AND EAST WALKER AREA, NEVADA AND CALIFORNIA

By

Patrick A. Glancy

Prepared cooperatively by the

Geological Survey, U.S. Department of the Interior

1971

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Residential development along the northwest shore of Topaz Lake in Antelope Valley.

WATER RESOURCES - RECONNAISSANCE SERIES

REPORT 53

WATER-RESOURCES APPRAISAL OF ANTELOPE VALLEY AND EAST WALKER AREA, NEVADA AND CALIFORNIA

By

Patrick A. Glancy

Hydrologist

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FOREWORD

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

This report is the 53d report prepared by the staff of the Nevada District Office of the U.S. Geological Survey. These 53 reports describe the hydrology of 174 hydrographic areas.

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

Roland D. Westergard
State Engineer

1971

Division of Water Resources

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WATER-RESOURCES APPRAISAL OF ANTELOPE VALLEY AND EAST WALKER AREA, NEVADA AND CALIFORNIA

By Patrick A. Glancy

SUMMARY

The study area includes Antelope Valley, with particular respect to the Nevada part, along the West Walker River and that part of the East Walker River drainage between Bridgeport Reservoir and Mason Valley. About 985 square miles are thus encompassed. Principal hydrologic estimates pertaining to the investigation are summarized in table 1.

The East and West Walker Rivers are the dominant hydrologic features of their respective areas or valleys. Water enters Antelope Valley by precipitation within the valley, as streamflow, and ground-water underflow from upstream. It leaves by evaporation, transpiration of vegetation, including both natural plants and crops, and by underflow and streamflow of the West Walker River. Small amounts are consumed by man and animals.

The East Walker Area receives its water from Bridgeport Reservoir and by precipitation within the area. Water leaves the area in essentially the same ways as from Antelope Valley; however, there may be an appreciable amount of ground-water outflow from the Rough Creek drainage southward to Mono Lake Valley.

Most crop irrigation in the East Walker Area utilizes diverted streamflow, whereas both ground-water and surface-water irrigation occur in Antelope Valley. Ground water, including springflow, furnishes most of the domestic and livestock water in both Antelope Valley and the East Walker Area.

Most natural discharge of water by evapotranspiration occurs along the rivers or near perennial streams tributary to the rivers.

The principal known aquifer system occurs within the valley-fill deposits. However, untapped aquifers may also exist locally within the consolidated rocks. Where data are

Table 1.--Hydrologic summary

[Estimates are in acre-feet per year, except where noted]

	Antelope Valley	East Walker Area
Approximate valley area (square miles)	250	735
Average annual river inflow	165,000	98,000
Surface-water runoff to the valley fill	5,600	30,000
Potential ground-water recharge	18,000	31,000
Ground-water inflow	1,000	200
Consumptive use by crops	35,000	11,000
Natural evapotranspiration	12,000	7,500
Average annual river outflow	150,000	97,000
Pumpage (1969)	2,000	15
Ground-water outflow	200	150
Minimum system yield	41,000	17,000
Ground water in storage	+350,000	800,000

sufficient to suggest direction of movement, ground-water flow through the valley-fill deposits is toward the perennial stream channels. However, ground-water data are generally scanty, particularly in the East Walker Area.

Most surface and ground waters in the area are of good chemical quality, as indicated by the low dissolved chemical content. Specific conductances of sampled water range from 62 to 500 micromhos. However, little or no data are available regarding presence of minor chemical constituents, which may strongly affect acceptability of the water for specific uses.

The available water supply, with regard to the present level of development in the area, is predicated on existing surface-water rights along the perennial streams. Increased development of the water resources may hinge, at least in part, on development of the ground-water system and salvage of any unappropriated flood waters, if any. Many areas that show good promise for ground-water development are near the perennial stream channels. There the interrelationships of ground- and surface-water systems might preclude extensive ground-water exploitation because of interference with existing surface-water rights.

INTRODUCTION

Purpose and Scope of the Investigation

Nevada is currently experiencing a rapid growth in population and associated development that began more than a decade ago. Increased water requirements for domestic, industrial, agricultural, and conservation uses have accompanied this growth. Anticipating these increasing water needs, the Nevada State Legislature enacted legislation (Chapter 181, Statutes of 1960) authorizing an expansion of the established program of hydrologic investigations being conducted by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The legislation provided financing, in the form of matching funds with the Federal Government, to conduct a reconnaissance appraisal of the water resources of the State. The appraisal is being made as a series of reconnaissance investigations of individual areas or groups of areas. This investigation is the 53d in the series.

The objectives of the reconnaissance investigation, including this study, are to (1) describe the general geology as it relates to the water resources, (2) appraise the source, occurrence, movement, and chemical quality of water in the area, (3) estimate average annual recharge to and discharge from the ground-water reservoir, (4) evaluate the surface-water resources in the valleys, and (5) provide preliminary estimates of the ground-water yield and ground water in storage. Although the area encompasses parts of two States, most quantitative estimates of the water resources are limited to Nevada.

The East Walker Area includes that part of the drainage in California tributary to the river downstream from Bridgeport Reservoir, because a convenient record of the main surface inflow to the area is provided by a streamflow gage just downstream from the reservoir. However, the California part of the East Walker Area included in this study is small compared to the Nevada part. Most of the water originating in California ultimately reaches Nevada because development within the California part is small at the present time.

Hydrology of the California part of Antelope Valley is discussed in a report by the California Department of Water Resources (Calif. Dept. of Water Resources, 1964). Therefore, additional hydrologic study of the California part during this study was limited to include only additional hydrologic data necessary to define quantitatively the hydrology of the Nevada part.

This investigation was made under the general supervision of G. F. Worts, Jr., district chief in charge of hydrologic studies by the Geological Survey in Nevada. Field work was done during August-October, 1968.

Location and General Geographic Features

Antelope Valley and East Walker Area of this report include much of the territory roughly enclosed by lat 38°10' and 38°50' N., and long 118°40' and 119°40' W. It is in west-central Nevada and includes some territory in California (fig. 1). It comprises areas tributary to the East and West Walker Rivers.

Antelope Valley, a hydrologic segment of the West Walker River drainage area, encompasses about 250 square miles of which about 115 are within Nevada (Rush, 1968, p. 19) and the remainder are in California. The East Walker Area of this report encompasses about 735 square miles of which about 586 are in Nevada (Rush, 1968, p. 19) and the remainder are in California.

Overall population of the area is sparse. The greatest number of inhabitants reside in Antelope Valley; there the Nevada residents are mainly concentrated around the northwest shore of Topaz Lake where some residential subdivision and development has occurred. Several other Nevada residents live along U.S. Highway 395 and Nevada State route 3. In comparison, the California part of Antelope Valley is generally more intensively developed (Calif. Dept. of Water Resources, 1964).

Population and development of the East Walker Area is currently almost exclusively geared to agriculture. Only about a dozen families reside in the area. However, the area has many visitors who come to hunt, fish and recreate in the outdoors, including those who enjoy exploring several prominent ghost towns (Aurora, Bodie, and Masonic). The ghost towns are historical reminders of an earlier era when mining was the major industry and the population was greater.

There are no incorporated towns within the Nevada part of the study area. U.S. Highway 395 and Nevada State route 3 pass through Antelope Valley in Nevada. Nevada State Highways 22 and 3C serve the East Walker Area.

Previous Work

Geology of the California part of the area is mainly covered by Koenig (1963), which is a compilation map that synthesizes information from several unpublished sources. Moore (1961) compiled a preliminary geologic map that includes the Douglas and Lyon Counties, Nevada, parts of the report area. Geology of Mineral County, Nevada, was compiled by Ross (1961).

Hydrology and geology of adjacent Smith Valley area were studied by Loeltz and Eakin (1954), and a study of the hydrology of Mason Valley was made by Huxel (1969). The physical and

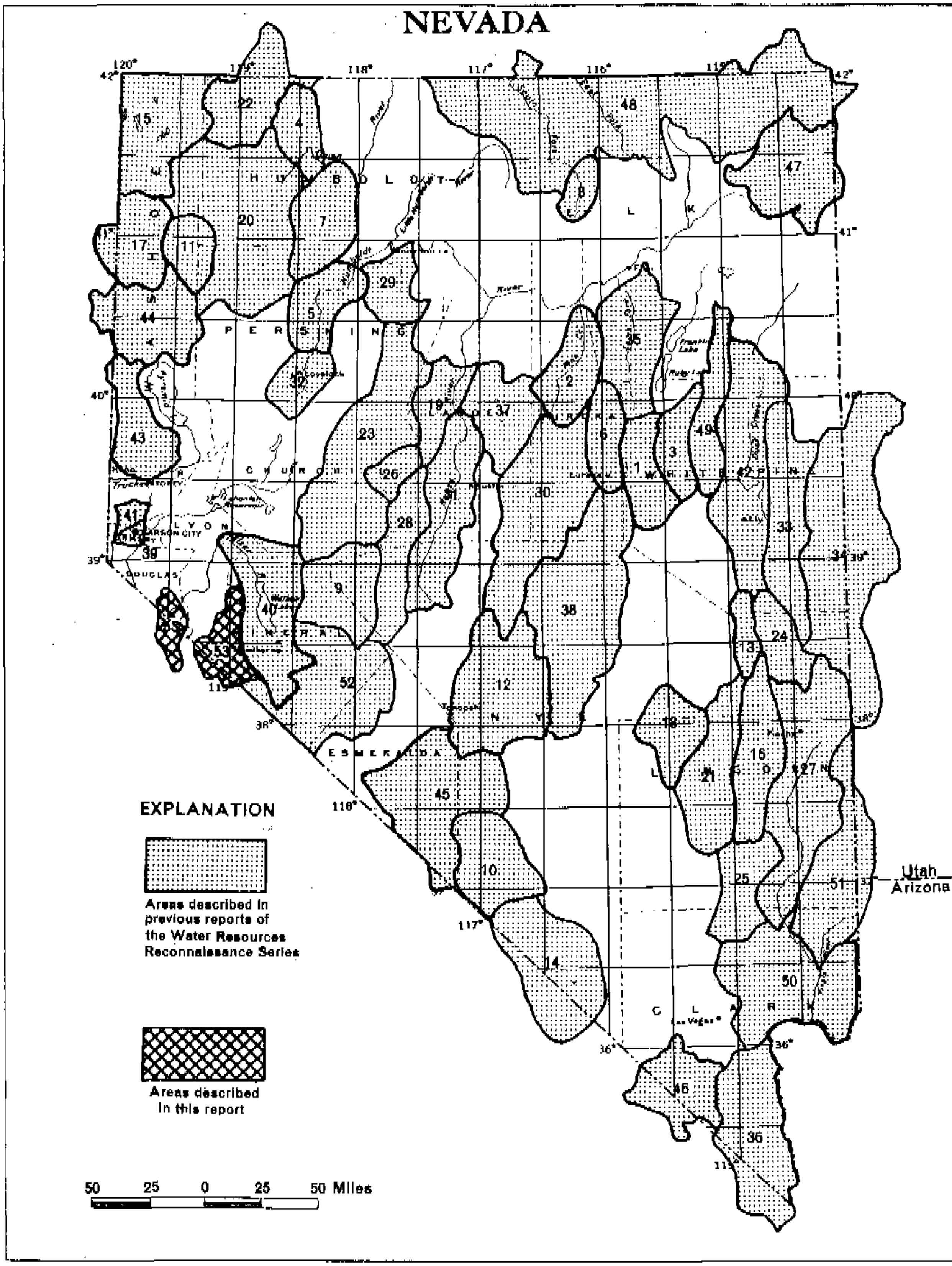

Figure 1.—Areas in Nevada described in previous reports of this series and the area described in this report

economical aspects of conjunctive use of irrigation water in Smith Valley were discussed by Dominico, Schulke, and Maxey (1966). Reconnaissance hydrologic reports on adjacent areas include Walker Lake area by Everett and Rush (1967) and Columbus Salt Marsh-Soda Spring Valley area by Van Denburgh and Glancy (1970). A detailed report on the water and land resources of the Walker River drainage basin was recently prepared by several State and Federal agencies (Nevada Dept. of Conservation and others, 1969).

The above reports and maps provide a basic reference list of hydrologic and geologic information in and near the report area; however, the list is not implied to be complete.

Acknowledgments

The writer is grateful to the many residents of the area who provided valuable information about water use and development, and allowed access to their land and wells. Especially helpful with specific information were Leonard Anker and Charles Saulisberry (U.S. Soil Conservation Service), George Brooks, Milton Cox (Mgr., Sweetwater Ranch), James Elliot and Rudy Reimold (U.S. Bureau of Land Management), Robert Frenzel (California Dept. of Parks and Recreation), Nell R. Fuller, Francis Goettsch, Oscar Ivey, Malcom E. Jones, James R. Kilduff (Mgr., Fairfield Ranch), Ambrose Rosaschi, Jack Sceirine, James B. Tuttle, and Henry Tyree (Mgr., Flying M Ranch).

GENERAL HYDROLOGIC ENVIRONMENT

Physiographic Features

The two north-south aligned valleys of the report area each enclose a major through-flowing, perennial stream. The West Walker River flows through Antelope Valley, and the East Walker River traverses its namesake area (pl. 1). The East and West Walker Rivers originate in the Sierra Nevada of California and their confluence, several miles downstream from the report area, forms the Walker River. The Walker River terminates in Walker Lake, which is the natural discharge sink of the hydrologic system (fig. 2).

Several small perennial streams flow into the East and West Walker Rivers within the report area. Lost Cannon and Slinkard Creeks join the West Walker River, and the East Walker receives tributary waters of Rough, Sweetwater, Murphy, and Water Canyon Creeks. Each drainage contains numerous ephemeral stream channels, many of which contain perennially flowing streams throughout restricted headwater segments. The localized perennial flows are caused by many small springs discharging in the higher altitude parts of the area. Occasionally, the ephemeral stream channels transmit snowmelt or thundershower runoff to the main streams.

Two man-made lakes are within or adjacent to the report area; Topaz Lake in Antelope Valley, and Bridgeport Reservoir in the East Walker Area (pl. 1). The outlet works of both lakes enable man to control to some extent the downriver streamflow in both rivers.

Antelope Valley and East Walker Area are surrounded by consolidated-rock mountain masses, as shown on plate 1. The Sierra Nevada is the major mountain system of the region, and its easterly slopes form the headwater drainage in the California part of Antelope Valley. Although the Sierra Nevada does not lie directly within that part of the East Walker River studied in this report, drainage from that massive mountain system dominates the annual streamflow of the East Walker River. Other major mountains within the report area include the Pine Nut, Sweetwater, and Wassuk Ranges (pl. 1 and fig. 2). Maximum altitudes of the various ranges within the area are approximately as follows: Sierra Nevada (Lost Cannon Peak), 11,099 feet; Pine Nut Mountains (Bald Mountain), 9,206 feet; Sweetwater Mountains (Mt. Patterson), 11,673 feet; and Wassuk Range (Corey Peak), 10,520 feet. Minimum altitude in Antelope Valley is about 4,980 feet and that in the East Walker Area is about 4,580 feet. Therefore, approximate maximum reliefs within the report area are 6,000 and 7,000 feet, respectively.

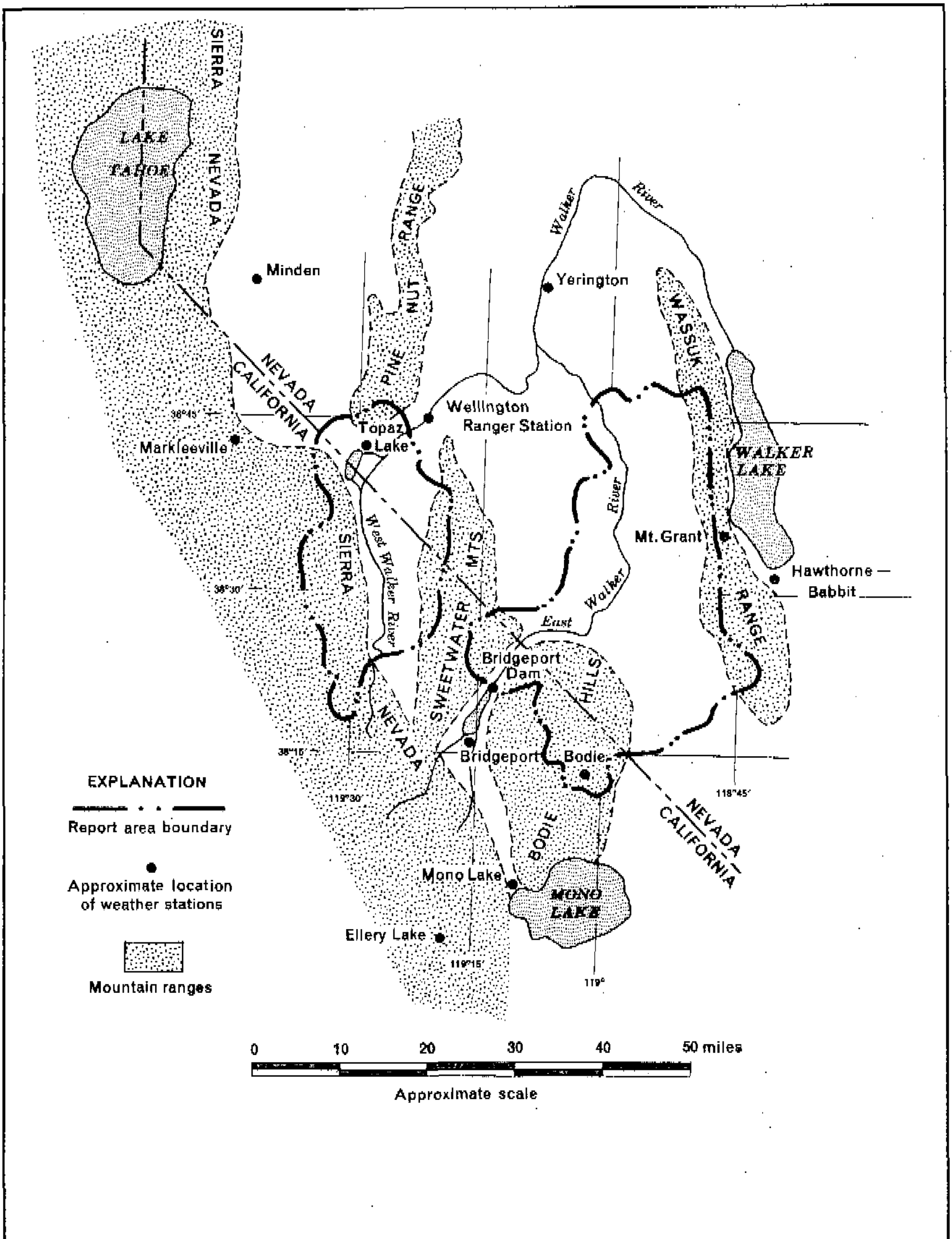

Figure 2.—Locations of weather stations and mountain ranges

Lithologic Units

The generalized surficial distribution of lithologic units in the area is shown on plate 1, and a summary of their character is included in table 2. Differentiation of the three lithologic units was based mainly on their hydrologic properties. For this reconnaissance, all alluvial deposits were grouped into older and younger alluvium. Criteria for separation of the units are as follows: (1) alluvial areas where erosion and deformation appear to be dominant over deposition are classified as older alluvium, (2) alluvial areas that are either thinly mantled by younger alluvium or mantled by younger alluvium that has no particular significance with respect to ground-water conditions are classed as older alluvium, (3) alluvial areas where recent deposition is the dominant process and where thickness and location of the deposits render them significant with respect to ground-water hydrology are classed as younger alluvium, and (4) younger alluvium is assumed to have been deposited during comparatively recent geologic time, and is commonly less than 100 feet thick.

For this report, all consolidated rocks are grouped into one lithologic unit, because there is no known evidence that indicates any marked variability in hydrologic characteristics among the different consolidated-rock types. Carbonate rocks are prevalent in many parts of Nevada, and in most places they differ markedly from the noncarbonate rocks in that they are capable of transmitting considerable quantities of ground water. However, carbonate rocks are not extensively exposed surficially within the report area, according to available geologic maps (Moore, 1961; Ross, 1961; and Koenig, 1963).

Structural deformation may have increased or decreased the transmissibility of the consolidated rocks. However, the reconnaissance nature of this report and lack of hydrologic data regarding consolidated rocks prohibits a detailed analysis of the effects of geologic structure on ground-water movement.

Table 2.--Generalized lithologic units and their water-bearing properties

Geologic age: Period	Geologic age: Epoch	Lithologic unit[1]		Thickness (feet)	General characteristics and extent (See pl. 1)	Water-bearing properties
QUATERNARY	Holocene and Pleistocene	Valley fill	Younger alluvium	0-100±	Unconsolidated lenses of gravel, sand, silt, and clay comprising fluvial deposits; detritus derived mainly from bordering upland consolidated rocks and reworking of older alluvium, and sediment load transported into the area by East and West Walker Rivers; although younger alluvium may mantle much of the area, its hydrologic significance is mainly restricted to flood plains of East and West Walker Rivers and their main tributaries.	Younger and older alluvium together form valley-fill reservoir, the principal source of water from wells in the area; where saturated, they yield water to domestic, irrigation, and stock wells; well yields are variable both in quantity (from a few gpm to possibly several thousand gpm) and quality, depending on character of deposits encountered, age of water, and source of recharge.
TERTIARY AND QUATERNARY	Pleistocene to Miocene	Valley fill	Older alluvium	0-several thousand(?)	Unconsolidated to consolidated deposits of boulders, gravel, sand, silt, and clay exposed in most of valley lowlands and buried at generally shallow depth beneath younger alluvium; composed mainly of debris from bordering mountains and probably some lacustrine deposits; locally cemented; probably thickest in valley troughs; mantles consolidated rock near mountains.	
PRE-PERMIAN(?) TO TERTIARY		Consolidated rocks		--	Igneous, metamorphic, and sedimentary rocks; igneous rocks are mainly Cretaceous granitic intrusive rocks and Tertiary volcanic rocks; metamorphic rocks include metavolcanic and metasedimentary deposits, generally of Mesozoic age or older; sedimentary rocks, mainly of Tertiary age, are least prevalent of major rock types and often contain interbedded volcanic rocks.	Generally untested by wells; yield minor amounts of water to springs; might yield small amounts of water to wells locally from fracture zones; considered poorest water-yielding unit in area.

1. Synthesized from various reports and maps, as credited on plate 1.

VALLEY-FILL RESERVOIRS

Extent and Boundaries

The valley-fill reservoirs are formed by the younger and older alluvium. Areal extent of these deposits is shown on plate 1. Antelope Valley has one large reservoir system. The East Walker Area has three major valley-fill reservoirs: (1) Sweetwater Flat, (2) Rough Creek area, and (3) the area tributary to the East Walker River in the downstream part of the report area, hereafter called the East Walker reservoir. A small valley-fill reservoir is along the upstream part of Bodie Creek; however, that reservoir is entirely within California, and the area within California is only considered in this report as it pertains to the quantitative hydrology of Nevada.

The East Walker reservoir is split by the river and therefore is controlled and affected by the river. The Sweetwater Flat and Rough Creek reservoirs might be considered independent ground-water systems to the extent that their hydrologic connection with the East Walker River probably is mainly by surface drainage. However, the ground-water reservoirs largely sustain the quantity of low flow discharged to the East Walker River.

The valley-fill reservoir boundaries are formed mainly by the consolidated rocks of the peripheral mountain ranges, as shown on plate 1. An alluvial topographic divide occurs between Sweetwater Flat and Smith Valley, and a ground-water divide is assumed to form the boundary between these two areas.

The maximum thickness of the valley-fill reservoirs locally may be as much as several thousand feet. Well 10/23-19ba is the deepest in Antelope Valley, Nevada, and penetrated 1,193 feet of alluvium without encountering bedrock (tables 19 and 20; see well-numbering system). Well 7/25-9cc1 is the deepest in Sweetwater Flat, at only 205 feet, and did not completely penetrate the alluvium. In the Rough Creek area, there are records of only three wells having been drilled; the deepest, well 6/27-14a, did not penetrate the alluvium at a depth of 420 feet. Very few well records are available for the East Walker reservoir; well 9/27-30da is the deepest known, and bottomed at 405 feet without encountering bedrock.

The paucity of wells in most of the valley-fill deposits, the local concentrations of existing wells, and the shallow depth of most wells fail to disclose much information about the area-wide subsurface character of the valley fill.

Occurrence and Movement of Ground Water

The known depth to water below land surface in the valley-fill reservoirs ranges from zero in springs and in swampy areas to a reported depth of 250 feet in well 10/22-29cb west of Topaz Lake in Antelope Valley, Nevada (table 19). The deepest water level of the East Walker Area was measured at 186 feet below land surface in well 7/27-23cd of the Rough Creek reservoir system. Most wells in the report area were drilled near perennial streams and therefore the depths to water are generally shallow.

The few available data confirm a pattern of ground-water movement characteristic of many valleys of Nevada; that is, ground water moves from the mountains through the valley-fill reservoirs, toward the topographically lower parts of the valleys. When it reaches the lower areas it is discharged by evapotranspiration or by outflow from the valley via a perennial stream system.

Some ground water moves through the consolidated rocks from the surrounding highlands to the valley fill. However, data are too scarse to identify and quantify the flow.

INFLOW TO THE VALLEYS

Precipitation

Precipitation within the report area provides local recharge to the hydrologic systems. However, the amount of this recharge to Antelope Valley and the East Walker Area is small compared to the inflow of the West and East Walker Rivers.

The climate of west-central Nevada ranges from subhumid to arid. Most precipitation falls during the winter months, and typically the amounts increase with altitude. The Sierra Nevada exerts a strong climatic control throughout the report area by providing a formidable orographic barrier to incoming westerly storms. The barrier strongly controls local precipitation patterns, and as a result precipitation quantities within similar altitude zones may vary considerably over short distances.

Some of the precipitation falls as rain, but winter snow generally accumulates in large amounts in the higher mountain areas. Table 3 summarizes average annual and summer precipitation at selected stations in and near the report area. The data suggest that the percentage of annual precipitation occurring during the summer increases with eastward distance from the Sierra Nevada. Summer precipitation often occurs as thunder-showers.

Precipitation falls directly on Topaz Lake and therefore contributes directly to the water inflow. Assuming an average lake area of 1,790 acres (table 13) and an annual precipitation of about 11 inches (table 3), the average annual contribution to the lake is about 1,600 acre-feet.

Table 3.--Summary of precipitation at selected stations

[Computed from published records of the U.S. Weather Bureau]

Station[1]	Approximate location[2]	Approximate altitude (feet)	Period of full-year record	Average annual precipitation for period of record (inches)	Average percentage of annual precipitation occurring during May-September	Adjusted average annual precipitation[3] (inches)
Bodie	4/32-17	8,370	1965-68	16.8	30	a,b 20
Bridgeport Dam	6/25-34	6,420	1932-56	10.1	19	
Bridgeport	5/25-33	6,470	1958-68	9.0	34	10
Ellery Lake	1/25-17	9,600	1925-47, 1949, 1955-68	25.7	16	26
Hawthorne-Babbitt	8/30-17	4,125	1938-50, 1958-68	5.0	41	5
Markleeville	10/20-21	5,546	1944, 1947-48, 1953-60	18.2	15	18
Minden	13/20-32	4,700	1943-68	8.3	21	8
Mono Lake	2/26-19	6,520	1951-68	12.6	21	b,c 13
Mt. Grant	8/28-12	9,000	July 1960-June 1965	12	--	c 10
Topaz Lake	10/22-27	5,020	1958-68	10.3	32	a,b 11
Wellington Ranger Station	10/23-2	4,820	1943-68	8.6	30	9
Yerington	13/25-15	4,375	1914-50, 1952-67	5.2	36	c 5

1. Approximate station locations are shown in figure 2.

2. Township/range-section.

3. Averages for stations with short record period were adjusted by comparing the same period average for (a) Ellery Lake, (b) Minden, and (c) Yerington with the long-term averages at those three key stations, as noted. Adjusted average rounded to nearest inch.

Surface Water

By D. O. Moore

General

Part of the flow of the West Walker River is diverted within the California segment of Antelope Valley to irrigation ditches and canals. Even though the irrigation structures permit the return of some flow to the river within the valley, the net river flow generally decreases downstream between the inflow and outflow gages (hydrologic sites 39 and 40, pl. 1). Some of the streamflow is diverted into Topaz Lake, an off-channel reservoir. Releases from Topaz Lake are used for irrigation in Smith and Mason Valleys downstream from the report area (pl.1).

Two perennial tributaries, Mill and Slinkard Creeks, flow into the West Walker River within the California part of Antelope Valley. All other tributaries to the river in the valley are ephemeral. Several tributaries flow perennially into the East Walker River within the report area. The largest are Sweetwater and Rough Creeks.

The East and West Walker Rivers receive flow from direct runoff within the report area and also from local ground-water discharge. As river flow passes through the report area, it loses water by natural evapotranspiration, irrigation use, and by local recharge to the ground-water reservoirs.

Available Surface-Water Records

The East and West Walker Rivers are presently gaged at the upstream and downstream boundaries of the report area (pl. 1). Table 4 shows data regarding the main streamflow gages referred to in this report.

In addition, miscellaneous measurements of streamflow were made on the East and West Walker Rivers and their tributaries. Some measurements had also been made in previous years. Data for all these measurements are shown in table 5, and the general locations of the measurement sites are shown on plate 1. Mean annual runoff was also determined at several stream sites using channel geometry techniques (Moore, 1968); those sites are not shown on plate 1.

Table 4.--Principal streamflow and lake gaging stations

Streamflow gaging station	U.S. Geol. Survey station number	Hydrologic site number (pl. 1)	Location[1]	Period of record (years)
West Walker River near Coleville, Calif.	10-2965	39	8/23-28ab	Oct. 1902-July 1908; Mar. 1909-Sept. 1910; June 1915-Mar. 1938; May 1957-present
West Walker River at Hoye Bridge, near Wellington, Nev.	10-2975	40	10/23-17da	Apr. 1910-Aug. 1910; July 1920-Sept. 1923; Mar. 1924-Sept. 1932; Oct. 1957-present
East Walker River near Bridgeport, Calif.[2]	10-2930	41	6/25-34ac	July 1911-Sept. 1914 (gage heights only); Oct. 1921-present
East Walker River above Strosnider ditch, near Mason, Nev.	10-2935	42	11/26-14cb	Jan. 1947-present
Topaz Lake near Topaz, Calif.	10-2970	43	10/22-33ab	Dec. 1921-present
Ephemeral tributary to Slinkard Creek near Topaz, Calif.	10-2968	44	9/22-9aa	1963-present[3]

1. See report section "Numbering system for wells, springs, and hydrologic sites."
2. Below Bridgeport Reservoir.
3. Crest-stage record only - no continuous recording of stage.

Table 5.--Miscellaneous streamflow measurements

Hydrologic site number (pl. 1)	Stream name	Location	Date	Discharge (cfs)
		WEST WALKER RIVER AREA		
1	Mill Creek	7/23-18a	8-27-68	0.78
2	Mill Creek	7/23-6a	8-27-68	0.66
3	Irrigation ditch	8/23-31c	8-27-68	6.75
4	Lost Cannon Creek	8/23-31d	8-27-68	0.10
5	Mill Creek	8/23-29a	8-27-68	0.49
6	Irrigation ditch	8/22-13c	8-27-68	0
7	*Unnamed tributary*	8/23-7c	8-27-68	0.04
8	Slinkard Creek	8/22-10c	8-28-68	0.08
9	Slinkard Creek	8/22-3c	8-28-68	0
10	Slinkard Creek	9/22-28c	8-28-68	0.75
11	Cedar Creek	9/22-5d	8-27-68	0.69
12	Slinkard Creek	9/22-10a	8-28-68	2.13
		EAST WALKER RIVER AREA		
13	Murphy Creek	6/25-14a	8-28-68	0.38
14	Water Canyon	6/26-6b	8-28-68	0
15	Frying Pan Creek	7/25-31c	8-28-68	0
16	Sweetwater Canyon	7/25-15c	9- 5-68	0.41
17	Unnamed tributary1/	7/25-9b	9- 5-68	0
18	Unnamed tributary1/	7/25-15b	9- 5-68	1.96
19	Silverado Canyon	7/25-20a	9- 5-68	0
20	Ferris Canyon	7/25-21b	9- 5-68	0
21	Green Creek	7/25-21b	9- 5-68	0.74
22	Sweetwater Creek	7/25-24c	8-28-68	2.57
23	Sonoma Canyon	7/26-29b	8-28-68	0
24	Red Wash Creek	7/26-34b	8-28-68	0
25	Rough Creek (West Fork)	5/27-16b	11-10-52	0.87
			11-28-52	0.49
26	Rough Creek	5/27-9c	11-10-52	3.20
			11-28-52	1.86
27	Rough Creek	6/27-22c	8-29-68	1.31
28	Rough Creek	6/27-14b	10-25-52	2.40
			11-10-52	3.50
			11-28-52	2.45
29	Bodie Creek	5/27-26d	11-28-52	0.44
30	Bodie Creek	5/27-26b	11-10-52	1.24
			11-28-52	0.68
			8-29-68	0.16
31	Bodie Creek	6/27-36d	10-25-52	1.16
			11-10-52	1.63
			11-28-52	0.96
			8-29-68	0.13

Table 5.--Continued

Hydrologic site number (pl. 1)	Stream name	Location	Date	Discharge (cfs)
32	Unnamed tributary	6/27-36d	8-29-68	0
33	Bodie Creek	6/27-24b	8-28-68	0
34	Fletcher Spring	6/28-19cdd	10-25-52	0.40
			11-10-52	0.18
35	Mud Spring Canyon	6/28-24b	8-29-68	0
36	Baldwin Creek	7/28-21a	12-17-52	0
			8-29-68	0
37	Lapon Canyon Creek	8/28-23	10-25-56	0.2
38	Lapon Canyon Creek	8/28-20	12-17-52	0

1. Location not shown on plate 1.

Flow of the East and West Walker Rivers

The inflow and outflow of the East Walker River are measured by the gages, East Walker River near Bridgeport, Calif. and East Walker River above Strosnider ditch, near Mason, Nev. (table 6). In general, the inflow to the study area from the East Walker River is greater than the outflow, as summarized in table 6 for the period 1948-68. During this period the average annual net loss was about 1,000 acre-feet. Considering the estimated annual runoff of about 20,000 acre-feet originating within the area, the average total streamflow loss is somewhat more than 30,000 acre-feet. Table 6 shows that only the high-flow years, above 110,000 acre-feet, indicate a gain in streamflow.

Figure 3 shows the mean monthly flows at the inflow and outflow gaging stations on the East Walker River for the period 1948-68. It also shows that on the average streamflow gains between the two gages from April to September.

The inflow and outflow of the West Walker River is also measured by the gages at West Walker River, near Coleville, and at Hoye Bridge, near Wellington. Table 7 shows the difference in annual inflow and outflow to the West Walker River area at these gages for the periods 1927-31 and 1958-68. It also shows the unadjusted and adjusted flow as related to diversions to Topaz Lake. During this 16-year period the average annual inflow was 165,000 acre-feet and the average adjusted outflow was 150,000 acre-feet suggesting an average loss of about 15,000 acre-feet. Assuming that an average annual runoff of about 5,600 acre-feet originates within the area (table 8), the average total streamflow loss was about 21,000 acre-feet per year.

Riverflow Characteristics

Runoff from snowmelt in the Sierra Nevada produces most of the streamflow in Antelope Valley and the East Walker Area. Because snowmelt runoff is dominant, the unregulated streamflow pattern into Antelope Valley during the year reflects that pattern. No streamflow pattern is apparent for the East Walker River, because the flow is regulated by Bridgeport Reservoir and, therefore, does not reflect natural conditions.

Figure 4 shows the average monthly discharge of the West Walker River near Coleville, Calif. as a percentage of its mean annual discharge. The dashed line in figure 4 indicates the median discharge for each month; that is, 50 percent of the monthly flows were less and 50 percent were greater than the value shown. The upper line defines the upper quartile which indicates the value for which only 25 percent of the monthly flows were greater and 75 percent were less than the value indicated.

Table 6 .--East Walker River: annual inflow, outflow, and gain or loss, 1948-68

Water year	Inflow, East Walker River near Bridgeport[1] (acre-feet)	Outflow, East Walker River near Mason[2] (acre-feet)	Difference in flow, gain (+), loss (-) (acre-feet)
1948	56,790	49,780	-7,010
1949	61,990	52,290	-9,700
1950	61,110	56,400	-4,710
1951	97,980	93,440	-4,540
1952	196,500	219,400	+22,900
1953	104,600	100,200	-3,600
1954	81,860	74,540	-7,320
1955	53,150	47,050	-6,100
1956	162,600	176,400	+13,800
1957	107,800	102,400	-5,400
1958	153,300	161,400	+8,100
1959	78,590	74,580	-4,010
1960	47,290	38,230	-9,060
1961	30,910	28,000	-2,910
1962	85,510	81,280	-4,230
1963	135,300	148,800	+13,500
1964	70,590	64,080	-6,510
1965	111,800	113,100	+1,120
1966	107,200	97,240	-9,960
1967	167,400	172,300	+4,900
1968	89,500	83,940	-5,560
Average (rounded)	98,000	97,000	-1,300

1. Below Bridgeport Reservoir.

2. Above Strosnider ditch.

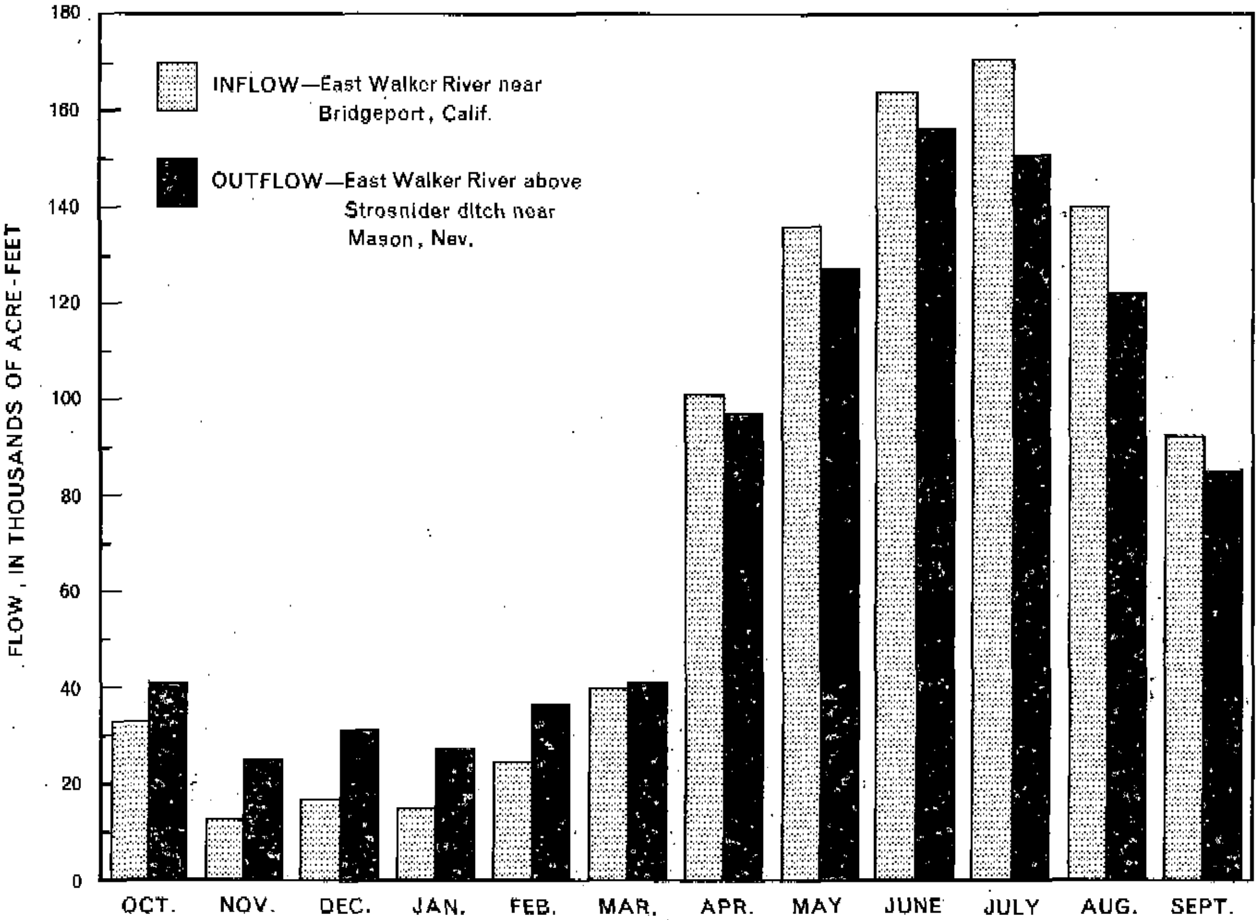

Figure 3.—Mean monthly inflow and outflow of East Walker River, 1948-68

Table 7.--West Walker River: annual inflow, outflow, and gain or loss, 1927-68

Water year	Inflow, West Walker River near Coleville (acre-feet)	Outflow, West Walker River near Wellington (acre-feet) Unadjusted	Outflow, West Walker River near Wellington (acre-feet) Adjusted[1/]	Difference in flow, gain (+), loss (-) (acre-feet) Unadjusted	Difference in flow, gain (+), loss (-) (acre-feet) Adjusted[1/]
1927	236,000	188,000	206,000	-48,000	-30,000
1928	138,000	135,000	119,000	-3,000	-19,000
1929	109,000	84,000	82,000	-25,000	-27,000
1930	133,000	113,000	114,000	-20,000	-19,000
1931	72,000	59,000	58,000	-12,000	-14,000
1958	272,000	240,000	262,000	-32,000	-10,000
1959	115,000	127,000	99,000	+12,000	-16,000
1960	105,000	82,000	78,000	-23,000	-27,000
1961	89,000	71,000	73,000	-18,000	-16,000
1962	183,000	148,000	163,000	-35,000	-20,000
1963	226,000	214,000	224,000	-12,000	-2,000
1964	126,000	125,000	106,000	-1,000	-20,000
1965	248,000	221,000	253,000	-27,000	+5,000
1966	142,000	161,000	127,000	+19,000	-15,000
1967	307,000	281,000	316,000	-26,000	+9,000
1968	136,000	151,000	117,000	+15,000	-19,000
Average (rounded)	165,000	150,000	150,000	-15,000	-15,000

1. Adjusted for storage changes in Topaz Lake.

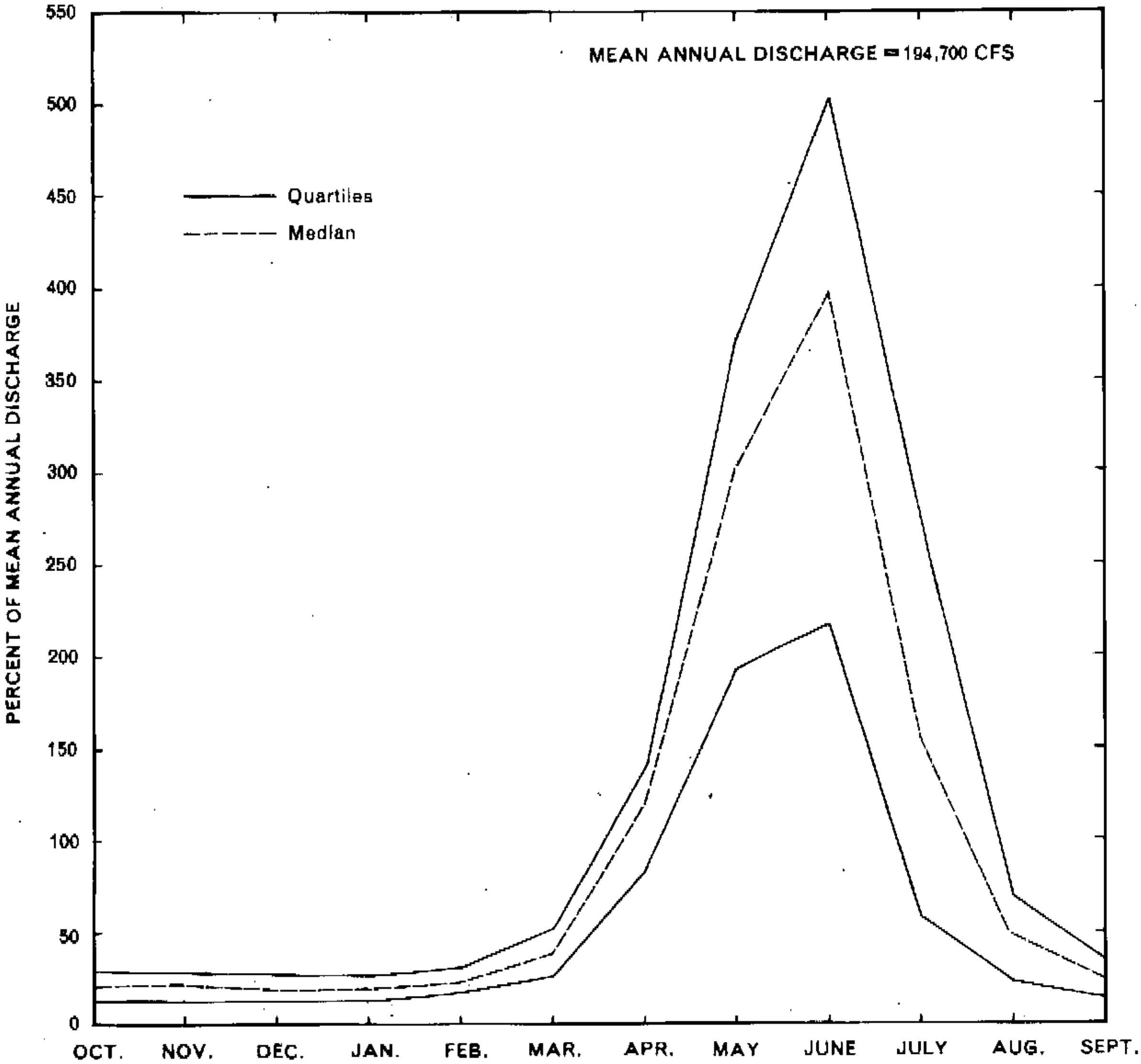

Figure 4.—Average monthly discharge as a percentage of mean annual discharge of the West Walker River near Coleville, California for the period 1910, 1916-37, 1958-65

Similarly, the lower line defines the lower quartile which indicates the value for which 75 percent of the monthly flows were greater and only 25 percent were less than the value indicated. Analysis of data for 31 years (1910, 1916-37, 1958-65) indicates that during 24 years, or about 77 percent of the time, 76 percent or more of each year's runoff occurred between April 1 and July 31. The percentage of annual runoff occurring between April 1 and July 31, during the 31 years of record, ranged from 68 percent in 1924 to 86 percent in 1922 and 1936.

Flow duration curves provide a means of estimating the amount of time during which specific river discharges might be equaled or exceeded, based on the stream's historical flow during a number of years. Figures 5 and 6 show flow duration curves for the East and West Walker Rivers, respectively, where they cross the upstream boundaries of the report valleys. As an example, figure 6 shows that the daily mean flow of the West Walker River near Coleville, Calif., was at least 30 cfs (cubic feet per second) during 88 percent of the time and at least 740 cfs during 5 percent of the time for the period of record on which the curve is based (1910, 1916-37, 1958-65). However, the curve does not imply that at least 740 cfs may be expected for 5 percent of the time each single year, but rather that over an extensive period, at least 740 cfs might be reasonably expected to occur about 5 percent of the total time. The flow duration curve for the East Walker River near Bridgeport, Calif., just downstream from the Bridgeport Reservoir, depicts man-controlled reservoir release rates.

Estimated Average Annual Runoff to the Valley-Fill Reservoirs

The greatest part of the flow of the East and West Walker Rivers originates in headwaters upstream from the report area. However, runoff originating within the area also contributes to the river flows, and this local contribution in part enters the river channels between the upstream and downstream gaging stations of the two river valleys. Part of this local runoff recharges the valley-fill reservoirs.

The amount of runoff that reaches the valley-fill reservoir from the mountains cannot be computed directly because of a scarcity of available streamflow data. Methods have been devised recently to estimate runoff in Nevada. The techniques are particularly useful in areas where few or no streamflow records are available. These methods were described in detail by Moore (1968). Using the drainage areas supplying the natural flow to streams where gaging stations had been or are operated, recorded runoff is prorated by altitude zones (1,000-foot intervals) with due regard to the proportional areas of the several zones, and with increasing unit values of runoff for increasing altitude. As the different physical characteristics, such as vegetation, geology, types of soil, and amounts of precipitation vary locally

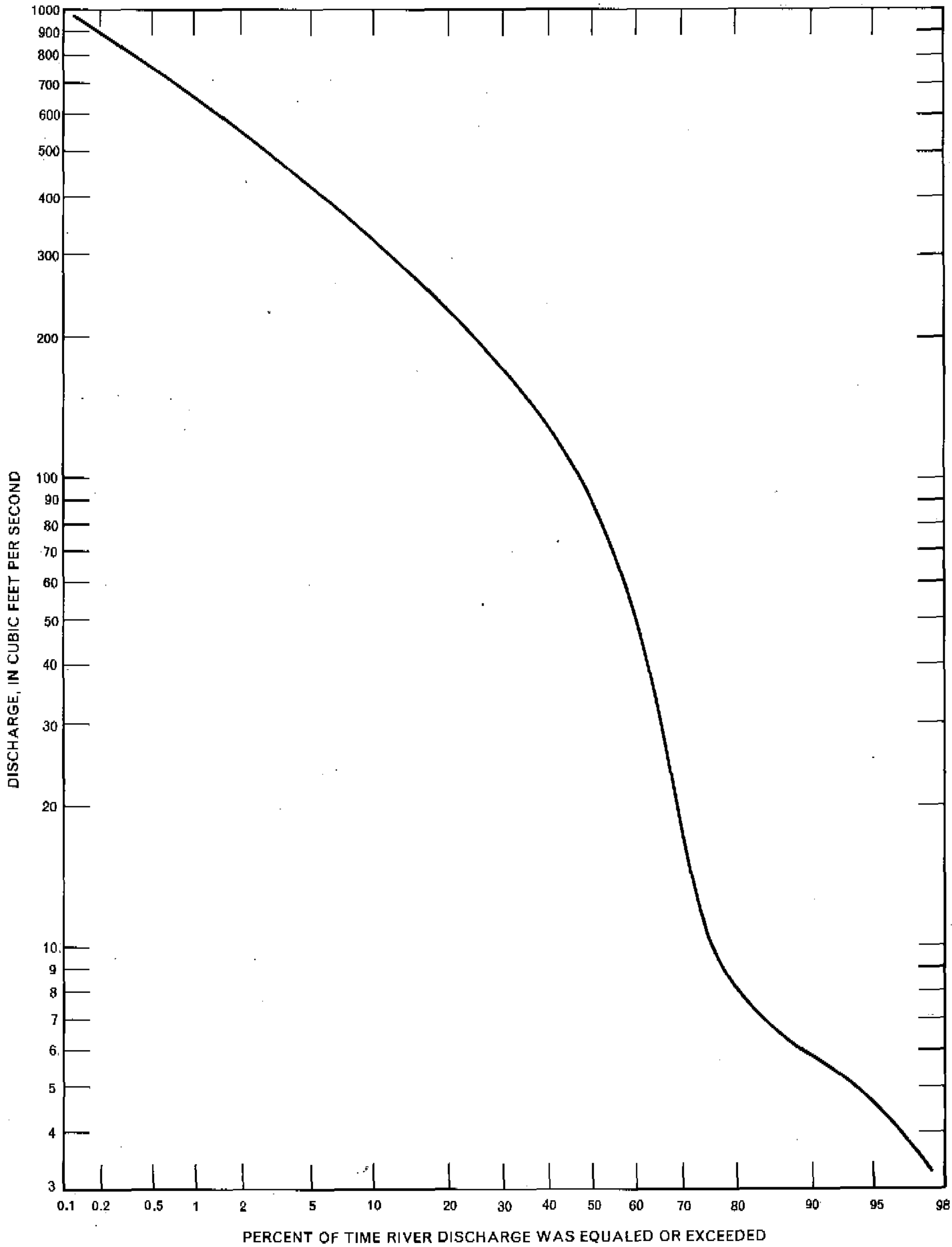

Figure 5.—Flow duration of mean daily discharge of the East Walker River near Bridgeport, California for the period 1923-24, 1926-65

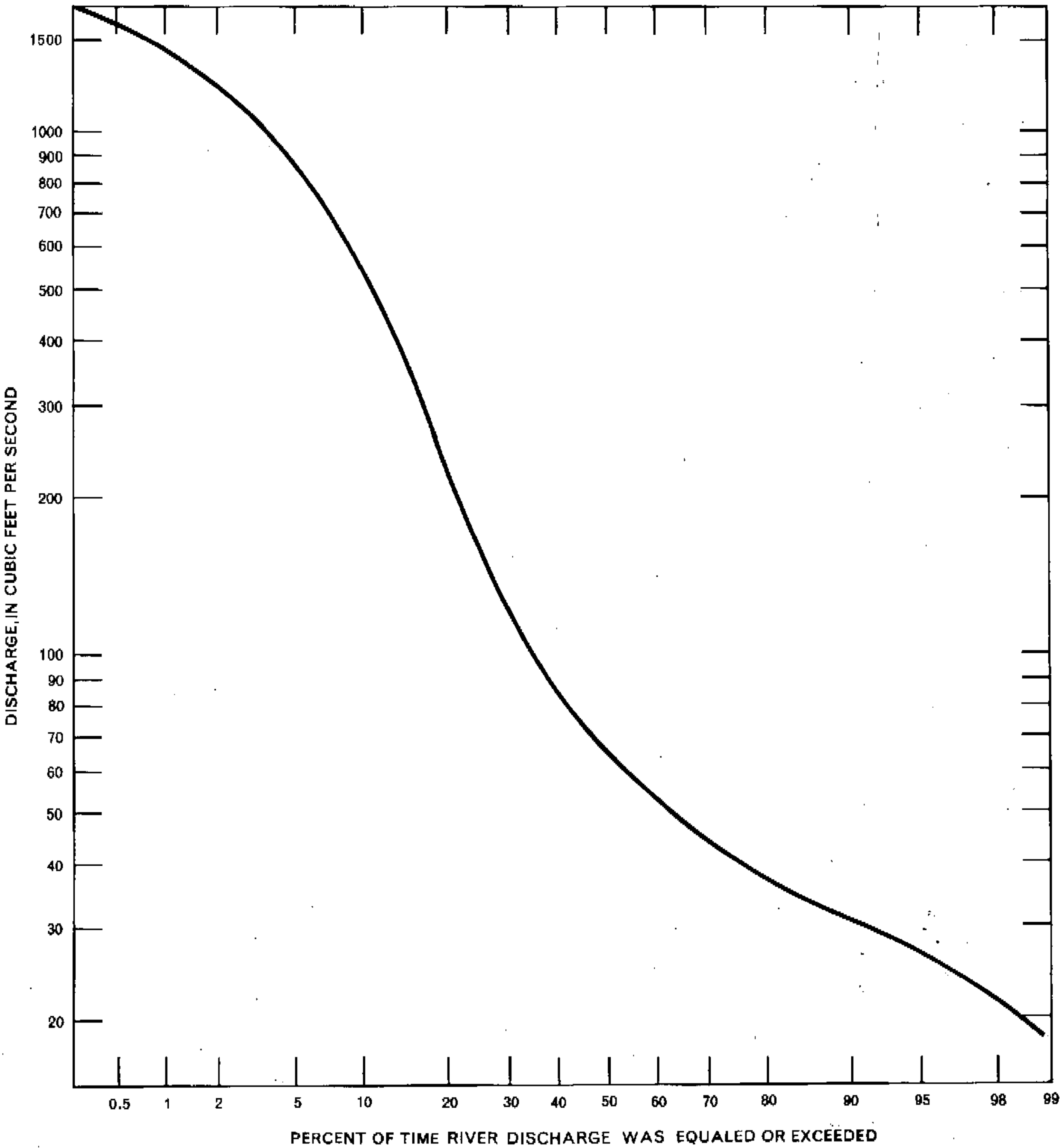

Figure 6.—Flow duration of mean daily discharge of the West Walker River near Coleville, California, for the period 1910, 1916-37, 1958-65

within large areas, the runoff for each altitude increment is adjusted accordingly. The adjustments of the runoff coefficients for local conditions are based on measurements of streamflow and channel geometry.

Table 8 shows estimates of runoff from above 7,000 feet in the area, which are assumed generally equivalent to runoff reaching the margins of the valley-fill reservoirs. Only 29 percent of the total area of Antelope Valley and 43 percent of that in the East Walker Area are assumed to yield tangible runoff.

Ground-Water Recharge

Ground-water recharge throughout the report area generally originates from precipitation within the report area. A method described by Eakin and others (1951, p.79-81) is used to estimate potential ground-water recharge from precipitation within the report area. Hardman (1965) demonstrated that in gross aspect the average annual precipitation in Nevada is related closely to altitude, and that it can be estimated with a reasonable degree of accuracy by assigning average precipitation rates to various zones. Apparent variability of precipitation in similar altitude zones but at different locations within the report area was discussed in the earlier "Precipitation" section of this report. This variability and the adjusted precipitation data of the U.S. Weather Bureau stations shown in table 3 resulted in the development of three altitude-precipitation relations which were used to estimate precipitation and recharge potential within the area, as presented in table 9.

Table 9 shows that the potential recharge ranges from 5 to 15 percent of the precipitation. The overall average for Nevada is roughly 5 percent. A comparison of estimates in tables 8 and 9 shows that upland runoff ranges from 15 to 110 percent of the potential recharge. This range is considerably lower than that computed for most areas of Nevada where upland runoff generally averages about twice the estimated potential recharge. For this area, the estimates suggest that much of the runoff becomes recharge in the consolidated rocks of the mountains.

Subsurface Inflow

Subsurface inflow occurs around the consolidated rock-alluvial boundary and is considered part of the potential recharge already estimated. Inflow to the valley also occurs through the alluvium beneath the West Walker River at the upper end of Antelope Valley. The magnitude of that inflow in the vicinity of the gaging station near Coleville is very small compared to

Table 8.--Estimated average annual runoff to the valley-fill reservoirs

Location	Runoff area: Acres	Runoff area: Percent of runoff area	Estimated runoff: Acre-feet per year	Estimated runoff: Percent of total runoff
	ANTELOPE VALLEY			
Area in California west of West Walker River	27,600	63	4,500	81
Area in California east of West Walker River	4,600	11	270	5
Subtotal (rounded)	32,200	74	4,800	86
Area in Nevada west of West Walker River	6,800	16	600	11
Area in Nevada east of West Walker River	4,500	10	150	3
Subtotal (rounded)	11,300	26	750	14
Total (rounded)	43,500	100	5,600	100
	EAST WALKER RIVER AREA			
Area in California west of East Walker River	29,000	14	11,000	36
Area in California east of East Walker River	54,900	27	9,700	32
Subtotal (rounded)	83,900	41	21,000	68
Area in Nevada west of East Walker River	27,400	14	2,100	7
Area in Nevada east of East Walker River	91,400	45	7,600	25
Subtotal (rounded)	118,800	59	9,700	32
Total (rounded)	203,000	100	30,000	100

Table 9.--Estimated average annual precipitation and potential ground-water recharge

Precipitation zone (feet)	Area (acres)	Estimated precipitation Range (inches)	Average (feet)	Average (acre-feet)	Estimated recharge Percentage of precipitation	(acre-feet per year)
			ANTELOPE VALLEY			
			Nevada Part			
Above 9,000	31	>24	2.0	62	25	16
8,000-9,000	2,010	20-24	1.8	3,600	20	720
7,000-8,000	9,300	15-20	1.5	14,000	15	2,100
6,000-7,000	17,200	12-15	1.1	19,000	7	1,300
5,000-6,000	36,900	8-12	.8	30,000	3	900
Below 5,000	4,810	<8	.5	2,400	--	--
Subtotal (rounded)	a 70,300			69,000		5,000
			California Part			
Above 9,000	4,180	>24	2.3	9,600	25	2,400
8,000-9,000	9,760	20-24	1.8	18,000	20	3,600
7,000-8,000	18,300	15-20	1.5	27,000	15	4,000
6,000-7,000	23,900	12-15	1.1	26,000	7	1,800
5,000-6,000	31,000	8-12	.8	25,000	3	750
Below 5,000	930	<8	.5	460	--	--
Subtotal (rounded)	88,100			106,000		13,000
Total	158,000			175,000		18,000

(Continued)

Table 9.--Estimated average annual precipitation--Continued

Precipitation zone (feet)	Area (acres)	Estimated precipitation Range (inches)	Average (feet)	Average (acre-feet)	Estimated recharge Percentage of precipitation	(acre-feet per year)
			EAST WALKER AREA			
			Nevada Part - West of Wassuk Range			
Above 9,000	1,200	>20	1.8	2,200	20	440
8,000-9,000	14,300	15-20	1.5	21,000	15	3,200
7,000-8,000	58,100	12-15	1.1	64,000	7	4,500
6,000-7,000	74,700	8-12	.8	60,000	3	1,800
Below 6,000	46,900	<8	.5	23,000	--	--
Subtotal (rounded)	195,000			170,000		10,000
			Nevada Part - Wassuk Range			
Above 9,000	3,880	>15	1.5	5,800	15	870
8,000-9,000	12,900	12-15	1.1	14,000	7	980
7,000-8,000	29,900	8-12	.8	24,000	3	720
Below 7,000	135,000	<8	.3	40,000	--	--
Subtotal (rounded)	182,000			84,000		2,600
Subtotal - Nevada	a 377,000			254,000		12,000
			California Part			
Above 11,000	1,550	>26	2.3	3,600	25	3,700
10,000-11,000	5,420	22-26	2.0	11,000		
9,000-10,000	10,800	20-22	1.8	19,000	20	3,800
8,000-9,000	39,800	15-20	1.5	60,000	15	9,000
7,000-8,000	26,200	12-15	1.1	29,000	7	2,000
6,000-7,000	9,760	8-12	.8	7,800	3	230
Below 6,000	310	<8	.5	160	--	--
Subtotal (rounded)	93,800			131,000		19,000
Total	471,000			385,000		31,000

a. Areas do not agree exactly with those of Rush (1968) because of difference in scales of the maps on which the areas were planimetered.

the surface-water inflow. It may be on the order of 1,000 acre-feet per year, assuming a transmissivity of 100,000 gallons per day per foot, an effective width of 500 feet, and a hydraulic gradient of 100 feet per mile.

Underflow beneath the East Walker River downstream from Bridgeport Reservoir near the gaging station is also small compared to the surface-water flow. It may be on the order of 200 acre-feet per year assuming a transmissivity of 50,000 gallons per day per foot, an effective width of a tenth of a mile, and a hydraulic gradient of 40 feet per mile.

OUTFLOW FROM THE VALLEYS

Surface-Water Discharge

Stream inflow and outflow is discussed in the report section titled "Surface water." The mean annual adjusted outflow of the West Walker River from Antelope Valley, for the period 1927-68, is 150,000 acre-feet (table 7). The average annual outflow of the East Walker River during the 1948-68 period is about 97,000 acre-feet (table 6).

Surface-Water Irrigation

Most Antelope Valley surface-water irrigation is within California. California diversions and irrigation are discussed in a report by the California Department of Water Resources (1964). Estimated annual consumptive use in Antelope Valley, Calif., including Slinkard Valley, is shown in table 11 of that report to be about 32,000 acre-feet. Although the use represents only water consumed during the irrigation season (April-September), water requirements of perennial plants during the non-irrigation season are assumed to be comparatively minor, and probably are mainly satisfied by the available soil moisture. The data for California are summarized in table 10 of this report.

Surface-water irrigation in the Nevada part of Antelope Valley consists of some meadowland watered mainly by tailwaste of the California irrigation systems. An estimated 560 acre-feet of surface water are annually consumed by crops in the Nevada part of Antelope Valley (table 10).

Almost all surface-water irrigation in the East Walker Area occurs within Nevada. Most of the irrigated lands are along the flood plains of the East Walker River and Sweetwater Creek. In those areas, much of the irrigated acreage is underlain by ground water at shallow depths, and therefore, possibly half of the water utilized by the crops is derived from the shallow ground-water reservoir. Estimates of water consumed by the irrigated crops is shown in table 11, which also shows that all farmed acreage produces native hay, pasture grass, or alfalfa. Although some grass and alfalfa is cut for winter livestock feed, most ranchers report the majority of croplands are mainly used as pasture.

Agriculture is related to the length of the growing season. Average growing season length throughout the report area probably ranges from about 3 to 5 months, depending on altitude and local climatic conditions.

Table 10.--Estimated acreage and consumptive use by crops in Antelope Valley

Location of area	Crop	Estimated area (acres)	Estimated consumptive use: Rate (feet per year)	Estimated consumptive use: Acre-feet per year
		NEVADA		
North of West Walker River	Alfalfa[1]	400	2	800
Do.	Pasture[1]	160	2	320
Along West Walker River flood plain near State line	Pasture	a 280	2	560
Subtotal (rounded)		840		1,700
		CALIFORNIA		
Antelope Valley	Alfalfa, pasture, and grain	b 11,000	(c)	d 31,890
Do.	Native pasture (subirrigated by ground water)	b 590	1.5	890
Subtotal (rounded)		11,600		33,000
Total (rounded)		12,400		35,000

1. Irrigated mainly by pumping ground water.

a. C. N. Saulisberry, U.S. Dept. Agriculture, oral commun., 1969.

b. California Dept. Water Resources, 1964, table 7, p. 66.

c. Use rates from Calif. Dept. Water Resources (1964, table 10, p. 81) as follows: alfalfa and pasture, 2.8 feet; grain (irrigated), 1.3 feet.

d. California Dept. Water Resources, 1964, table 11, p. 82. Also includes 1,000 acre-feet of pumpage from wells drilled since compilation of the California report.

Table 11.--Estimated acreage and consumptive use by crops in the East Walker Area

Location of area	Crop[2]	Estimated area[2] (acres)	Estimated consumptive use[1]: Rate (feet per year)	Estimated consumptive use[1]: Acre-feet per year
		NEVADA		
Sweetwater Flat	Pasture	2,100	2	4,200
Rough Creek	Pasture[3]	560	1	560
Lapon Meadows[4]	Pasture[3]	40	1	40
East Walker River flood plain	Alfalfa	800	2	1,600
Do.	Pasture	800	2	1,600
Do.	Pasture	1,800	1	1,800
Subtotal (rounded)		6,100		9,800
		CALIFORNIA		
East Walker River flood plain and Frying Pan Creek area	Pasture[3]	590	1	590
Upper Bodie Creek	Pasture[3]	130	1	130
Subtotal (rounded)		720		720
Total (rounded)		6,800		11,000

1. In most areas, crops are subirrigated naturally by shallow ground water as well as irrigated by surface water.
2. Most crop and acreage data furnished by C. N. Saulisberry, U.S. Dept. Agriculture, oral commun., 1969.
3. Irrigated only when water is available.
4. Area not shown on plate 1; location is along upper reaches of Lapon Canyon Creek.

The estimated consumptive-use rates shown in tables 10 and 11 are modified after Houston (1950), on the basis of crop type and a reconnaissance estimate of the amount of irrigation the croplands receive during an average year. Therefore, the consumptive-use rates are generally estimated to the nearest foot.

Evapotranspiration

The main areas of phreatophytes and cropland are shown on plate 1. A substantial quantity of water is discharged from the report area by evapotranspiration in areas of native phreatophytic vegetation and evaporation from free-water surfaces. Phreatophytes obtain much of their water from the ground-water reservoir or overlying capillary fringe. Throughout the report area, most ground-water bodies shallow enough to support phreatophytes are near perennial streams, namely, the East and West Walker Rivers, and Sweetwater, Rough, Frying Pan, and Bodie Creeks. Total quantities of water evaporated from free-water surfaces is greater in this area than in most of Nevada because of the prevalence of perennial streams. Topaz Lake also exposes an appreciable water-surface area to the atmosphere.

Along the river flood plains, the phreatophytes consist mainly of willows, buffaloberry, wildrose, native grasses, rabbitbrush, cottonwood trees, and some greasewood. The small tributary creeks have the same plant species growing in areas adjacent to their middle and lower reaches. Aspens are commonly prevalent along streams and spring zones in the higher altitudes. Several small marshy areas support tules, cattails, marsh grasses, and related swamp-type vegetation.

Estimates of evapotranspiration are shown in tables 12 and 13. The estimated consumptive-use rates are modifications of rates determined for other areas by White (1932), Young and Blaney (1942), Houston (1950), and Robinson (1965). The estimated evaporation rate from a free-water surface is based on information published by Kohler and others (1959).

Ground-Water Pumpage

The ground-water resources of the report area are mainly undeveloped and generally untested. There is presently no known ground-water pumpage for irrigation in the East Walker Area. In Antelope Valley, Nev., one ranch pumps ground water to irrigate alfalfa and pasture. The estimated annual consumptive use (net pumpage) of those crops is about 1,100 acre-feet per year (table 10). Ground-water pumpage and future development in Antelope Valley, Calif., are discussed by the

Table 12.--Estimated natural evapotranspiration in the East Walker Area

Area	General plant assemblage[1/]	Estimated area (acres)	Approximate depth to water table (feet)	Estimated water use: Rate (feet per year)	Estimated water use: Acre-feet per year
	NEVADA				
Sweetwater Flat	Mostly willows, wildrose, buffaloberry, and grass with some aspen trees	200	0-20	1.5	300
East Walker River flood plain between Nevada-Calif. border and 7/27-8c	Mostly willows, buffaloberry, wildrose, greasewood, rabbitbrush, grass, and a few cottonwood trees	1,100	0-20	1.5	1,600
Rough Creek basin	Rabbitbrush and greasewood	370	5-30	0.2	70
Do.	Sparse rabbitbrush and greasewood	450	10-40	0.1	40
Do.	Swamp grass, tules, and native grass	10	0-20	2	20
East Walker River flood plain between 8/27-22 and stream gage near Mason	Willows, cottonwood trees, buffaloberry, wildrose, rabbitbrush, and native grass	860	0-20	2	1,700
Do.	Willows, buffaloberry, wildrose, rabbitbrush, native grass, and some greasewood	1,200	0-20	1.5	1,800
Do.	Greasewood	20	10-30	0.2	4
Free-water surfaces	Mostly East Walker River and some irrigation canals	320	--	a 3	1,000
Subtotal (rounded)		4,500			6,500

Continued

Table 12.--Estimated natural evapotranspiration in the East Walker Area--Continued

Area	General plant assemblage[1]	Estimated area (acres)	Approximate depth to water table (feet)	Estimated water use: Rate (feet per year)	Estimated water use: Acre-feet per year
	CALIFORNIA				
Sweetwater Flat	Mostly willows, wildrose, apsen trees, and grass	160	0-20	1.5	240
Upper Bodie Creek	Native grass, wildrose, and some aspen trees	320	0-20	1	320
East Walker River flood plain between Bridgeport Reservoir and Calif.-Nev. State line	Willows, buffaloberry, wildrose, grass, and some aspen trees	200	0-20	1.5	300
Free-water surfaces	East Walker River and Murphy pond[2]	60	--	3	180
Subtotal (rounded)		740			1,000
Total (rounded)		5,200			7,500

1. Excludes native pasture, which is considered a crop.

2. Murphy pond (not shown on plate 1) is at confluence of Murphy Creek and East Walker River.

a. Assumed average rate of annual evaporation minus precipitation.

Table 13.--Estimated natural evapotranspiration in Antelope Valley

Area	General plant assemblage[1]	Estimated area (acres)	Approximate depth to water table (feet)	Estimated water use: Rate (feet per year)	Estimated water use: Acre-feet per year
	NEVADA				
West Walker River flood plain	Mostly native grass, willows, and other unidentified brush with some tules and associated marsh vegetation	1,500	0-20	1.5	2,200
North of West Walker River flood plain	Mostly greasewood and rabbitbrush with some scattered saltgrass	1,300	10-40	0.3	390
Do.	Mostly greasewood and some rabbit-brush	440	20-50	0.1	40
Topaz Lake (part)	Free-water surface	970	0	a 3	2,900
West Walker River and irrigation drainage near State line	do.	60	0	a 3	180
Subtotal (rounded)		4,300			5,700
	CALIFORNIA				
Valley lowlands	Mostly native grass and willows; some cottonwood trees, greasewood, rabbitbrush, unidentified brush, and marsh vegetation	2,400	0-20	1.5	3,600
Topaz Lake (part)	Free-water surface	820	0	a 3	2,500
West Walker River and irrigation canals	do.	100	0	a 3	300
Subtotal (rounded)		3,300			6,400
Total (rounded)		7,600			12,000

1. Excludes native pasture, which is considered a crop.

a. Assumed average rate of annual evaporation minus precipitation.

California Department of Water Resources (1964, p. 45-47 and 103-109). Several irrigation wells have been drilled in the California part of Antelope Valley since the data were compiled for the above mentioned study (Kenneth M. Turner, Hydraulic Engineer, California Dept. Water Resources, oral commun., 1970). However, the wells are only pumped to supplement surface-water irrigation. There probably aren't more than six active irrigation wells in Antelope Valley, Calif., and the combined pumpage of all wells for all purposes is believed to average less than 1,000 acre-feet per year. Therefore, total pumpage in all of Antelope Valley (California and Nevada) is estimated to average about 2,000 acre-feet annually.

The estimated ground-water pumpage for domestic and livestock use in Antelope Valley, Nev., was about 20 acre-feet in 1968 and 1969. The estimate assumes a population of about 120 people using 0.1 acre-foot each per year and about 1,000 head of livestock averaging about 6 gallons per day apiece. Most of the human population and domestic wells are concentrated around the northwest shore of Topaz Lake (pl. 1). Assuming the same consumptive rates and an estimated population of about 70 people and 1,000 head of livestock, consumption in the East Walker Area is about 15 acre-feet per year.

Springs

Numerous springs occur in the report area. Locations of some springs are shown on plate 1, and data pertaining to them are shown in tables 14 and 16. Most springs flow only a few gallons per minute; however, several larger springs were noted during the field reconnaissance. Many springs in the area discharge from consolidated rocks, commonly at altitudes considerably above the valley fill. Most of the developed and used springs in the area are listed in table 14, and several having the greater flows discharge from the valley fill.

Spring 4/26-2a has special historical significance in that it provided most of the water supply for the town of Bodie, Calif., during much of that mining town's existence. Although Bodie is a ghost town, with respect to mining, it is now a California State Park. The spring continues to supply drinking water to thousands of visitors annually through a pipeline several miles long (Robert Frenzel, oral commun., 1968).

Subsurface Outflow

Subsurface outflow occurs beneath the East and West Walker Rivers at the downstream edge of the project area. Also, as described in the next section of the report, the imbalance between estimates of recharge and discharge in the Rough Creek drainage suggests subsurface outflow from that area to the south.

Table 14.--Spring data[1]

Use: D, domestic; I, irrigation;
P, State Park facilities; S, stock

Spring number	Name or owner	Estimated discharge (gpm)	Use	Temperature (°F)	Temperature (°C)
4/26-2a	State of California	a 5	P	--	--
6/28-19cdd	J. B. Tuttle	50	D	54	12
7/25-9d	Sweetwater Ranch	a <50	D	--	--
7/25-26cc	Jack Sceirine	2	D	53	12
7/25-15c	Ambrose Rosaschi	a 40	D	--	--
7/28-6da	U.S. Bureau of Land Management	a <10	S	--	--
8/27-25ac	Mitchell Spring	<10	S	56	13
9/22-17c	Fairfield Ranch	5	S	55	13
10/22-19bb	Fairfield Ranch	50	S,I	--	--

1. Chemical analyses for most springs shown in table 16.

a. Reported. All others estimated during this study.

Underflow along the West Walker River at the downstream end of Antelope Valley past the Hoye Bridge stream-gaging station is estimated to be only about 200 acre-feet per year, assuming a transmissivity of 50,000 gallons per day per foot, a hydraulic gradient of 15 feet per mile, and an effective underflow width of a quarter of a mile. Similarly, the estimated underflow beneath the East Walker River near the Strosnider stream-gaging station is about 150 acre-feet per year, assuming a transmissivity of 50,000 gallons per day per foot, a hydraulic gradient of 20 feet per mile, and an effective width of an eighth of a mile.

WATER BUDGETS

For long-term natural conditions, inflow to and outflow from an area are equal, provided that the climatic regimen remains nearly constant. The equilibrium condition is assumed to prevail in the study area.

Water budgets for Antelope Valley and the East Walker Area are shown in table 15. The budgets include known or estimated major elements of inflow to and outflow from the combined ground-water and Walker River flow systems. Local runoff reaching the rivers, although possibly a quantity great enough to be a significant item of inflow to the rivers, was not estimated because techniques are not available to differentiate several components of the inflow; therefore, lack of differentiation would probably result in some quantity of water being counted more than once as inflow for budgetary purposes.

The water budgets for both valleys have imbalances of similar magnitude, but opposite mathematical sign, as shown in table 15. In both budgets, river inflows and outflows are by far the dominant and most accurate budget items. Measurements of river flow are generally considered accurate to within 10 percent during the periods of record. The greatest probability of errors is believed to be in the other budget elements, which are not measured.

The imbalances in the budgets for Antelope Valley and East Walker Area probably are mainly the result of inherent inaccuracies in the techniques of estimating the various components of inflow and outflow. Therefore, for preliminary purposes, mean annual inflow-outflow values have been selected that represent nearly the average of the total inflow and outflow estimates, or about 190,000 acre-feet for Antelope Valley and 120,000 acre-feet for the East Walker Area.

However, with regard to the imbalance in the East Walker Area, the conditions in the Rough Creek drainage may be significant. The estimated potential ground-water recharge is 18,000 acre-feet, whereas the natural discharge by evapotranspiration is only about 500 acre-feet. Runoff from the drainage is average compared to the rest of the report area. A substantial part of the suggested surplus may be subsurface flow southward to Mono Valley. If so, the budget for the East Walker Area would be nearly in balance at about 120,000 acre-feet.

Table 15.--Preliminary water budgets

[All estimates in acre-feet per year]

Budget elements	Antelope Valley	East Walker Area
INFLOW:		
River inflow (tables 6 and 7)	a 165,000	b 98,000
Local runoff to river	Not estimated	
Potential ground-water recharge (table 9)	18,000	31,000
Subsurface inflow	1,000	200
Total (rounded): (1)	184,000	129,000
OUTFLOW:		
River outflow (tables 6 and 7)	a 150,000	b 97,000
Crop consumption use (tables 10 and 11)	c 35,000	11,000
Pumpage for domestic and livestock use (p. 40)	20	15
Natural evapotranspiration (tables 12 and 13)	12,000	7,500
Subsurface outflow	200	150
Total (rounded): (2)	197,000	116,000
IMBALANCE: (1) - (2)	-13,000	+13,000
RECONNAISSANCE VALUE SELECTED FOR INFLOW AND OUTFLOW	190,000	120,000

a. According to Lamke and Moore (1965, p. 23) this flow may be only about 90 percent of the long-term average. However, somewhat different periods of streamflow record were utilized in this study that would allow meaningful comparisons of inflow and outflow.

b. Both inflow and outflow are affected by man-controlled releases from Bridgeport Reservoir, and therefore, it is not known how these flows compare with long-term natural conditions.

c. Includes ground-water pumpage of about 2,000 acre-feet (1,100 in Nevada and 1,000 in California) as noted in table 10.

CHEMICAL QUALITY OF THE WATER

Chemical data pertaining to water from wells, springs, and streams within the area investigated are shown in table 16. Locations of the data-collection points are shown on plate 1. All data reported resulted from analyses of water samples collected during this reconnaissance investigation; additional chemical data and interpretations pertaining to water within Antelope Valley, Calif., are included in the West Walker River Investigation published by the California Department of Water Resources (1964, p. 41-44). The University of Nevada, Agricultural Experiment Station, has also published some water-quality data pertaining to the area (Miller and others, 1953, p. 36-39).

General Chemical Character

Specific conductances listed in table 16 can be used as preliminary indications of a water's general chemical character. The concentration of dissolved solids in water, expressed as milligrams per liter, is generally about two-thirds the specific conductance. (Micromhos per centimeter at 25 C are the listed units of specific conductance in table 16; for simplicity, they are hereafter referred to as micromhos. Also the chemical concentration units, milligrams per liter (mg/l) are equivalent to parts per million in most waters; see footnote 1, table 16.)

All sampled waters had specific conductances between 62 and 500 micromhos, and therefore, if the samples are representative, most waters in the area probably have a dissolved-solids content of 40 to 350 mg/l, which is low to moderately low. Most comparable-sized areas of Nevada contain waters with a considerably greater range in dissolved solids. The apparent restricted range in dissolved solids probably reflects the following general hydrologic characteristics of the area: (1) the area, being in or adjacent to the Sierra Nevada, is dominantly a natural-input, or recharge area, in contrast to areas such as the Walker Lake Valley, Clayton Valley, Columbus Salt Marsh, and Death Valley, which are dominantly natural discharge areas; (2) most of the easily obtainable water in the present report area either originated in an environment that is not conducive to natural mineralization, or is moving out of the area fast enough to avoid appreciable pickup of salts; and (3) although substantial natural evapotranspiration occurs within the area, most of this discharge occurs in places where the residual saline end products of evapotranspiration are leached and removed by the large flows of the river systems rather than being allowed to accumulate, as in the case of hydrologically closed basins.

Table 16.--Partial chemical analyses of water from wells, springs, and streams

[Field-office analyses by the U.S. Geological Survey]

Location	Source	Date sampled	Temperature °F	Temperature °C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)[3]	Bicarbonate (HCO_3)[4]	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	Sodium-adsorption ratio (SAR)	Sodium hazard
					Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]									Factors affecting suitability for irrigation[2]		
								EAST WALKER AREA								
4/26-2	Spring	10- 9-68	--	--	6 0.30	1 0.08	4 0.19	31 0.51	0 0.00	2 0.06	19 0.38	62	7.3	Low	0.4	Low
6/25-34ac	East Walker River	10- 8-68	52	11	28 1.40	6 0.46	15 0.64	134 2.20	13 0.27	1 0.03	93 1.86	280	7.7	Low	0.7	Low
6/27-14ba	Well (150 ft)	10- 8-68	--	--	21 1.05	6 0.47	45 1.94	136 2.23	39 0.81	15 0.42	76 1.52	390	8.0	Low	2.2	Low
6/27-14ba	Rough Creek	10- 8-68	--	--	11 0.55	3 0.27	16 0.71	78 1.28	8 0.17	3 0.18	41 0.82	170	7.5	Low	1.1	Low
6/27-36dbc	Bodie Creek	10- 9-68	45	7	22 1.10	9 0.70	24 1.06	120 1.97	33 0.69	7 0.20	90 1.80	320	7.9	Low	1.1	Low
6/28-19cdd	Fletcher Spring	10- 9-68	54	12	18 0.90	8 0.66	25 1.08	121 1.98	17 0.35	11 0.31	78 1.56	300	7.8	Low	1.2	Low
7/25-7bc	Sweetwater Canyon Creek	10- 8-68	43	6	33 1.65	4 0.31	6 0.28	56 0.92	62 1.29	1 0.03	98 1.96	260	7.5	Low	0.3	Low
7/25-9d	Spring	10- 8-68	--	--	28 1.40	4 0.30	7 0.31	70 1.15	40 0.83	1 0.03	85 1.70	230	7.4	Low	0.3	Low
7/25-15c	Spring	10- 8-68	--	--	31 1.55	6 0.49	25 1.09	94 1.54	71 1.48	4 0.11	102 2.04	360	7.2	Low	1.1	Low
7/25-24d	Sweetwater Creek	10- 8-68	50	10	40 2.00	8 0.62	18 0.77	122 2.00	63 1.31	3 0.08	131 2.62	380	8.0	Low	0.7	Low
7/25-26cc	Spring	10- 8-68	53	11	30 1.50	8 0.66	26 1.13	159 2.61	19 0.40	10 0.28	108 2.16	360	7.6	Low	1.1	Low
7/26-25dd	East Walker River	10- 9-68	50	10	--	--	--	--	--	--	--	280	--	Low	--	--
7/27-23cd	Well (231 ft)	10-10-68	--	--	31 1.55	10 0.79	48 2.10	130 2.13	91 1.89	15 0.42	117 2.34	480	7.9	Low	1.9	Low
8/27-15cad	East Walker River	10-10-68	50	10	--	--	--	--	--	--	--	300	--	Low	--	--
8/27-25ac	Mitchell Spring	10-10-68	56	13	48 2.40	12 0.96	35 1.53	183 3.00	73 1.52	13 0.37	168 3.36	490	8.2	Low	1.2	Low
10/27-16cdd	Well (depth unknown)	10-10-68	--	--	37 1.85	8 0.69	33 1.43	164 2.69	48 1.00	10 0.28	127 2.54	420	8.0	Low	1.3	Low
11/26-14cb	East Walker River	10-10-68	55	13	34 1.70	6 0.52	21 0.91	157 2.57	23 0.48	3 0.08	111 2.22	320	7.8	Low	0.9	Low
								ANTELOPE VALLEY[5]								
8/23-28ab	West Walker River	10-30-68	46	8	13 0.65	3 0.21	17 0.73	76 1.25	11 0.23	4 0.11	43 0.86	160	7.7	Low	1.1	Low
9/22-17c	Tin Cup Spring	8-28-68	55	13	34 1.70	6 0.46	20 0.88	155 2.54	21 0.44	2 0.06	108 2.16	330	8.1	Low	0.8	Low
9/22-28ac	Irrigation ditch	8-28-68	62	17	23 1.15	8 0.67	12 0.54	139 2.28	1 0.02	2 0.06	91 1.82	250	8.0	Low	0.6	Low
10/22-18ad	Well (depth unknown)	10-16-68	--	--	55 2.74	21 1.74	20 0.89	248 4.06	52 1.08	8 0.23	224 4.48	500	7.6	Low	0.6	Low
10/22-19b	Spring	10-16-68	--	--	71 3.54	11 0.94	15 0.65	194 3.18	90 1.87	3 0.08	224 4.48	500	8.1	Low	0.4	Low
10/22-22bd	Well (605 ft)	10-17-68	--	--	63 3.14	19 1.56	21 0.90	241 3.95	71 1.48	6 0.17	235 4.70	500	8.1	Low	0.6	Low
10/22-29bdd	Well (depth unknown)	10-29-68	--	--	41 2.05	6 0.51	17 0.75	165 2.70	21 0.44	6 0.17	128 2.56	350	7.4	Low	0.7	Low
10/22-29cdd	Well (depth unknown)	10-29-68	--	--	28 1.40	9 0.72	15 0.67	151 2.47	14 0.29	1 0.03	106 2.12	290	8.0	Low	0.7	Low
10/23-17dac	West Walker River	10-17-68	55	13	20 1.00	5 0.40	23 0.99	107 1.75	16 0.33	11 0.31	70 1.40	250	7.6	Low	1.2	Low

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 increas[ing] 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 (water suitable for almost all applications); 750-1,500, medium (can be detrimental to sensitive crops); 1,500-3,000, high (can be detrimental to many crops); 3,000-7,500, very high (should be used only for tolerant plants on permeable soils); >7,500, unsuitable. Sodium-adsorption ratio (SAR) provides an indication of what effect an irrigation water will have on soil-drainage characteristics. SAR is calculated as follows, using milliequivalents per liter: $SAR = Na/\sqrt{(Ca + Mg)/2}$. Sodium hazard is based on an empirical relation between salinity hazard and sodium-adsorption ratio. Residual sodium carbonate (expressed in milliequivalents per liter) is tentatively related to suitability for irrigation as follows: safe, 0-1.25; marginal, 1.26-2.50; unsuitable, >2.50. RSC is 0.00 (safe) for all analyses listed above. 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. 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.

4. All carbonate (CO_3) values 0 mg/l.

5. Additional chemical analyses data for Antelope Valley, California are included in the West Walker River Investigation by the California Department of Water Resources (1964, p. 41-46).

The data in table 16 show that only partial chemical analyses were made to determine the presence of the major ions; no minor elements or trace elements were determined, nor was biologic quality investigated. A comparison of millequivalent-per-liter values in the table permits the following generalizations regarding the samples analyzed: (1) calcium was the dominant cation in all waters sampled, except Rough Creek, West Walker River at 8/23-28ab, Fletcher Spring, and wells 6/27-14ba1 and 7/27-23cd; (2) calcium was always more prevalent than magnesium; (3) no carbonate was detected in any samples; (4) bicarbonate was the dominant anion in all samples, except that for Sweetwater Canyon Creek, in which sulfate was more prevalent; (5) sulfate was more prevalent than chloride in all samples except spring 4/26-2, Rough Creek, and irrigation ditch 9/22-28ac; (6) specific conductance, and probably dissolved-solids content, were slightly greater in East Walker River than in West Walker River; (7) specific conductance increased only slightly downstream along the East Walker River, but increased more than 50 percent along the West Walker River. At the time of sample collection, the irrigation season was at, or nearing, its end for the year. Also, the East Walker River was turbid throughout its course, because of suspended sediment that was being discharged from Bridgeport Reservoir.

Suitability for Domestic Use

The U.S. Public Health Service (1962, p. 7-8) has formulated drinking water standards that are generally accepted as a guideline for public supplies. Several of the standards are as follows:

Constituent	Recommended maximum concentration (milligrams per liter)
Iron (Fe)	0.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	a 1.8
Nitrate (NO_3)	45
Dissolved solids	500

a. Based on an approximate annual average maximum daily air temperature of 65 F (18 C).

Most of these are recommended limits, and therefore water may be acceptable to many users despite concentrations somewhat exceeding the given values.

Among the listed constituents, large amounts of chloride and dissolved solids impart an unpleasant taste, and sulfate can have a laxative effect on persons who are drinking the water for the first time.

The analyses in table 16 do not include determinations of fluoride or nitrate; however, these constituents are important to human health. Excessive fluoride tends to stain teeth, especially of children, and a large amount of nitrate is dangerous for infants and pregnant women because it may increase the possibility of "blue baby" disease. Some data on fluoride are available for the California part of Antelope Valley in the West Walker River Investigation report (Calif. Dept. Water Resources, 1964, p. 38-40). The data specify high fluoride concentrations in several ground-water samples collected in Antelope Valley, California.

Some farmers along the lower reaches of the East Walker River within the area report problems of high iron content in their domestic-well water, but determinations of iron were not within the reconnaissance scope of this study. Excessive iron causes staining of porcelain fixtures and clothes, and may also cause clogging of well screens, which results in reduced well efficiencies.

Other ions, such as arsenic, cyanide, and selenium, can have serious physiological affects if present in more than trace amounts in drinking water. The U.S. Public Health Service (1962, p. 8) has established concentration limits for the several ions (for example, 0.05 mg/l for arsenic). Unfortunately, no known trace-element analyses are available for water in the report area. Limited data on arsenic in the California part of Antelope Valley are given in the West Walker River Investigation report (Calif. Dept. Water Resources, 1964, p. 39). The data show an arsenic content of 0.18 mg/l from an analysis of water from hot springs in the approximate area of 9/22-13ad (not shown on pl. 1). The California Department of Water Resources data also show arsenic contents of 0.12 mg/l and 0.06 mg/l in waters from flowing wells (not shown on pl. 1) in the areas of 9/23-30ba and 9/23-20cd, respectively.

The hardness of a water is important to many domestic users, and therefore is listed in table 16. The U.S. Geological Survey has adopted the following rating:

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

The bacteriological quality of drinking water also is important, but is outside the scope of this report.

All sampled waters within the report area are well within the accepted Public Health Service standards regarding chloride, sulfate, and dissolved solids. Most of the sampled waters range from moderately hard to very hard.

If any doubt exists regarding the acceptability of a drinking-water supply, contact the Nevada Health Division, Bureau of Environmental Health, Carson City.

Suitability for Agricultural Use

In evaluating the desirability of a water for irrigation, the most critical factors 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 16, and are discussed briefly in footnote 2 of that table. Minor amounts of boron (up to about 0.5 mg/l) are essential to plant nutrition, but larger concentrations can be highly toxic. The approximate upper limits recommended for boron in water irrigating sensitive, semitolerant, and tolerant crops are, respectively, 0.5-1.0, 1.0-2.0, and 2.0-4.0 mg/l (National Technical Advisory Committee, 1968, p. 153).

The East and West Walker Rivers, which presently supply most irrigation water in the study area, have proved generally acceptable chemically; this is because (1) soil drainage is adequate in most irrigated areas, (2) the waters have a low sodium hazard, and (3) the crops grown (largely alfalfa) are adequately tolerant. Boron apparently is not a problem in most of the study area. Some data regarding boron are available for the California part of Antelope Valley in the West Walker River Investigation report (Calif. Dept. Water Resources, 1964, p. 38-40). The data specify boron concentrations in several ground-water samples collected in Antelope Valley, Calif.

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

Most animals are more tolerant of poor-quality water than man. Although available data are somewhat conflicting, dissolved-solids concentrations below 4,000-7,000 mg/l apparently are safe and acceptable for most animals (McKee and Wolf, 1963, p. 112-113), provided that specific undesirable constituents are not present in excessive concentrations. All water sampled within the study area is sufficiently dilute for livestock use.

THE AVAILABLE WATER SUPPLY

Sources of Supply

In both Antelope Valley and the East Walker Area, the available water supply consists of two interrelated quantities: (1) the system yield, and (2) part of the ground water in storage. The valley-fill reservoir of Antelope Valley is generally similar to that of many valleys of the Great Basin, but one atypical characteristic is the large through-flowing river it contains. The inflow to Antelope Valley is unregulated by man and depends on the whims of nature: however, the surface outflow is regulated in small part by the "off-channel" Topaz Lake. The East Walker Area is also unlike most Nevada valleys because it hosts a through-flowing river and also because its valley-fill reservoir is fragmented into several ground-water basins that are apparently mainly interconnected only through their natural attachment to the East Walker River. The East Walker River is the major inflow element to its area's hydrologic system and its flow is regulated by man-controlled releases from Bridgeport Reservoir; therefore, the river's outflow from the East Walker Area is also mainly affected by man's control plus the superimposed minor pulses supplied by nature within the area.

System Yield

System yield has been defined by Worts and Malmberg (1966, p. 37) as the maximum amount of surface and ground water of usable chemical quality that can be obtained economically each year from sources within the system for an indefinite period of time. System yield cannot exceed the natural inflow to or outflow from a system. Under practical conditions of development, the yield is limited to the maximum amount of surface-water, ground-water, and water-vapor outflow that can be salvaged or diverted economically and legally each year for beneficial use.

The estimated system yields of the valleys in the report area are based on estimated quantities listed in table 17 and the following limitations and assumptions: (1) use by irrigation is considered salvage; (2) most of the evapotranspiration of phreatophytes can be salvaged; (3) none of the subsurface outflow suspected of leaking to Mono Valley from the Rough Creek drainage can be salvaged; (4) no surface-water outflow or subsurface outflow beneath the rivers is considered salvable at this time because of downstream water-rights requirements and because no analysis has been made of any unappropriated flows; (5) evaporation from water surfaces cannot be salvaged; (6) water quality is acceptable for all intended uses; and (7) the estimated system yield is within the limits allowed by legal appropriations and decrees.

Table 17.--Preliminary estimates of a minimum system yield

Hydrographic area	Minimum system yield (acre-feet per year)		
	Consumptive use by crops[1]	Evapotranspiration by phreatophytes[2]	Total (rounded)
Antelope Valley, Nevada part	1,700	2,600	4,300
Antelope Valley, California part	33,000	3,600	37,000
Total (rounded)	35,000	6,200	41,000
East Walker Area, Nevada part	9,800	5,500	15,000
East Walker Area, California part	720	860	1,600
Total (rounded)	11,000	6,400	17,000

1. From tables 10 and 11. Amount diverted from river is considerably more.

2. From tables 12 and 13.

For this reconnaissance, the system yields of the two areas are considered to be the sum of consumptive use by crops, the pumpage, and salvage of virtually all evapotranspiration in phreatophyte areas. In addition, the areas may be entitled to a fair share of any unappropriated streamflow--particularly flood flows. However, evaluation of a fair share of the unappropriated waters was beyond the scope of this reconnaissance. Any plan to apportion the unappropriated waters probably should involve consideration of the rights along the entire stream system including those for Walker Lake. The estimated yields shown in table 17 are considered preliminary minimum values.

Ground-Water Storage in the Valley-Fill Reservoirs

The amount of ground water stored in the valley-fill reservoirs to any selected depth below the ground-water surface is the product of the area, the selected depth, and specific yield of the deposits. The selected depth for this study is the uppermost 100 feet of saturation. Specific yield of a rock or soil with respect to water is the ratio of (1) the volume of water which, after being saturated, the deposit will yield by gravity to (2) its own volume, commonly expressed as a percentage (Meinzer, 1923, p. 28).

In the Nevada part of Antelope Valley and the East Walker Area, the specific yield of the uppermost 100 feet of saturated valley fill is assumed to average 10 percent. The alluvial areas, shown on plate 1, were adjusted to estimate the area of the valley fill most probably underlain by at least 100 feet of saturated deposits. The adjustments were based on topography, assumptions regarding the subsurface distribution of the alluvium, depth to water, and the shape of the alluvial areas. The areas, adjustments, and estimates of stored ground water are summarized in table 18.

Although the estimates of stored ground water are large, the amount in areas where the depth to water is less than 100 feet and where suitable land is available for cultivation is appreciably less. The amount of usable ground water in storage that is economically available depends in part on the distribution of water-storing deposits, their yield to wells, the distribution and range in chemical quality of the ground water, and the number and distribution of pumped wells. Also, large withdrawals of ground water along the flood plains of perennial streams would affect the flow of surface water and therefore would legally infringe on previously decreed surface-water rights.

Table 18.--Estimated stored water in the upper 100 feet of saturated valley fill in Nevada

Hydrographic area	Approximate area of valley fill (acres)	Adjusted area of valley fill probably underlain by 100 feet or more of saturated valley fill (acres)	Estimated stored water in the upper 100 feet of saturated valley fill[1] (acre-feet)
Antelope Valley,[2] Nevada part	26,000	20,000	200,000
East Walker Area, Nevada part			
Sweetwater Flat	9,000	7,000	70,000
Lower part of Rough Creek drainage	50,000	30,000	300,000
Areas along lower reaches of East Walker River	70,000	40,000	400,000
Total (rounded)	130,000	80,000	800,000

1. Computed by multiplying the adjusted area by 100 feet and by 10 percent (assigned specific yield).

2. California Department of Water Resources (1964, table 2) estimated a storage capacity of about 164,000 acre-feet for the 10- to 100-foot zone in the California part of Antelope Valley. For the entire valley, estimated total storage in the upper 100 feet of saturation exceeds 350,000 acre-feet.

NUMBERING SYSTEM FOR WELLS, SPRINGS, AND HYDROLOGIC SITES

Numbers assigned to wells and springs in this report are based on the rectangular subdivisions of the 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 section number, which in turn is followed by a letter that indicates the quarter section. The quarter sections are designated counterclockwise "a" through "d" in sequence beginning with "a" for the northeast quarter section. When field maps of sufficient accuracy are available, additional letters "a" through "d", also assigned in counterclockwise sequence, specify the particular 40- or 10-acre tract. If more than one well is within the same lettered tract, a number indicates the order in which the well or spring was recorded within that particular tract. For example, well 7/25-9cb2 is the second well recorded in NW¼SW¼ sec. 9, T. 7 N., R. 25 E., Mount Diablo base line and meridian.

FUTURE WATER DEVELOPMENT AND

RECOMMENDATIONS FOR FUTURE HYDROLOGIC STUDIES

Present water development in the report area centers mainly around the East and West Forks of the Walker River. Several Federal agencies have made feasibility studies of proposed surface-water development projects or have proposed projects that would further alter the natural streamflow of these rivers. Surface-water use might further evolve when and if any of the proposals, or future proposals, are accepted and when the accepted projects become a reality.

Ground water is presently a relatively untapped resource of the area, except for a small amount of irrigation (table 10) along the West Walker River and limited domestic and livestock use in both areas. Therefore, water-resource development in the near future might be expected to consider ground water as a principal source. However, the major ground-water reservoirs have the two rivers flowing across them, and therefore it is doubtful whether large-scale ground-water development could occur without affecting the presently appropriated flow of these streams.

Because any large-scale future development probably would involve the complete hydrologic system, future hydrologic studies should attempt to describe the specific interrelations of surface and ground water to allow their orderly development without causing undesirable stresses on either component. Such studies would require many more detailed data on the ground-water reservoirs than are presently available.

Table 19.--Well data

Depth: All depths reported or from driller's logs.

Use: D, domestic; I, irrigation; R, recreation; S, stock; T, test; U, unused or abondoned (intended use shown in parentheses).

Water level: Depth in feet below land surface. Depths followed by asterisk were measured by U.S. Geological Survey personnel; all other depths are reported.

Remarks: R, reported well depth when drilled; T, length of time between start of pump test and measurement of drawdown, in hours; F, depth, in feet, of first water encountered during drilling; S, log in files of State Engineer (State log number is indicated); L, driller's log in table 20; C, chemical analysis in table 16.

Location number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement Depth (feet)	Water-level measurement Date	Remarks
					WEST WALKER RIVER AREA					
10/21-1da	R. Jepsen	1964	241	6	D	17/--	5,700	80	4- -64	F=220; S=7,778; L
10/22-12cd	Unknown	--	--	--	U	--	5,110	37.00*	10-16-68	
-13ac	Fairfield Ranch	--	--	6	S	--	5,040	--		
-14ac	Fairfield Ranch	1951	432	16	U(I)	--	5,070	42.00*	9-20-51	F=46; S=1,790; L
-17cc	Fairfield Ranch	--	--	14	I	--	5,280	55±*	10-16-68	
-18ac	Fairfield Ranch	1953	330	14	I	400/212	5,380	24.20*	10-16-68	F=40; S=2,246; L
-18ad	Viola Ramsey	--	--	6	D	--	5,370	39.48*	10-16-68	C
-18dc1	Fairfield Ranch	1951	100	6	D	30/8	5,430	31	6- -51	F=34; S=1,696; L
-18dc2	Fairfield Ranch	1952	155	6	D	50/Flowing	5,430	--	--	F=30; S=2,006; L
-22adc	Fairfield Ranch	--	--	14	I	--	5,040	--	--	
-22bac	Fairfield Ranch	--	--	--	I	--	5,100	116.14*	10-17-68	
-22bd	Fairfield Ranch	1950	605	14	D,S,I	--	5,100	40±	9- -50	F=30; S=1,490; L; C
-24bb	Fairfield Ranch	1951	553	16	S(I)	--	4,995	24*	9-20-51	F=40; S=1,791; L
								41.52	10-17-68	
-25ad	Fairfield Ranch	1951	555	16	U(I)	--	4,990	26.00*	9-20-51	F=30; S=1.792; L
-25bd	Fairfield Ranch	1950	855	14	U(I)	--	4,990	5.28*	10-17-68	S=913; L
-26ab	Fairfield Ranch	1950	684	14	U(I)	--	5,010	10.80*	10-17-68	F=38; S=1,491; L
-26ad	Fairfield Ranch	--	--	10	S	--	5,010	--	--	
-27cc	Walker River Irrigation Dist.	--	--	--	D	--	5,020	50±*	10-29-68	

Table 19.--Well data--Continued

Location number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement Depth (feet)	Water-level measurement Date	Remarks
10/22-28dd	Charlanda, Inc.	1967	222	8	R	20/160	5,000	21	7- -67	S=9,631
-29bdd	George Brooks	--	--	6	D	--	5,050	117.90*	10-29-68	C
-29cb	Wayne Thietten	1963	350	6	D	5/--	5,160	250	11- -63	F=245; S=7,792; L
-29cdc	E. D. Kay	1967	203	6	D	60/--	5,080	124	9- -67	F=146; S=3,726; L
-29cdd	Topaz Lodge Subdivision	--	--	14	D	--	5,020	--	--	C
-32bd	W. Vomacka	1964	60	6	D	45/--	5,020	35	3- -64	F=35; S=7,729; L
10/23-19ba	Fairfield Ranch	1950	1,193	14	I	--	4,990	14.90*	10-16-68	F=37; S=1,488; L
					EAST WALKER RIVER AREA					
6/27-14a	Flying M Ranch	1956	420	12	U(I)	1,100/70	5,930	60	8- -56	F=150; S=3,846; L
-14ba	Flying M Ranch	1956	150	6	D	--	5,930	15	7- -56	F=90; S=3,555; L; C
7/25-9ca	Sweetwater Ranch	1951	82	6	U	38/12	6,600	11	9- -51	F=20; S=1,758; L
-9cb1	Sweetwater Ranch	1958	80	10	U	--	6,600	3	9- -58	F=5; S=5,657; L
-9cb2	Sweetwater Ranch	1951	173	16	U	65/29	6,600	21	6- -51	F=23; S=1,687; L
-9cc1	Sweetwater Ranch	1951	205	6	T	25/20	6,580	33	4- -51	F=43; S=1,606; L
-9cc2	Sweetwater Ranch	1951	100	6	T	--	6,580	--	--	S=1,616; L
-9cc3	Sweetwater Ranch	1951	60	6	T	--	6,580	--	--	S=1,617; L
-9cc4	Sweetwater Ranch	1951	80	6	U	42/7	6,580	10	9- -51	F=10; S=1,757; L
-9cc5	Sweetwater Ranch	1958	80	10	U	--	6,580	20	10- -58	F=20; S=5,656; L
-16aa	Sweetwater Ranch	1958	80	6	U	900/--	6,400	Flowing	8- -58	F=5; S=5,658; L
-16bb	Sweetwater Ranch	1951	150	6	U	75/15	6,560	6	9- -51	F=15; S=1,759; L
7/27-23cd	BLM "Baldwin Canyon Well"	1966	231	6	S	--	6,095	186.45*	10-10-68	L; C
8/27-5bb	Flying M Ranch	1949	143	6	D	30/--	4,960	56	3- -49	F=61; S=818; L
9/27-4bb	Francis Goettsch	--	--	6	D	--	4,790	--	--	
-29cb	Flying M Ranch	1949	77	6	D	--	4,930	20	2- -49	F=22; S=817; L
-30da	Flying M Ranch	1960	405	16	U	1,230/65	4,930	40	7- -60	F=40; S=5,477; L
10/27-16cdd	Oscar Ivey	--	--	8	D	--	4,770	--	--	C
11/26-23dac	Oscar Ivey	--	--	6	D	--	4,620	70	--	
-36abc	Oscar Ivey	--	--	6	D	--	4,640	--	--	

Table 20.--Well logs

[Asterisks indicate principal water-bearing zones]

Material	Thickness (feet)	Depth (feet)
6/27-14a (cased to 400 ft; perforated from 250 to 400 ft)		
Sand and rock	30	30
Rock	10	40
Sand and round rock	25	65
Shale, soft	85	150
Sand and rock, waterbearing*	50	200
Sand	185	385
Rock or round rock	15	400
Sand and rock	20	420
6/27-14ba (cased to 140 ft; perforated from 80 to 140 ft)		
Sand and hard rock	18	18
Sandstone	52	70
Sand and round stone	60	130
Sand and rock, waterbearing*	20	150
7/25-9ca (cased to 74 ft; perforated from 31 to 74 ft)		
Surface clay and coarse sand	12	12
Clay, coarse clayey sand	10	22
Clayey gravel, waterbearing	18	40
Gravel and coarse sand, waterbearing*	22	62
Gravel, streaks of clay, waterbearing*	13	75
Clay, gray, and cemented gravel	7	82
7/25-9cb1 (cased to 70 ft; perforated from 40 to 70 ft)		
Boulders and clay, waterbearing	25	25
Boulders and sand	15	40
Boulders and sand*	40	80
7/25-9cb2 (cased to 173 ft; perforated from 50 to 170 ft)		
Clay, gravel, and cobbles	8	8
Sand, clay, and gravel	17	25
Gravel, cemented	7	32
Sand and clay	9	41
Gravel	10	51
Gravel, cemented, waterbearing	39	90
Sand and clay	11	101
Gravel, cemented	4	105
Clay, sand, and gravel	45	150
Gravel, cemented	13	163
Clay, sand, and gravel	10	173
7/25-9cc1		
Topsoil	4	4
Gravel, cemented	13	17
Gravel and brown clay	9	26
Gravel and yellow clay	10	36
Clay, yellow, and gravel	7	43
Gravel, loose, and cobbles, waterbearing	19	62
Sand, gravel, and clay	88	150
Gravel, loose	5	155
Gravel, cemented	32	187
Clay, sandy, and gravel	18	205
7/25-9cc2		
Clay, sandy, and gravel	15	15
Gravel, cemented	5	20
Clay, sandy, and gravel	6	26
Gravel, cemented	26	52
Clay, sandy, and gravel	37	89
Gravel, cemented	5	94
Clay, sandy	6	100
7/25-9cc3		
Topsoil	5	5
Gravel, cemented	14	19
Mud, blue, and gravel	9	28
Clay, sand, and gravel	17	45
Sand	15	60
7/25-9cc4 (cased to 75 ft; perforated from 31 to 75 ft)		
Clayey gravel (waterbearing below 10 ft)	16	16
Clay, tan, gritty	8	24
Clay, tan, gravel streaks, waterbearing	36	60
Gravel, waterbearing*	8	68
Gravel, clay streaks, waterbearing	12	80
7/25-9cc5 (cased to 68 ft; perforated from 40 to 68 ft)		
Boulders, loose	40	40
Boulders, loose, waterbearing*	10	50
Boulders, loose, and clay, waterbearing*	10	60
Boulders, loose, waterbearing*	20	80

Table 20.--Well logs (continued)

Material	Thick-ness (feet)	Depth (feet)
7/25-16aa (cased to 56 ft; no perforations, open end)		
Soil, black, and peat	13	13
Clay, white to cream, with pebbles imbedded	7	20
Clay with gravel and cobbles	5	25
Clay, light tan, and cream clay with pebbles imbedded, sandy streaks	23	48
Clay, blue gray, sticky	6	54
Clay, dull gray, with brown streaks and spots of carbonaceous material	14	68
Volcanic sand, dark gray, coarse, with small pebbles, waterbearing	12	80
7/25-16bb (cased to 143 ft; perforated from 51 to 143 ft)		
Topsoil and sand	2	2
Clay and gravel	8	10
Clayey sand and gravel, tan, waterbearing below 15 ft	7	17
Boulder	1	18
Gravel, clayey	4	22
Boulders in cemented gravel	10	32
Boulders, clay, and gravel	5	37
Clay, gravel, and sand, tight	15	52
Gravel, some tan clay	5	57
Gravel and boulders*	5	62
Gravel and some clay*	3	65
Rock (boulders), solid*	7	72
Boulders and gravel*	10	82
Rock and gravel*	5	87
Gravel and clay	5	92
Clay, tan, and gravel	8	100
Clay and gravel, tan	35	135
Gravel, gray, cemented	15	150
7/27-23cd (cased to 231 ft)		
Clay, brown, sandy, and boulders	20	20
Clay, brown, sandy	20	40
Clay, brown, sandy, with streaks of gravel	80	120
Clay, brown, sand, lava rock	80	200
Sand and clay, some rocks	10	210
Gravel and lava rock, water-bearing	21	231
8/27-5bb (cased to 143 ft; perforated from 74 to 142 ft)		
Loam, sandy	3	3
Boulders, sand	12	15
Gravel, sand	7	22
Gravel, cemented	39	61
Gravel, clay, waterbearing	25	86
Clay, gray, sandy	11	97
Clay, brown, sandy	18	115
Clay, blue, sandy	22	137
Gravel, waterbearing	6	143
Hard rock bottom		
9/27-29cb (cased to 77 ft; perforated from 63 to 75 ft)		
Loam, sandy	5	5
Sand, coarse	11	16
Gravel, clay	6	22
Boulders, sand, waterbearing	1	23
Gravel, sand, and clay	16	39
Clay, sandy	24	63
Sand, coarse, waterbearing*	14	77
9/27-30da (cased to unknown depth; perforated from 124 to 384 ft)		
Clay, sandy, and gravel	12	12
Sand, loose, gravel, and boulders	48	60
Gravel, loose, clay streaks	45	105
Silt and boulders*	19	124
Clay and gravel*	24	148
Gravel, some clay*	22	170
Gravel and boulders*	30	200
Sand, coarse*	10	210
Clay, brown*	82	292
Sand and gravel*	24	316
Clay, brown, hard, with gravel embedded*	89	405

Table 20.--Well logs (continued)

Material	Thick-ness (feet)	Depth (feet)
10/21-1da (cased to 241 ft; perforated from 220 to 238 ft)		
Clay and boulders	14	14
Clay, red	11	25
Rocks	6	31
Clay, red	9	40
Sandstone	11	51
Clay, red	8	59
Sandstone	5	64
Clay, red	13	77
Sandstone	5	82
Clay, blue	1	83
Sandstone	37	120
Clay, yellow	32	152
Gravel, cemented	33	185
Clay	35	220
Sandstone, waterbearing*	20	240
Clay, gray	1	241
10/22-14ac (cased to 432 ft; perforated from 60 to 432 ft)		
Unknown	28	28
Shale, sticky; water sand, streaks of clay, coarse gravel; waterbearing below 46 feet	89	117
Clay, sticky; coarse and fine water gravel and sand; few streaks of thin sandy shale	110	227
Gravel, coarse; thin streaks of sticky clay; coarse sand and fine white sand; hard black shale	106	333
Shale, black, hard; sticky clay and water sand; large round gravel and then shale	60	393
Shale, sandy, with a few streaks of water sand	39	432
10/22-18ac (cased to 312 ft; perforated intervals unknown)		
Topsoil	2	2
Rocks, sandy	5	7
Clay and rocks	8	15
Boulders	2	17
Clay, gray	23	40
Sand, black, hard, fine, waterbearing	7	47
Sand, gravel, water	3	50
Clay and sand	30	80
Rock and gravel	10	90
Sand, gravel, and rock	18	108
Clay, brown, and sand	40	148
Clay and rocks	53	201
Rocks	5	206
Gravel, cemented	9	215
Sand, and gravel	15	230
Gravel, clay, and sand	50	280
Gravel	5	285
Sand, clay, and gravel	45	330
10/22-18dc1 (cased to 100 ft; perforated from 50 to 96 ft)		
Clay, cobbles, and boulders	34	34
Sand, fine, waterbearing	8	42
Clay, sandy, and gravel	8	50
Rock, loose, waterbearing*	13	63
Clay, sandy	7	70
Clay, sandy, and gravel	19	89
Clay, gravel, and boulders	11	100
10/22-18dc2 (cased to 155 ft; perforated from 30 to 153 ft)		
Clay, red	30	30
Clay, sandy, waterbearing	15	45
Sand, fine	20	65
Clay	6	71
Sand	14	85
Clay, sandy	12	97
Lava rock, red	20	117
Rock, porous, waterbearing*	23	140
Clay and rock, waterbearing*	15	155

Table 20.--Well logs (continued)

Material	Thick-ness (feet)	Depth (feet)
10/22-22bd (cased to 605 ft; perforated from 20 to 605 ft)		
Shale	27	27
Gravel, with streaks of shale, waterbearing below 30 ft	71	98
Water sand, round gravel, streaks of shale, rocks, some streaks of red shale and hard gray shale	154	252
Limestone, green, streaks of water sand, then gray and red shale	84	336
Shale, red and gray, green limestone with streaks of shale and water sands	86	422
Sand, green, in streaks, then shale and hard round water sand, then green sandy shale	89	511
Shale, gray, sandy, then hard sand, then gray shale, then hard sandy streaks	66	577
Rocks, hard, round, red sandy shale, then hard rocks again	28	605
10/22-24bb (cased to 553 ft; perforated from 50 to 553 ft)		
Unknown	28	28
Shale with streaks of sand, waterbearing below 40 ft	87	115
Shale with streaks of large bodies of water sand containing large and small gravel	110	225
Shale, brown, and coarse gravel in streaks, then streaks of shale with large bodies of large gravel and water shale	172	397
Sand gravel with few streaks of brown shale	109	506
Shale, brown, with streaks of water sand and then hard black shale	47	553
10/22-25ad (cased to 555 ft; perforated from 80 to 555 ft)		
Unknown	26	26
Shale, sticky, with small and large streaks of coarse and fine gravel, also streaks of shale, waterbearing below 39 ft	91	117
Shale, thin; wide and narrow layers of washed rock and shale, both large and small with shale and streaks of hard green shells	128	245
Shale, sandy; lots of sand and coarse gravel bed. Hard green shells approx. 10 ft thick. Underlying this large gravel beds, coarse and water sand	173	418
Sand, hard, and large hard gravel with streaks of fine water sand and clay shells	66	484
Gravel, large; fine water sand, fractured shale, and large gravel and water sand which overlays the conglomerate	71	555

Table 20.--Well logs (continued)

Material	Thickness (feet)	Depth (feet)
10/22-25bd		
Topsoil, river clay	10	10
Sand, black, water	2	12
Gravel, brown, clay	7	19
Clay, brown, sandy	8	27
Gravel, sand, water	11	38
Sand, coarse	19	57
Clay, brown	17	74
Clay, white; 2 ft water sand	5	79
Clay, brown, sandy	13	92
Clay, brown; 3 ft water sand	42	134
Gravel clay, brown	17	151
Sand, brown, water; 3 ft water sand	7	158
Clay, brown	7	165
Gravel clay, brown	15	180
Sand, coarse, water	5	185
Gravel, brown, sandy clay	30	215
Gravel, white, sandy clay	3	218
Sand, hard; gravel; some clay and water heave	37	255
Gravel, washed, small streaks of shale from 4 to 8 feet thick	167	422
Rocks, small, round; water gravel; some streaks of shale and hard shells 2 to 4 feet thick	110	532
Rocks, small, round; water gravel, sand	175	707
Shale, hard, and streaks of water sand	60	767
Rocks, white, hard, similar to granite; streaks of quartz carrying water	27	794
Conglomerate of hard sand	59	853
Granite	2	855

Material	Thickness (feet)	Depth (feet)
10/22-26ab (cased to 684 ft.; perforated to 684 ft)		
Shale	28	28
Shale gravel and streaks of shale	10	38
Shale, sticky, with streaks of sand and water sand	209	247
Shale, thin streaks, with water sand and gravel	218	465
Rocks, hard, round with streaks of red shale	55	520
Rocks, hard, round with gravel and water sand	55	575
Shale, gray, hard, and hard sand	27	684
10/22-29cb (cased to 250 ft; perforated from 210 to 250 ft)		
Rock, brown, and clay	80	80
Clay, brown, and gravel mix	190	270
Rock, brown, hard, water-bearing*	80	350

Table 20.--Well logs (continued)

Material	Thickness (feet)	Depth (feet)
10/22-28dd (cased to 222 ft; perforated from 196 to 218 ft)		
Clay, yellow	31	31
Rocks, waterbearing	8	39
Clay, rocky	165	204
Rock, broken, waterbearing*	18	222
10/22-29cdc (cased to 203 ft; perforated from 149 to 203 ft)		
Clay, brown, and broken rock	8	8
Clay, brown, and boulders	3	11
Clay, brown, and broken rock	12	23
Clay, brown, and boulders	2	25
Clay, brown, and broken rock	9	34
Clay, brown, and boulders	2	36
Clay, brown, and broken rock	37	73
Clay, brown, and boulders	4	77
Clay, brown, and broken rock	19	96
Clay, brown, and boulders	4	100
Clay, brown, and broken rock	8	108
Clay, brown, and boulders	16	124
Clay, brown, and broken rock	3	127
Clay, brown, and boulders	2	129
Clay, brown, and broken rock	2	131
Clay, brown, and boulders	2	133
Clay, brown, and broken rock	6	139
Clay, brown, and boulders	4	143
Rock, brown, cemented	3	146
Clay, brown, and broken rock, waterbearing	4	150
Boulders, brown, cemented	6	156
Clay, brown, and small broken rock	13	169
Clay, brown, hard, and broken rock	4	173
Clay, brown, and small broken rock	3	176
Clay, brown, and small boulders	2	178
Clay, brown, and gravel, waterbearing*	13	191
Gravel, brown, cemented, waterbearing*	12	203
10/22-32bd (cased to 60 ft; perforated from 45 to 60 ft)		
Gravel and boulders	35	35
Gravel and sand, waterbearing	25	60
10/23-19ba (cased to 1,193 ft; perforated from 78 to 1,193 ft)		
Unknown	27	27
Shale, sticky, gravel, small streaks of shale, gravel and streaks of shale, waterbearing below 37 ft	180	207
Gravel, round, and washed rocks, water shale and thin sandy shale streaks	199	406
Shale, sandy, containing large streaks of water sand and a few hard shells	130	536
Shale, red, and thick streaks of water sand, then red shale and more streaks of hard water sand	129	665
Shale, red, and hard streaks of water sand	281	946
Shale, light gray, and streaks of water sand	44	990
Shale, hard chert, streaks of shale, sand and gravel	44	1,034
Shale streaks and some sand with white quartz rock	67	1,101
Lime	44	1,145
Limestone and coarse sand	48	1,193

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LIST OF PREVIOUSLY PUBLISHED REPORTS IN THIS SERIES

(See fig. 1)

Report no.	Valley or area	Report no.	Valley or area
1	Newark (out of print)	25	Coyote Spring, Kane Springs, and Muddy River Springs
2	Pine (out of print)	26	Edwards Creek
3	Long (out of print)	27	Lower Meadow, Patterson, Spring (near Panaca), Rose, Panaca, Eagle, Clover, and Dry
4	Pine Forest (out of print)	28	Smith Creek and Ione
5	Imlay area (out of print)	29	Grass (near Winnemucca)
6	Diamond (out of print)	30	Monitor, Antelope, Kobeh, and Stevens Basin (out of print)
7	Desert (out of print)	31	Upper Reese
8	Independence (out of print)	32	Lovelock
9	Gabbs (out of print)	33	Spring (near Ely; out of print)
10	Sarcobatus and Oasis (out of print)	34	Snake, Hamlin, Antelope, Pleasant, and Ferguson Desert (out of print)
11	Hualapai Flat	35	South Fork, Huntington, and Dixie Creek-Tenmile Creek (out of print)
12	Ralston and Stone Cabin	36	Eldorado, Piute, and Colorado River (out or print)
13	Cave	37	Grass (near Austin) and Carico Lake (out of print)
14	Amargosa Desert, Mercury, Rock, Fortymile Canyon, Crater Flat, and Oasis	38	Hot Creek, Little Smoky, and Little Fish Lake (out of print)
15	Sage Hen, Guano, Swan Lake, Massacre Lake, Long, Macy Flat, Coleman, Mosquito, Warner and Surprise	39	Eagle (Ormsby County)
16	Dry Lake and Delamar	40	Walker Lake and Rawhide Flats
17	Duck Lake	41	Washoe
18	Garden and Coal	42	Steptoe
19	Middle Reese and Antelope	43	Honey Lake, Warm Springs Newcomb Lake, Cold Spring, Dry, Lemmon, Red Rock, Spanish Springs, Bedell Flat, Sun, and Antelope
20	Black Rock Desert, Granite Basin, High Rock Lake, Mud Meadow, and Summit Lake		
21	Pahranagat and Pahroc		
22	Pueblo, Continental Lake, Virgin, and Gridley Lake		
23	Dixie, Stingaree, Fairview, Pleasant, Eastgate, Jersey, and Cowkick		
24	Lake		

Report no.	Valley or area	Report no.	Valley or area
44	Smoke Creek Desert, San Emidio Desert, Pilgrim Flat, Painters Flat, Skedaddle Creek, Dry (near Sand Pass), and Sano (out of print)		
45	Clayton, Stonewall Flat, Alkali Spring, Oriental Wash, Lida, and Grapevine Canyon		
46	Mesquite, Ivanpah, Jean Lake, and Hidden		
47	Thousand Springs and Grouse Creek		
48	Little Owyhee River, South Fork Owyhee River, Independence, Owyhee River, Bruneau River, Jarbidge River, Salmon Falls Creek, and Goose Creek		
49	Butte		
50	Lower Moapa, Black Mountains, Garnet, Hidden, California Wash, Gold Butte, and Greasewood		
51	Virgin River, Tule Desert, and Escalante Desert		
52	Columbus Salt Marsh, and Soda Spring		

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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

EXPLANATION
(Top half Plate 1)

QUATERNARY — Pleistocene and Holocene — Younger alluvium

TERTIARY AND QUATERNARY — Miocene to Pleistocene — Older alluvium

PRE-PERMIAN (?) TO TERTIARY — Consolidated rocks

Drainage divide

Geologic contact

0 1 2 3 4 5 miles
1:250,000

EXPLANATION
(Bottom half Plate 1)

Phreatophytes and irrigated areas

9b — Well and number

17be — Spring and number

21 — Flow measurement site and number

Drainage divide

Boundary of phreatophyte area

0 1 2 3 4 5 miles
1:250,000

Base from U.S. Geological Survey 1:250,000 scale map:
Walker Lake, Nevada and California (1957)

Hydrology by P. A. Glancy, 1968–69
Geology modified from Koenig, 1963;
Moore, 1963; and Ross, 1961
Drafting by C. Bosch

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF ANTELOPE VALLEY AND EAST WALKER AREA, NEVADA AND CALIFORNIA