STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND

NATURAL RESOURCES

DIVISION OF WATER RESOURCES

WATER RESOURCES BULLETIN NO. 38

WATER RESOURCES AND DEVELOPMENT IN MASON VALLEY, LYON AND MINERAL COUNTIES, NEVADA, 1948-65

By C. J. HUXEL, JR.

with a section on Surface Water

By E. E. HARRIS

Prepared in cooperation with the

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

1969

CONTENTS

ILLUSTRATIONS

TABLES

WATER RESOURCES AND DEVELOPMENT IN MASON VALLEY, LYON AND MINERAL COUNTIES, NEVADA, 1948-65

By C. J. Huxel, Jr.

ABSTRACT

The study area comprises 510 square miles in the Walker River basin of western Nevada. Precipitation in the area ranges from about 5 inches per year on the valley floor (altitude 4,700-4,300 feet) to about 20 inches in the surrounding mountains. The average growing seasons between frosts of 32° and 24°F. are about 110 and 200 days, respectively.

The Mason Valley floor is underlain by a thick sequence of alluvium and fan deposits that forms the principal source of ground water in the valley. The alluvium contains abundant well-sorted sand and gravel with transmissibilities generally in the range from 50,000 to 200,000 gallons per day per foot, and specific yields of about 20 percent. The total amount of water stored in the uppermost 50 feet of saturation (which in most parts of the valley begins less than 10 feet below land surface) is about 1,100,000 acre-feet.

East and West Walker Rivers, which enter the valley from the south and join to form the main stem, contributed an average of 216,000 acre-feet per year during the period 1948-65. In an average year, about 140,000 acre-feet was diverted and about 3,000 acre-feet of ground water was pumped to irrigate about 30,000 acres. Of the total, about 41,000 acre-feet was consumed, and the remainder consisted of return flow, canal loss, and evapotranspiration. During the same period, about 4,000 acre-feet per year of ground water was used for mining, municipal, domestic, and stock purposes. Surface-water outflow from the valley via Walker River and Adrian Gap averaged about 108,000 acre-feet per year for the 18 years ending in 1965, and evapotranspiration losses were about 57,000 acre-feet per year.

In the drought years 1959-62, an average of 30,000-35,000 acre-feet of surface water and 7,000 acre-feet of ground water was used annually for irrigation, and almost the entire amount was consumed. Inflow and outflow in the Walker River system averaged only 107,000 and 25,000 acre-feet per year, respectively.

Most stream and ground water in the valley is of suitable quality for agricultural and domestic use, as well as for ore-processing and plant needs at the large Anaconda open-pit operation west of Yerington. Specific conductances are characteristically less than a thousand micromhos, except for waters from thermal springs and flowing wells north and east of Wabuska.

Conjunctive use of surface and ground water, together with salvage of natural water losses, would provide an obvious way to improve the economy of the area, as well as to utilize more effectively the water resources. The system yield, or maximum amount of surface and ground water that can be salvaged for beneficial use may be as much as 100,000 acre-feet per year. This figure is based on the present use of about 40,000 acre-feet of streamflow, plus salvage of substantial amounts of the present-day evapotranspiration loss and up to about one-fourth of the average surface-water outflow, plus pumpage of about 25,000 acre-feet of ground water per year. However, Mason Valley is only one segment of the Walker River system. Therefore, the actual system yield may prove to be more or less than that suggested above, depending principally upon upstream diversions, future construction of holdover-storage reservoirs, needs of downstream users, and any plans for sustained recreation at Walker Lake, where the level has been declining about 2 feet per year.

INTRODUCTION

Purpose and Scope

This hydrologic study of Mason Valley was made by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The need for a study became apparent during and following a drought in 1959-62. During the drought, the flow in the Walker River was insufficient to furnish adequate irrigation water to crops in the valley. More than 50 irrigation wells were drilled and pumped to meet the needs. As more wells were drilled, the State wanted to know whether the additional ground-water rights granted might exceed the system yield of the valley, and whether increased pumpage of ground water might interfere with existing surface-water rights.

Accordingly, the main purpose of this study was to appraise the hydrology of Mason Valley with particular emphasis on the amounts of water available for use during both normal and drought periods, and to determine where, how much, and by what processes water is lost during its movement through the valley. An additional objective was a qualitative examination of the relation between surface water and ground water in the valley.

This report describes the geologic and hydrologic properties of the water-bearing deposits; estimates both the long-term and drought-period inflow to and outflow from the valley; determines the loss and gain characteristics of streamflow; evaluates the possible effects of increased supplemental pumping on ground water and surface water; describes the chemical quality of water, its suitability for various uses, and its relation to the flow system; and estimates the long-term and drought-period system yields of the valley and the possible limitations imposed by them on future development.

Field work was done in 1965 and the spring and early summer of 1966 and consisted primarily of water-level measurements in many of the wells in the valley in the fall and spring of 1965 and in the spring of 1966, miscellaneous surface-water measurements along selected sections, pumping tests of selected wells, collection of samples from streams, ditches, and wells for chemical analysis, mapping of phreatophytes, collection and analysis of available well logs, and mapping of geologic units.

Location and Areal Extent

Mason Valley, as described in this report, covers about 510 square miles in the Walker River drainage basin, Nevada. Most of the valley is in Lyon County, with a small area in Mineral

County; it lies approximately between lat 38°35' and 39°15' N. and long 118°50' and 119°20' W. The valley ranges in width from about 9 miles in the south to nearly 20 miles in the central part, and is about 40 miles long.

The valley is bounded on the east by the Wassuk Range, on the west by the Singatse Range, on the south by the Pine Grove Hills, and on the north by the Desert Mountains (pl. 1). The East and West Walker Rivers flow into the valley from the south, and join to form the main Walker River, which flows northward through the valley. The Walker River flows out of the valley through a gap, herein referred to as Walker Gap, in the low hills between the Wassuk Range and the Desert Mountains.

The chief agricultural activities in the valley are hay and grain farming, cattle feeding, and some dairying. In addition, small amounts of onions and garlic are raised. The principal mining industry is operated by the Anaconda Copper Co. and consists of an open-pit copper mine, leaching plant, and concentrator. The mine and plants furnish employment to about 550 people. The Peoples Packing Co., a local meat-packing concern employs about 22 persons.

The only city in the valley is Yerington, the seat of Lyon County (population 2,150, 1964 estimate). Smaller settlements include Weed Heights (population 1,500), an industrial community serving the employees of the Anaconda Copper Co., Mason (population 300), a few miles south of Yerington, and Wabuska (population 40), a small railroad community at the north end of the valley. The rural population of the valley is about 1,500.

Subareas

For the purposes of this report, the floor of Mason Valley has been divided into four subareas, from south to north: Missouri Flat, Mason, Yerington, and Wabuska (pl. 3). Estimates of inflow and outflow and water budgets are presented and discussed with respect to these subareas.

Previous Studies

The earliest geological studies that touched on the Mason Valley area were made by Russell (1885) and Smith (1904). Subsequent studies by Hill (1915) and Knopf (1918) evaluated the geology and ore deposits of the area. The geologic map presented in this report is based on work done by Moore (1961) and Ross (1961).

Unpublished data relating to the water resources of Mason Valley were supplied by the U.S. Bureau of Reclamation (written commun., 1964).

Acknowledgments

The cooperation of local, State, and Federal agencies, private companies, and residents of Mason Valley is gratefully acknowledged. Personnel of the Nevada Department of Conservation and Natural Resources made available well-log and water-level records. Mr. Herbert E. Rowntree and Mr. A. W. Reymers gave valuable assistance in providing access to records of the Walker River Irrigation District. The staff of the Sierra Pacific Power Co. office in Yerington compiled records on power consumption in the study area. Mr. Fred Batchelder, Lyon County Extension agent, prepared estimates of crop acreage in the valley.

Local residents were particularly helpful in permitting private wells to be used for pumping tests, and their assistance is especially appreciated.

HYDROLOGIC ENVIRONMENT

Landforms and Structural Features, and Geologic Units

The principal landforms of Mason Valley are the central valley area and surrounding mountain ranges. The two major ranges bordering the valley, the Singatse and the Wassuk, are north-northwest trending fault blocks. Uplift has occurred primarily along the steep east-facing slopes of the ranges. The maximum altitudes of the Wassuk and Singatse Ranges within the Mason Valley drainage area are about 9,000 and 6,700 feet, respectively. Maximum altitude in the Pine Grove Hills is about 8,650 feet, and in the Desert Mountains, about 6,710 feet.

The mountain blocks are composed of granitic, metamorphic, and volcanic rocks, and to a lesser extent, of semiconsolidated to consolidated sedimentary deposits. The nature and occurrence of these rocks are summarized in table 1, and their distribution is shown on plate 1.

The valley floor ranges in altitude from 4,600 to 4,700 feet at the south end to 4,290 feet at the north end. The East and West Walker Rivers enter the valley at altitudes of 4,600 and 4,680 feet, respectively, and the main Walker River flows out of the valley at an altitude of 4,290 feet. At one time the river flowed out of the basin through Adrian Valley (pl. 1) and entered the Carson River near Fort Churchill (not shown on map); during large floods, minor flows still spill through this gap. Maximum relief in the area is about 4,700 feet.

The valley area is a structural trough which has been filled with unconsolidated alluvial deposits derived in part by erosion of the emerging mountain blocks and in part from materials transported into the valley by the East and West Walker Rivers. The alluvial apron and the valley floor are the two major landforms comprising the lowland area.

The unconsolidated deposits underlying the valley floor are collectively called the valley-fill deposits, and they constitute the main ground-water reservoir of Mason Valley. The valley-fill deposits comprise four geologic units: younger alluvium (which includes the lacustrine deposits of Lake Lahontan), younger fan deposits, older alluvium, and older fan deposits. The lithology and general characteristics of these units are summarized in table 1, and their areal distribution is shown on plate 1 (except for the older alluvium, which is not exposed). Their general stratigraphic relations are shown in figure 1.

Table 1.--Geologic units: their lithologic and hydrologic characteristics

Geologic age		Geologic unit		Thickness (feet)	Lithology	Hydrologic characteristics
QUATERNARY	Pleistocene to Holocene	Valley fill	Younger alluvium	0-100±	Loose, well-sorted sand, gravel, cobbles, and boulders, with layers of silt or sandy clay. Comprises channel, flood-plain, and terrace deposits laid down by the Walker River and its major tributaries, plus strand-line and bottom deposits of Pleistocene Lake Lahontan. Bottom deposits consist of silt, fine sand, and clay.	Channel and flood-plain deposits are highly permeable and are good aquifers. Coarse deposits in the Holocene channels of the Walker River provide the best avenue of recharge to the ground-water reservoir.
QUATERNARY	Pleistocene to Holocene	Valley fill	Younger fan deposits	0-100±	Poorly sorted, gravelly clay, sandy clay, and fine sand with occasional stringers and lenses of sand and gravel. Locally, derived from erosion of older rocks and deposits in Mason Valley; generally equivalent to younger alluvium (fig. 2).	In general, younger and older fan deposits are of low permeability, however, stockwatering and mining wells penetrating buried sand and gravel deposits yield small to moderate amounts of water. Properly constructed, large-diameter wells may yield up to several hundred gallons per minute.
QUATERNARY	Pleistocene	Valley fill	Older fan deposits	0-700±	Sandy to gravelly clay with abundant cobbles and boulders and occasional lenses of semiconsolidated to cemented sand and gravel. Locally derived from erosion of consolidated rocks of the surrounding mountains. Equivalent in part to older alluvium (fig. 2).	
QUATERNARY	Pleistocene	Valley fill	Older alluvium	0-500±	Similar in lithology to younger alluvium described above. Deposited by ancestral Walker River; underlies valley floor at depths greater than about 100 feet. Not exposed at land surface.	Constitutes largest and most productive aquifer in the area, with tested transmissibility as high as 270,000 gpd/ft. Wells yield up to 3,000 gpm.

Table 1.--Geologic units (continued)

Geologic age		Geologic unit		Thickness (feet)	Lithology	Hydrologic characteristics
TERTIARY	Miocene and Pliocene	Consolidated rocks	Sedimentary rocks	--	Sandstone, mudstone, shale, marl, diatomite, and limestone. Includes interbedded tuffaceous rocks, lava flows, and breccia.	Consolidated rocks are generally impermeable; however, where they are fractured or jointed, they yield small to moderate amounts of water to wells.
TERTIARY	Oligocene to Pliocene	Consolidated rocks	Volcanic rocks	--	Rhyolite flows and tuff, andesite and dacite lava flows, breccia, and agglomerate. Includes interbedded sedimentary rocks and locally, thin basalt flows with interbeds of scoriaceous basalt breccia.	
CRETACEOUS		Consolidated rocks	Granitic rocks	--	Granodiorite, quartz monzonite, and granite porphyry.	
PERMIAN TO JURASSIC		Consolidated rocks	Metamorphic rocks	--	Metamorphosed andesite, basalt, and rhyolite flows, tuff and breccia, metamorphosed limestone, lime shale, dolomite, and gypsum and volcanically derived sedimentary rocks.	

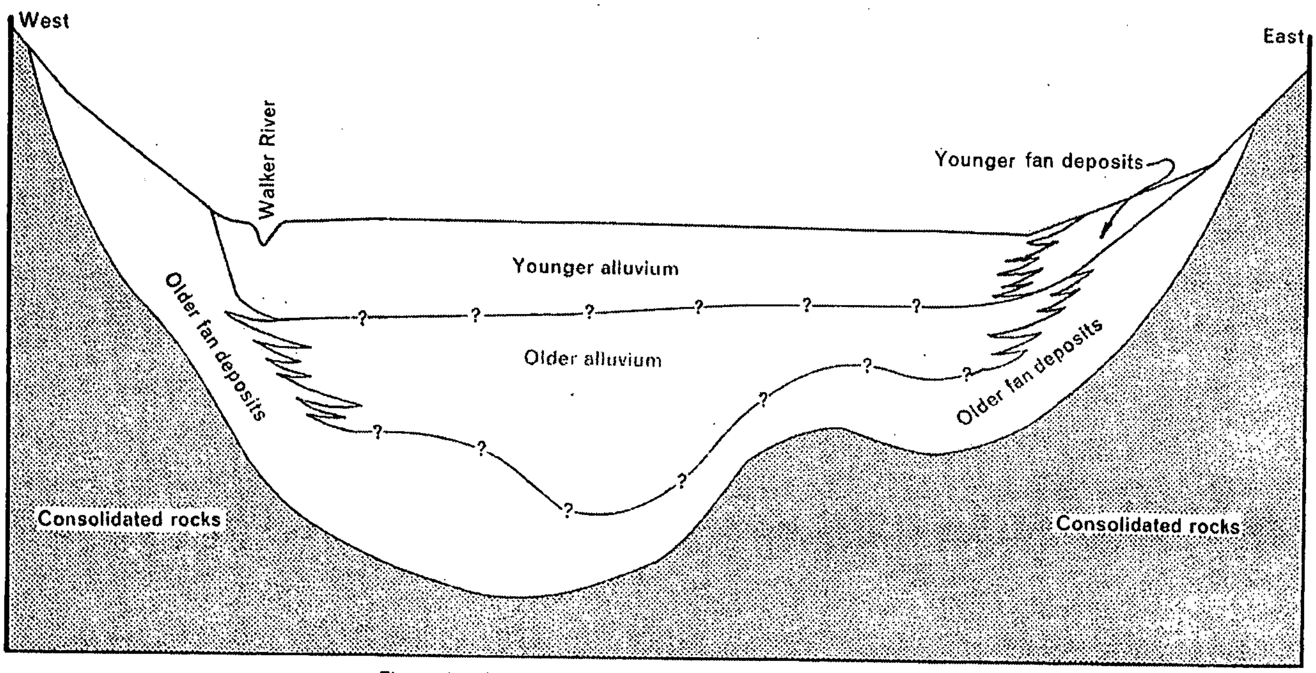


Figure 1.—Generalized geologic section near Yerington.

Most of the Lake Lahontan lacustrine deposits of Pleistocene age have been removed or reworked by the Walker River as it has meandered back and forth across the valley. Lake Lahontan strandline units, consisting of beach, bar, and beach-ridge deposits, were formed for the most part on alluvial aprons between altitudes of 4,340 and 4,375 feet (pl. 1). They are not areally extensive and, with one or two exceptions, are not strongly developed. The lake in Mason Valley seemingly had a relatively short life, and probably was less than 60 feet deep during much of its existence (Morrison, 1964, pl. 9). The maximum lake level is shown on plate 1.

Climate

The climate of the Mason Valley area is arid to semiarid. Precipitation ranges from about 5 inches per year on the valley floor to about 20 inches on the mountains. During the winter, much of the precipitation falls as snow, whereas during the summer, thundershowers contribute significant amounts. Annual precipitation and cumulative departure from average annual precipitation at Yerington for the water years 1915-65 are shown in figure 2. The cumulative-departure curve shows that annual precipitation was generally less than average during 1919-21, 1924-34, 1946-50, and 1959-60, and was generally average or above average during the remaining years.

Average temperatures over the period 1921-65 at Yerington are shown in table 2. The average growing seasons in the valley for crops experiencing killing frosts at 32°F, 28°F, and 24°F are, respectively, 109 days (46-year average), 134 days (40-year average), and 198 days (38-year average).

Prevailing winds traverse the valley from the west, and storm trajectories are generally westerly (Thomas, 1962, p. A10). The annual evaporation rate is about 4 feet (Kohler and others, 1959, pl. 2).

Table 2.--Average temperatures at Yerington, 1921-65

(Records from U.S. Weather Bureau)

Month	Average temperature (°F)	Average maximum daily temperature (°F)	Average minimum daily temperature (°F)
January	30.8	45.8	15.4
February	36.6	53.1	21.2
March	41.9	59.5	24.4
April	49.2	68.0	30.6
May	56.4	74.7	37.8
June	63.3	83.4	44.1
July	70.6	92.3	49.4
August	68.8	90.9	47.0
September	61.0	83.0	38.9
October	51.3	71.8	30.8
November	39.4	58.4	20.8
December	32.4	47.8	16.1
Entire year	50.1	69.1	31.4

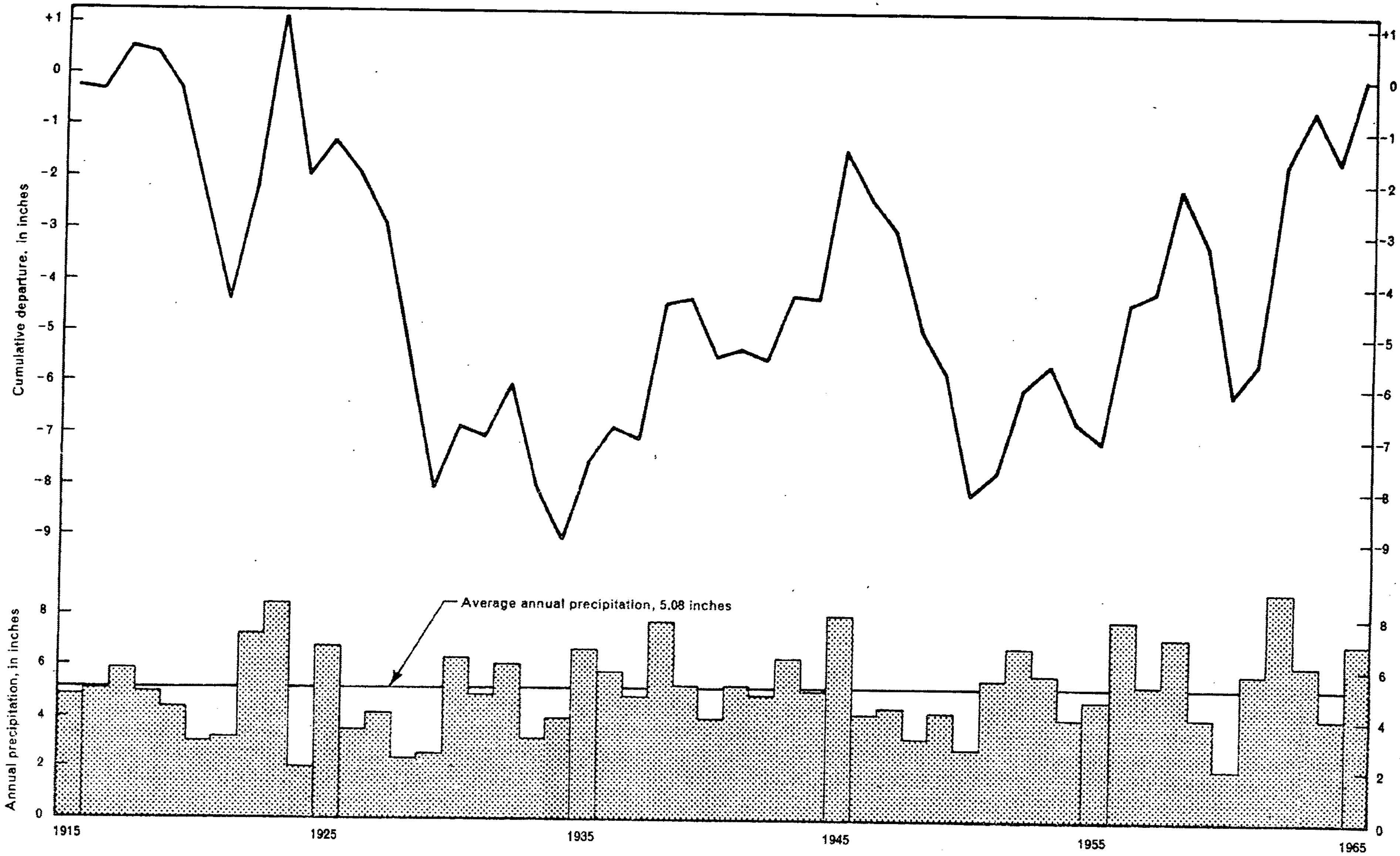


Figure 2.—Annual precipitation and cumulative departure from average precipitation at Yerington, 1915-65.

VALLEY-FILL RESERVOIR

Extent and Boundaries

The valley-fill reservoir, formed by the younger and older alluvium and the younger and older fan deposits, is the principal source of ground water in Mason Valley. The fan deposits underlie about 110,000 acres (170 square miles) on the alluvial aprons. In several places, stockwatering wells have penetrated as much as 400 feet of older fan deposits overlying consolidated rocks (see log of well 11/25-26bal, table 26), whereas in many other places, the upland alluvial deposits form only a veneer over the consolidated rocks (see log of well 12/26-4bal).

The younger and older alluvium underlie an area of about 87,000 acres (almost 140 square miles) beneath the valley floor. Some irrigation wells have penetrated nearly 600 feet of younger and older alluvium without encountering bedrock or buried older fan deposits, and one well (15/25-15cbl) has penetrated 800 feet of valley fill overlying bedrock. The total thickness of the valley fill may be more than a thousand feet in the deeper parts of the valley.

The external hydraulic boundaries of the valley-fill reservoir are leaky along the contact with granitic, metamorphic, and most volcanic rocks, and moderately leaky along the contact with sedimentary and more permeable volcanic rocks. Recharge boundaries within the valley-fill reservoir are formed by the East, West, and mainstem Walker Rivers, and by the numerous irrigation canals and ditches that interlace the valley floor. Discharge boundaries are formed by the drainage canals and in most of the downstream half of the valley by the Walker River.

Thickness and Distribution of Sand and Gravel

Well-sorted deposits of sand and gravel are abundant in the valley fill underlying the central part of Mason Valley. Figure 3 shows the distribution of sand and gravel in relation to all other materials in the first 100 feet of saturated deposits. Most of the sand and gravel has been deposited in channels of the Walker River, and the distribution patterns are thus an indication of the more persistent courses followed by the river during the time interval represented by this upper 100 feet of saturated deposits.

North of Yerington, deep wells penetrate channel and flood-plain deposits of younger and older alluvium to depths of nearly 600 feet (well 14/25-4dal, table 26). These fluviatile deposits were laid down by the river at an altitude as much as 500 feet below its present outlet. Either the former outlets of the river were cut down to that altitude and then backfilled by alluviation, or, as is more likely, the valley has been downfaulted several times in its history, and has each time been filled with alluvium to the outlet level. That the Walker River as a through-flowing system has been a major long-term factor in deposition of the valley-fill deposits is shown by the abundance of coarse-grained, well-sorted alluvium.

Transmissibility and Storage Coefficients

The coefficient of transmissibility is a measure of the capability of an aquifer to transmit water. The coefficient of storage of an unconfined valley-fill reservoir is a measure of the amount of water that will drain--given enough time--from the deposits as the water level is drawn down by pumping. When utilized together in certain types of mathematical models or when simulated in electrical models, the two coefficients define the hydraulic diffusivity of the system. In simpler terms, they can be used to describe the distribution and amount of water-level change that will result under certain pumping and boundary conditions.

Seven pumping tests were run in Mason Valley to determine principally the coefficient of transmissibility. Most tests were of short duration (about a hundred minutes), and therefore did not yield accurate values of storage coefficients, primarily because of the slow downward drainage of water from the alluvial deposits. Values of transmissibility obtained from these tests ranged from 14,000 to 270,000 gpd (gallons per day) per foot, with most of the values falling between 50,000 and 200,000 gpd per foot. Figure 4 is a preliminary expression of the areal distribution of transmissibility in the valley-fill reservoir. By relating reported specific capacities of untested wells to the specific capacity-transmissibility relation for the tested wells, and the unit permeabilities to the estimated thickness of the valley fill, transmissibility estimates were extrapolated to untested areas.

The large yields of most wells, together with the apparently abundant distribution of sand and gravel in the valley-fill deposits underlying the valley floor (fig. 3), correspond with the relatively high transmissibility values obtained from the pumping tests.

The coefficient of storage, which over the long term may be nearly equal to the specific yield of the valley-fill deposits, is computed from well logs to be about 0.2, or equivalent to a

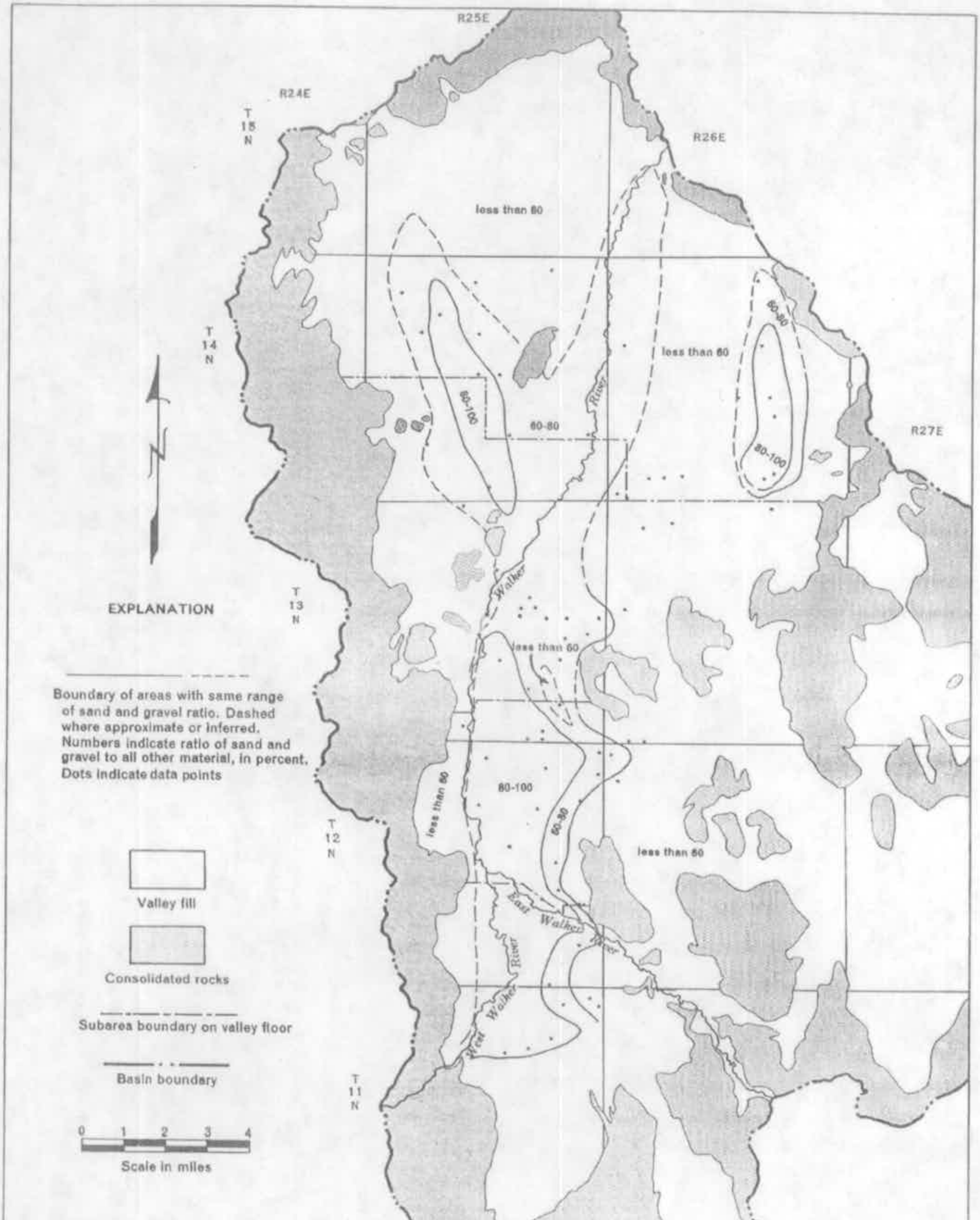


Figure 3.—Thickness and distribution of sand and gravel in the upper 100 feet of saturated valley fill.

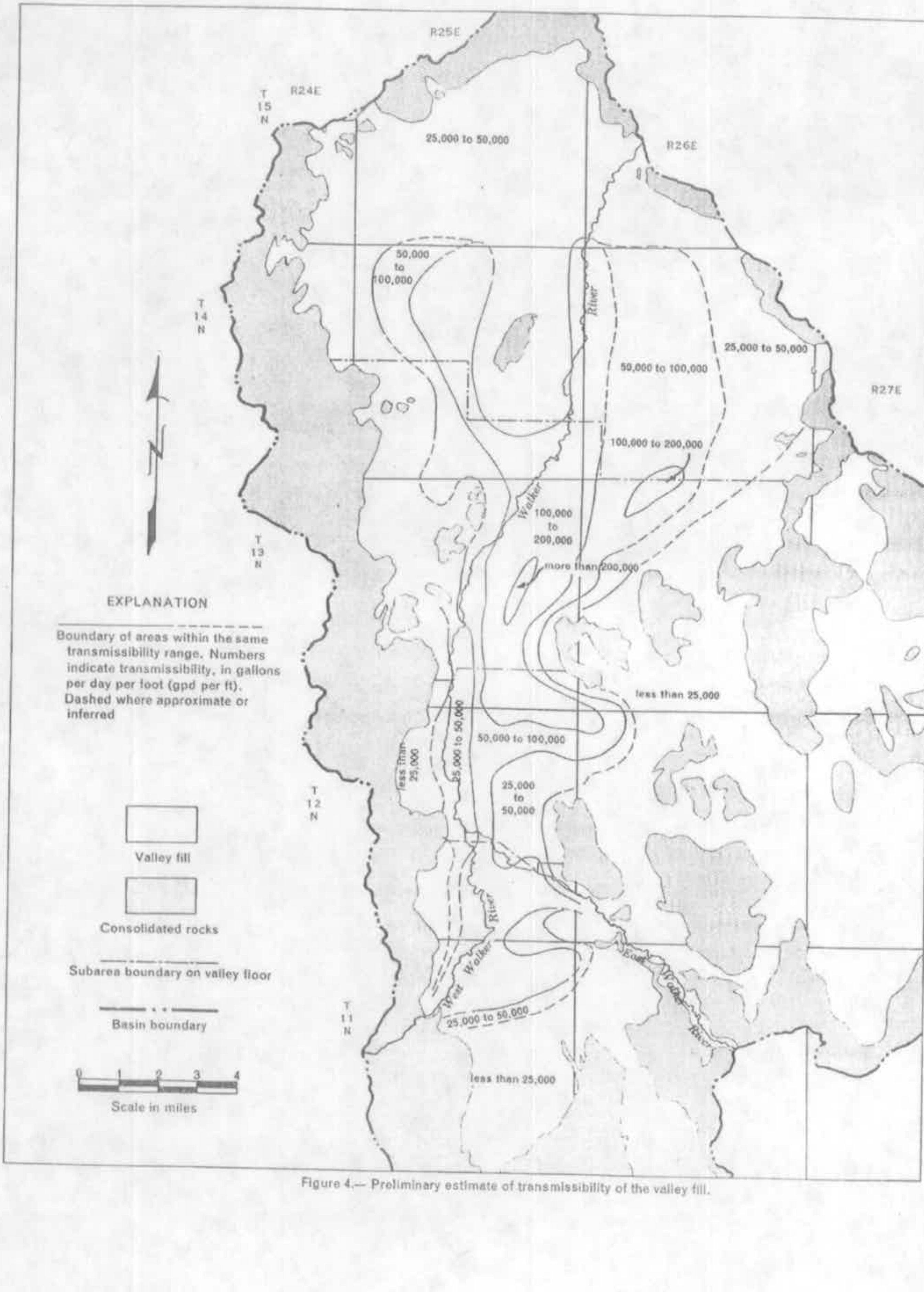


Figure 4.— Preliminary estimate of transmissibility of the valley fill.

specific yield of about 20 percent. (See section, "Ground water in storage.") Lenses of less permeable silt and clay interspersed throughout the sand and gravel of the valley fill act as semiconfining beds. Thus, locally and for short periods of time, the flow system responds to stress the same way as does an artesian system. This is especially true in the northern part of the valley near Wabuska, where fine-grained clay, silt, and silty sand beds confine more permeable deposits. (See log of well 15/25-32ad1, table 26.) The boundary of the artesian area of flowing wells in the northern part of the Wabuska subarea is shown in figure 5. Thermal springs may be related to faults underlying the valley fill. Long-term, large-scale pumping in this part of the valley probably would cause most of the wells and springs to cease flowing and would eventually dewater the upper deposits.

In general and over the long term, the valley-fill reservoir has reacted as a water-table system. Under native conditions, part of the runoff recharged the valley-fill reservoir by infiltration through the channel deposits and by infiltration of ponded water resulting from over-bank flooding, but much of the runoff flowed out of the valley near Wabuska. With the advent of crop farming and widespread irrigation, streamflow was diverted from the Walker River and spread on cultivated lands and native pasture. The large-scale diversion of streamflow to the fields and pastures, along with the stabilization of flow through creation of upstream reservoir storage, decreased the annual discharge by streamflow from the valley and increased the annual volume of water going into ground-water storage, thus causing a rise in ground-water levels. The rising ground-water levels have (1) fostered an increase in the area of phreatophyte growth and consequently in the amount of waste evapotranspiration, (2) caused water logging in some areas in the northern part of the valley, and (3) necessitated the construction of more and larger drainage ditches.

Depth to Water

The depth to water in the valley lowland is generally less than 10 feet, and in a large part of the area it is less than 5 feet (fig. 5). Depth to water increases sharply where the land surface rises beyond the edge of the valley floor, as the position of the 100-foot depth-to-water contour indicates. In some parts of the valley, water levels are at or very near the surface, and in much of the area north of Yerington, water levels are sufficiently shallow to support abundant phreatophyte growth. Drains extending throughout the valley help to minimize water-logging in areas of crops.

Ground Water in Storage

The amount of ground water stored, or more precisely in transient storage, in the valley-fill reservoir to any selected depth below the water table is the product of the area, the selected depth, and the specific yield of the deposits. The selected depth for this study is the uppermost 50 feet of saturation, which is considered a reasonable drawdown for conjunctive use of surface and ground water, and the area is that portion of the valley enclosed within the 100-foot depth-to-water contour (fig. 5).

The specific yield of a deposit with respect to water is the ratio of (1) the volume of water which the deposit, after being saturated, will yield by gravity to (2) its own volume (Meinzer, 1923, p. 28). The average specific yield of the materials in the upper 50 feet of saturation in the four subareas was estimated from drillers' logs of wells. The materials recorded in the logs were grouped into five general lithologic categories, using the method described by Davis and others (1959, p. 202-206). Table 3 shows the five general categories and the assigned specific yields, which are based on studies and tests of the Hydrologic Laboratory of the U.S. Geological Survey (Johnson, 1966, p. 111).

Table 3.--Lithologic categories and their assigned specific-yield values

Lithologic category (drillers' designation)	Symbol[1]	Assigned specific-yield value (percent)
Sand, medium or coarse	S	30
Sand and gravel, gravel and sand, gravel, cobbles, boulders or any mixture thereof	G	25
Sandy clay, dirty or muddy gravel; sand and/or gravel with clay layers	F	15
Cemented sand or gravel, sandstone, gravelly clay, gravel and clay, silt, clay and rock	Cg	10
Clay	C	5

1. Used in table 4.

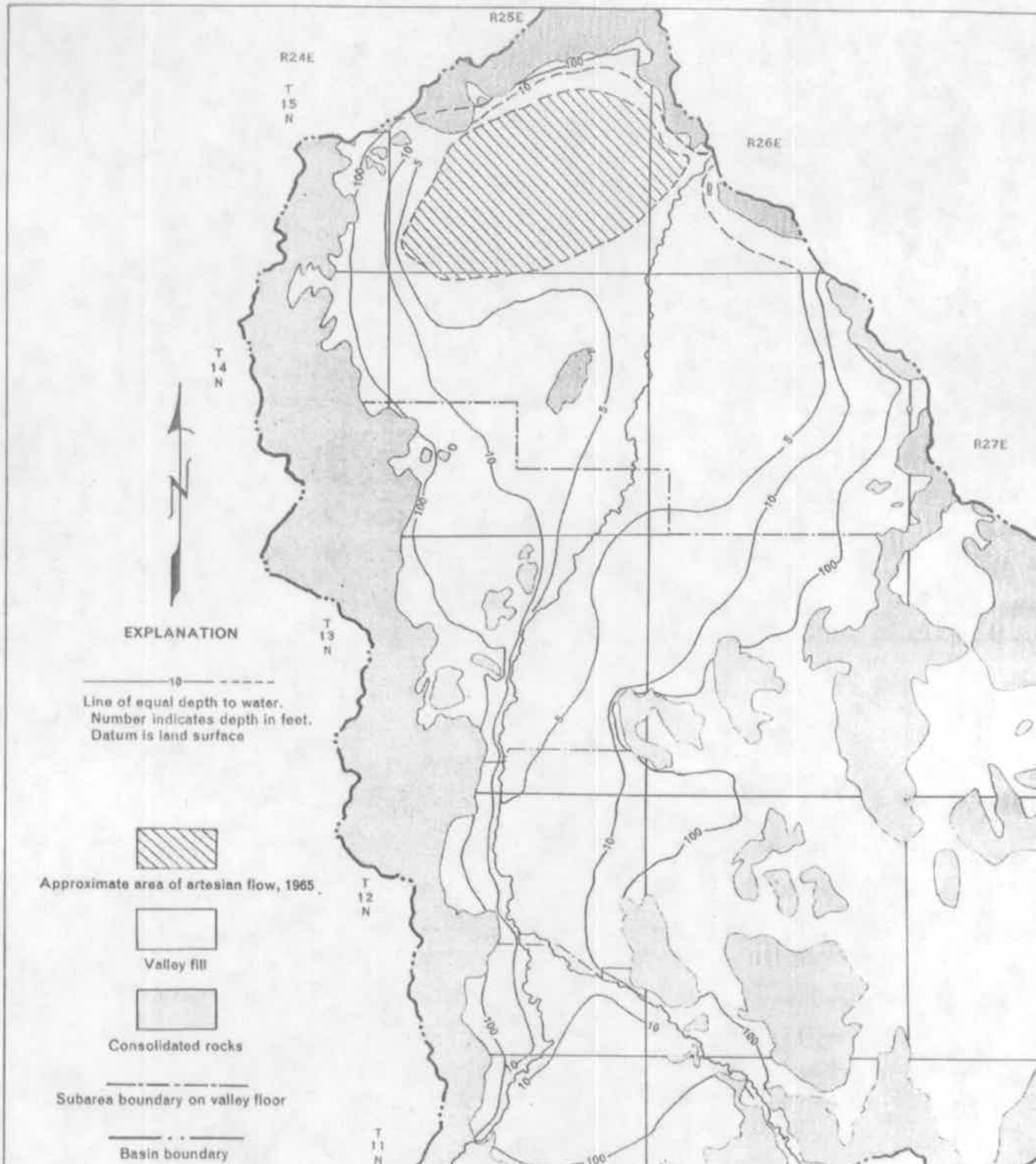


Figure 5.—Depth to water and approximate area of artesian flow, 1965.

Table 4 shows the pertinent data used in estimating the specific yield of each subarea, and table 5 lists the estimated total amount of ground water in storage in the uppermost 50 feet of saturation in each subarea. The average specific yield of all subareas is 20 percent, and the total amount of ground water stored in the uppermost 50 feet of saturation is about 1,100,000 acre-feet.

Ground-Water Flow

Ground-water flow in the valley-fill reservoir is from areas of recharge to the principal areas of discharge in the northern part of the valley. Plate 2 shows that the major components of ground-water flow generally parallel the direction of surface-water movement from south to north. Ground-water flow toward the channels and flood plain of the Walker River system persists throughout most of the year and results from the fact that much of the streamflow is diverted from the rivers in their upper reaches. The diverted streamflow is conveyed through a complex system of ditches to cultivated fields and pastures on the valley floor (pl. 3). Much of the diverted streamflow recharges the valley-fill reservoir each year, thereby causing an increase in hydrostatic head and a general hydraulic gradient toward the river.

In the southeastern part of the area, ground water flows generally northward through alluvium between isolated consolidated-rock hills, then into younger alluvium east of Yerington (pl. 2).

Local cones of depression in the ground-water reservoir are created by heavy pumping at two places. Seven large-diameter wells (not shown on maps) around the eastern perimeter of the large open pit mine west of Yerington are pumped at rates sufficient to maintain the water level 100 feet below the bottom of the pit (Holmes, 1966, p. 12), thereby creating a hydraulic gradient toward the pit. Two wells just north of the pit and near the tailings pond are pumped to lower water levels enough to create a cone of depression in this area (pl. 2).

Not shown by the water-level contours are vertical components of ground-water flow, which are downward in areas of recharge beneath and adjacent to ditches, river channels, and flooded fields, and upward in areas of natural discharge and in the artesian area in the northern part of the Wabuska subarea. Small amounts of ground water flow out of the valley through the valley fill in Adrian Valley, Walker Gap, and Parker Gap (pl. 2). (See section, "Ground-water outflow, and flow between subareas.")

Table 4.--Summary of data used to estimate specific yield of valley-fill deposits[1]

Subarea (storage unit)	Number of well logs	Total footage	Percentage of total footage assigned to each lithologic category (table 3)					Average specific yield (percent)[2]
			G	S	F	Cg	C	
Missouri Flat	9	450	54	0	39	0	7	20
Mason	25	1,250	67	2	20	7	4	21
Yerington	25	1,200	36	12	38	2	12	20
Wabuska	26	1,300	51	24	20	2	3	20[3]
Total	85	4,200			Average specific yield			20

1. For the uppermost 50 feet of saturated deposits below the average water level in 1965-66.

2. Based on percentages in each lithologic category and assigned specific yields for each category (table 3).

3. Arbitrarily adjusted downward to compensate for fine-grained material in the northern part of the subarea where well-log data are sparse.

Table 5.--Estimated ground water in storage in the valley-fill reservoir

Subarea (storage unit)	Area to valley fill within 100-foot depth-to-water contour (acres; see fig.5)	Average specific yield (percent)	Stored water[1/] (acre-feet)
Missouri Flat	13,160	20	130,000
Mason	13,500	21	140,000
Yerington	28,150	20	280,000
Wabuska	57,230	20	570,000
Total (rounded)	112,000	20	1,100,000

1. For the uppermost 50 feet of saturation below the average water level in 1965-66.

SURFACE-WATER RESOURCES

By E. E. Harris

Sources and Development

The principal source of water in Mason Valley is streamflow in the Walker River system. The headwaters of the Walker River rise in watersheds of the Sierra Nevada in Mono County, Calif. Fed by melting snowpacks, streams flow northeastward to form the East and West Walker Rivers. Upstream from Mason Valley, the West Walker River flows through Antelope Valley, where a part of its flow has been diverted to storage in the offstream Topaz Reservoir (usable capacity 59,440 acre-feet), and through Smith Valley. Diversions in both valleys are for irrigation of cropland.

The East Walker River flows into Bridgeport Valley, where its waters are regulated by Bridgeport Reservoir (usable capacity 42,460 acre-feet). Below Bridgeport Reservoir, the river flows through a mountainous reach where small diversions are made for irrigation of hay lands adjacent to the river.

The East and West Walker Rivers merge in Mason Valley to form the main Walker River, which flows northward through the valley. At Walker Gap the river turns eastward then southeastward and flows through Walker Lake Valley, where its waters are impounded in Weber Reservoir and diverted for use on Indian lands. The river ultimately empties into Walker Lake.

The waters of the Walker River system were well developed for irrigation, their principal use, by the late 1880's. By that time much of the presently irrigated land in Mason Valley had been brought under development. The ditches and diversion works in the valley have been gradually developed and improved over the years by individual farmers and small groups or corporations. The Walker River Irrigation District was organized in 1919 to administer the allocation of streamflow from the Walker River system in Nevada and to maintain the diversion works along the main channels. The District built Topaz Reservoir in 1922, which was enlarged in 1937, and the Bridgeport Reservoir in 1924. In 1936, U.S. District Court Decree C-125 defined existing water rights on the river in Mason Valley and throughout the Walker River basin.

Streamflow data on Walker River in the vicinity of Mason Valley have been collected intermittently since 1895 and continuously since 1947. Gaging stations were installed in January 1947 on East Walker River above Strosnider ditch and on West Walker River near Hudson. These gaging stations measure all the river inflow to Mason Valley. The Walker River station near Wabuska has been in continuous operation since 1939, and measures practically all the surface-water outflow from Mason Valley. Table 6 lists the gaging stations in Mason Valley, and the period for which records have been published. Figure 6 shows the station locations.

Table 6.--Gaging stations, and period of published record1/

Station name (and map location number, fig. 6)	Period of record
East Walker above Strosnider ditch, near Mason (11/26-14cb)	1947-date
East Walker River above Mason Valley, near Mason (11/26-4c)	1916-17, 1921-24
East Walker River near Yerington (11/26-5)	1902-8
East Walker River near Mason (12/25-26) . . .	1910-16
West Walker River near Hudson (11/25-18cd)	1914-25, 1947-date
Walker River near Nordyke (12/25-16)	1895
Walker River at Mason (13/25-33ac)	1910-16, 1921-22
Walker River near Wabuska (15/26-20bd)	1902-8, 1920-35, 1939-date

1. U.S. Geological Survey (see "References cited").

Runoff Characteristics

Characteristically, the greatest volume of runoff in the Walker River basin occurs during the period March-July, when the winter snowpack in the Sierra Nevada thaws. Exceptions to this pattern occurred during the disasterous winter floods of 1937, 1950, 1955, and 1963, because of warm rain on snow. The large volume of snowmelt runoff provides irrigation water naturally during the first part of the irrigation season, and seasonal storage upstream from the valley usually provides necessary water during the latter part of the season.

Storage in Bridgeport and Topaz Reservoirs tends to stabilize streamflow throughout the irrigation season, and in addition provides moderate flood-protection benefits. Figure 7 shows the seasonal pattern of inflow to Mason Valley before and after development of upstream storage facilities. Streamflow is minimized during the winter months by storing winter storm water for later release. The irrigation season begins in about mid-March, and releases from storage are usually begun about that time. The impact of the reservoirs is most significant during the late summer months of August, September, and October (fig. 7). During these months of maximum irrigation demand, particularly in August and September, streamflow is maintained by the release of stored water at a rate several times that of natural runoff.

Even with storage reservoirs upstream, Mason Valley is subject to flooding as the result of winter storms. These floods do considerable damage to diversion dams, headgates, and road bridges, as well as to agricultural land adjacent to the river channels. The winter floods have high peak discharges but are usually of fairly short duration, and generally do not produce as large a volume as the spring snowmelt.

Inflow to the Valley

Under present conditions of development, inflow varies widely during the year and from year to year, despite the influence of upstream reservoirs. Figure 8 shows the maximum, minimum, and average monthly inflow to Mason Valley, on the basis of streamflow records for the period 1948-65. During that period, the maximum and minimum annual inflows were 456,000 acre-feet (in 1952) and 85,400 acre-feet (in 1961), and the average was about 217,000 acre-feet per year (table 7). Correlation with records outside the valley suggest that 1911 and 1938 may have been the wettest years since 1900, with estimated inflows of 580,000 and 530,000 acre-feet, respectively. Similar correlations indicate that 1931 may have been the driest year, with an inflow of only about 69,000 acre-feet.

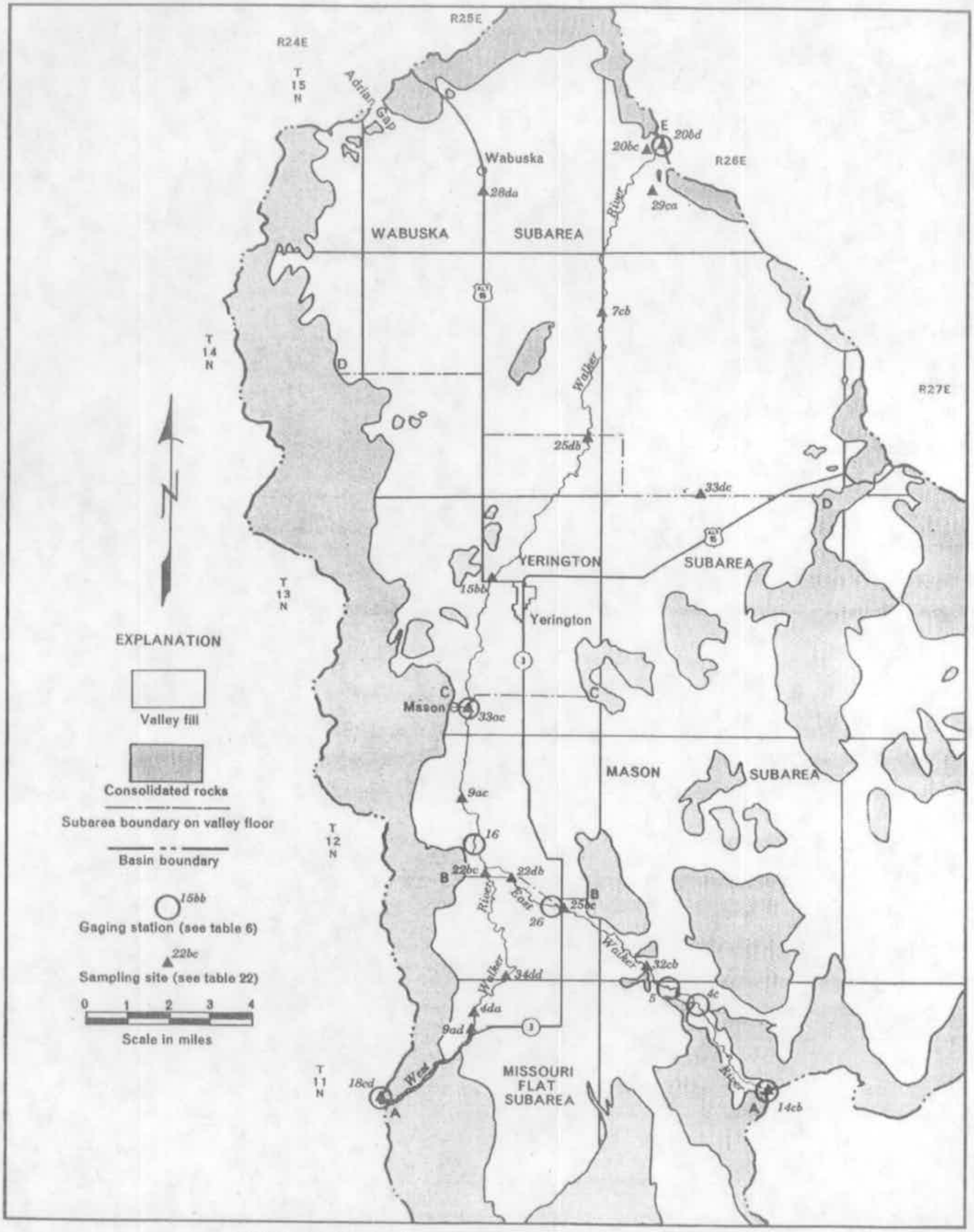


Figure 6.—Location of surface-water gaging stations and sampling sites.

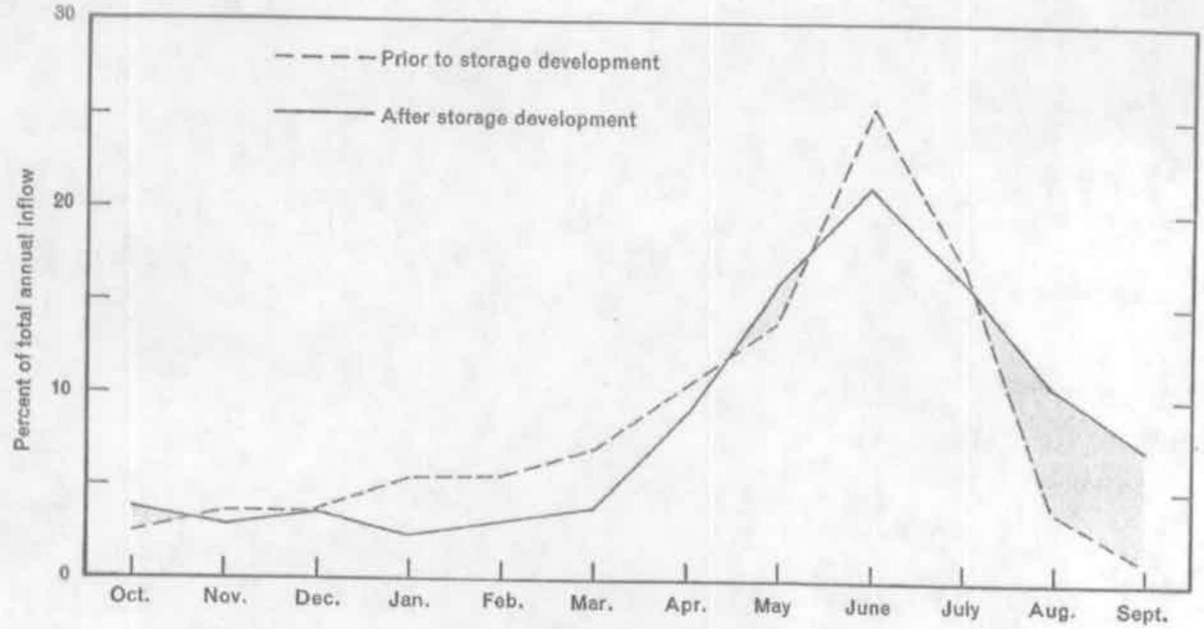


Figure 7.—Average monthly inflow to Mason Valley before and after upstream storage development.

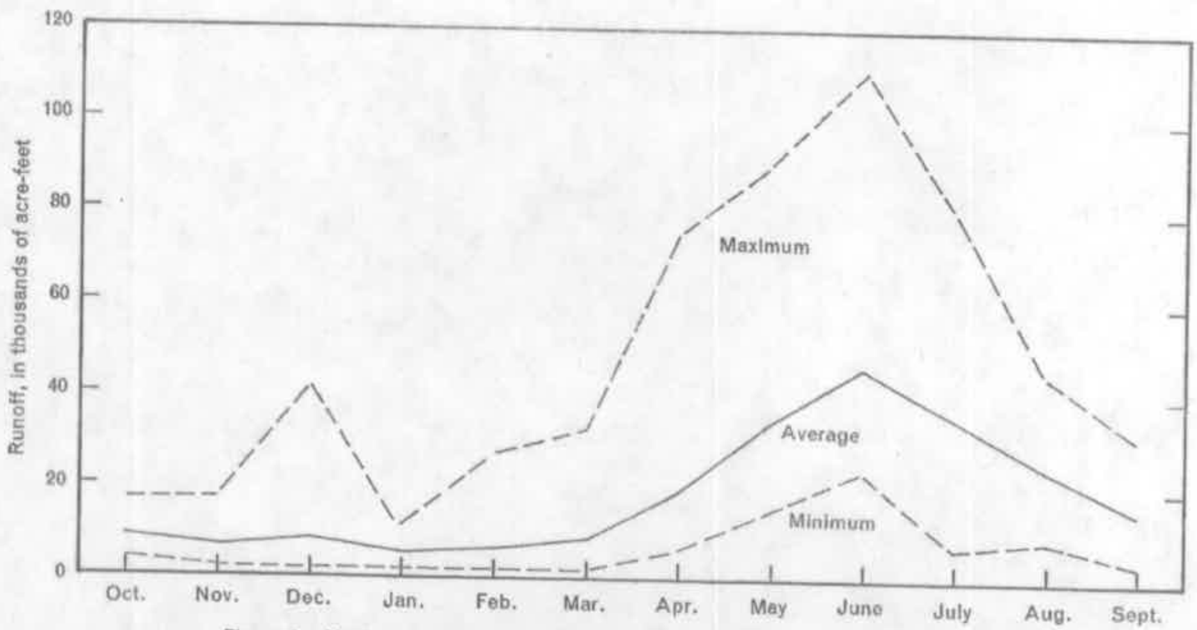


Figure 8.—Maximum, minimum, and average monthly runoff into Mason Valley, 1948-65.

Table 7.--Annual surface-water inflow, outflow, and loss within Mason Valley, 1948-65

(Quantities in acre-feet)

Water year	Inflow: East Walker River (1)	Inflow: West Walker River (2)	Inflow: Total (3)=(1)+(2)	Outflow[1/] Walker River (4)	Loss (5)=(3)-(4)
1948	49,780	78,090	127,900	31,070	96,830
49	52,290	80,670	133,000	36,520	96,480
1950	56,400	94,260	150,700	30,330	120,400
51	93,440	172,700	266,100	158,600	107,500
52	219,400	236,300	455,700	379,000	76,700
53	100,200	136,600	236,800	121,800	115,000
54	74,540	100,700	175,200	43,340	131,900
1955	47,050	84,870	131,900	34,620	97,280
56	176,400	223,400	399,800	277,000	122,800
57	102,400	124,800	227,200	88,350	138,800
58	161,400	184,400	345,800	227,300	118,500
59	74,580	87,710	162,300	70,590	91,710
1960	38,230	65,330	103,600	26,260	77,340
61	28,000	57,420	85,420	23,780	61,640
62	81,280	86,920	168,200	37,260	130,900
63	148,800	158,500	307,300	169,200	138,100
64	64,080	85,400	149,500	51,460	98,040
1965	113,100	157,450	270,600	123,200	147,400
18-year average			216,500	107,200	109,300

1. Does not include outflow through Adrian Valley.

Local natural runoff, principally from the Wassuk and Singatse Ranges, at times contributes to surface-water inflow to the valley, although the contribution is minor compared to the river inflow. The method of estimating local runoff has been described by Eakin and others (1965). Using this method, the annual local runoff has been estimated to average about 2,500 acre-feet in the Missouri Flat subarea, 2,000 acre-feet total in the Mason and Yerington subareas, and 1,400 acre-feet in the Wabuska subarea, which is a total of about 5,900 acre-feet.

Normally, local runoff occurs only during wet years or following summer thunderstorms that produce flash floods in some of the dry washes. For example, in July and August 1965, several tributaries to Mason Valley produced floods of considerable magnitude following intense thunderstorm activity. On two of these streams, indirect measurements were made of the peak flow. Pine Grove Flat tributary, which flows into the Missouri Flat subarea, had a calculated peak flow of 720 cfs on August 15, 1965. Pumpkin Hollow tributary, which flows into the Mason subarea, had a calculated peak flow of 750 cfs on July 31, 1965.

Outflow from the Valley

Surface-water outflow from Mason Valley is measured at the Walker River gaging station near Wabuska (fig. 6). The average annual discharge for the 18-year period (1948-65) was 107,200 acre-feet (table 7). During extremely wet years surface-water outflow is discharged into the Carson River basin through Adrian Gap (fig. 6) in the northwest corner of the valley. For the period 1949-65, the estimated average flow was 1,000 acre-feet per year.

Disposition and Routing

Losses in Streamflow

Excellent records of surface-water inflow to and outflow from Mason Valley are available. However, the disposition and routing of water within the valley is complex, owing to the many points of diversions from the river and drains that return water to the river from irrigated fields. Walker River Irrigation District maintains records on diversions from the river, but very little is known about return flow in the drains. Gross streamflow losses within Mason Valley are shown in table 7. To determine the areal distribution of these losses, several cross sections and subareas were established at strategic locations shown in figure 6, where the sections are denoted by letters A-E. The cross sections were selected at points where discharge measurements could be made of flow in the river and use could be made of the records of ditch flow collected by Walker River Irrigation District. By measuring the flow at these cross sections, losses could be computed by subarea. Measurements made of the river flow are listed in table 8. Periodic discharge measurements were made during the water year 1965 in drains and ditches at points where records were not obtained by Walker River Irrigation District. These were compared with recorded flows at other sites to estimate total downvalley movement of surface water.

Table 8.--Miscellaneous discharge measurements, 1965

Measuring site	Location	Cross section (fig. 6)	Date	Discharge (cfs)
East Walker River near Nordyke	At road crossing 1 mile above confluence with West Walker River.	B	3- 2-65 5-10-65 6-21-65 9-21-65 11- 8-65	112 23.7 135 118 47.1
West Walker River near Nordyke	At road crossing 0.4 mile above confluence with East Walker River.	B	3- 2-65 5-10-65 6-21-65 9-21-65 11- 8-65	77.3 492 629 136 39.1
Walker River at Mason	At road crossing.	C	3- 2-65 5-10-65 6-21-65 9-22-65 11- 9-65	197 602 780 314 97.0
Walker River near Mason Butte	At Miller Lane crossing, 2½ miles southeast of Mason Butte	D	3- 2-65 5-11-65 6-21-65 9-23-65 11- 9-65	216 476 612 290 119

Mean annual runoff of the river at the cross sections was determined by the following methods: (1) correlation of miscellaneous discharge measurements listed in table 8 with gaging station records; and (2) empirical relationships between channel geometry and mean annual runoff (being developed by W. B. Langbein and D. O. Moore, U.S. Geological Survey; oral commun., 1965). These figures of streamflow plus the records of ditch flow produced mean annual discharges at the cross sections for the period of record (table 9). Although this information indicates losses in streamflow within the valley, other factors such as contribution of local runoff and ground-water underflow must be considered before these data are meaningful. The data are incorporated later in the water-budget section of the report, which includes all hydrologic factors affecting the disposition of water within the valley.

Table 9 also shows that the net water loss between sections A (inflow) and E (outflow) averaged about 108,000 acre-feet per year for the period 1948-65.

Table 9.--Estimated mean annual surface-water flow, in acre-feet, at five valley cross sections, 1948-65

Cross section[1]	East Walker River	West Walker River	Main Walker River	Ditches and drains	Total surface-water flow
A (inflow)	a 93,400	a 123,100	--	0	216,500
B	45,000	120,000	--	43,000	208,000
C	--	--	188,000	4,000	192,000
D	--	--	80,000	80,000	160,000
E (outflow)	--	--	a 107,200	b 1,000	108,200

1. See Figure 6.
   - A. Near upstream edge of Missouri Flat subarea.
   - B. Near boundary between Missouri Flat and Mason subareas.
   - C. Near boundary between Mason and Yerington subareas.
   - D. Near boundary between Yerington and Wabuska subareas.
   - E. At Walker Gap.

a. Measured at gaging station.
b. Estimated outflow through Adrian Valley.

Stream Diversions for Irrigation

Streamflow diverted from the Walker River system has been spread on cultivated fields and native pastures for many years. Table 10 shows the types of crops raised and the acreages cultivated between 1880 and 1965 in Mason Valley. Plate 3 shows the distribution of cropland and irrigated native pasture in 1965, based on information provided by Fred C. Batchelder, Lyon County Extension Agent, U.S. Department of Agriculture (written commun., 1965).

During the period 1948-65, streamflow diverted from the river averaged about 140,000 acre-feet annually (Walker River Irrigation District records, 1965). Table 11 shows that during this same period an average of about 30,000 acres of crops and native pasture was irrigated annually. The table also shows that an estimated 41,000 acre-feet was consumed by the crops and pasture. The difference of nearly 100,000 acre-feet per year between diversions and water consumed consisted of return flow to the river, seepage losses from canals and laterals, and evapotranspiration. Return flow to the river in the upper reaches of Mason Valley is rediverted into downstream canals and ditches, and therefore the water is measured more than once.

Table 10.--Agricultural development

	Acreage		
	1880-1940[1]	1940-45[2]	1946-65[3]
Crop			
Alfalfa, grain, and orchard and truck products	10,000 - 12,000	--	--
Alfalfa and other hay	--	12,500	18,000
Grain (wheat, barley, oats)	--	2,500	5,000
Onions, garlic, potatoes, and other truck crops	--	300	400
Subtotal	10,000 to 12,000	15,300	23,400
Pasture			
Planted grass	--	--	a 2,000
Irrigated native pasture	--	--	6,000
Subtotal	--	--	8,000
Total	--	--	b 31,400

1. First ranches and farms were established in 1860; between 1880 and 1940, agricultural activity increased moderately.
2. After Smith and others (1940).
3. Based on data furnished by F. C. Batchelder, Lyon County Extension Agent, U.S. Dept. Agriculture (written commun., 1965).
a. Of this total, about 700 acres are irrigated.
b. Of this total, about 30,000 acres are irrigated.

Table 11.--Estimated acreage irrigated and average annual consumptive use of irrigation water during a year of average inflow[1/]

Crop	Use factor (acre-feet per year)[2/]	Missouri Flat Area (acres)	Missouri Flat Annual use (ac-ft)	Mason Area (acres)	Mason Annual use (ac-ft)	Yerington Area (acres)	Yerington Annual use (ac-ft)	Wabuska Area (acres)	Wabuska Annual use (ac-ft)	Entire valley Area (acres)	Entire valley Annual use (ac-ft)
Cropland, including planted grasses	1.6	3,500	5,600	7,800	12,500	6,700	10,700	5,400	8,600	23,400	37,400
Irrigated native pasture	0.5	1,500	800	200	100	3,000	1,500	1,900	1,000	6,600	3,400
Total	--	5,000	6,400	8,000	12,600	9,700	12,200	7,300	9,600	30,000	41,000

1. In a year of average inflow, an estimated 80 percent of the available cropland and planted grass and 60 percent of the irrigated pasture (100 percent in Missouri Flat and Mason subareas) are irrigated.

2. Use factors for cropland and planted grass are after Houston (1950, p. 21-27).

RECHARGE TO THE VALLEY-FILL RESERVOIR

Recharge from Precipitation

Only a small part of the ground-water recharge to the valley-fill reservoir is derived from precipitation in Mason Valley; most is supplied by seepage loss from the Walker River. A method of estimating the locally derived recharge to a ground-water reservoir was devised by Eakin and others (1951) and is based upon the relation between precipitation, altitude, and recharge. The method assumes that a percentage of the average annual precipitation recharges the ground-water reservoirs. Table 12 shows that the estimated local recharge from precipitation totals about 2,000 acre-feet per year, which is only about 1 percent of the estimated precipitation of 160,000 acre-feet per year.

Infiltration of Streamflow

The amount of recharge derived by infiltration from stream channels, ditches, and deep percolation from flooded fields varies from year to year, depending upon the volume of streamflow entering the basin, the amount of streamflow diverted from the river for irrigation, and the amount of ground-water storage space available. Assuming that all streamflow not consumptively used for irrigation or flowing out of the valley recharges the valley-fill reservoir, the quantity of annual recharge has ranged from about 30,000 to about 100,000 acre-feet and has averaged about 70,000 acre-feet during the years 1948-65 (the quantities are computed as inflow minus the sum of surface-water outflow and consumptive use by crops and pastures; tables 7, 11, and 17).

Ground-Water Inflow

Ground-water inflow occurs through the valley fill, principally beneath the East and West Walker Rivers, to the Missouri Flat subarea. As shown in table 13, the inflow may total 500 acre-feet per year.

Table 12.--Estimated average annual precipitation and ground-water recharge to the valley-fill reservoir

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation			Estimated recharge	
		Range (inches)	Average			
			Feet	Acre-feet	Percentage of precipitation	Acre-feet per year
Above 8,000	2,300	15 to 20	1.5	3,500	15	500
7,000 to 8,000	10,400	12 to 15	1.1	11,000	7	800
6,000 to 7,000	20,900	8 to 12	.8	17,000	3	500
5,000 to 6,000	95,500	5 to 8	.5	48,000	Minor	--
Below 5,000	196,000	<5	.4	78,000	Minor	--
Total (rounded)	325,000			160,000		2,000

Table 13.--Estimated annual ground-water inflow, outflow, and flow between subareas

Flow section	Estimated transmissibility (gpd/ft)	Hydraulic gradient (ft/mi)	Effective width (miles)	Estimated flow (acre-feet)
INFLOW				
To Missouri Flat subarea	50,000	25	0.5	500
FLOW BETWEEN SUBAREAS				
Missouri Flat subarea to Mason subarea	40,000	16	3.5	2,500
Mason subarea to Yerington subarea:				
(1) Beneath flood plain	75,000	11	3.0	2,800
(2) Sec. 8, T. 13 N., R. 26 E.	10,000	20	0.5	100
(3) Sec. 10, T. 13 N., R. 26 E.	10,000	14	0.7	100
Total to Yerington subarea				3,000
Yerington subarea to Wabuska subarea	70,000	6	11.0	5,200
OUTFLOW				
Wabuska subarea:				
(1) Through Adrian Gap	50,000	15	0.2	150
(2) Through Walker Gap	150,000	6	0.7	700
(3) Through Parker Gap	50,000	12	1.1	700
Total subsurface outflow from Mason Valley				1,600

DISCHARGE FROM THE VALLEY-FILL RESERVOIR

Ground-Water Outflow, and Flow Between Subareas

Ground-water outflow from the valley-fill reservoir occurs through Adrian Gap, Walker Gap, through which the Walker River leaves the valley, and Parker Gap (pl. 2). Subsurface flow also occurs from upstream to downstream subareas. The ground-water flow at these various sections can be computed by use of a form of Darcy's law:

$$Q = 0.00112\ TIW$$

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

The tentative distribution of transmissibility is shown in figure 4, and the hydraulic gradients and widths of cross sections are taken from plate 2. Table 13 lists the estimated annual inflow, underflow between the several subareas, and the total outflow from Mason Valley through three gaps.

Evapotranspiration

About 53,000 acres on the valley floor are subject to water losses from phreatophytes and bare soil. Most of the phreatophytes are in the Wabuska subarea. Phreatophytes have been grouped into eight major assemblages according to associated plants, relative density, occurrence, and depth to water. The principal phreatophytes in Mason Valley are saltgrass, greasewood, rabbitbrush, buffaloberry, willow, cottonwood, tules, and marsh plants. A few isolated patches of salt cedar occur in the Yerington subarea, but they are not native to the area. The areal distribution of the several assemblages is shown on plate 3, and is based on field observations by the author in 1965-66. Table 14 shows the estimated average annual ground-water discharge by evapotranspiration of the various assemblages in each subarea. The annual use factors for the phreatophyte assemblages and bare soil are modified from work done by White (1932, p. 84-93), Young and Blaney (1942, p. 41, 95, 98), Robinson (1958, p. 49-66), and Houston (1950, p. 21-22). The estimated draft on the valley-fill reservoir in the phreatophyte areas averages about 57,000 acre-feet per year.

Table 14.--Estimated average annual ground-water discharge by evapotranspiration

Phreatophytes		Occurrence and depth to water	Annual use factor (acre-feet per acre)	Subarea	Area (acres)	Annual use (ac-ft)
Assemblage	Density					
Saltgrass	Moderate to dense			Missouri Flat	510	500
Greasewood-				Mason	--	--
rabbitbrush . .	Scattered to sparse	Open meadow.	1.0	Yerington	960	1,000
Buffaloberry,		5 to 10 feet		Wabuska	4,480	4,500
weeds, grasses.	Scattered			Subtotal	5,950	6,000
Saltgrass	Moderate to dense	Flood plains and low		Missouri Flat	1,270	1,900
Greasewood-		poorly drained areas		Mason	--	--
rabbitbrush . .	Scattered to dense	with marshes covering	1.5	Yerington	1,280	1,900
		less than 25 percent.		Wabuska	7,180	11,000
		0 to 10 feet		Subtotal	9,730	15,000
Saltgrass	Moderate to dense	Low poorly drained		Missouri Flat	--	--
Greasewood-		areas with marshes		Mason	--	--
rabbitbrush . .	Scattered	and ponds covering	3.0	Yerington	--	--
Tules and marsh		around 50 percent.		Wabuska	5,760	17,000
growth	Moderate to dense	0 to 5 feet		Subtotal	5,760	17,000
Buffaloberry and						
cottonwood . .	Moderate to dense			Missouri Flat	460	700
Willow	Scattered to moderate	Channels and recently		Mason	705	1,100
Greasewood-		formed flood plains.	1.5	Yerington	3,560	5,300
rabbitbrush . .	Scattered to moderate	0 to 10 feet		Wabuska	1,380	2,100
Tules and marsh				Subtotal	6,100	9,200
growth	Scattered					
Greasewood						
associated with				Missouri Flat	450	100
shadscale and	Scattered to moderate,	Interflood-plain areas		Mason	535	100
sagebrush . . .	occasionally dense	and older flood plains.	.25	Yerington	2,750	700
Saltgrass	Scattered to moderate	5 to 20 feet		Wabuska	10,400	2,600
Rabbitbrush . . .	Scattered to moderate			Subtotal	14,100	3,500

Table 14.--continued

Phreatophytes: Assemblage	Phreatophytes: Density	Occurrence and depth to water	Annual use factor (acre-feet per acre)	Subarea	Area (acres)	Annual use (ac-ft)
Greasewood associated with shadscale . . .	Scattered to moderate	Old lake bottom and dune areas. Includes bare alkali ground.	.25 to .5	Missouri Flat	--	--
				Mason	--	--
				Yerington	--	--
Saltgrass	Moderate	0 to 10 feet		Wabuska	5,910	2,400
				Subtotal	5,910	2,400
Greasewood associated with other nonphreatophytes . . .	Scattered to moderate	Edges of valley floor. 5 to 15 feet	.1	Missouri Flat	665	100
				Mason	--	--
				Yerington	850	100
				Wabuska	1,680	200
Saltgrass	Moderate to nearly absent			Subtotal	3,200	400
Willows, cottonwoods, tules, grasses, and weeds[1]	Moderate to dense	Adjacent to ditches, canals, and laterals traversing croplands. 0 to 5 feet	2.0	Missouri Flat	240	500
				Mason	700	1,400
				Yerington	750	1,500
				Wabuska	270	500
				Subtotal	1,960	4,000
Totals (rounded)				Missouri Flat	3,600	3,800
				Mason	1,940	2,600
				Yerington	10,200	10,000
				Wabuska	37,000	41,000
				Mason Valley total	52,700	57,000

1. Losses along main ditches and laterals in cultivated areas. Not shown on plate 3.

Springs and Flowing Wells

Nearly all springs and flowing wells in Mason Valley are in the northern part of the Wabuska subarea (pl. 2) within the artesian area indicated in figure 5. The exceptions are Wilson Hot Spring (11/25-34cd1), which is not flowing but consists of a small area of steam vents, and a seep area in the flood plain of the West Walker River (12/25-34ca1). The 2 springs and 15 flowing wells in the Wabuska subarea and pertinent data on each are listed in table 25. The combined flow of all springs and flowing wells is about 1,700 acre-feet per year, all of which is consumed locally by evapotranspiration and is included in table 14.

Pumpage

Mining and Industrial Use

The only appreciable pumpage for the mining industry is from wells owned by the Anaconda Co. The large open pit west of Yerington is dewatered by seven wells around its eastern perimeter. Several other wells in the plant area supply additional water for ore processing, plant needs, and the town of Weed Heights (population 1,500). Gross annual pumpage for all purposes at the mine is about 4,300 acre-feet, and the net draft on the ground-water reservoir is about 3,400 acre-feet (Holmes, 1966, p. 12). Pumping in the valley for other industrial uses probably is less than 100 acre-feet per year.

Municipal and Rural Supply

In 1966, the city of Yerington supplied about 550 acre-feet to 610 users (City Engineer, Yerington, written commun., 1967). A single well supplies the residents in the town of Mason with domestic water. Rural pumpage for domestic use and stockwatering was about 400 acre-feet in 1965. In recent years the total municipal and rural pumpage may have averaged about 1,000 acre-feet per year, and the net draft, about 600 acre-feet per year.

Pumping for Irrigation

During 1959-61 and the first part of 1962, streamflow into Mason Valley was far below normal. The annual average for the period April 1959-April 1962 was only 107,000 acre-feet, in contrast to about 216,000 acre-feet for the long-term period 1948-65. Because of this drought (hereafter referred to as the drought of 1959-62), ground-water pumping was initiated to provide supplemental irrigation water. Most of the existing irrigation wells in 1966 in the valley were drilled during or after that period. In 1966, approximately 65 wells may have been pumped to provide supplemental irrigation water for crops. Nearly all operational well pumps are powered by electric motors. To compute gross pumpage for the period 1962-65, power-consumption figures supplied by Sierra Pacific Power Co. were used in conjunction with pumping lift and an estimated average wire-to-water efficiency of about 60 percent. Of the gross pumpage, an estimated one-third returns to the ground-water reservoir. Thus, net pumpage is assumed to be two-thirds of the gross pumpage. Table 15 shows the estimated gross and net pumpage figures for the period 1959-65.

Table 15.--Estimated pumpage for irrigation, 1959-65[a]

(All estimates in acre-feet, rounded to two significant figures)

	SUBAREA									
	Missouri Flat		Mason		Yerington		Wabuska		Total	
Year	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
1959	--	--	--	--	--	--	--	--	2,000	1,300
1960	--	--	--	--	--	--	--	--	10,000	6,700
1961	--	--	--	--	--	--	--	--	20,000	13,000
1962	840	560	2,100	1,400	3,100	2,100	3,200	2,100	9,200	6,200
1963	1,600	1,100	1,700	1,100	1,700	1,100	1,700	1,100	6,700	4,400
1964	2,500	1,700	6,000	4,000	4,900	3,300	7,600	5,100	21,000	14,000
1965	10	7	450	300	460	300	240	160	1,200	800
Total	5,000	3,400	10,000	6,800	10,000	6,800	13,000	8,500	70,000	46,000

a. Estimates for 1959-61 based on number of wells and acreage irrigated; estimates for 1962-65 based on electric power consumption.

V EFFECTS OF DEVELOPMENT ON EQUILIBRIUM AND STREAMFLOW

The development of Mason Valley for agricultural purposes has caused moderate changes in the hydrologic system. Under long-term natural or predevelopment conditions, inflow to and outflow from the valley were about equal. The predevelopment equilibrium of the system was first upset by the diversion of water from the rivers for spreading over extensive areas on the valley floor. As previously mentioned, this action increased the amount of water infiltrating to ground-water storage, thereby causing water levels to rise with a consequent increase in the area and density of nonbeneficial or marginally beneficial phreatophytes. The increased loss of water through evapotranspiration from phreatophyte areas, along with the additional draft imposed by consumptive use of introduced crops, resulted in a total net draft on the system exceeding that imposed by evapotranspiration under native conditions. The building of upstream storage dams in the 1920's resulted in increased regulation of streamflow and some expansion of agricultural development. In effect, the volume of surface-water outflow from the valley was diminished.

In Mason Valley, the hydrologic system reached a new equilibrium some time after development began, and for selected periods, inflow equalled outflow with little or no major long-term changes of ground water in storage. The initiation of ground-water pumpage for irrigation in 1959, however, introduced a new factor which created an imbalance in the system during the 1959-62 drought. Local intense pumping by the Anaconda Co. for mining purposes is presumed to have caused little change in ground-water regimen in the adjacent area of the valley.

For the period 1948-65, when detailed inflow and outflow measurements are available for the valley, a seasonal pattern of streamflow is apparent. A comparison of inflow and outflow hydrographs shows that streamflow in the Walker River decreased, beginning in about mid-March of each year, when diversions for irrigation began. This, of course, reflects the losses caused by spreading diverted water on fields for irrigation, and by evapotranspiration of crops and phreatophytes within the valley. The hydrographs show that for every year during the period 1948-65, the streamflow decreased from about mid-March to about mid-November, which is the end of the irrigation season.

Prior to 1959, the response of the stream to cessation of irrigation in mid-November was characteristically immediate. The streamflow changed from a decrease to an increase within a few days. This characteristic is exemplified in figure 9 by the relation between inflow to and outflow from the valley during October-January 1958.

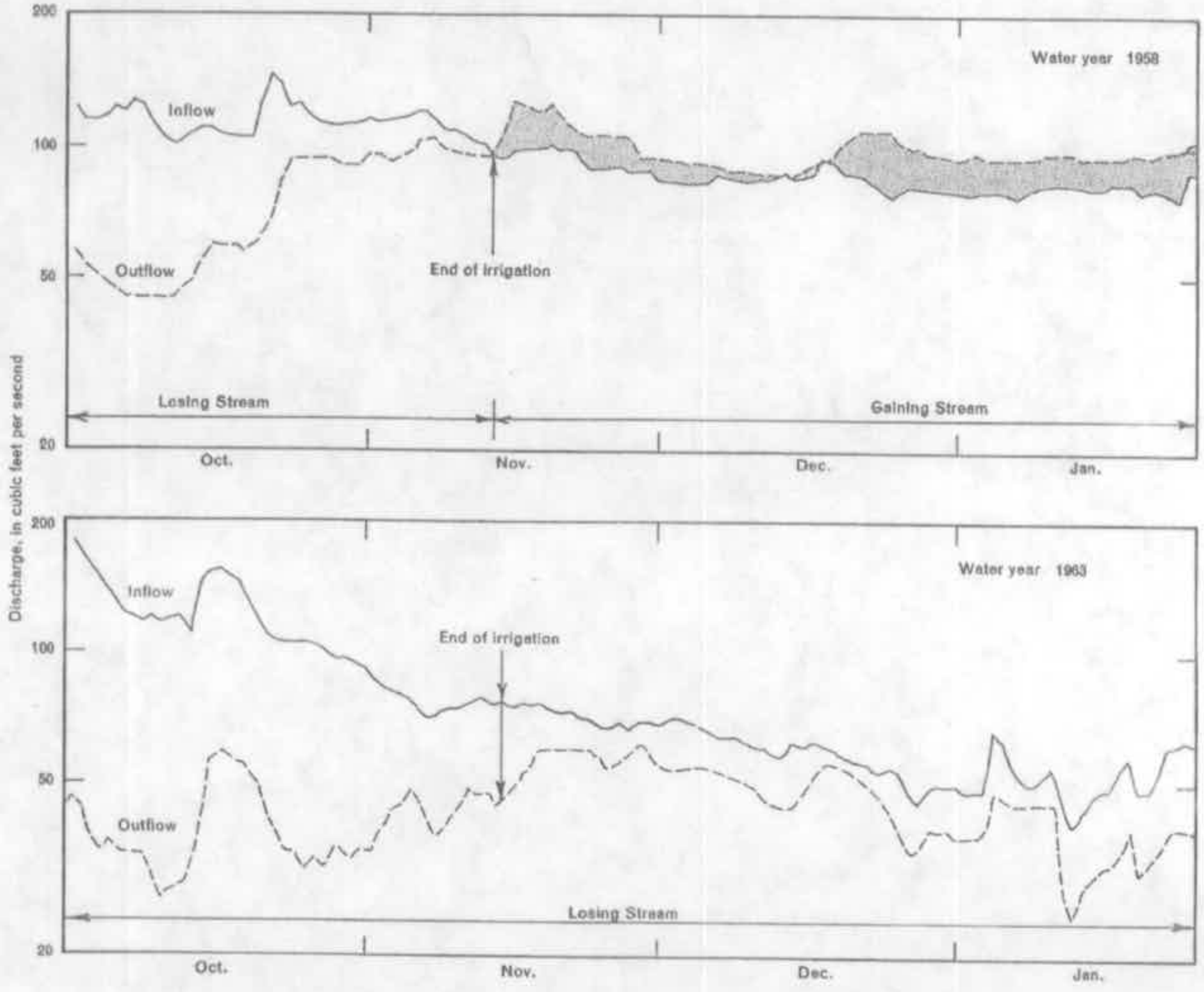


Figure 9.—Effect of pumping for irrigation on the relation between inflow to and outflow from the valley.

As indicated previously, pumping started in the summer of 1959 and continued each summer through 1965 (table 15). However, pumpage in 1965 was negligible. During the years 1959-64 the stream response in November was the same; however, the increase in outflow was considerably less and was not enough to produce a gaining stream, as shown by the data for 1963 in figure 9. The hydrographs indicate that some of the inflow was going into storage to replenish the depletion of the ground-water reservoir due to pumping. The comparison of the inflow and outflow hydrographs, as shown in figure 9, does indicate in a qualitative manner the influence of pumping on streamflow.

GROUND-WATER STORAGE CHANGES

Water-Level Fluctuations

Water levels in five index wells in the valley have been measured periodically during the period 1948-65. The hydrographs in figure 10 show that during the period net water-level changes in these wells were not large. The greatest changes occurred in response to the combined effects of pumping and the 1959-62 drought. The effects of pumping were most pronounced in the areas immediately surrounding the pumped wells. Water-level changes occurred seasonally in response to the diversion of water for irrigation and to the volume of streamflow entering the valley available for irrigation. The lack of large, sustained water-level changes indicates that over the period 1948-65 recharge to and discharge from the ground-water reservoir were nearly equal and that the system has been nearly in equilibrium.

Ground-water levels in the valley are normally highest in the fall at the close of the irrigation season, and they decline during the winter, reaching low points in the spring just prior to the start of irrigation. This pattern is reversed or modified near irrigation wells and in the northern part of the valley where dense phreatophyte growth causes water levels to be lowest in the fall and highest in the spring (well 15/25-26c1, fig. 10).

Storage Depletion, 1959-62

The lowering of water levels caused by the 1959-62 drought is apparant to varying degrees in four of the five index wells (fig. 10). In addition, the effects of pumping during the drought are evident in wells 11/25-11ac1 and 12/25-35dc1.

The estimated net decrease in stored ground water during the 3-year period from April 1959 to April 1962 is based on the estimated and measured water-level lowering in 17 wells, which averaged about 2.7 feet. The area of change was about 140,000 acres (fig. 11), so the volume of dewatered alluvium was about 380,000 acre-feet. Using the computed average specific yield of about 20 percent for the alluvial deposits in the dewatered zone (table 5), the net storage depletion during the 3-year period was about 75,000 acre-feet. Of that total, only about 21,000 acre-feet was due to pumping (net draft for 1959-61, table 15). The remainder of the depletion was due largely to evapotranspiration losses.

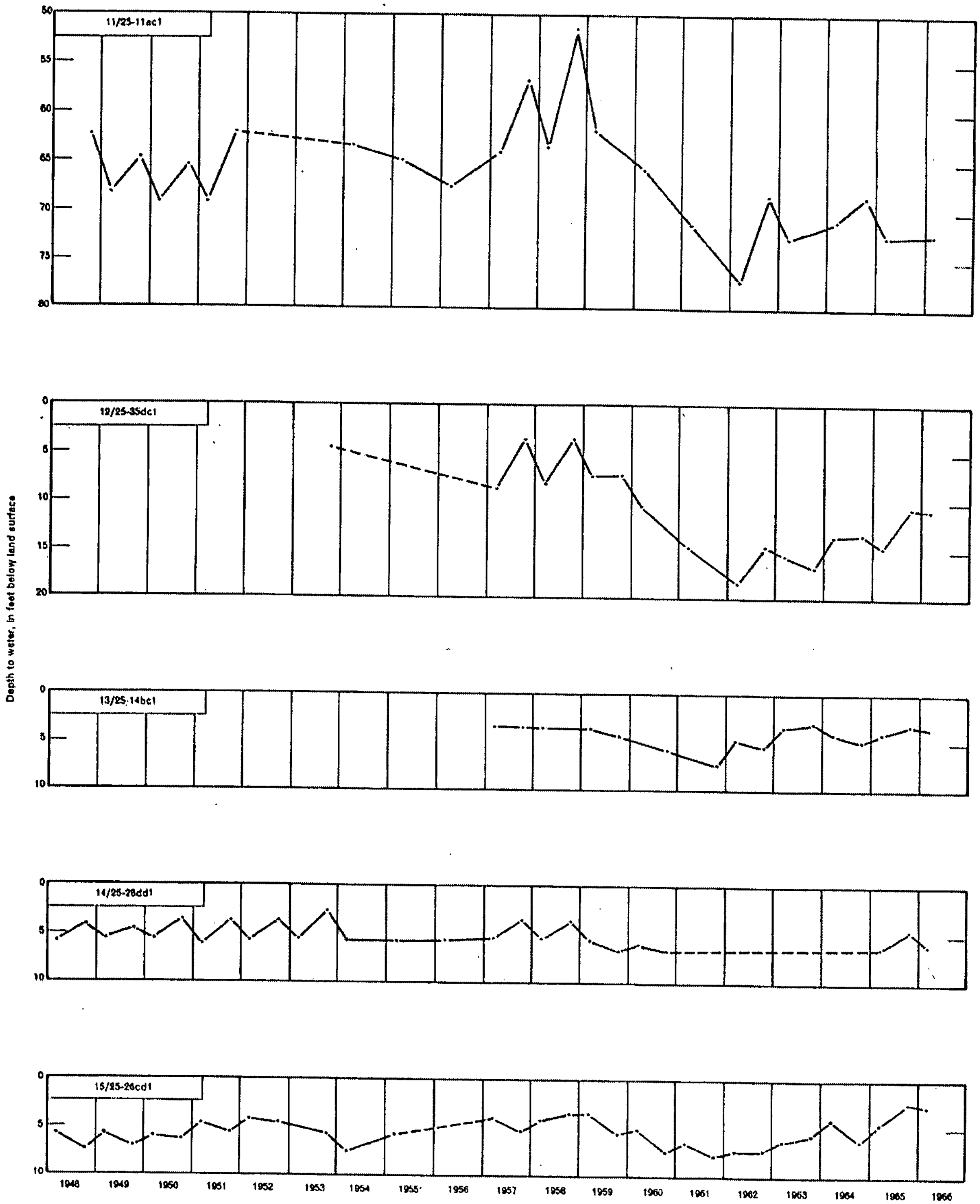


Figure 10.—Hydrographs of five index wells, 1948-65.

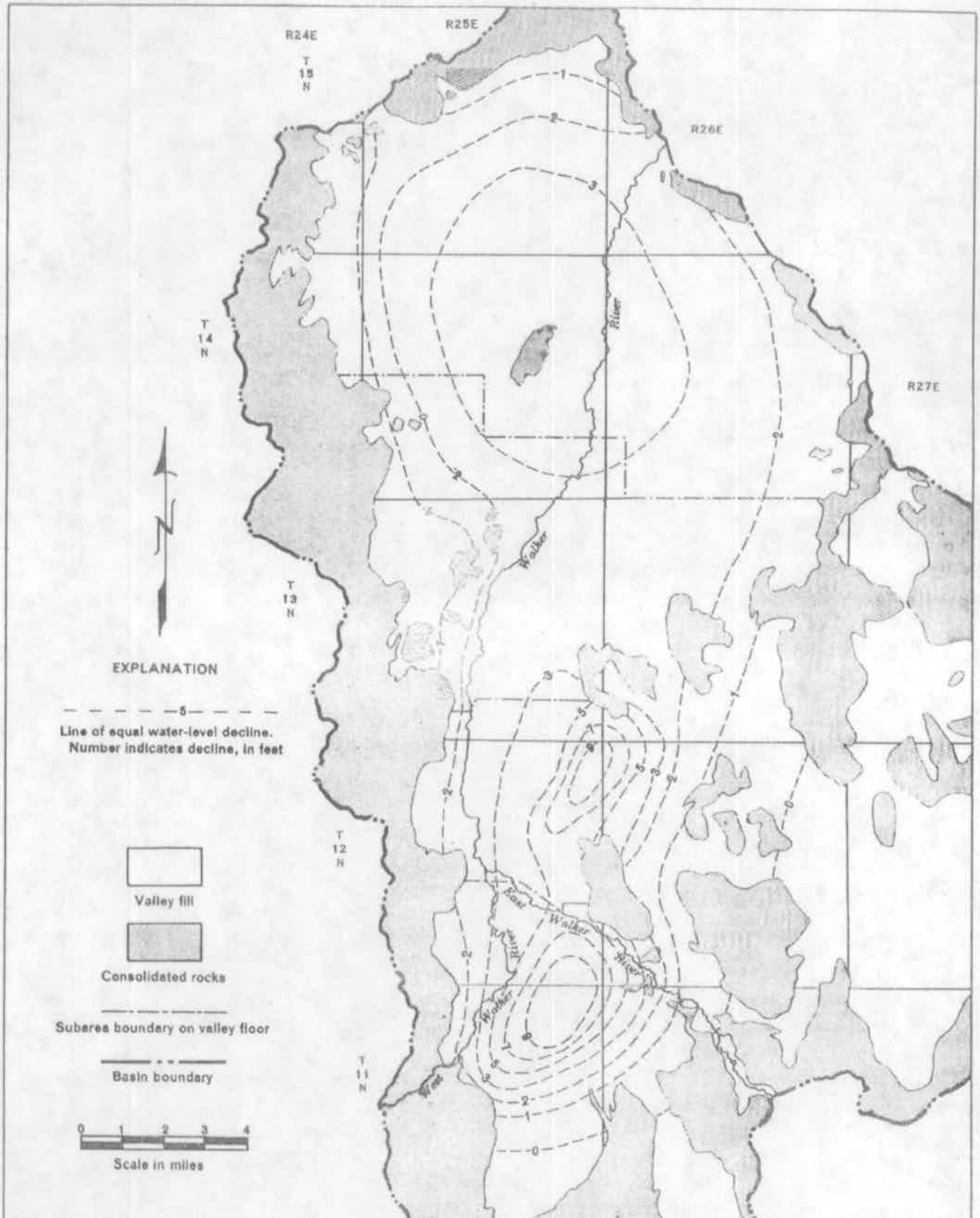


Figure 11.—Approximate decline of water levels in the valley-fill reservoir, April 1959—April 1962.

Storage Increase, April-October 1965

During the period April-October 1965, inflow to the system was above-average, and ground-water levels rose (fig. 10). The estimated net increase in stored ground water during this period, estimated on the basis of the approximate magnitudes of water-level rise (fig. 12), the area involved, and the specific yield, was about 32,000 acre-feet. Table 16 summarizes the net increase in storage for each subarea.

Table 16.--Estimated net increase in stored ground water, April-October 1965

Subarea	Area (acres) (1)	Average water-level rise (feet) (2)	Volume of deposits (acre-feet) (1)x(2)=(3)	Average specific yield (percent) (4)	Net increase in storage (acre-feet) (3)x(4)
Missouri Flat	13,160	2.5	33,000	20	6,600
Mason	13,500	2.1	29,000	21	6,100
Yerington	28,150	1.2	34,000	19	6,500
Wabuska	57,230	1.1	65,000	20	13,000
Total (rounded)	112,000	1.4	160,000	20	32,000

WATER BUDGETS

Water budgets summarizing the estimates of inflow, outflow, and changes of ground water in storage have been prepared for three periods: (1) The 18-year period 1948-65, which shows the long-term condition under present development; (2) the 3-year period April 1959-April 1962, which shows the effects of a severe short-term drought; and (3) the 6-month period April-October 1965, which shows the effects of a single irrigation season. No budget was prepared for natural conditions, because data are not available and over the past 100 years the system has been moderately altered by agricultural development. Subsurface inflow from the consolidated rocks to the valley fill, which may be minor, has not been estimated, and has been omitted from all three budgets.

Table 17 shows the budget for the period 1948-65, which presumably represents near-equilibrium conditions for Mason Valley. Accordingly, the net change of ground water in storage for the period is considered negligible. Imbalances in the budget range from 1,000 to 11,000 acre-feet per year, which is 5 percent or less of the annual inflow and outflow for the period.

Table 18 shows the excess of outflow over inflow and the net depletion in storage during the 3-year drought of 1959-62. The difference between values obtained by the two methods (inflow minus outflow compared to net storage depletion) is 20-25 percent of the average annual water depletion for the period.

Table 19 shows the budget for the 1965 irrigation season. The large quantity of water entering storage within the valley during the 6-month period is mainly the result of carry-over conditions from the previous (1964) water year: below-average streamflow (about 70 percent of normal, table 7) and depletion of stored ground water.

The extensive application of irrigation water in 1965 probably permitted more water than usual to go into storage. The difference between the two methods (inflow minus outflow compared to net increase in storage) is less than 20 percent of the water gain for the season.

In general, the lack of closure in each of the three water budgets is the result of the assumptions made and the values selected in deriving the estimates of inflow, outflow, and storage change. The estimates most likely to be in error are the larger components comprising evapotranspiration, crop use, and changes in the amount of ground water in storage.

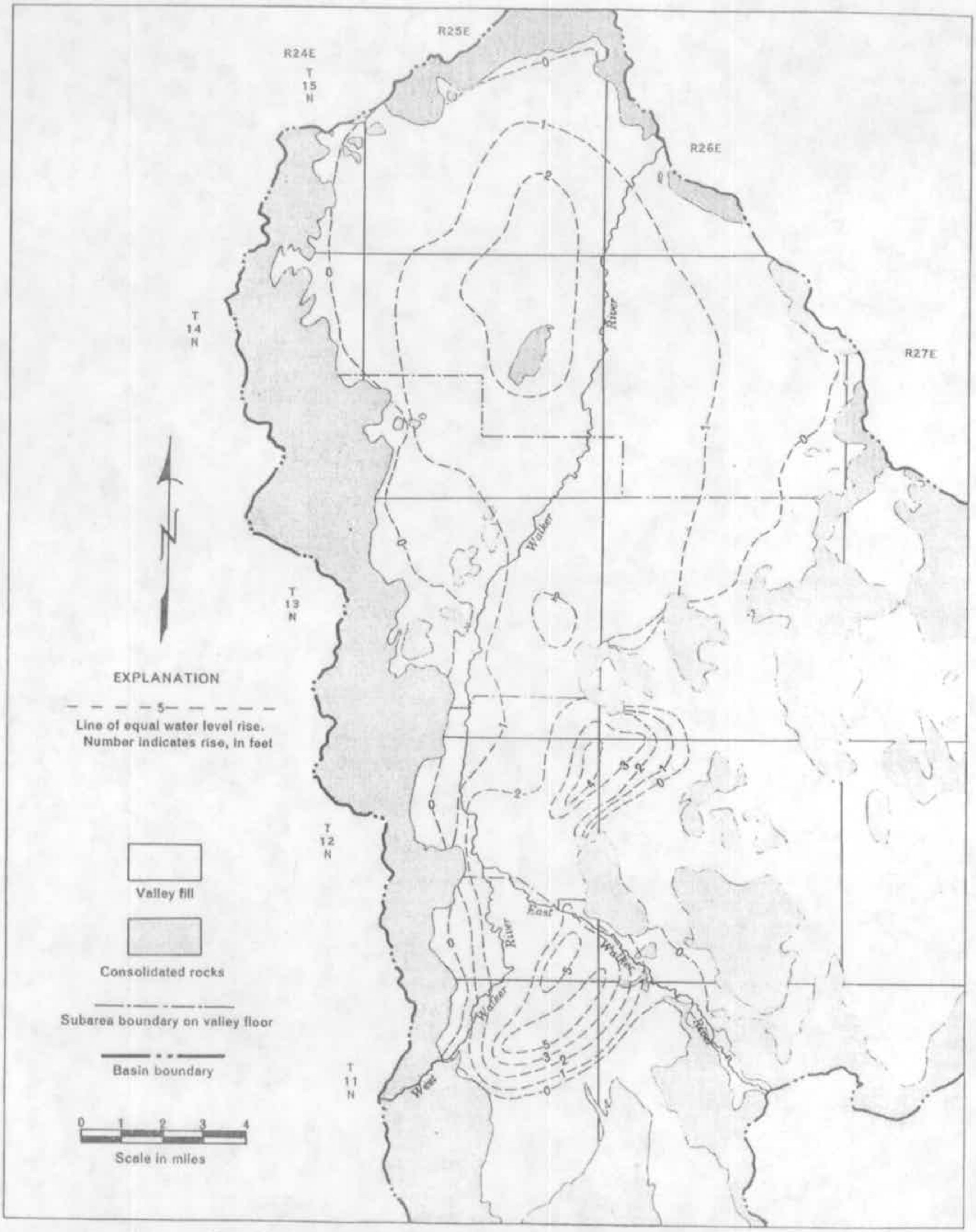


Figure 12.—Approximate rise of water levels in the valley-fill reservoir, April to October 1965.

Table 17.--Water budget for long-term record, 1948-65

(Quantities, in acre-feet per year, significant to two figures)

Budget element	SUBAREA				Entire valley
	Missouri Flat	Mason	Yerington	Wabuska	
INFLOW:					
East and West Walker Rivers (tables 7 and 9)	a 216,500	208,000	192,000	160,000	a 216,500
Local runoff (p. 20)	2,500	2,000	(b)	1,400	5,900
Ground water (table 13)	500	2,500	3,000	5,200	500
Total (1)	220,000	212,000	195,000	167,000	223,000
OUTFLOW:					
Surface water (tables 7 and 9)					
Walker River	c 165,000	188,000	80,000	d 108,200	d 108,200
Irrigation ditches	43,000	4,000	80,000	0	0
Ground water (table 13)	2,500	3,700	5,200	1,600	1,600
Evapotranspiration (table 14)1/	3,800	2,600	10,000	41,000	57,000
Consumptive use by crops and pastures (table 11)2/	6,400	12,600	12,200	9,600	41,000
Net pumpage for mining, industrial, public-supply, and rural use (p. 33)	20	50	3,900	50	4,000
Total (2)	221,000	211,000	191,000	160,000	212,000
IMBALANCE (1) - (2):	-1,000	+1,000	+4,000	+7,000	+11,000

1. Includes loss from springs and flowing wells.
2. Includes estimated net pumpage for irrigation (table 15), which totals only 2,600 acre-feet per year if averaged for the 18-year period.
a. East Walker River 93,400 acre-feet plus West Walker River 123,100 acre-feet.
b. Minor.
c. East Walker River 45,000 acre-feet plus West Walker River 120,000 acre-feet.
d. Includes estimated 1,000 acre-feet per year flow through Adrian Gap (table 9).

Table 18.--Water budget for drought period April 1959-April 1962

Budget element	Average for 3-year period (acre-feet per year)
INFLOW:	
East and West Walker River	107,000
Local runoff (p. 20)	minor
Ground water (table 13)	500
TOTAL (1):	108,000
OUTFLOW:	
Walker River	25,000
Ground water (table 13)	1,600
Evapotranspiration (table 14)[1]	57,000
Consumptive use by crops and pastures	a 40,000
Net pumpage for mining, industrial, public-supply, and rural use (p. 33)	4,000
TOTAL (2):	128,000
IMBALANCE (3) = (1) - (2):	-20,000
NET STORAGE DEPLETION (p. 38) (4):	-25,000
DIFFERENCE (3) - (4):	5,000

1. Includes loss from springs and flowing wells.

a. Includes an estimated 30,000 to 35,000 acre-feet of surface water and 7,000 acre-feet of ground-water pumpage (table 15).

Table 19.--Water budget for irrigation season April-October 1965

Budget element	Total for 6 months (acre-feet)
INFLOW:	
East and West Walker Rivers	233,800
Local runoff	a 7,000
Ground water (computed from data in table 13)	250
TOTAL (1):	241,000
OUTFLOW:	
Walker River	99,400
Ground water (computed from data in table 13)	800
Evapotranspiration 1/	50,000
Consumptive use by crops and pastures	b 50,000
Net pumpage for mining, industrial, public-supply, and rural use (p. 33)	2,500
TOTAL (2):	203,000
IMBALANCE (3) = (1) - (2):	+38,000
NET INCREASE IN STORAGE (table 16) (4):	+32,000
DIFFERENCE (3) - (4):	6,000

1. Full-year evapotranspiration is 57,000 acre-feet (table 14). Loss during April-October is estimated to be about 50,000 acre-feet. Includes loss from springs and flowing wells.

a. Estimate is based on wetness of 6-month period during the wet year 1965.

b. Estimate assumes that most of the irrigable land (39,000 acres) was irrigated; includes about 800 acre-feet of ground-water pumpage (table 15).

CHEMICAL QUALITY OF WATER

Almost 60 water samples were collected from wells, auger holes and springs, from sites along the East, West, and main-stem Walker Rivers, and from selected irrigation and drainage ditches in the basin during 1965 and 1966. Detailed chemical analyses are presented in table 20, and partial field-office analyses are shown in tables 21 and 22. The ground-water sampling sites are shown in figure 13, while the river and ditch sites, which were sampled during March 1966, are shown in figure 6. Because the chemical quality of surface water generally varies according to volume of flow and the extent of seasonal irrigation activity, the analyses in table 22 do not represent the mean annual concentration of dissolved constituents. They do, however, indicate the general chemical character of water flowing in the rivers and ditches.

General Types of Water

On the basis of samples collected during March 1966, stream water entering Mason Valley via the East and West Walker Rivers is a calcium bicarbonate type (11/26-14cb and 11/25-18cd in table 22), whereas the water discharging from the basin is a more concentrated sodium-calcium bicarbonate type with much greater proportions of sulfate and chloride (15/26-20bd). The increase in both dissolved solids and volume of flow within the valley, along with pronounced increases in sodium, sulfate, and chloride (table 23), all indicate that the river was receiving a significant contribution of ground water during the sampling period. Ground water is contributed by lateral and upward percolation into canals, drainage ditches, and the river.

The situation depicted in table 23, however, is not typical of conditions throughout the year. Although the concentration of dissolved solids (as indicated by specific conductance) generally increases in a downstream direction, table 24 shows that the tonnage does not always follow the March 1966 pattern of pronounced downstream increase. In December 1959 and August 1960, when inflow to the valley exceeded outflow, the outgoing tonnage was either about the same as or appreciably less than the quantity brought in by the East and West Walker Rivers. This subject is discussed in greater detail in the section entitled "Salt Balance" (p. 53).

Thirty-seven ground-water samples were collected during April, June, and November 1965 and February and March 1966. These samples provide a fair representation of the general distribution of water quality in the ground-water reservoir.

Table 20.--Detailed chemical analyses of water from selected wells

(Analyses by the U.S. Geological Survey)

Location	Date sampled	Temperature °C	Temperature °F	Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1/]														Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Factors affecting suitability for irrigation[2/]	
				Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)[3/]	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved-solids content[4/]					Sodium-adsorption ratio (SAR)	Residual sodium carbonate (RSC)
11/25-1bc1	4-15-65	--	--	62	0.21	95 4.74	24 1.98	58 2.52	12 0.31	353 5.79	91 1.89	40 1.13	0.0 0.00	50 0.81	2.7	609	289	888	8.1	1.4	0.00
11/25-9dd1	6- 8-65	16	60	43	.03	76 3.79	14 1.13	62 2.70	6.4 .16	397 6.51	37 .77	16 .45	.3 .02	7.7 .12	.4	459	326	700	7.8	1.7	1.59
12/25-9cb1	6- 9-65	18	64	53	.21	113 5.64	15 1.20	72 3.13	6.2 .16	274 4.49	196 4.08	65 1.83	.5 .03	.0 .00	.7	657	225	982	8.0	1.7	.00
12/26-6cd1	6- 8-65	16	60	54	.40	63 3.14	3.4 .28	36 1.57	5.5 .14	259 4.25	38 .79	7.8 .22	.3 .02	3.7 .06	.2	340	212	509	7.9	1.2	.83
12/26-33cc1	6- 8-65	14	57	60	.05	9.2 .46	1.2 .10	34 1.48	5.0 .13	96 1.57	24 .50	4.4 .12	.5 .03	.0 .00	.1	185	79	222	7.8	2.8	1.01
13/25-13ba2	6- 8-65	14	58	49	.10	25 1.25	5.7 .47	30 1.30	4.0 .10	102 1.67	53 1.10	12 .34	.7 .04	.0 .00	.2	230	84	323	7.7	1.5	.00
13/25-26cc1	4-15-65	--	--	40	.10	42 2.10	15 1.22	33 1.44	4.5 .12	204 3.34	59 1.23	10 .28	.1 .01	6.2 .10	.6	310	167	469	7.5	1.1	.02
13/26-9ac1	6- 8-65	16	60	65	.02	72 3.59	7.4 .61	112 4.87	1.7 .04	117 1.92	219 4.56	89 2.51	2.5 .13	5.4 .09	.6	633	96	928	7.6	3.4	.00
14/25-3cc1	6- 9-65	14	58	52	.10	22 1.10	4.9 .40	19 .83	3.9 .10	119 1.95	17 .35	4.7 .13	.5 .03	.0 .00	.2	183	98	233	8.0	.95	.45
14/25-26ca1	4-15-65	--	--	46	3.9	15 .75	6.0 .49	17 .74	3.7 .09	97 1.59	18 .37	5.0 .14	.2 .01	1.2 .02	.4	160	80	215	7.5	.94	.35
14/25-31db1	4-15-65	17	62	23	2.1	37 1.85	4.7 .39	163 7.09	1.7 .04	440 7.21	25 .52	46 1.30	1.8 .09	2.0 .03	2.7	524	361	850	7.5	6.7	4.97
14/25-33cd1	4-15-65	--	--	37	.05	65 3.24	24 2.00	158 6.87	5.3 .14	378 5.87	225 4.68	54 1.52	.3 .02	15 .24	1.4	771	310	1,150	8.4	4.2	.63
14/26-23cb1	6- 9-65	13	56	55	.03	28 1.40	3.2 .26	79 3.44	2.9 .07	132 2.16	116 2.42	22 .62	1.2 .06	.1 .00	.3	373	108	528	7.7	3.8	.50
15/25-15cb1	10-15-59	97	207	109	.06	40 2.00	1.0 .08	313 13.62	13 .33	52 .85	642 13.37	49 1.38	8.2 .43	.0 .00	1.0	1,210	105	1,630	8.6	13	.00
15/25-15cb2	10-15-59	87	188	100	.01	37 1.85	8.7 .72	276 12.01	12 .31	80 1.31	566 11.78	45 1.27	7.6 .40	.0 .00	1.0	1,090	128	1,490	8.0	11	.00
15/25-16dd1	10-15-59	97	207	99	.02	39 1.95	.0 .00	291 12.66	12 .31	68 1.11	596 12.41	46 1.30	7.7 .41	.0 .00	1.0	1,130	98	1,580	8.3	13	.00
15/25-27bb1	6- 9-65	13	56	55	.08	4.8 .24	1.5 .12	66 2.87	3.3 .08	114 1.87	46 .96	12 .34	4.0 .21	.0 .00	.6	249	93	334	7.9	6.8	1.51
15/26-20bd1	6- 9-65	18	64	53	.09	14 .70	2.7 .22	109 4.74	3.0 .08	130 2.13	128 2.66	30 .85	4.7 .25	.0 .00	.9	409	107	605	7.8	7.0	1.21

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

2. Salinity hazard is based on specific conductance as follows: low hazard, 0-250 micromhos; medium, 251-750; high, 751-2,250; very high, >2,250. 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: $SAR = Na/\sqrt{(Ca + Mg)/2}$. Residual sodium carbonate (expressed in milliequivalents per liter) is tentatively related to suitability for irrigation as follows: safe (S), 0-1.25; marginal (M), 1.26-2.50; unsuitable (U), >2.50. 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 U.S. Salinity Laboratory Staff (1954).

3. All carbonate (CO_3) values 0 mg/l except: 14/25-33cd1, 10 mg/l (0.33me/l); 15/25-15cb1, 12 mg/l (0.40 me/l); 15/25-16dd1, 2 mg/l (0.07 me/l).

4. Calculated, with HCO_3 expressed as CO_3.

Table 21.--Partial chemical analyses of water from selected wells, auger holes, and springs

(Field-office analyses by the U.S. Geological Survey)

Location	Date sampled	Temperature °C	Temperature °F	Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1/]: 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)	Factors affecting suitability for irrigation[2/]: Sodium-adsorption ratio (SAR)	Residual sodium carbonate (RSC)
11/25-26ba1	3-18-66	10- 13	50- 55	26 1.30	5.8 0.48	134 5.82	172 2.82	147 3.06	61 1.72	89 1.78	838	7.9	6.2	1.04
12/25-1aa1	11-10-65	14	57	46 2.30	27 2.26	50 2.16	336 5.51	49 1.02	6.6 .19	228 4.56	559	7.9	1.4	.95
12/25-15db1	11- 9-65	13	56	34 1.70	23 1.86	76 3.32	222 3.64	123 2.56	24 .68	178 3.56	616	7.5	2.5	.08
12/25-36bc1	3- 9-66	13	55	84 4.19	29 2.36	28 1.20	269 4.41	124 2.58	27 .76	328 6.55	748	7.9	.7	.00
13/25-14dc1	11- 3-65	14	57	15 .75	6.4 .53	46 2.02	105 1.72	58 1.21	13 .37	64 1.28	303	7.6	2.5	.44
13/26-9db1	3-30-66	17	62	59 2.94	8.0 .66	121 5.26	100 1.64	221 4.60	93 2.62	180 3.60	957	8.0	3.9	.00
14/25-5ba1	3-28-66	13	56	18 .90	9.2 .76	22 .95	98 1.61	37 .77	8.2 .23	83 1.66	213	7.7	1.0	.00
14/25-8ad1	11- 4-65	12	54	24 1.20	11 .88	19 .82	120 1.97	31 .65	10 .28	104 2.08	259	7.7	.8	.00
14/25-9dd1	11- 4-65	--	--	35 1.75	13 1.11	33 1.40	165 2.70	54 1.12	17 .48	143 2.86	373	7.8	1.2	.00
14/25-9dd2	11- 4-65	12	54	50 2.50	24 1.98	40 1.76	219 3.59	96 2.00	23 .65	224 4.48	531	7.9	1.2	.00
14/25-19ac1	3-15-66	17	62	31 1.55	17 1.41	72 3.11	156 2.56	106 2.21	46 1.30	148 2.96	646	8.1	2.6	.00
15/25-11cc1	2-24-66	--	--	40 2.00	13 1.08	241 10.47	60 .98	539 11.22	48 1.35	154 3.08	1,610	7.8	8.4	.00
15/25-14ab3	2-17-66	86	187	39 1.95	1.6 .13	273 11.86	72 1.12	552 11.49	45 1.27	104 2.08	1,480	7.9	12	.00
15/25-21ca1	2-16-66	29	84	4.6 .23	.6 .05	124 5.40	187 3.06	80 1.67	24 .68	14 .28	560	8.6	14	3.05
15/25-25dc1	2-25-66	--	--	182 9.08	65 5.35	141 6.15	211 3.46	562 11.70	192 5.42	722 14.43	2,010	8.1	2.3	.00
15/25-25dd1	2-25-66	--	--	30 1.50	23 1.86	50 2.18	132 2.16	111 2.31	38 1.07	168 3.36	573	8.1	1.7	.00
15/25-28ad2	3-28-66	30	86	7.2 .36	1.7 .14	129 5.59	159 2.61	128 2.66	29 .82	25 .50	652	8.2	11	2.11
15/25-31aa3	2-25-66	--	--	109 5.44	36 2.99	89 3.87	277 4.54	259 5.39	84 2.37	422 8.43	1,210	8.1	1.9	.00
15/26-18cc1	2-25-66	--	--	9.8 .49	5.5 .45	320 13.90	261 4.28	312 6.50	98 2.76	47 .94	1,530	9.0	20	4.64
15/26-35ac1	3-30-66	19	66	7.8 .39	6.9 .57	113 4.92	.0 .00	77 1.60	117 3.30	48 .96	688	10.1	7.1	.02

1. See footnote 1, table 20.

2. See footnote 2, table 20.

3. Computed as the milliequivalent-per-liter difference between the determined negative and positive ions; expressed as sodium. Computation assumes that concentrations of undetermined ions--especially nitrate--are small.

4. All carbonate (CO_3) values 0 mg/l except: 15/25-21ca, 8 mg/l (0.27 me/l); 15/26-18cc, 39 mg/l (1.30 me/l); 15/26-35ac, 28 mg/l (0.93 me/l)

Table 22.--Partial chemical analyses of water from the Walker River system and selected ditches

(Field-office analyses by the U.S. Geological Survey)

Source[3]	Map location number (fig. 6)	Date sampled	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)[4]	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)
			Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]										Factors affecting suitability for irrigation[2]	
EAST WALKER RIVER														
At Strosnider gage	11/26-14cb1	3- 8-66	33 1.65	12 0.99	16 0.70	148 2.43	0 0.00	37 0.77	4.8 0.14	132 2.64	314	7.9	0.6	0.00
Near Strosnider Ranch	12/26-32cb1	3- 8-66	34 1.70	17 1.38	11 .47	152 2.49	0 .00	42 .87	6.8 .19	154 3.08	314	8.2	.4	.00
At State Highway 3 bridge	12/25-25bc1	3- 7-66	35 1.75	16 1.33	15 .67	158 2.59	1 .03	45 .94	6.8 .19	154 3.08	337	8.6	.5	.00
At bridge near Nordyke	12/25-22db1	3- 7-66	35 1.75	13 1.05	26 1.12	160 2.62	0 .00	49 1.02	10 .28	140 2.80	352	8.2	.9	.00
WEST WALKER RIVER														
At Hudson gage	11/25-18cd1	3- 7-66	32 1.60	17 1.40	31 1.34	159 2.61	8 .27	44 .92	19 .54	150 2.58	391	8.5	1.1	.00
At State Highway 3 bridge	11/25-9ad1	3- 7-66	32 1.60	12 .98	39 1.70	168 2.75	2 .07	44 .92	19 .54	129 2.58	395	8.5	1.5	.24
At dam above Kelly-Alkali ditch	11/25-4da1	3- 8-66	32 1.60	2- 1.62	25 1.09	141 2.31	19 .63	40 .83	19 .54	161 3.22	393	8.8	.9	.00
1.2 miles downstream from dam	12/25-34dd1	3- 9-66	37 1.85	16 1.29	47 2.04	201 3.29	0 .00	64 1.33	20 .56	157 3.14	473	8.2	1.6	.15
At bridge near Nordyke	12/25-22bc1	3- 7-66	36 1.80	12 1.00	52 2.24	175 2.87	6 .20	65 1.35	22 .62	140 2.80	465	8.4	1.9	.27
WALKER RIVER														
At bridge near Snyder Ranch	12/25-9ac1	3- 9-66	37 1.85	9.6 .79	50 2.17	188 3.08	0 .00	60 1.25	17 .48	132 2.64	460	8.2	1.9	.44
At Mason	13/25-33ac1	3- 9-66	38 1.90	15 1.22	38 1.67	184 3.02	0 .00	62 1.29	17 .48	156 3.12	440	8.1	1.3	.00
At Goldfield Ave. bridge	13/25-15bb1	3- 9-66	37 1.85	19 1.53	34 1.48	188 3.08	0 .00	61 1.27	18 .51	169 3.38	445	8.1	1.1	.00
At Miller Lane bridge	14/25-25db1	3- 9-66	40 2.00	18 1.46	32 1.38	190 3.11	0 .00	60 1.25	17 .48	173 3.46	449	8.1	1.0	.00
At Wild Life Management Area bridge	14/26-7cb1	3- 9-66	39 1.95	16 1.31	38 1.67	194 3.18	0 .00	58 1.21	19 .54	163 3.26	449	8.2	1.3	.00
At Wabuska gage	15/26-20bd1	3-10-66	46 2.30	15 1.22	63 2.72	210 3.44	0 .00	90 1.87	33 .93	176 3.52	595	8.2	2.1	.00
DITCHES AND SLOUGHS														
Wabuska ditch at U.S. Highway Alt. 95 culvert	15/25-28da1	3-28-66	50 2.50	16 1.34	52 2.26	212 3.47	0 .00	83 1.73	32 .90	192 3.84	635	8.2	1.6	.00
Wabuska ditch above Wabuska gage	15/26-20bc1	3-28-66	54 2.69	16 1.33	89 3.89	221 3.62	0 .00	133 2.77	54 1.52	201 4.02	788	8.2	2.7	.00
Joggles ditch at Miller Lane crossing	14/25-25db2	3-30-66	33 1.65	10 .83	41 1.77	169 2.77	0 .00	51 1.06	15 .42	124 2.48	415	8.2	1.6	.29
Joggles Slough above confluence with Perk Slough	15/26-29ca1	3-30-66	58 2.89	22 1.83	128 5.56	336 5.51	0 .00	145 3.02	62 1.75	236 4.72	1,000	8.2	3.6	.79
Perk Slough at dam	15/26-29ca2	3-30-66	50 2.50	18 1.50	159 6.91	326 5.34	10 .33	172 3.58	59 1.66	200 4.00	1,060	8.5	4.9	1.67
East drain ditch at U.S. Highway Alt. 95 culvert	14/26-33dc1	3-30-66	43 2.15	11 .89	65 2.82	204 3.34	0 .00	87 1.81	25 .71	152 3.04	551	8.2	2.3	.30

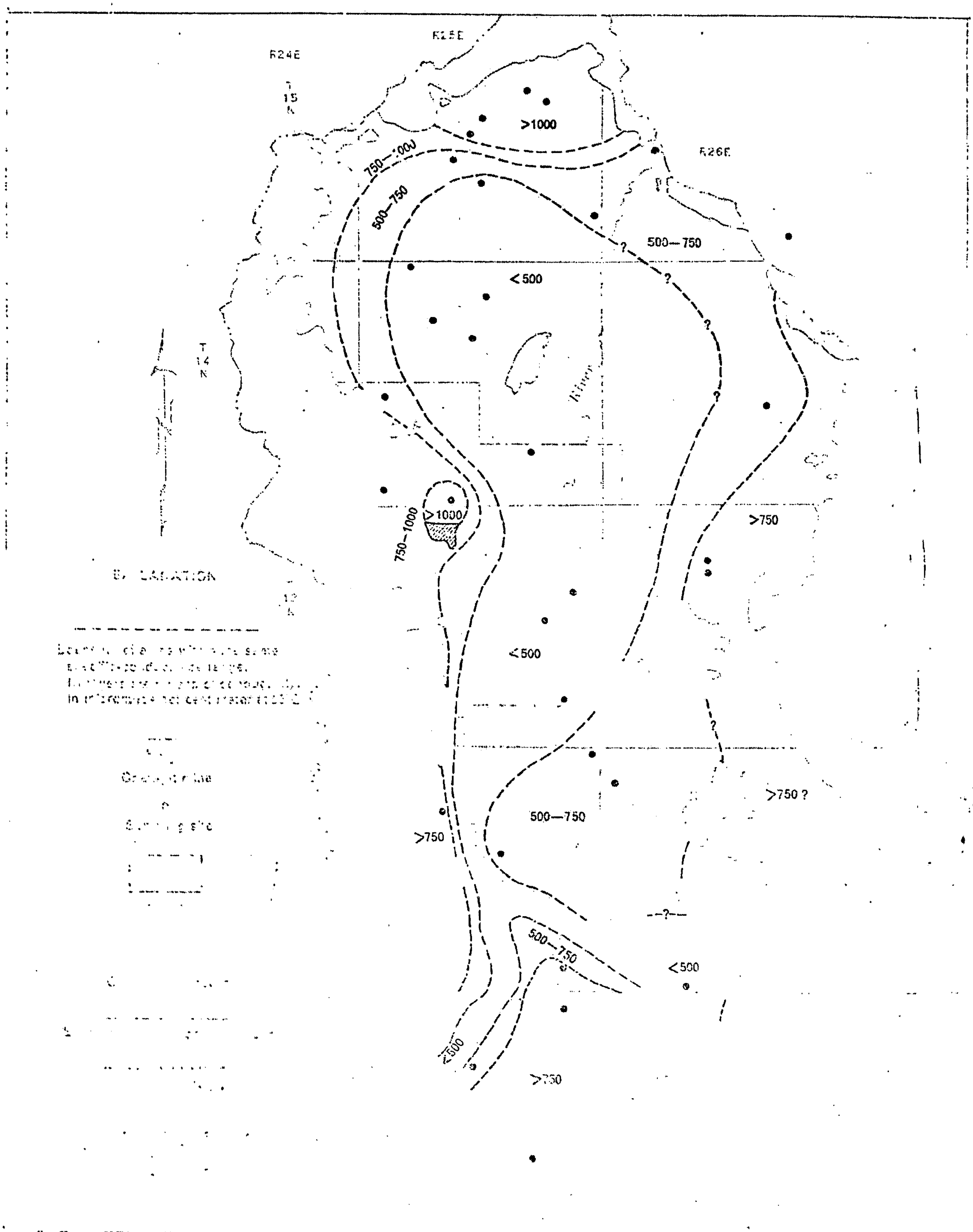
1. See footnote 1, table 20.

2. See footnote 2, table 20.

3. Sample sites for each river are arranged in downstream order.

4. See footnote 3, table 21.

CORRECTED FIG. 14



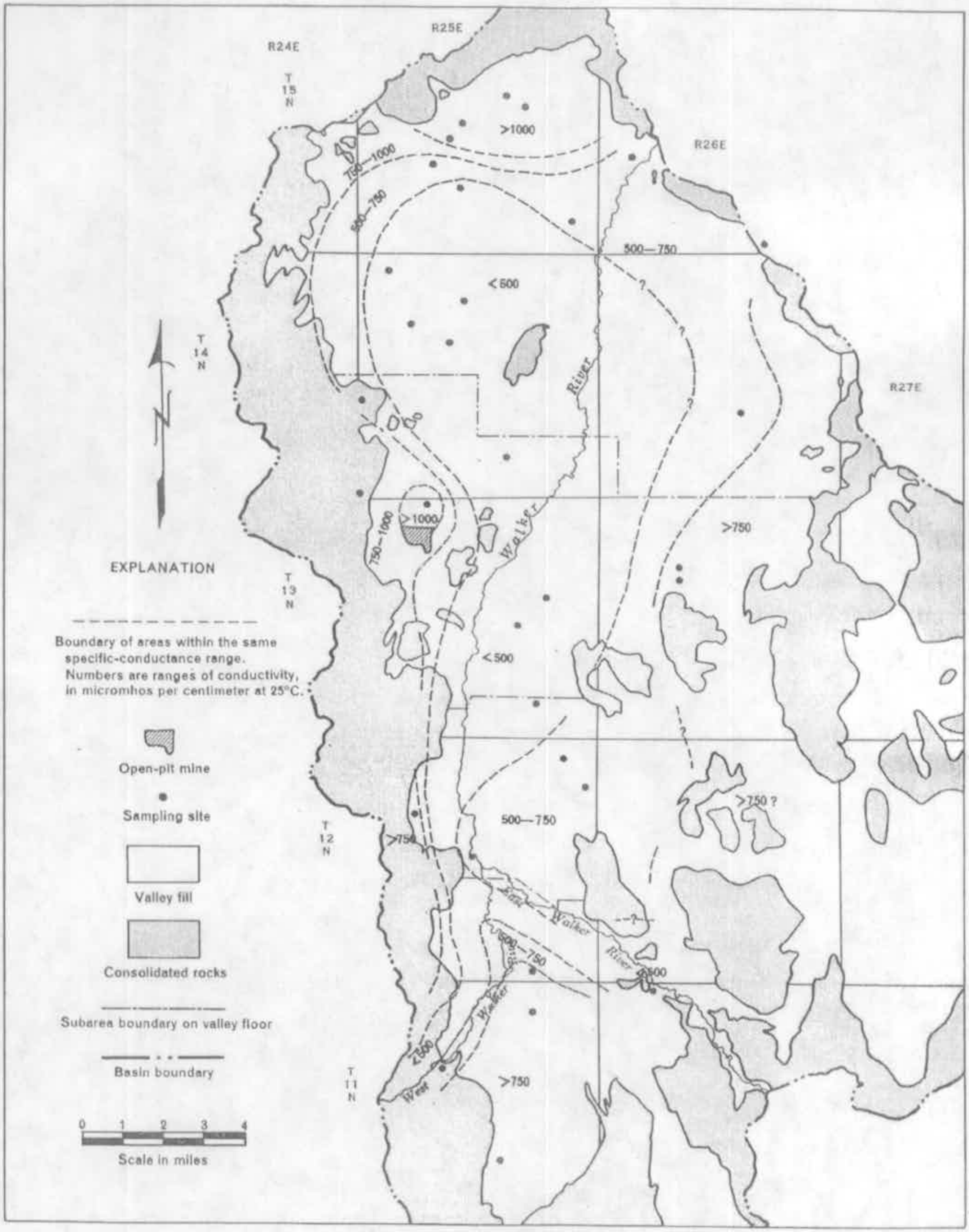


Figure 13.—Specific conductance of ground water.

Table 23.--Relation between incoming and outgoing quantities of water and dissolved solids in the Walker River system, March 7-10, 1966[1]

(Quantities in tons per day, except discharge)

	Inflow to valley			Outflow	Percentage gain within basin, relative to incoming quantity
	East Walker River	West Walker River	Total	Walker River	
Discharge, in acre-feet per day	80	136	216	272	26
Calcium	3.6	5.9	9.5	17	79
Magnesium	1.3	1.8	3.1	5.6	81
Sodium plus potassium[2]	1.7	5.7	7.4	23	210
Carbonate plus bicarbonate[3]	8.0	16	24	38	58
Sulfate	4.0	8.1	12	33	180
Chloride	.5	3.5	4.0	12	200
Dissolved-solids content[4]	22	47	69	143	107

1. Based on average discharge for the 4-day period and analyses for sites 11/26-14cb, 11/25-18cd, and 15/26-20bd (table 22).

2. As sodium.

3. As carbonate.

4. Estimated by assuming that dissolved-solids content, in milligrams per liter, is about 65 percent of the specific-conductance value.

Table 24.--Comparison of incoming and outgoing quantities of water and dissolved solids in the Walker River system, December 1959, August 1960, and March 1966

Date	Inflow to valley								Outflow		
	East Walker River			West Walker River			Total		Walker River		
	Discharge (cfs)	Specific conductance (micromhos)	Tons per day1/	Discharge (cfs)	Specific conductance (micromhos)	Tons per day1/	Discharge (cfs)	Tons per day1/	Discharge (cfs)	Specific conductance (micromhos)	Tons per day1/
Dec. 15, 1959a/	22	430	17	30	550	29	52	46	38	760	51
Aug. 8, 1960a/	107	293	55	44	410	32	151	87	43	406	31
Mar. 7-10, 1966b/	40	314	22	69	391	47	109	69	137	595	143

1. Estimated by assuming that dissolved-solids content, in milligrams per liter, is about 65 percent of the specific-conductance value.
a. Data from U. S. Bureau of Indian Affairs.
b. Discharge is average for 4-day period. Specific conductances from table 22.

The chemical character of ground water in the valley-fill reservoir varies widely with depth, lateral position, and texture and composition of the aquifer materials. For example, water from well 11/25-1bc is a calcium bicarbonate type (table 20), while that from well 15/25-14ab is a sodium sulfate type (table 21). The specific conductance of samples collected ranged from 213 micromhos per centimeter at 25°C (hereafter abbreviated "micromhos") in well 14/25-5ba to 2,010 micromhos in well 15/25-25dc. Figure 13 shows the areal variation of specific conductance. Water having the greatest specific conductance (and therefore, dissolved-solids content) is found west of Yerington and in shallow aquifers in the northern part of the area, where large natural discharge has caused the concentration and extensive deposition of salts in the soil. Water discharging from the thermal springs and flowing wells north and east of Wabuska is similarly high in dissolved solids, but for different reasons (see p. 51-52).

Although the quality of ground water in certain parts of the valley may change in response to hydrometeorologic events and cultural activity, such as recycling of irrigation water and discharge of mine-dump effluent, such changes probably would take place over relatively long periods of time.

Suitability for Irrigation

According to the U.S. Salinity Laboratory Staff (1954, p. 69-82), the most critical factors in evaluating the chemical suitability of water for irrigation include dissolved-solids content, the relative proportion of sodium to calcium plus magnesium, and the presence and concentration of constituents that can be toxic to plants. Four factors that are used by the U.S. Salinity Laboratory to evaluate the suitability of irrigation water are listed in tables 20-22 and discussed briefly in footnote 3 of table 20.

One of the most critical constituents with regard to plant growth is boron. This element is essential to plant nutrition in minor amounts, but is highly toxic to some plants when it exceeds certain limits. The permissible limits for boron in irrigation water for sensitive, semitolerant, and tolerant crops are about 1, 2, and 3 mg/l (milligrams per liter, which are equivalent to parts per million; see footnote 1, table 20), according to Scofield (1936).

Except for supplemental supplies pumped from the ground-water reservoir during years of deficient flow (table 16), the Walker River system provides nearly all the irrigation water used in the basin. According to standards presented by the U.S. Salinity Laboratory Staff (1954, p. 79), the river water sampled during this study had a medium salinity hazard and a low sodium hazard (samples a-g, fig. 14), placing it well within the suitable limits for irrigation use. Mean salinity and sodium hazards for samples collected during years of deficient flow, when water quality would be at its worst, do not exceed these limits (unpublished data, U.S. Bureau of Indian Affairs), and the residual Na_2CO_3 (sodium carbonate) content is probably safe. The poorest-quality surface water for irrigation purposes in the valley is found in ditches such as Joggles and Perk Sloughs, which drain the Mason Valley Wildlife Management area, where natural discharge is extensive. In March 1966 the salinity hazard of this water was high, the sodium hazard was very close to medium (sample i, fig. 14), and the residual Na_2CO_3 content was marginal.

Although no surface-water samples collected during the study were analyzed for boron, data from the U.S. Bureau of Indian Affairs suggest that concentrations do not exceed 0.7 mg/l.

Water from wells pumping from the valley-floor alluvial deposits in the Missouri Flat and Mason subareas generally has a medium to high salinity hazard and low sodium hazard (samples 1, 3, 5, 6; fig. 14). In general, ground water from the deeper aquifers is of better quality for irrigation than that of the shallower aquifers. Well 12/26-33cc1, which penetrates channel deposits of the East Walker River in the Missouri Flat subarea, yielded water with a lower salinity hazard than that of the nearby river (12/26-32cb).

Water from wells tapping fan deposits along the south and west edges of the Missouri Flat and Mason subareas has a high salinity hazard and a low to medium sodium hazard (samples 2 and f, fig. 14). Of the five boron analyses for samples in the Missouri Flat and Mason subareas, only one (well 11/25-1bc1, table 20; 2.7 mg/l) exceeds the permissible limit for semitolerant plants.

In general, ground water in the alluvial deposits of the Missouri Flat and Mason subareas is of better quality for irrigation than ground water in the fan deposits.

Water from wells in the valley-fill deposits of the Wabuska subarea has salinity and sodium hazards that range from low (samples 9 and 12, fig. 14) to high (sample 6, fig. 14). Wells west of the river near the boundary between the Yerington and Wabuska subareas yield the best-quality water; in fact, some of this ground water has a lower salinity hazard than that of the river. Well 14/25-33cd1, half a mile north of the Anaconda tailing pond, yielded water with a boron concentration of 1.4 mg/l (table 20), which exceeds permissible limits for sensitive plants. The water

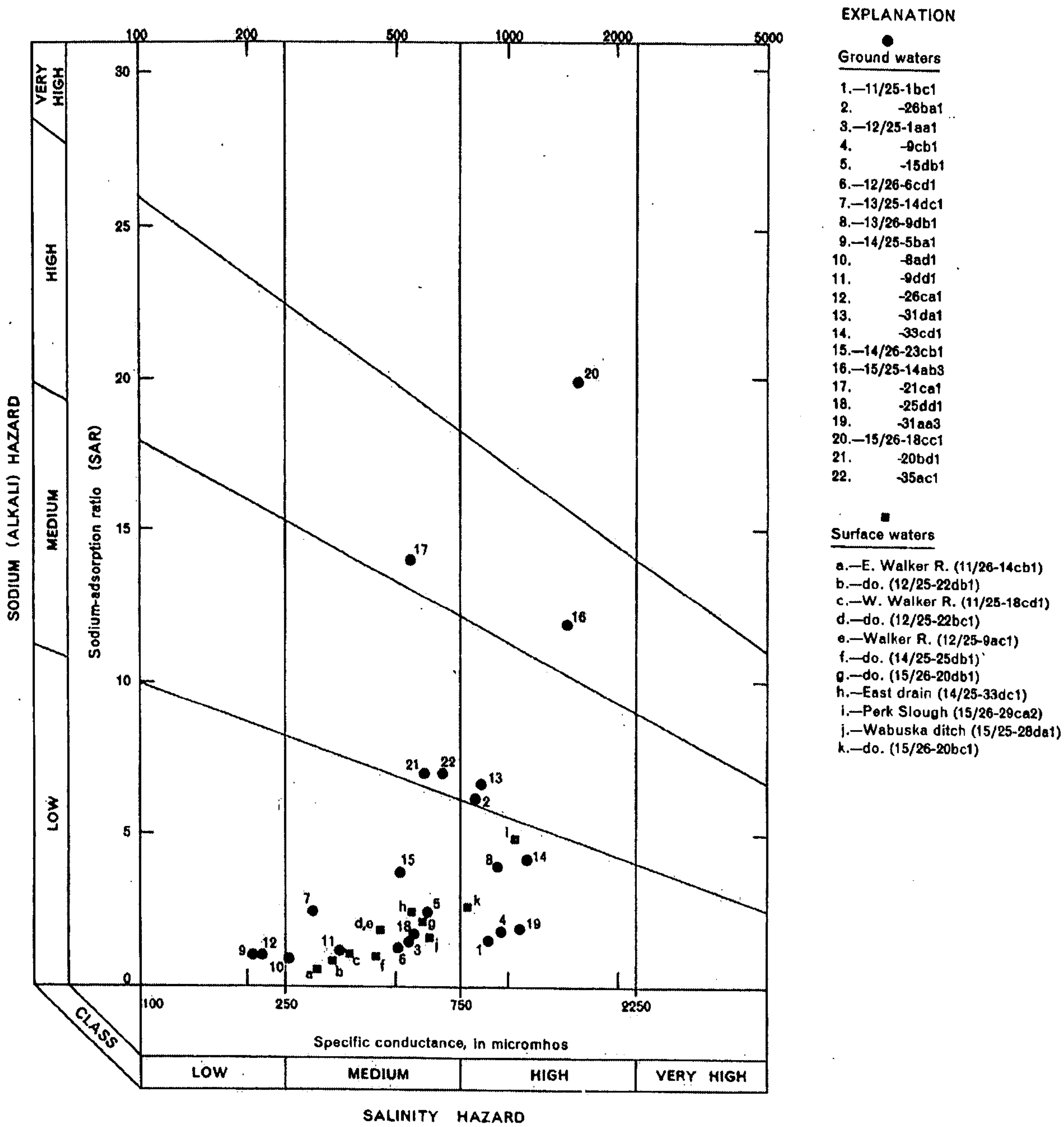


Figure 14.— Classification of selected irrigation water

from well 14/25-31dal, which is derived from fan deposits, contains enough boron (2.7 mg/l) to exceed the limit for semitolerant plants, and the residual Na_2CO_3 concentration probably renders the water unsuitable for most irrigation uses. Springs and flowing wells north of Wabuska yield hot water with a medium to high salinity hazard and a high sodium hazard. This water probably is marginal to unsuitable for irrigation of most crops in Mason Valley. Water from shallow auger holes in the Wabuska subarea has a high salinity hazard and a low to high sodium hazard (samples 19 and 20, fig. 14, and well 15/25-25dcl, table 21). The salinity and sodium hazards in shallow ground water generally decrease with proximity to the Walker River.

Water from most wells in the southern part of the Yerington subarea, especially in the vicinity of Yerington, is of good chemical quality, with a low to medium salinity hazard and a low sodium hazard (sample 7, fig. 14). Well 13/26-9dbl east of Yerington, however, yielded water of high salinity (sample 8, fig. 14). In general, wells pumping from the older alluvium in the Yerington and Wabuska subareas yield water with medium salinity hazard and low sodium hazard. Judging from the poor quality of water in the ditches draining the Wabuska subarea, however, the shallow ground water probably is of marginal quality for irrigation (sample 9, fig. 14).

Suitability for Domestic Use

The limits recommended by the U.S. Public Health Service (1962, p. 7-8) for drinking water used on interstate carriers commonly are cited as standards for domestic use. On the basis of these recommendations, the following substances should not be present in a water in excess of the listed concentrations where more suitable supplies are available:

Constituent	Concentration (milligrams per liter)
Iron (Fe)	0.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	a 1.2
Nitrate (NO_3)	45
Dissolved-solids content	500

a. Based on an average annual maximum daily temperature of about 70°F.

None of the wells sampled contained chloride in excess of 250 mg/l (tables 20-21). Excessive iron, which may impart a bitter and astringent taste to water and may stain laundry and fixtures, was found only in irrigation well 12/26-6cdl, and in domestic wells 14/25-26cal and 31dal, several miles north and northwest, respectively, of Yerington (table 20).

Water from domestic well 11/25-1bcl contains 50 mg/l of nitrate (table 20), which is above the recommended limit. A possible hazard with water containing more than 45 mg/l nitrate is methemoglobinemia, or "blue baby" disease.

Thermal springs, flowing thermal wells, and shallow auger holes in the northern part of the valley (15/25-11ccl, -15cbl, -15cb2, -16ddl, -25dcl, -31aa3, and 15/26-18ccl) were found to contain excessive sulfate. None of them are used for domestic purposes. The analyses indicate that the water is unsuitable also from the standpoint of excessive total dissolved solids.

Water from wells 13/26-9acl, 14/25-31dal, 15/25-15cbl, -15cb2 -16ddl, -27bbl, and 15/26-20bdl contains excessive fluoride (table 20). Fluoride above the recommended limits is known to cause mottled tooth enamel when used by children during the time when permanent teeth are forming.

Excessive hardness in water, although not a health hazard, may adversely affect the water's suitability for cooking and washing. The U.S. Geological Survey uses the following classification of water hardness:

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

On this basis, water from the Walker River system is generally hard, and ground water in the area ranges from moderately hard to very hard.

Relation to Flow System

The kinds and amounts of dissolved constituents in natural waters are determined by several factors, such as the geologic, meteorologic, and hydrologic environments, and the cultural activities of the inhabitants of the area. Except for the geologic environment, all of these factors are dynamic, in that they change with time. The relatively static physical framework through and over which the natural waters of the area move is the geologic environment.

The chemical quality of the ground water in the valley reflects the chemical character of the rocks that comprise the valley-fill reservoir, and the degree to which the valley fill permits movement and circulation of water. For example, the water from well 11/25-26ba1 is high in sodium and low in calcium and magnesium (table 21), reflecting the influence of soda-rich igneous rocks in the Pine Grove Hills. The moderately high specific conductance of this water is characteristic for most of the alluvial-fan deposits, in which ground-water circulation is slow because very little recharge to the ground-water reservoir occurs in the upland areas.

Ground water underlying the valley floor in the Missouri Flat and Mason subareas is primarily a calcium bicarbonate type, reflecting the large quantities of streamflow of similar type that infiltrate the ground-water reservoir. The specific conductance of water beneath the valley floor improves downgradient (north) from the Missouri Flat and Mason subareas because of the increasing amounts of better-quality irrigation water that infiltrate to the ground-water reservoir.

Wells 14/25-33cd1 and 13/26-9ac1 are both downgradient from mining areas in which copper ores are now or were in the past extracted and processed. The moderately high sodium and sulfate content of water from these wells (table 20) probably reflects the influence of the granitic rocks and the associated sulfide ores.

The specific conductance of calcium-magnesium bicarbonate water from several wells in the Wabuska and Yerington subareas is low (see analyses for wells 14/25-3cc1, -5ba1, -8ad1, and -26ca1, tables 20 and 21), and the general quality of the water is better than that of samples collected from the river in March 1966 (see surface-water samples 14/25-25db1 and 14/25-7cb, table 22).

This indicates that the valley fill from which the ground water is pumped is permeable and permits good circulation. The areas of low specific conductance shown in figure 13 correspond with the areas of high sand and gravel ratios and transmissibilities shown in figures 3 and 4, respectively. These facts indicate that substantial quantities of good-quality surface water are able to infiltrate the valley fill during high flows. Later, when somewhat poorer quality water is being carried in the river during low flows, only small quantities enter the valley fill because the sediment has already been saturated by recharge during the preceding spring and summer. Thus, these areas are most favorable for irrigation development by wells.

The high specific conductance of water from shallow wells, auger holes, and drainage ditches in the Wabuska subarea reflects the concentration of salts caused by substantial natural discharge (table 10).

Most water from the flowing thermal wells in the northern part of the Wabuska subarea is a sodium sulfate type, and is markedly different from other ground water in the valley. The flowing wells in the vicinity of Wabuska yield water of substantially lower specific conductance and of a different type than the thermal wells and springs north and east of the town, indicating that the two water types are from different sources.

Effects of Development

Agricultural development in a basin having areas of natural ground-water discharge and inadequate drainage usually is accompanied by a deterioration of water quality. Because past records of ground-water quality are unavailable for Mason Valley, the effects of past development cannot readily be determined. However, as pointed out previously, parts of the Wabuska subarea have become waterlogged as a result of irrigation. Waterlogging has in turn increased the amount of nonbeneficial phreatophytes, which have increased the discharge of water through waste evapotranspiration. This water loss has caused the accumulation of salts in the soil and shallow aquifers, to the detriment of cropfarming.

The recycling of surface and ground water for irrigation, as well as the use of fertilizers, causes a deterioration of quality in a downstream direction. River samples collected at the upstream end of the valley are characteristically of better quality and contain less sodium, sulfate, and chloride than those collected at the downstream end (tables 22-24).

Salt Balance

The salt balance in a basin is the relation between incoming and outgoing solutes. The balance is critical to the long-term maintenance of a successful irrigation operation; it is favorable when the outflow of salts from the basin exceeds the inflow (Hem, 1959, p. 243). In Mason Valley, as in many other developed basins, drains must be maintained through which ground-water discharge and return flow from irrigated fields can reach the river and subsequently flow out of the basin. If the quantity of salts carried by the drainage water leaving the basin is less than the quantity entering, the stranded salts can accumulate within the basin, either in the soil or as constituents of ground water. In either case, the balance is unfavorable and detrimental to the continued practice of irrigation farming. On the other hand, the imbalance can be apparent rather than real if appreciable amounts of salts leave the basin as windblown dust or, to a lesser extent, as components of exported crops.

Although conclusive data are not available on the long-term salt balance in Mason Valley, information supplied by the U.S. Bureau of Indian Affairs (written commun., 1965) shows that salts were lost from the Walker River system within the valley during water years 1960-62:

Water year	Tons of dissolved solids lost (rounded values)
1960	12,000
1961	12,000
1962	20,000

Because 1960-62 was during and immediately following a severe drought, the data are inconclusive in determining long-term conditions. An extension of the information in table 24 suggests that during the long-term period 1948-65, when inflow to the valley averaged about twice the outflow (table 7), the total solute tonnage carried by the inflow may have been somewhat greater than that of the outflow. Unfortunately, though, the discharges recorded in table 24 are all far less than the annual averages (about 300 cfs incoming and 150 cfs outgoing). Furthermore, the importance of solute contributions and losses other than those in the river has not been evaluated. As a result, the inferences may be misleading.

To determine accurately the long-term salt balance in Mason Valley, data should be collected throughout several years of variable wetness. These data would also help determine the degree to which the quality of water leaving the valley for downstream use is deteriorated relative to that of water entering the valley.

SYSTEM YIELD

System yield has been defined by Worts and Malmberg (1967, 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. The system yield cannot exceed the natural inflow to or outflow from the 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 economically and legally each year for beneficial use.

Prior to the first agricultural development in the 1860's, the hydrologic system in Mason Valley was in equilibrium. Over the long term, inflow and outflow were equal, and no net change in storage occurred either in the ground-water reservoir or in surface-water bodies. At the same time that development started in Mason Valley, similar activity was also taking place in basins upstream and downstream. As a result, the inflow of the East and West Walker Rivers to Mason Valley was diminished by upstream diversions. Similarly, the net diversions from the Walker River in Mason Valley decreased the outflow from the valley. In addition to the added crop use, the density and distribution of native phreatophytes increased as ground-water levels rose in response to more extensive infiltration of water from irrigated fields and diversion ditches. Thus, in Mason Valley, the nonequilibrium condition resulting from development caused an increase in the amount of water entering ground-water storage and an even greater decrease in surface-water outflow. In time, a new equilibrium was reached, and net diversions and additional phreatophyte losses equaled the amount by which natural outflow was diminished or diverted for beneficial use.

Another change that disturbed the system was the construction of surface-water storage reservoirs in the 1920's on the upper reaches of the East and West Walker Rivers. The increased regulation of river flow permitted more widespread diversion of water for irrigation, and further diminished surface-water outflow to downstream users. Since the introduction of supplemental pumping from the ground-water reservoir in 1959, the hydrologic system in Mason Valley has undergone another change in equilibrium. Although the period of pumping was too short to have caused large effects, continued and increased pumping in future years could cause profound changes, especially in the characteristics of surface-water flow.

Present conditions in Mason Valley cannot be considered natural, as legal, economic, and physical factors affect the amount of water that may be salvaged and, ultimately, the system yield as defined above. Major physical controls to be considered in evaluating the system yield of Mason Valley include: (1) upstream water rights and use; (2) downstream water rights and use; (3) water rights and use within the valley; (4) long-term salvable natural water losses by evapotranspiration; (5) availability of surface-water outflow for use within the valley; (6) potential for increased pumping; and (7) water quality, including salt balance.

For the 18-year period 1948-65, only about 45,000 acre-feet per year (crop use plus pumpage for minor uses), or 20 percent of the total annual outflow of about 212,000 acre-feet (table 17), was used beneficially within the valley. Downstream users in the Walker Lake basin have rights to nearly 32,000 acre-feet of water of suitable quality for irrigation, of which approximately 9,400 acre-feet must be available each year from natural flow during the 180-day period of April through September (U.S. District Court Decree C-125, 1936). Annual surface-water outflow from Mason Valley through Walker Gap is about 107,000 acre-feet (table 17). The difference between the surface-water outflow at Walker Gap and the amount allocated to Walker Lake basin, or about 75,000 acre-feet, is the maximum amount that theoretically could be diverted during an average year for beneficial use in Mason Valley. This amount, of course, includes flood flows in excess of upstream reservoir capacity, and much of it therefore is not actually available for use.

The next largest budget item that offers the possibility of water salvage for beneficial use is evapotranspiration, which is estimated to total about 57,000 acre-feet per year (table 14). Reduction of this loss probably could be accomplished under the existing methods of farming by conversion of the acreage involved to cropland, except for the lands within the Mason Valley Wildlife Management Area (pl. 1). Adequate drainage would be required, particularly in the low-lying Wabuska subarea. Phreatophytic use along existing canals and laterals, estimated to total 4,000 acre-feet per year (table 14), could be reduced by an eradication program. If ground-water pumping were more widespread during both drought and wet years, a reduction in evapotranspiration losses would occur in response to lowered water levels in phreatophyte areas. However, any substantial program of ground-water development and accompanying water-level decline would have to be evaluated in terms of its effect on the regimen of the Walker River.

The third consideration in the development of the system yield is the limitation imposed by drought periods, such as 1959-62, which is depicted by the water budget in table 18. During this period, the surface-water inflow was only half the long-term average, or about 107,000 acre-feet per year. Surface-water outflow was less than one-fourth the long-term average, or about 25,000 acre-feet per year (which is 7,000 acre-feet less than the downstream entitlement). Water use during the period was about 44,000 acre-feet per year, including an average of about 7,000 acre-feet per year of ground-water pumpage for irrigation (table 18).

The preceding paragraphs lead to several criteria for estimating the system yield: (1) Over both the long term and during a series of drought years, evapotranspiration losses may be about the same; therefore, a large part could be salvaged for beneficial use under either circumstance; (2) without a substantial increase in upstream holdover storage, large quantities of water will continue to flow to Walker Lake during wet periods, and water deficiencies will occur in Mason Valley and in downstream areas during dry periods. Moreover, the quality of water reaching the downstream areas during dry periods is likely to be inferior relative to that during wetter periods; and (3) conjunctive use of ground water and surface water could be effectively increased, particularly during drought periods, such as 1959-62 but on an even larger scale, to help balance the inequitable time distribution of the surface-water supply. However, the water requirements for Walker Lake, which has declined about 2 feet per year (Everett and Rush, 1967, fig. 3) and which is becoming an important recreation area, are not here considered. Accordingly, any appreciable increase in upstream use, of course, would cause an accelerated rate of decline in lake stage.

Using the concepts and limitations presented in the preceding paragraphs, the system yield of Mason Valley can be estimated to the following extent: System yield equals the present use plus salvage of a substantial part of the evapotranspiration loss, plus moderately large ground-water pumpage during periods of drought. Basic controlling assumptions are as follows: Total inflow would average 200,000 acre-feet per year or more over the long term and 100,000 acre-feet per year or more during drought periods; surface-water outflow at Walker Gap during drought periods would not decrease below an average of about 50,000 acre-feet per year, which is about twice the average for 1959-62 (table 17).

The following tabulation demonstrates the possibility of developing a system yield of 100,000 acre-feet per year, the impact of a development of that magnitude on storage depletion during drought years, and the probable distribution of the available water supply for average long-term conditions.

Item	Drought conditions (ac/ft per year)	Average conditions (ac/ft per year)
Total inflow (tables 17 and 18)	108,000	223,000
Surface-water outflow	a -50,000	b -80,000
Available water	58,000	143,000
Possible evapotranspiration loss	c -18,000	c -18,000
Net water supply	40,000	125,000
Surface-water use (1)	d 40,000	b 75,000
Ground-water pumpage (2)	60,000	25,000
Ground-water storage change	-60,000	b,e 50,000
System yield: (1) + (2)	100,000	100,000

a. Possible minimum outflow to meet downstream entitlements (possibly sufficient to maintain water quality).

b. Distribution of the supply among surface-water outflow, surface-water use, and ground-water replenishment would vary widely from year to year, but would total about 200,000 acre-feet in an average year, provided evapotranspiration losses are substantially reduced. The quantities presented actually are only one example of the way in which the supply could be distributed.

c. Assumes that about two-thirds of the evapotranspiration loss of about 57,000 acre-feet per year (table 14) could be salvaged for beneficial use. The Mason Valley Wildlife Management Area would be largely unaffected.

d. Only slightly more than that used during the drought of 1959-62 (table 18).

e. Assumes that pumpage plus evapotranspiration in the average year would deplete storage to the extent shown, and that streamflow would replenish ground water to the same extent, perhaps in large part concurrently. Replenishment would be considerably larger following droughts.

The tabulation and footnotes indicate that many different combinations of water development and distribution are possible. For example, during an average year, if irrigation pumpage were reduced to zero (leaving about 5,000 acre-feet pumpage for other uses), then surface-water use would have to be increased to about 95,000 acre-feet, and the change in ground-water storage might decrease to about 30,000 acre-feet because the reduced ground-water pumpage would in turn reduce the available reservoir space. As another example, if irrigation pumping were nil in an average year, but ground-water reservoir was fully replenished, all water in excess of surface-water use and evapotranspiration loss would be surface-water outflow to downstream areas.

During droughts, an average pumpage of 60,000 acre-feet per year would create a substantial depletion of ground water over a period of years--about 180,000 acre-feet for a 3-year period such as 1959-62. As shown in table 5, the estimated storage capacity in the upper 50 feet of saturation is more than a million acre-feet. Thus, the water in storage is more than ample to sustain a moderately widespread depletion of this magnitude. More critical, however, is the effect of a large ground-water depletion on streamflow, particularly when trying to maintain a surface-water outflow of about 50,000 acre-feet per year during drought years. The placement of irrigation wells throughout the valley and the pumping schedule would be among the factors controlling the magnitude of streamflow depletion.

A system yield of about 100,000 acre-feet per year might be developed in Mason Valley, provided that considerable care and thought are given to development and management of the water supply. Any such undertaking might best be accomplished in several steps over a period of several decades to determine the cause-and-effect relations brought about by each step.

SUMMARY AND CONCLUSIONS

This water-resources appraisal of Mason Valley suggests that, over the long term, a total of about 100,000 acre-feet per year might be developed for beneficial use--about 75,000 acre-feet from the Walker River and about 25,000 from ground water in an average year. This is more than twice the average annual use for the period 1948-65, most of which was for irrigation and was supplied from the river. However, development of a supply of this magnitude could be accomplished only by a substantial decrease in natural evapotranspiration losses and surface-water outflow, and a substantial increase in ground-water pumping. Moreover, such a development should provide for at least 50,000 acre-feet per year of surface-water outflow of acceptable quality to satisfy downstream entitlements.

Under the pattern of development during 1948-65, water use has averaged only about 45,000 acre-feet per year--about 38,000 acre-feet of surface water and about 7,000 of ground water. At the same time, evapotranspiration losses and surface-water outflow have averaged about 57,000 and 108,000 acre-feet per year. For a system yield of 100,000 acre-feet per year, about two-thirds of the evapotranspiration loss and about one-fourth the surface-water outflow would have to be salvaged.

Evapotranspiration losses, however, could not be salvaged wholly by increased pumping and the consequent lowering of water levels to depths below the roots of phreatophytes, because this would unduly deplete the river and the diversion ditches. Replacing the phreatophytes with beneficial crops would salvage most of the lands where evapotranspiration losses now are large, principally in the Wabuska and Yerington subareas. A moderate amount of pumping in these areas would provide water late in the season, as needed, to supplement surface-water diversions.

Surface-water outflow during 1948-65 has ranged from about 24,000 acre-feet in 1961 to 379,000 acre-feet in 1952. The salvaging of 25,000 to 50,000 acre-feet for crop use and ground-water recharge in an average or wet year would pose no problem, but the routing of 50,000 acre-feet through the valley in a drought year could be difficult, considering that the minimum inflow of record was only about 85,000 acre-feet (1961). To provide 100,000 acre-feet during drought years, pumpage would have to be 60,000 acre-feet per year or more. A pumpage of this magnitude for about 3 years would significantly deplete the ground water in storage; it might be equivalent to a valley-wide decline of only 10 feet, but probably several times that much in the areas of concentrated pumping. The effects of large-scale, short-term pumping on river flow could be minimized by placing wells as far from the river as possible. On the other hand, this concept of conjunctive use of surface and ground water also provides for the replenishment of ground water by seepage loss from the river and irrigated fields during wet periods.

In considering the entire river system, of which Mason Valley is only one segment, those concerned with the adminstration and management of the water resources may consider several alternatives, such as:

1. Does the economic possibility for recreation at Walker Lake outweigh the advantages of agricultural and industrial expansion in upstream areas? If so, further upstream development may be limited to salvage of water now wasted by evapotranspiration, with a minimum effect on streamflow. If two-thirds of these losses could be salvaged in Mason Valley without unduly depleting streamflow or affecting the wildlife refuge, crop acreage could be doubled as a result of an increase in water use from the estimated 40,000 acre-feet per year in 1948-65 to 80,000 acre-feet per year.

2. The regimen of the Walker River system could be changed in two principal ways: (1) increased upstream diversions and (2) larger reservoirs for upstream holdover storage. For example, holdover storage probably would reduce flood flows and increase low flows during droughts, which might permit a larger sustained diversion in Mason Valley. On the other hand, upstream diversions might substantially reduce the supply available for diversion in Mason Valley.

3. Conjunctive use of surface and ground water, together with a reduction in the waste by evapotranspiration throughout the Walker River system, would provide a much greater beneficial use of the water resources for all valley segments.

4. Increased use of water, of course, should be evaluated in terms of the salt balance in each valley segment of the Walker River system. Water-quality monitoring stations at key inflow and outflow gaging stations would provide the data needed to analyze the salt balance throughout the river system.

NUMBERING SYSTEM FOR WELLS, SPRINGS, AND SURFACE-WATER SITES

The numbering system used in this report indicates hydrologic sites on the basis of 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; and the third unit, separated from the second by a dash, lists the section number followed by two letters that designate the quarter section and quarter-quarter section, respectively. The northeast quarter of a subdivision is designated by the letter a, the northwest quarter by the letter b, the southwest quarter by the letter c, and the southeast quarter by the letter d. Following the letters, a number indicates the order in which the well or spring was recorded within the 10-acre subdivision. For example, well 12/25-11ca1 is the first well recorded in the NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 11, T. 12 N., R. 25 E., Mount Diablo base line and meridian.

Because of the limitation of space, wells and springs are identified on plate 2 only by that part of the number which designates the subdivision of the section and, if two or more wells are in one subdivision, the order in which the well or spring was recorded in that section. Township and range numbers are shown along the margins of the plate.

Table 25.--Records of selected wells, testholes, and springs

Owner: BLM, Bureau of Land Management; USGS, U.S. Geological Survey
Use: D, domestic; I, irrigation; S, stock; PS, public supply; M, mining;
In, industrial; T, testhole; A, auger hole; U, unused; O, observation;
Ds, destroyed; Sp, spring or seep
Yield: In gallons per minute (gpm)
Altitude: Determined from topographic maps and altimeter measurements
Water-level measurements: Depth in feet below land-surface datum. R, reported
Log number: In files of State Engineer

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement		State log number
								Date	Depth	
11/25- 1ab1	Lazy GF Ranch	1960	400	16	I	2700/79	4,542	3-14-66	55.88	5363
- 1ad1	Bolton Minister	1960	484	18	I	2560/76	4,562	3-15-66	63.84	5362
- 1bc1	Minister Bros.	1948	228	6	D	--	4,522	3-14-66	28.76	5124
- 2bc1	--	1966	11	--	A	--	4,497	3- 8-66	9.00	--
- 9ac1	Cottonwood Ranch	--	--	6	D	--	4,520	3-14-66	16.61	--
- 9ad1	Do.	--	--	6	D	--	4,500	3-13-66	8.76	--
- 9dd1	Stan Simmons	--	--	6	D	2600/75	--	--	--	--
-10db1	Louis Scatena	1961	597	16	I	--	4,565	3-14-66	70.89	5946
-11ac1	William Rouse	1948	257	12	I	--	4,562	3- 7-66	72.37	519
-11bc1	Steve Capurro	1961	532	16	I	2750/50	4,565	3-14-66	78.54	6183
-11cc1	Calmer Johnson	1957	150	12	Ds	--	4,590	--	--	4055
-26ba1	BLM	1941	400	10	S	--	4,820	3-18-66	335	669
-34cd1	Wilson's hot spring	--	--	--	U,Sp	--	--	--	--	--
11/26- 6bb1	--	--	--	48	U	--	4,540	3-14-66	44.61	--
- 6bc1	--	--	65-70	6	U	--	4,540	3-14-66	45.93	--
-20ba1	BLM	1966	260	6	S	--	4,750	8-18-66	220(R)	--
-33ba1	Seagrave and Cox	--	425	--	S	--	4,850	--	--	--
12/25- 1aa1	G. Menesini	1960	306	14	I	2100/27	4,450	3-15-66	32.53	5307
- 1dd1	C. W. Clark, Jr.	1960	355	14	I	2600/44	4,460	3-15-66	37.80	5274
- 2db1	D. B. and Lillian Justice	1961	440	14	I	2400/105	4,427	3-15-66	10.53	5803
- 3bc1	Sceirine Ranches	1961	334	16	I	2800/103	4,415	3-16-66	11.90	5913

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Depth	State log number
12/25- 3dal	L. K. De Chambeau	--	--	6	D	--	4,419	3-15-66	5.82	--
- 9acl	Snyder	--	--	6	D	--	4,420	3-15-66	11.03	--
- 9cbl	Carl Hebrew	1959	121	6	D	25/22	4,450	3-15-66	36.97	4448
- 9dal	Eddie Snyder	1961	307	14	I	1800/129	4,423	3-14-66	10.20	5879
-10cal	Roy Osborne	--	35	14	O	--	4,424	3-14-66	8.87	--
-11bbl	Freitas	--	--	6	D	--	4,427	3-15-66	8.98	--
-11bcl	Diamond A Ranch	--	--	6	--	--	4,430	3-16-66	6.09	--
-11cal	Diamond A Ranch	1961	245	14	I	2500/103	4,436	3-16-66	7.02	5837
-11cdl	R. R. Hamilton	--	--	6	--	--	4,438	3-15-66	6.92	--
-12bal	Harry Lee	--	--	6	D	--	4,442	3-15-66	17.57	--
-12bdl	Harry Lee	1961	364	14	I	1060/50	4,460	3-15-66	33.16	5810
-12cbl	--	--	--	6	D	--	4,440	3-15-66	9.74	--
-12dal	U. Giorgi, Jr.	1957	76	6	D	20/18	4,480	3-14-66	45.23	3796
-14bcl	--	1966	9	--	A	--	4,497	3- 8-66	9.00	--
-14bdl	--	--	--	6	O	--	4,443	3-14-66	5.33	--
-14ccl	Menesini	--	--	6	D	--	4,446	3-14-66	7.00	--
-14ddl	F. A. Glock	1960	272	14	I	1450/104	4,458	3-14-66	11.33	5225
-14dd2	Do.	1960	344	14	I	1450/80	4,458	3-14-66	13.54	5271
-15bbl	--	1966	8	--	A	--	4,434	3-10-66	6.00	--
-15dbl	Dave Menesini	1960	310	14	I	2000/65	4,440	3-14-66	12.45	5314
-21acl	Kay Bunn	--	--	6	D	--	4,460	3-15-66	23.89	--
-23bdl	--	--	--	6	D	--	4,454	3-14-66	5.88	--
-23cdl	Mat Lamorri	1961	325	16	I	2300/118	4,460	3-14-66	8.05	5943
-23dal	Pete Fenili	1960	300	16	I	2200/108	4,465	3-14-66	10.75	5342
-24ccl	Lucky "J" Ranch	1960	370	16	I	2000/58	4,472	3-14-66	10.78	5228
-24cdl	Jamestown Enterprises	1960	106	--	Ds	--	4,485	--	--	5229
-24dcl	Do.	1960	162	16	Ds	--	4,478	--	--	5227
-25cdl	Keller Cattle Co.	1960	435	16	I,D	1800/58	4,487	3-14-66	1.00	6856
-26adl	R. E. West	--	--	4	D	--	4,470	3-14-66	2.15	--
-26bdl	Lucky "J" Ranch	--	--	8	S	--	4,463	3-14-66	5.25	--

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
12/25-27db1	--	1966	10.5	--	A	--	4,460	3-10-66	7.50	--
-33ac1	Wm. Hoskins	1949	68	6	D	--	4,500	4-20-65	20.99	810
-34ca1	--	--	--	--	Sp	--	4,470	--	flowing	--
-35bd1	--	1966	11.5	--	A	--	4,480	3- 9-66	10.50	--
-35dc1	Smith Ranch	1952	253	16	I,O	1250/86	4,500	3- 7-66	10.87	1848
-36aa1	--	1966	10	--	A	--	4,500	3- 8-66	10	--
-36bc1	Dick Heffern	--	--	6	D	--	4,502	3- 9-66	14.27	--
12/26- 3bd1	U.S. Steel	1961	462	8	M	190/50	4,680	3-15-66	274.2	6327
- 4ba1	R. C. Biedebach	1959	270	16	D,I	--	4,560	3-15-66	141.90	4911
- 4bb1	Biedebach	--	800	6	T	--	4,520	3-15-66	104.69	--
- 4bd1	--	1961	1,500	6	T	--	4,540	3-15-66	131.13	--
- 5bb1	--	--	--	6	D	--	4,479	3-15-66	54.44	--
- 6ac1	Clay Carpenter	1960	245	12	Ds	--	4,480	--	--	5347
- 6ba1	--	--	--	6	D,S	--	4,462	3-15-66	42.35	--
- 6bb1	Ugo Giorgi, Jr.	1960	325	14	I	2200/23	4,460	3-15-66	39.83	5287
- 6cd1	C. A. Eller	1960	205	12	I	1845/30	4,483	3-15-66	62.30	5348
-33cc1	Seagraves and Cox	--	--	6	D	--	4,540	--	--	--
-33cc2	Strosnider Ranch	--	220	8	S	--	4,538	3-15-66	15.88	--
12/27- 4bc1	BLM	--	--	6	U	--	5,157	8- 6-65	111.45	--
-17cd1	--	--	--	8	U	--	4,989	8- 6-65	dry	--
-17db1	--	--	--	8	U	--	5,023	--	--	--
-18bc1	BLM	1941	400	8	S	--	4,875	1941	344	--
13/25- 1cc1	McDell Matheson	--	--	6	D	--	4,366	3-16-66	6.94	--
- 1db1	R. W. Densmore	--	100	6	D	--	4,363	11- 1-65	6.62	--
- 3ba1	--	--	--	4	S	--	4,362	3-15-66	9.18	--
- 4ab1	Anaconda Co.	1961	373	14	I	2250/32	4,357	3-15-66	18.84	5949
- 4bb1	Do.	--	--	6	S	--	4,354	3-15-66	9.60	--
- 4bc1	Do.	1965	465	16	M	1490/120	4,357	3-15-66	22.99	8402
- 8aa1	Do.	1959	270	13	M	600/101	4,365	5-28-59	6.5(R)	6130
- 9bb1	Do.	1959	415	14	M	630/36	4,365	10-30-59	5.0(R)	6128

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
13/25- 9da1	Drive-In Theater	--	--	6	D	--	4,390	3-16-66	12.17	--
-10cd1	W. J. Lagomarsino	1960	328	14	I	2700/74	4,375	4- 8-65	7.30	5308
-11cc1	Yerington Airport	1960	100	6	PS	--	4,375	10-29-65	5.50	--
-13ba1	Tom Guild	--	--	6	D	--	4,375	3-16-66	6.05	--
-13ba2	Do.	1950	45	4	S	--	--	--	--	--
-13cc1	Mrs. A. Sciarani	1961	308	16	I	2900/63	4,382	3-16-66	6.27	5942
-13dd1	John A. Connolly	1960	160	14	I	1500/43	4,378	3-16-66	6.10	5320
-14bc1	Yerington High School	1952	60	8	PS	--	4,379	3- 7-66	3.37	2057
-14ca1	City of Yerington	1963	330	16	PS	2200/55	4,382	4- 8-65	7.27	7277
-14dc1	Luigi Lommori	1961	329	16	I	3500/27	4,384	11- 1-65	3.47	5941
-15bb1	Victor Tamagni	--	--	4	U	--	4,378	3-28-66	5.42	--
-15cb1	--	--	--	6	U	--	4,388	3-28-66	9.48	--
-15cc1	G. S. Williams	1960	302	16	I	2725/74	4,382	3-16-66	8.86	5519
-15cd1	Snyder	--	--	6	U	--	4,384	3-16-66	7.76	--
-15da1	City of Yerington	--	--	16	PS	--	4,384	3-16-66	7.30	--
-16aa1	--	--	--	6	--	--	4,395	3-28-66	19.11	--
-16ad1	--	--	--	6	D	--	4,395	3-28-66	13.76	--
-17aa1	Anaconda Co.	1960	610	14	M	595/81	4,480	3-22-60	100(R)	6129
-21aa1	G. S. Williams	1925	60	6	D,S	--	4,383	3-16-66	12.45	--
-21ab1	Anaconda Co.	1952	314	12	M	500/--	--	4-24-52	70(R)	1915
-21ab2	Do.	1952	240	14	M	600/--	--	8-29-52	40(R)	2423
-21ac1	Do.	1952	320	14	M	658/0	--	11- 6-52	34(R)	2424
-21ad1	G. S. Williams	1961	297	16	I	2750/44	4,390	3-16-66	8.85	5939
-21bd1	Anaconda Co.	1952	349	14	M	--	--	4-29-52	71(R)	1914
-21da1	Peoples Market	1939	90	12	In	--	4,400	4- 8-65	9.39	223
-22cd1	Rio Vista Ranches Assn.	--	26	2	U	--	4,390	3-16-66	5.36	--
-22cd2	Do.	1964	300	8	D	500/37	4,390	3-16-66	3.86	7971
-23dd1	W. Seyden	1961	308	14	I	2800/57	4,394	3-16-66	5.88	5811
-24aa1	Henry Washburn	--	60	6	D	--	4,379	3-16-66	5.60	--
-24ac1	Connolly and Washburn	1960	200	14	I	3000/67	4,390	3-16-66	5.92	5346

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
13/25-24bb1	A. J. Frade	1950	200	8	In	--	--	--	--	--
-24bc1	Antone Frade	1960	326	14	I	2800/34	4,390	3-16-66	4.46	5356
-24bc2	--	--	--	16	I	--	4,390	3-16-66	5.84	--
-25ba1	Lyon County	--	--	6	D	--	4,410	3-16-66	9.53	--
-25cd1	Giorgi Bros.	--	45	6	S	--	4,425	11- 1-65	14.68	--
-26cb1	E. Petroni	1960	200	12	I	--	4,403	3-16-66	9.22	5168
-26cc1	--	--	--	6	D	--	--	--	--	--
-27db1	Domenici	--	47	6	U	--	4,400	3-16-66	6.16	--
-28dd1	Folsom	--	--	6	U	--	4,400	3-15-66	5.86	--
-33bd1	Vernon Peterson	1960	155	12	PS	--	4,475	3- 5-60	70(R)	5109
-33db1	R. M. Cates	1961	140	8	D,I	--	4,420	3-15-66	17.91	5705
-34aa1	--	--	--	6	D	--	4,405	3-16-66	8.60	--
-34ca1	Anne Lucas	--	--	6	U	--	4,406	3-16-66	4.65	--
-35cc1	A. J. Pederson	1961	417	16	I	2800/28	4,415	5-23-61	57(R)	5914
-35db1	Tony Masini	1961	330	16	I	2400/148	4,415	3-15-66	10.55	5878
-36dc1	Louie Menesini	1960	271	14	I	2100/23	4,434	3-15-66	14.63	5231
13/26- 2aa1	R. D. Lance	1964	130	8	D	15/--	4,463	3-16-66	122.90	8214
- 2ba1	Luther Reese	1957	150	12	I	--	4,420	3-16-66	84.18	--
- 2bb1	Carrol Haskins	1961	203	12	I	126/115	4,408	3-16-66	69.48	6292
- 5db1	Jamestown Enterprises	1960	333	14	I	2500/43	4,356	3-16-66	7.86	5357
- 6da1	Vaughan B. Silva	1961	241	14	I	2350/97	4,358	3-30-66	5.68	5940
- 7da1	Leonard Fox	1961	300	16	I	2700/108	4,365	6-23-61	9(R)	5986
- 7dc1	L. A. Fox Ranch	--	--	6	D,S	--	4,370	3-16-66	8.06	--
- 8ac1	A. A. Joplin	--	--	6	D	--	4,360	3-16-66	9.05	--
- 8dd1	--	--	--	6	--	--	4,370	3-16-66	23.15	--
- 9ab1	E. E. Willhoyt	1958	160	12	I	900/30	4,355	3-16-66	15.33	5561
- 9ac1	Moffitt	1956	60	6	D	--	4,365	6- 8-65	14(R)	--
- 9ca1	H. H. Thurston	--	41	6	U	--	4,368	3-16-66	22.06	--
- 9cd1	Smith	1966	38	6	D	--	4,338	6- 6-66	33.50	--
- 9db1	H. H. Thurston	1956	166	12	I	1050/--	4,380	10-29-65	45.15	4358

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Depth	State log number
13/26-17aa1	W. E. Bryan	--	130	6	D	--	4,370	3-16-66	16.00	--
-18db1	A. J. Frade	1964	273	14	I	2200/90	4,375	5-20-64	12(R)	7863
-31dc1	Sam Johnston	1960	172	12	I	--	4,457	3-15-66	42.5	5520
-32cc1	B. Oldbury	1960	138	10	I	650/20	4,463	3-16-66	41.65	5321
-33cc1	U.S. Steel Co.	--	--	6	T	--	4,514	3-15-66	105.07	--
-34bc1	--	--	--	6	S	--	4,569	3-15-66	174.16	--
13/27- 8ca1	BLM	1942	274	8	S	--	4,885	1942	150(R)	--
-16ad1	--	--	--	4'x4'	U	--	5,255	8- 6-65	7.64	--
-32db1	BLM	1960	--	6	S	--	5,128	8- 6-65	86.01	--
14/24-12aa1	Ahlswede Ranch	1961	24	6	U	--	4,319	3-14-66	6.38	6024
14/25- 1ad1	Sierra Pacific Power Co.	1966	595	--	In	2600/58	4,310	--	--	--
- 2ac1	St. Isadore Ranch	1961	500	14	I	3000/90	4,320	3-14-66	3.70	5805
- 3ad1	Herb Penrose	--	52	6	S	--	4,320	3-14-66	4.68	--
- 3cc1	Archie Johnson	1959	60	6	D	--	--	6- 9-65	7(R)	--
- 3dc1	Robert Brown	--	120	6	S	--	4,322	10-26-65	7.28	--
- 3dd1	Robert Brown	--	85	6	D	--	4,323	3-14-66	6.12	--
- 4ba1	George McMaster	--	--	6	S	--	4,315	3-14-66	4.34	--
- 4bd1	Do.	1960	438	16	I	--	4,316	3-14-66	4.24	7762
- 4da1	Larry Masini	1960	585	16	I	2400/34	4,319	3-14-66	4.88	5230
- 4dd1	I. E. Bowdish	1963	100	12	I,D	--	4,320	3-14-66	6.44	7126
- 5ba1	George McMaster	--	--	6	S	--	4,312	3-14-66	3.98	--
- 6ba1	--	--	--	8	U	--	4,312	3-14-66	3.34	--
- 6dd1	Calmer J. Johnson	1964	400	14	I	2700/62	4,315	3-14-66	2.62	8001
- 8ad1	Ted Faber	1960	523	16	I	2200/28	4,320	3-14-66	5.29	5521
- 8bd1	A. C. Ahlswede	--	40	6	S	--	4,318	3-15-66	6.61	--
- 8cc1	Do.	--	--	6	D	--	4,320	3-15-66	4.90	--
- 8da1	George McMaster	--	75	6	U	--	4,320	3-14-66	5.77	--
- 8dc1	Ahlswede Ranch	1960	418	16	I	--	4,319	3-15-66	5.26	6857
- 9dd1	Hill and Compston	1961	280	16	I	1500/54	4,330	3-28-66	8.25	6138
- 9dd2	Compston	--	83	4	D	--	4,330	3-14-66	13.98	--

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement Date	Depth	State log number
14/25-11bal	Herb Penrose	--	53	6	S	--	4,327	3-14-66	5.84	--
-11bdl	Do.	--	60	6	S	--	4,330	3-14-66	6.50	--
-11cal	Do.	--	--	6	D	--	4,335	10-27-65	6.61	--
-11dbl	Do.	--	--	6	S	--	4,340	3-14-66	12.36	--
-15cdl	W. D. Colburn	1960	286	14	I	2600/114	4,345	3-14-66	9.31	5286
-16ddl	J. P. Peeples, Jr.	1960	225	16	I	1785/52	4,343	3-14-66	9.63	6394
-17cal	Dixon	--	32	4	D	--	4,330	4- 7-65	6.80	--
-18dcl	--	--	73	10	U	--	4,345	3-14-66	20.59	--
-19acl	BLM	1958	120	8	S	--	4,400	3-15-66	68.38	--
-20abl	--	--	--	--	U	--	4,335	3-14-66	7.16	--
-20cdl	--	--	--	6	D	--	4,360	10-27-65	27.10	--
-20dbl	--	--	--	6	D	--	4,350	10-27-65	17.36	--
-22acl	C. W. Twombly	--	--	4'x4'	D	--	4,345	11- 1-65	4.67	--
-22cbl	Do.	--	80	6	D	--	4,340	3-15-66	7.41	--
-25acl	St. Isadore Ranch	1961	417	14	I	2000/46	4,340	10-28-65	4.70	5804
-26cal	--	--	--	6	D	--	4,350	3-15-66	5.10	--
-27abl	Twombly Ranch	--	--	6	S	--	4,348	3-15-66	7.40	--
-27acl	Twombly-Poli Ranch	1960	319	16	I	2200/108	4,349	3-15-66	9.80	5793
-28ddl	--	--	--	4	U,O	--	4,348	3-15-66	5.99	--
-29dbl	C. J. Simmons	1960	150	10	I,D	50/5	4,390	3-15-66	48.49	5608
-31dbl	--	--	117	8	S	--	4,440	10-27-65	80.20	--
-32bdl	--	--	--	84	S	--	4,355	3-15-66	14.52	--
-33adl	Herbert Penrose	1960	250	12	I,D	1250/60	4,355	3-15-66	19.65	--
-33cdl	--	--	--	6	D	--	--	--	--	--
-34cbl	Antone Farias	1961	358	16	I	2500/61	4,360	3-15-66	14.00	5944
14/26- 3acl	Gene Bingeman	1964	75	16	I	--	4,320	3-16-66	5.77	8104
- 3dbl	Do.	1959	160	12	I	500/10	--	5- 1-59	2(R)	4756
-13dcl	USGS	1964	95	1½	T	--	4,400	3-16-66	53.38	--
-14ddl	Clinton D. Journey	1958	63	10	I,D	--	4,350	3-16-66	25.22	3983
-15aal	A. Burgess	1961	158	12	I	--	4,328	3-16-66	2.48	5868

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
14/26-18ba1	Nevada Fish and Game Commission	1961	550	16	I	4000/74	4,327	3-15-66	3.94	--
-22bd1	Juanita Bybee	1961	176	12	I	--	4,338	3-30-66	3.90	5867
-22da1	Clarence Johnson	1963	112	6	D	--	4,338	10-28-65	6.50	--
-22dd1	Do.	1958	96	12	I	550/00	4,340	3-16-66	9.55	4234
-23bc1	Ruth E. Ogden	1964	140	16	I	--	4,336	3-30-66	5.80	8103
-23cb1	R. D. Ogden	1960	75	6	D	--	--	--	--	--
-23cc1	Do.	1950	135	12	I,D	--	4,342	3-16-66	8.42	4992
-26ac1	Lonnie Glen	1960	151	10	D	800/10	4,395	10-28-65	56.78	--
-26ac1	Do.	1959	157	12	I	--	4,405	3-16-66	74.00	4786
-26bc1	Vernon Lambert	--	100	6	D	--	4,370	3-16-66	35.72	--
-26bd1	Do.	1953	160	12	I	--	4,390	3-16-66	48.32	4088
-26cd1	Larimer Henry	1964	250	12	I	--	4,415	3-16-66	74.81	7907
-29db1	John Ritter	--	68	4	U	--	4,344	3-15-66	6.70	--
-31cd1	Angela Aiazzi	1961	329	14	I	2400/70	4,355	3-15-66	8.37	5838
-31dc1	John Ritter	1960	241	16	I	2250/76	4,355	3-15-66	6.88	5315
-32ac1	Joseph Landolt	1964	73	8	D	50/--	4,349	3-15-66	6.37	7965
-32ad1	Joe Menesini	1961	308	14	I	2000/53	4,350	3-15-66	5.21	5822
-32bb1	O. D. Gable	--	288	6	D	--	4,350	11- 1-65	5.58	--
-32bc1	Do.	1960	120	12	I	--	4,350	3-15-66	5.16	5319
-32bd1	J. Manha	1949	104	6	D	20/64	4,350	3-15-66	6.60	1031
-32ca1	Do.	1960	140	12	I	1000/36	4,352	3-15-66	6.60	5419
-34ad1	R. F. Douglas	1960	200	12	I	--	4,405	3-15-66	71.29	5474
-34ca1	Bradway	1955	48	12	I,D	580/19	--	3-16-66	40.46	3885
-34cd1	George Conn	1958	120	12	I	520/--	4,380	3-16-66	42.51	4136
-34dc1	Arthur Adams	1957	190	10	I,D	350/30	--	1- -57	67(R)	5634
-35aa1	J. A. McKenzie	1964	330	14	I	--	4,480	3-16-66	124.90	8005
-35ad1	Do.	1959	262	12	I,D	300/--	4,475	3-16-66	144.83	4991
-35bc1	R. N. Powell	1958	215	10	I	--	4,415	3-16-66	83.70	4217
14/27- 8ac1	USGS	1964	52	1½	T	--	4,310	3-16-66	43.20	--
- 9bb1	Do.	1964	62	1½	T	--	4,280	3-16-66	52.26	--

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diam-eter (inches)	Use	Yield(gpm)/drawdown (feet)	Altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
14/27-17dd1	BLM	1941	260	6	S	--	4,505	5-11-65	200.50	--
15/24-12dd1	USGS	1964	22	1½	T	--	4,287	3-14-66	16.49	--
15/25-11cc1	BLM	1938	--	1½	S	2/--	4,315	--	flowing	--
-14ab1	--	--	145	2	S	--	4,315	2-17-66	flowing	--
-14ab2	--	--	500	6	S	25/--	4,315	2-17-77	flowing	--
-14ab3	--	--	145	2	S	25/--	4,315	2-17-66	flowing	--
-14ab4	--	--	118	2	S	25/--	4,315	2-17-66	flowing	--
-15cb1	--	--	--	10	S	400/--	4,300	3- 8-66	flowing	--
-15cb2	--	--	2,223	10	S	25/--	4,300	3- 8-66	flowing	--
-16dd1	--	--	--	10	S	400/--	4,300	3- 8-66	flowing	--
-18cd1	USGS	1964	22	1½	T	--	4,293	3-14-66	10.61	--
-19ca1	BLM	1945	121	6	S	--	4,300	3-29-66	7.75	--
-21ca1	--	--	400	6	U	200/0	4,298	2-16-66	flowing	--
-23cb1	--	1966	7	--	A	--	4,298	2-24-66	3.75	--
-25dc1	--	1965	18	--	A	--	--	2-25-66	14.04	--
-25dd1	--	1965	35	--	A	--	--	2-25-66	6.27	--
-26cd1	Mason Valley Ranch	--	50	8	U	--	4,304	3- 7-66	2.58	--
-27ab1	--	1966	10	--	A	--	4,299	2-24-66	6.56	--
-27bb1	--	--	--	6	U	--	--	--	flowing	--
-28ad1	Arthur Lee	--	350	2	U	1/0	4,300	3-15-66	flowing	--
-28ad2	Do.	1890's	1,000	6	D	15/--	4,300	3-15-66	flowing	--
-31aa1	George McMaster	--	60	10	--	--	4,300	3-14-66	2.84	--
-31aa2	--	--	--	2	U	1/--	--	10-26-65	flowing	--
-31aa3	--	1966	6	--	A	--	4,300	2-25-66	2.71	--
-31cb1	--	--	177	1½	U	--	4,315	3-16-66	.30	--
-32aa1	Jones	--	180	6	U	--	--	10-26-65	flowing	--
-32ad1	Alfred Palmer	1962	460	16	I	1974/135	4,302	3-16-66	2.45	6819
-34bc1	--	--	--	4	D,S	--	4,309	3-14-66	7.88	--
-34cc1	--	--	--	--	D	--	--	3-30-66	flowing	--
-35aa1	Bolster Ranch	--	--	6	D,S	--	4,307	3-14-66	1.96	--

Table 25.--Continued

Well number	Owner	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield(gpm)/ drawdown (feet)	Altitude (feet)	Water-level measurement		State log number
								Date	Depth	
15/25-35aa2	Bolster Ranch	1965	--	6	S	2/--	4,306	3-14-66	flowing	--
15/26-10bd1	BLM	1955	103	6	S	--	4,330	5-11-65	66.15	3379
-18cc1	--	1966	13	--	A	--	4,300	2-24-66	8.85	--
-18cd1	--	1966	5	--	A	--	4,308	2-24-66	1.80	--
-19ad1	--	--	--	--	Sp	2/--	--	--	flowing	--
-20bd1	J. F. Julian	--	84	6	D,S	--	--	--	--	--
-21cb1	USGS	1964	32	1½	T	--	4,312	3-16-66	25.07	--
-26dd1	Do.	1964	42	1½	T	--	4,310	3-16-66	39.02	--
-35ac1	Do.	1964	42	1½	T	--	4,315	3-16-66	25.27	--

Table 26.--Selected drillers' logs of wells in Mason Valley

Material	Thickness (feet)	Depth (feet)
11/25-26bal U.S. Bureau of Land Management		
Boulders, loose, and gravel	50	50
Boulders, big, and hardpan	55	105
Gravel, coarse, running	3	108
Hardpan and boulders	47	155
Boulders	62	217
Rock, large	18	235
Boulders	10	245
Gravel	20	265
Gravel and clay	55	320
Gravel, small, very little clay	10	330
Gravel	15	345
12/25-11cal Diamond A Ranch		
Surface sand, gravel, and boulders	50	50
Sand, coarse, and boulders	50	100
Sand, coarse, and small rocks	26	126
Gravel and boulders	44	170
Sand, coarse, with streaks of clay and boulders	50	220
Sand, coarse, and boulders	10	230
Rock	15	245
12/25-15dbl Dave Menesini		
Topsoil and clay streaks	18	18
Gravel and coarse sand	24	42
Sand, coarse	8	50
Gravel and coarse sand	6	56
Sand and boulders	81	137
Gravel, sand, and clay	83	220
Gravel and sand	28	248
Sand, gravel, and clay streaks	15	263
Boulders and gravel	17	280
Gravel and sand	30	310
Clay, sand, and gravel	22	332
12/25-25cdl Keller Cattle Co.		
Clay, sticky	10	10
Clay, sandy	12	22
Clay, sandy, and gravel	8	30
Clay, sandy, gravel, and boulders	12	42
Sand, coarse, gravel, and boulders	108	150
Clay, sandy, brown, and gravel	205	355
Clay, sandy, green, and gravel	80	435
12/26-4bal R. C. Biedebach		
Sand	6	6
Gravel	34	40
Sandstone, brown	20	60
Boulders	20	80
Volcanic rock, hard	12	92
Rock, hard	23	115
Granite, very hard	35	150
Clay	13	163
Lava and quartz rock	17	180
Granite, very hard	22	202
Sandstone, slightly water-bearing	13	215
Sandstone and granite	55	270
Clay (bentonite)	5	275
13/25-14cal City of Yerington		
Topsoil	5	5
Clay	15	20
Sand	45	65
Clay	15	80
Sand and gravel	205	285
Sand and gravel with clay streaks	45	330

Table 26.--Continued

Material	Thickness (feet)	Depth (feet)
13/25-35ccl A. J. Pederson		
Clay	5	5
Sand and clay	5	10
Clay	8	18
Gravel and boulders	21	39
Sand and gravel	48	87
Sand and boulders	53	140
Gravel and sand	55	195
Sand and boulders	25	220
Gravel and boulders	30	250
Boulders	34	284
Sand, some boulders and small gravel with thin streaks of brown clay	132	416
Rock, hard	1	417
13/26-5dbl Jamestown Enterprises		
Clay	7	7
Gravel and sand with streaks of clay	43	50
Clay with streaks of sand	10	60
Sand with streaks of clay	25	85
Clay with streaks of sand	27	112
Sand and soft mud	31	143
Clay with streaks of sand	19	162
Sand and gravel	28	190
Sand and fine gravel	13	203
Gravel with streaks of sandy clay	64	267
Sand with streaks of clay	19	286
Sand	9	295
Sand and boulders with streaks of clay	22	317
Clay, sandy	12	329
Rock	4	333
14/25-4dal Larry Masini		
Surface soil and sand	20	20
Sand, coarse, and clay	60	80
Sand, fine, gravel, and clay	25	105
Sand, fine, and clay	25	130
Gravel, coarse, and clay streaks	20	150
"Trees," coarse gravel, and clay	40	190
Sand, coarse, and clay	25	215
Sand, coarse, and gravel	20	235
Sand and clay	25	260
Sand and clay streaks	20	280
Sand, coarse, and gravel	110	390
Gravel and clay	45	435
Gravel, coarse, and clay	45	480
Gravel, coarse, and clay streaks	20	500
Gravel and sand	60	560
Gravel and clay	25	585
14/25-27acl Twombly-Poli Ranch		
Topsoil	7	7
Sand and small gravel	33	40
Gravel, large	35	75
Gravel, coarse, and clay	74	149
Gravel and coarse sand	67	216
Gravel and sand	22	238
Gravel and clay streaks	47	285
Clay and sand	10	295
Sand, coarse	15	310
Gravel and sand	8	318
Clay	1	319

Table 26.--Continued

Material	Thickness (feet)	Depth (feet)
14/26-18ba1 Nevada Fish and Game Commission		
Sand and fine gravel	20	20
Sand and gravel	20	40
Gravel, coarse	15	55
Clay, blue, and gravel	15	70
Clay, soft, and gravel	20	90
Sand and gravel plus clay	55	145
Sand, coarse, and gravel	40	185
Sand and clay streaks	120	305
Sand and boulders	8	313
Sand, gravel, and clay	47	360
Clay (sand and clay)	20	380
Sand, gravel, and clay	20	400
Sand	20	420
Sand and some clay	20	440
Sand and clay streaks	72	512
Sand, coarse with fine gravel	5	517
Clay, sand, and gravel - mostly clay	33	550
14/26-27bd1 Juanita Bybee		
Topsoil	4	4
Sand	4	8
Clay, brown	3	11
Sand	5	16
Clay, blue	2	18
Sand and birdseye gravel	22	40
Clay	3	43
Sand and gravel	18	61
Sands	26	87
Clay, brown	6	93
Gravel	15	108
Clay, gray	3	111
Sand, coarse	15	126
Clay, brown	4	130
Sand and small gravel	46	176
15/25-32ad1 Alfred Palmer		
Topsoil and sandy clay	7	7
Clay	5	12
Sand, coarse	5	17
Sand, medium, and clay	28	45
Clay, blue, some sand	15	60
Sand, gravel, and clay	14	74
Gravel, coarse	44	118
Streaks of sand, gravel, and clay	149	267
Mostly clay, fine sand	45	312
Clay, sandy, and some coarse gravel	38	350
Clay, sandy, gravel and boulders	40	390
Gravel, coarse, clean	35	425
Clay, blue	35	460

REFERENCES CITED

Davis, G. H., Green, J. H., Olmstead, F. H., and Brown, D. W., 1959, Ground-water conditions and storage capacity in the San Joaquin Valley, California: U.S. Geol. Survey Water-Supply Paper 1469, 287 p.

Eakin, T. E., and others, 1951, Contributions to the hydrology of eastern Nevada: Nevada State Engineer, Water Resources Bull. 12, 171 p.

Eakin, T. E., Moore, D. O., and Everett, D. E., 1965, Water-resources appraisal of the upper Reese River Valley, Lander and Nye Counties, Nevada: Nevada Dept. Conserv. and Nat. Resources, Water Resources - Reconn. Ser. Rept. 31, 47 p.

Everett, D. E., and Rush, F. E., 1967, A brief appraisal of the water resources of the Walker Lake area, Mineral, Lyon, and Churchill Counties, Nevada: Nevada Dept. Conserv. and Nat. Resources, Water Resources - Reconn. Ser. Rept. 40, 44 p.

Hem, J. D., 1959, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 269 p.

Hill, J. M., 1915, Some mining districts in northeastern California and northwestern Nevada: U.S. Geol. Survey Bull. 594, 200 p.

Holmes, G. H., Jr., 1966, Water requirements and uses in Nevada industries: U.S. Bur. Mines Inf. Circ. 8288, 66 p.

Houston, C. E., 1950, Consumptive use of irrigation water by crops in Nevada: Nevada Univ. Agr. Expt. Sta. Bull. 185, 27 p.

Johnson, A. I., 1966, Specific yield--compilation of specific yields for various materials: U.S. Geol. Survey open-file report, 119 p.

Kohler, M. A., Nordenson, T. J., and Baker, D. R., 1959, Evaporation maps for the United States: U.S. Weather Bur. Tech. Pub. 37, 13 p.

Knopf, Adolf, 1918, Geology and ore deposits of the Yerington District, Nevada: U.S. Geol. Survey Prof. Paper 114, 68 p.

Meinzer, O. E., 1923, Outline of ground-water hydrology, with definitions: U.S. Geol. Survey Water-Supply Paper 494, 71 p.

Moore, J. G., 1961, Preliminary geologic map of Lyon, Douglas, Ormsby, and part of Washoe Counties, Nevada: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-80.

Morrison, R. B., 1964, Lake Lahontan: Geology of the southern Carson Desert: U.S. Geol. Survey Prof. Paper 401, 156 p.

Robinson, T. W., 1958, Phreatophytes: U.S. Geol. Survey, Water-Supply Paper 1423, 84 p.

Ross, D. C., 1961, Geology and mineral deposits of Mineral County, Nevada: Nevada Bur. Mines Bull. 58, 98 p.

Russell, I. C., 1885, Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada: U.S. Geol. Survey Mon. 11, 288 p.

Scofield, C. S., 1936, The salinity of irrigation water: Smithsonian Inst. Ann. Rept., 1935, p. 275-287.

Smith, D. T., 1904, Geology of the upper region of the main Walker River: California Univ., Dept. Geology Bull., v. 4, p. 1-32.

Smith, R. T., Kock, E. C., and McCormick, J. A., 1940, Report of the physical survey of the Mason Valley Soil Conservation District, Nevada: U.S. Dept. Agriculture, 59 p.

Thomas, H. E., 1962, The meteorologic phenomenon of drought in the southwest: U.S. Geol. Survey Prof. Paper 372-A, 43 p.

U.S. Geological Survey, 1960, Compilation of records of surface waters of the United States through September 1950; pt. 10, The Great Basin: U.S. Geol. Survey Water-Supply Paper 1314, 485 p.

_____ 1963, Compilation of records of surface water of the United States, Oct. 1950-Sept. 1960, pt. 10, The Great Basin: U.S. Geol. Survey Water-Supply Paper 1734, 318 p.

U.S. Geological Survey, 1961-64, Surface water records for Nevada: U.S. Geol. Survey Ann. Reports.

_____1965, Water resources data for Nevada: U.S. Geol. Survey Ann. Report.

U.S. Public Health Service, 1962, Drinking water standards, 1962: U.S. Public Health Service Pub. 956, 61 p.

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. Agriculture Handb. 60, 160 p.

White, W. N., 1932, A method of estimating ground-water supplies based on discharge by plants and evaporation from soil; results of investigations in Escalante Valley, Utah: U.S. Geol. Survey Water-Supply Paper 659-A, 105 p.

Worts, G. F., Jr., and Malmberg, G. T., 1967, Water-resources appraisal of Eagle Valley, Ormsby and Douglas Counties, Nevada: Nevada Dept. Conserv. and Nat. Resources, Water Resources - Reconn. Ser. Rept. 39, 55 p.

Young, A. A., and Blaney, H. F., 1942, Use of water by native vegetation: California Dept. Pub. Works, Water Res. Div. Bull. 50, 154 p.

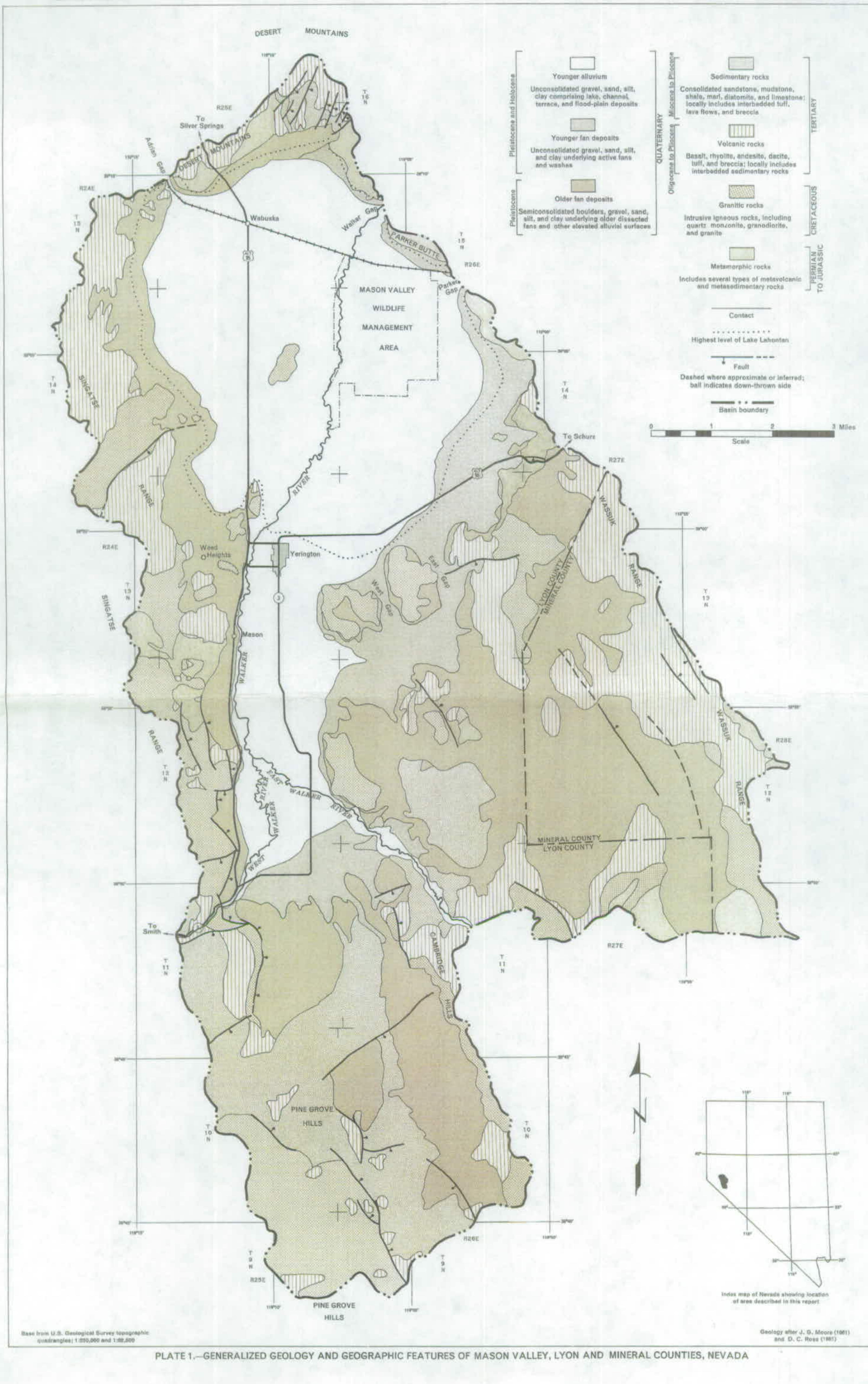
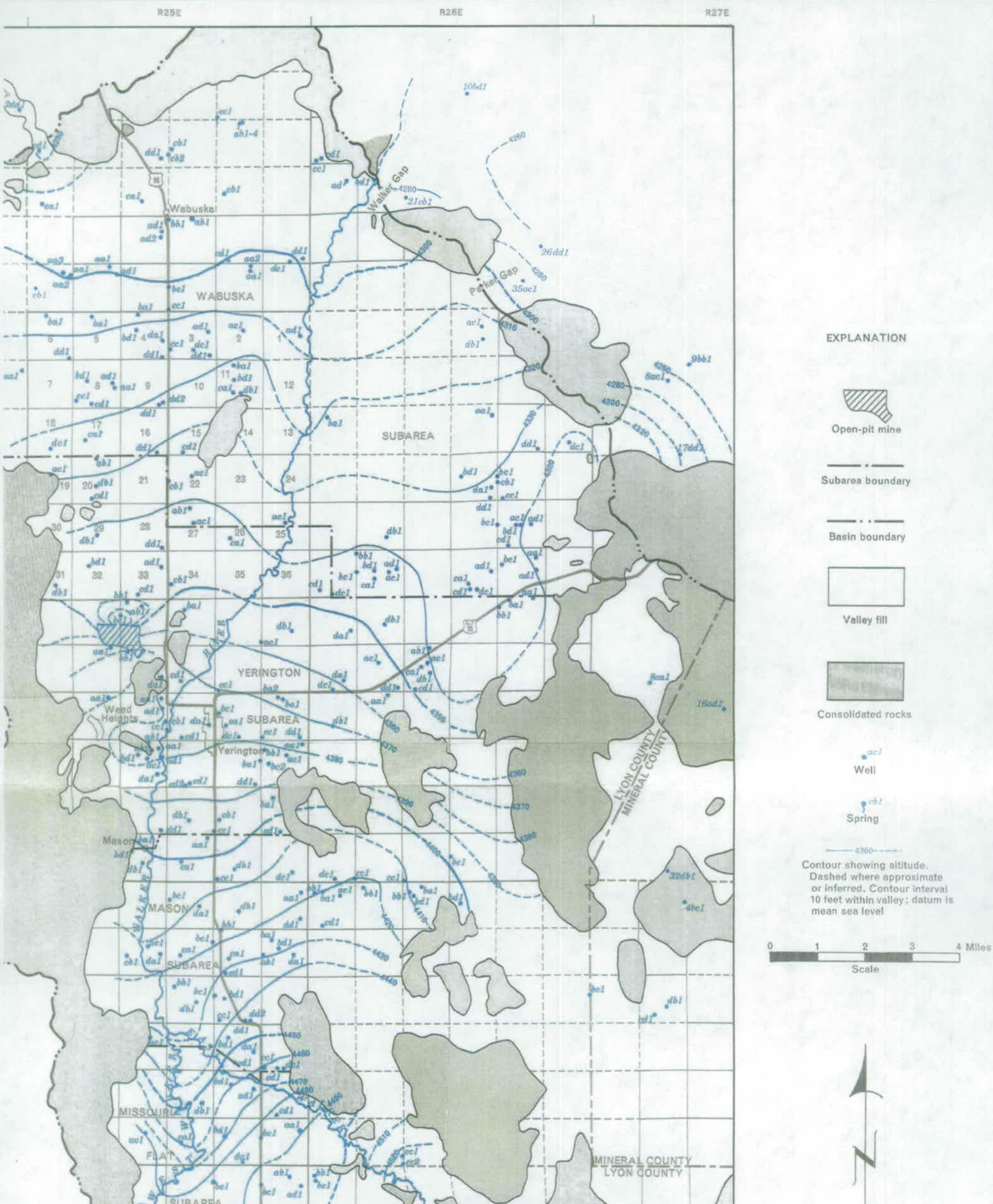


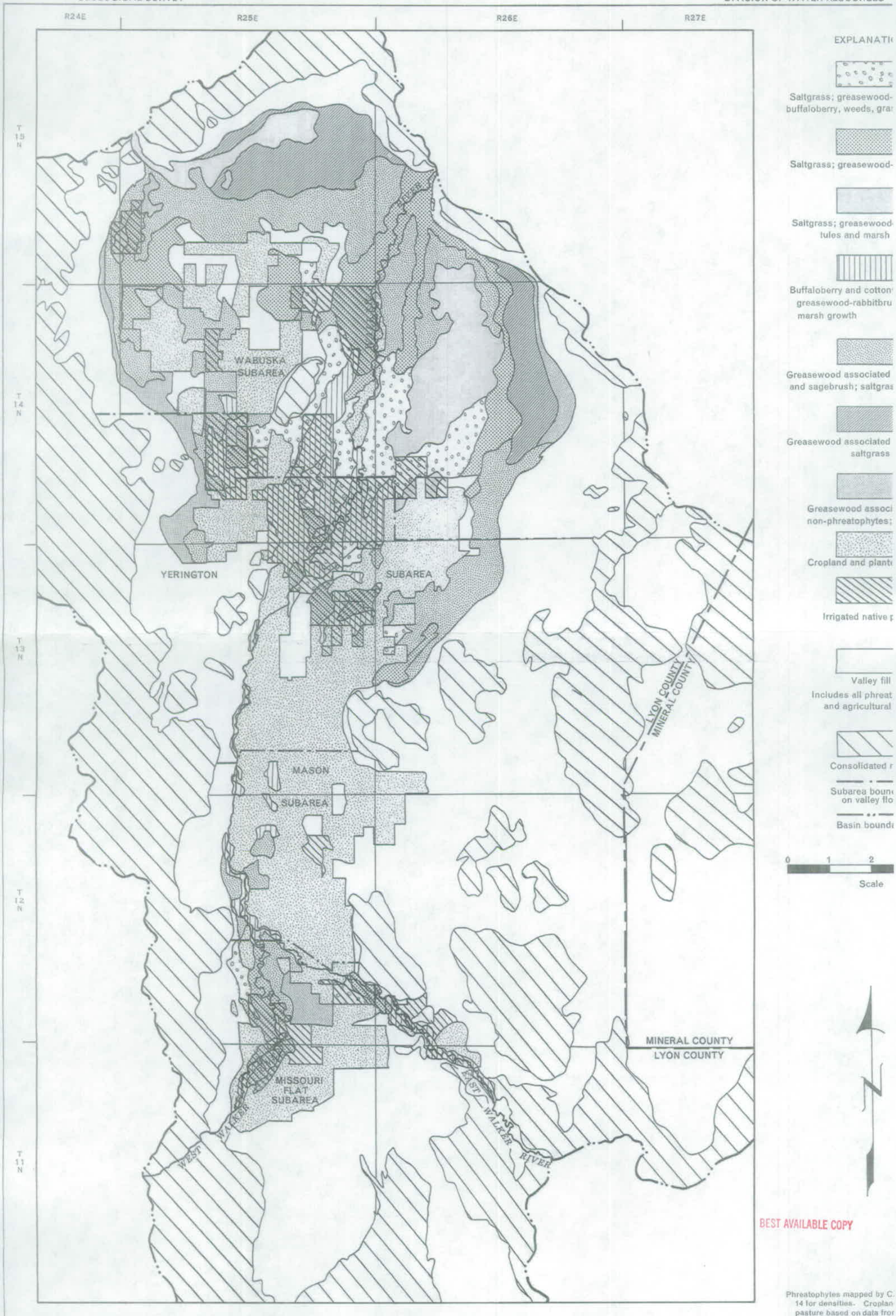
PLATE 1.—GENERALIZED GEOLOGY AND GEOGRAPHIC FEATURES OF MASON VALLEY, LYON AND MINERAL COUNTIES, NEVADA



ical Survey topographic quadrangles; 1:250,000 and 1:62,500

Hydrology by C. J. Huxel Jr., 1966

CATION OF WELLS, SPRINGS, AND AUGER HOLES; WATER LEVEL CONTOURS FOR 1965-66; AND SUBAREA BOUNDARIES IN MASON VALLEY, LYON AND MINERAL COUNTIES, NEVADA



Base from U.S. Geological Survey topographic quadrangles; 1:250,000 and 1:62,500

PLATE 3.—DISTRIBUTION OF PHREATOPHYTES, CROPLAND, AND PASTURE IN MASON VALLEY, LYON AND MINERAL COUNTIES, NEV