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

Mesquite tree, the dominant phreatophyte in Mesquite Valley.

WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 46

WATER–RESOURCES APPRAISAL OF MESQUITE–IVANPAH VALLEY AREA, NEVADA AND CALIFORNIA

By
Patrick A. Glancy

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

JUNE 1968

Mohave Yucca, a typical plant of alluvial slopes in Mesquite Valley, derives its water from soil moisture. Spring Mountains are in the background.

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FOREWORD

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

This report is the 46th report prepared by the staff of the Nevada District of the U.S. Geological Survey. These 46 reports describe the hydrology of 117 valleys.

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

Roland D. Westergard
State Engineer

Division of Water
Resources

June 1968

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TABLES

WATER-RESOURCES APPRAISAL OF MESQUITE-IVANPAH VALLEY AREA,
NEVADA AND CALIFORNIA

By Patrick A. Glancy

SUMMARY

The Mesquite-Ivanpah Valley area includes four valleys mainly in southern Nevada. It covers a total area of about 830 square miles; however, about 220 square miles of Mesquite Valley is in southeastern California. The report area does not formally include that part of Ivanpah Valley in California, although readily available data for this area are included in the report where practicable. Major valleys are Mesquite and Ivanpah Valleys; minor areas include Jean Lake and Hidden Valleys.

Precipitation within the area is the source of virtually all the water resources. However, the recharge divide in Mesquite Valley may extend north of the surface drainage divide in the Spring Mountains, from which some recharge may occur by underflow through carbonate rocks to Mesquite Valley. Principal hydrologic facts and estimates resulting from this reconnaissance are summarized in table 1. The principal known and developed aquifers occur in the valley fill at relatively shallow depths. However, abundant carbonate rocks in the area constitute an unexplored but probably significant ground-water system.

Natural ground-water discharge in Mesquite Valley is by evapotranspiration, but discharge from the remaining valleys apparently is entirely by subsurface outflow to adjacent valleys.

Chemical analyses of water from 29 underground sources show that water quality in the area ranges from good to very poor. The quality of water in shallow aquifers upgradient from naturally discharging playas is suitable for most purposes; poorer quality water is found in shallow aquifers near natural discharge areas and reportedly at greater depths in Mesquite Valley. Poor quality water is also encountered in shallow alluvial aquifers of Ivanpah Valley near the State line.

Water resources of the area have been developed for domestic use and for mining, agricultural, railroad, and tourist industries. Present use in Mesquite Valley is about half the estimated perennial yield; in the other valleys, use is less than 10 percent of the estimated perennial yield. Future development may depend

Table 1.--Hydrologic summary

[All estimates in acre-feet per year, except where noted]

	Hydrologic units (valleys)			
	Mesquite Valley	Ivanpah Valley (Nevada)	Jean Lake Valley	Hidden Valley
Approximate valley area (square miles)	460	240	100	30
Probable hydrologic closure	(a,b)	(a,c)	(a,c)	(a,c)
Surface-water runoff from mountains	2,100	1,200	250	50
Ground-water recharge from precipitation	1,500	700	100	minor
Natural ground-water discharge	2,200	1,500	100	minor
Preliminary estimate of perennial yield	2,200	700	50	minor
Preliminary estimate of transitional storage reserve[1/]	480,000	280,000	150,000	38,000
Present ground-water withdrawal	1,400	30	minor	none

a. Internal surface drainage.

b. Significant subsurface inflow from adjacent valleys.

c. Significant subsurface outflow to adjacent valleys.

1. Total acre-feet.

principally upon whether the quantity and quality of available water are adequate for the intended use.

INTRODUCTION

Purpose and Scope of the Investigation

Nevada is currently experiencing a rapid growth in population and associated development that began more than a decade ago. Increased water requirements for domestic, industrial, agricultural, and recreation uses have accompanied this growth. Anticipating these increasing water needs, the Nevada State Legislature enacted legislation (Chapter 181, Statutes of 1960) authorizing an expansion of the established program of hydrologic investigations being conducted by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The legislation now provides financing, in the form of matching funds with the Federal Government, to conduct reconnaissance appraisals of the water resources of the State. This investigation is the 46th in the series.

The objectives of the reconnaissance investigations, including this study, are to (1) present the general geologic setting, (2) appraise the source, occurrence, movement, storage, and chemical quality of water in the area, (3) estimate average annual recharge to and discharge from the ground-water reservoir, (4) evaluate the surface-water resources in the valleys, and (5) provide preliminary estimates of the perennial yield and transitional storage reserve.

This investigation was made under the general supervision of G. F. Worts, Jr., district chief in charge of hydrologic studies by the Geological Survey in Nevada. Field work and analysis of hydrologic data were done during the period January-March 1967.

Location and General Geographic Features

The Mesquite-Ivanpah Valley area, as used in this report, is enclosed by lat 35°25' and 36°05' N. and long 115°05' and 115°50' W. (fig. 1). The area is mainly in southwestern Clark County, Nevada, although the southwestern part of Mesquite Valley (known locally as Sandy Valley) is in Inyo and San Bernardino Counties, California. Ivanpah Valley also extends southwestward into San Bernardino County, California. The area includes about 830 square miles, spanning a maximum of about 36 miles in a north-south direction and 46 miles in an east-west direction. It includes four individual drainage basins which, with their approximate respective drainage areas, are: Mesquite Valley, 460 square miles; Ivanpah Valley (Nevada segment), 240 square miles; an unnamed valley east of the town of Jean, herein referred to as Jean Lake Valley, 100 square miles; and Hidden Valley, 30 square miles. Ivanpah Valley has an additional 450 square miles in California.

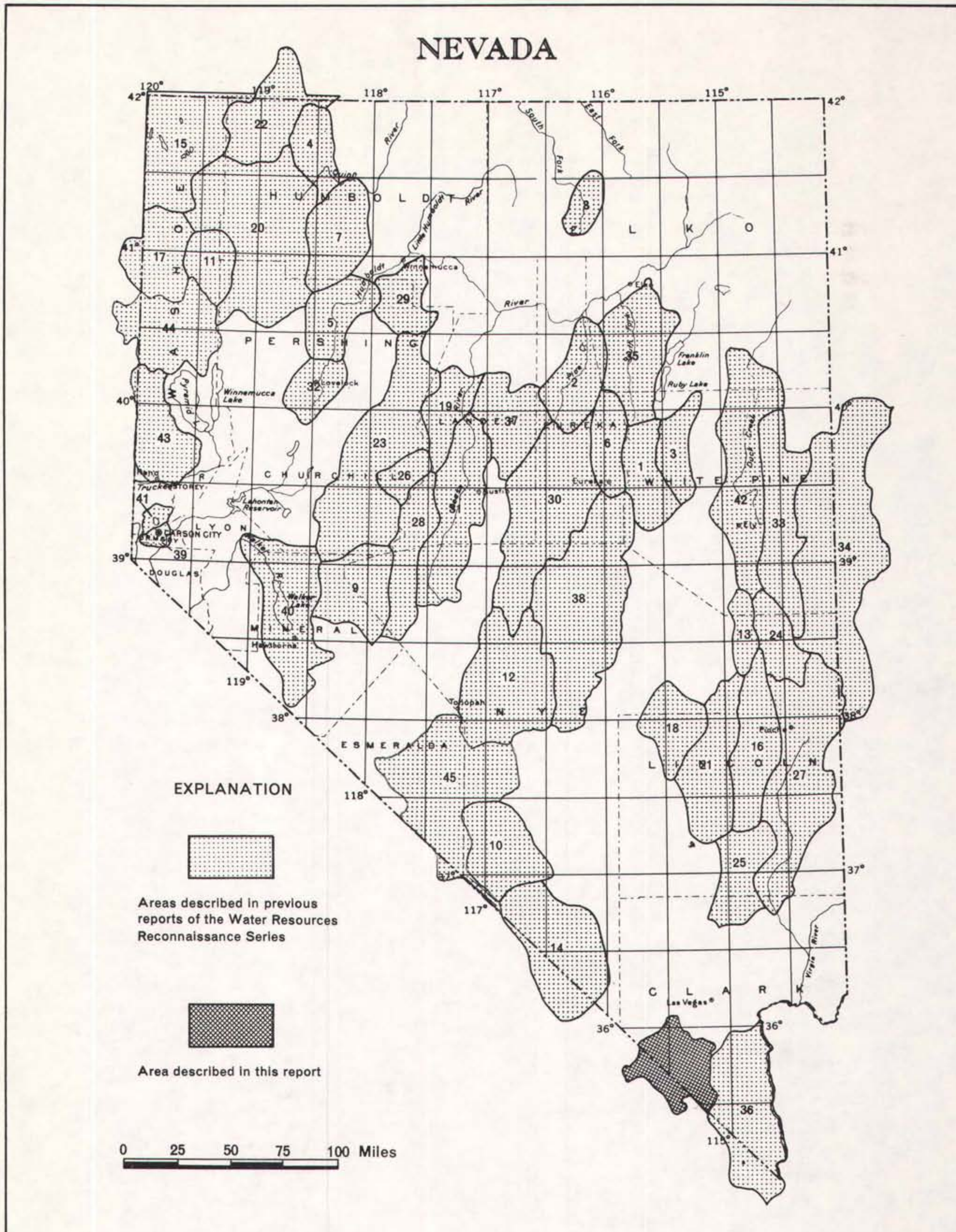

Figure 1.—Area described in this report and others in previous reports of the Water Resources—Reconnaissance Series

The area is thinly populated. Mesquite Valley presently has about 25 to 30 permanent residents, some of whom live in Sandy, which has only three or four homes. Ivanpah Valley (Nevada) includes the small towns of Goodsprings and Jean, with populations of about 150 and 65 people, respectively. Two businesses providing roadside services and several mobile homes are along Interstate Highway 15 (also U.S. Highways 91 and 466) at the Nevada-California border; the permanent residents in this locality are estimated to total about 20 people. The Ivanpah Valley settlements of Erie, Borax Station, and Roach Station, shown on plate 1, originally were very small railroad communities but are now abandoned. Very small settlements in the California segment of Ivanpah Valley include Desert, Desert City, Nipton, Border Station, Ivanpah, and Cima. The last two mentioned communities are south of the area included on plate 1. The Molybdenum Corporation of America mining operation at Mountain Pass has greatly expanded during the past few years and several hundred people now reside in the community. Las Vegas is the nearest major population center and is about 20 miles north of Ivanpah Valley. Jean Lake and Hidden Valleys, two small topographically closed valleys at the eastern edge of the report area, have no permanent residents.

Interstate Highway 15, connecting Las Vegas and Los Angeles, bisects Ivanpah Valley (Nevada); at Jean it intersects Nevada Highway 53, which passes through Goodsprings, crosses the Spring Mountains, and then passes southwestward through Mesquite Valley (fig. 2). Nevada State Highway 85, connecting Las Vegas and Pahrump, crosses the Spring Mountains and goes through the northern part of Mesquite Valley. Many unpaved roads connect with the highways and crisscross both valleys; numerous unimproved roads and trails provide access to other parts of the study area.

The Union Pacific Railroad, connecting Las Vegas and Los Angeles, passes through Ivanpah Valley and roughly parallels Interstate Highway 15.

Economy of the area includes farming, ranching, and providing services to travelers and tourists. Tourism dominates the economy of Ivanpah Valley (Nevada segment). Several attempts have been made to farm in the area, particularly in Mesquite Valley. Although land was cleared and wells were drilled, most of the partially developed areas have not yet produced a crop. Some ranching and associated livestock grazing occurs, but lack of good natural forage in the arid environment of the area inhibits this enterprise. Historically, mining dominated the local economy, but little mining is now done, except for the Molybdenum Corporation of America rare-earth operation at Mountain Pass.

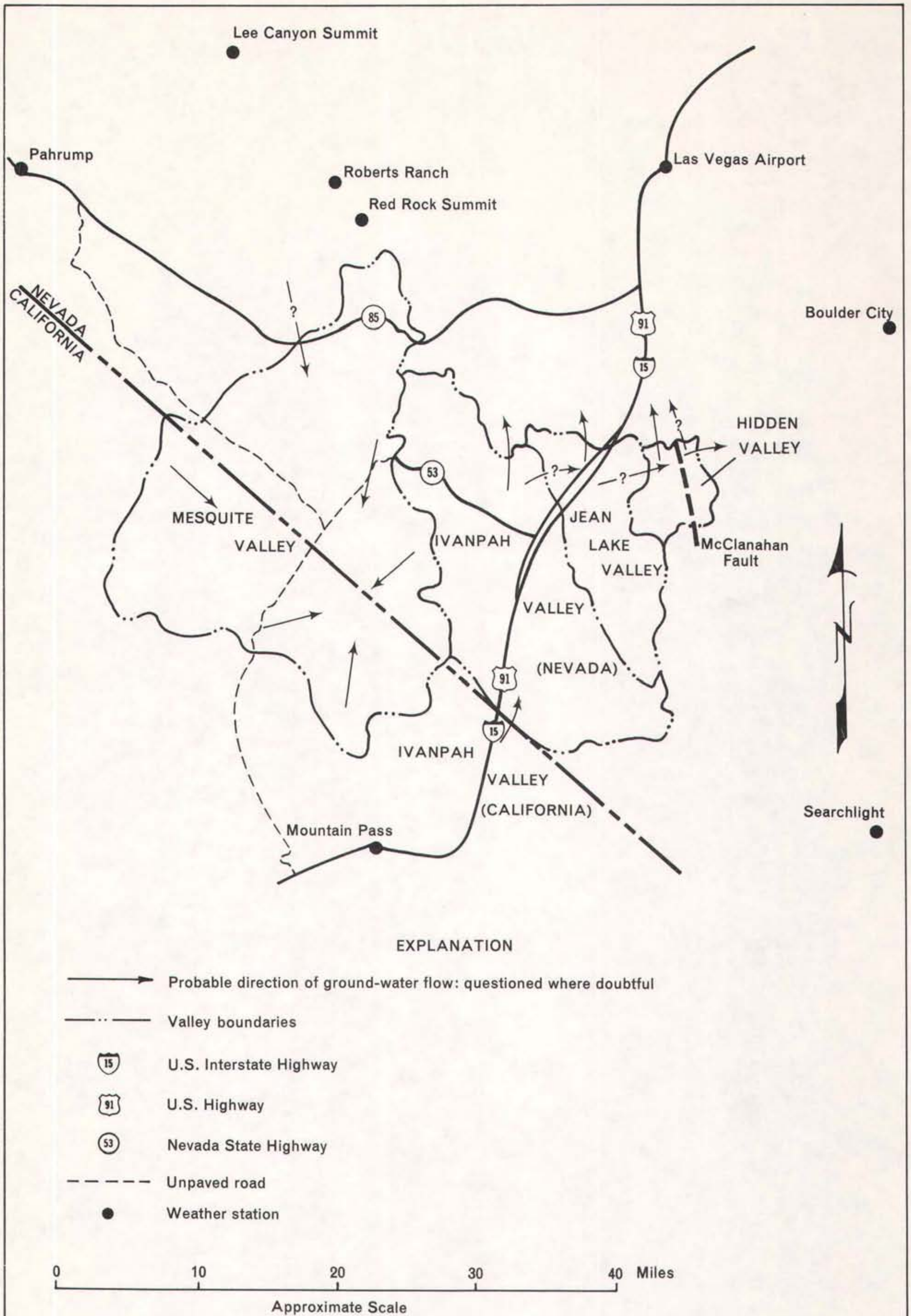

Figure 2.—Generalized map showing probable direction of ground-water flow and the locations of roads and weather stations.

Previous Work

The earliest-known documented hydrologic facts about the region were the general locations and descriptions of springs recorded by Fremont (1845, p. 264-266) during his expedition of 1844. Albritton and others (1954) discuss ore deposits in the Goodsprings area. Hewett (1956) mapped and described the geology of the entire area and also discussed hydrology in the Goodsprings mining district (1931, p. 5-8). Geology of the region is also portrayed in maps and text by Longwell and others (1965). Waring (1920, p. 51-81) provided the first detailed account of hydrology within the area. Hydrology was also discussed in two publications by Thompson (1921 and 1929). The hydrology of neighboring Pahrump and Las Vegas Valleys is described by Maxey and Robinson (1947) and Maxey and Jameson (1948). The California Department of Water Resources (1956; 1964a, p. 221-238; 1964b, p. 50-51; 1964c, p. 1; and 1966, p. 25 and 26) has collected a considerable amount of data throughout the area, particularly in Mesquite Valley, and has interpreted some of the data; many of these data were utilized in the preparation of this report. Hydrology of Ivanpah Valley was briefly mentioned by Malmberg (1965, p. 9, 23, and 31), who also discussed in moderate detail the hydrology of Pahrump Valley (1967). The hydrology of Eldorado and Piute Valleys, northeast and east of Ivanpah Valley, is covered in a reconnaissance report by Rush and Huxel (1966). Hughes (1966) investigated the springs in the Spring Mountains.

Acknowledgments

The writer is grateful to the residents of the area who provided valuable information on water use and development of the area. Landowners kindly permitted access to their property and farmers provided useful data on their wells and irrigation practices. The California Department of Water Resources kindly supplied data on wells in California. The water superintendent at Jean, Nevada, furnished data on the municipal water supply. Mr. H. D. Bailey of the Molybdenum Corporation of America provided data on water development and use at the Mountain Pass mine. Mr. R. D. Smith, Superintendent, Union Pacific Railroad Co., furnished information on their wells in Ivanpah Valley. Many owners permitted sampling of their water supplies for analytical purposes and furnished data on water use.

GENERAL HYDROLOGIC ENVIRONMENT

Physiographic Features

The valleys of the report area are principally alluvial-filled depressions surrounded by bedrock mountains. The shapes and sizes of the depressions, as shown on plate 1, are mainly controlled by the gross geologic structures. The valleys have interior surficial drainage and collectively make up a small segment of the southwestern part of the Great Basin.

Mesquite Valley, as shown on plate 1, ranges in altitude from about 2,540 feet to about 8,510 feet. The general landscape consists mainly of steep-sloping, consolidated rock, mountain masses surrounding a relatively flat playa; the playa and mountain masses are separated by extensive alluvial fans. This physiographic arrangement is also typical of the other valleys of the report area.

Ivanpah Valley (Nevada) ranges in altitude from about 2,600 feet to about 8,510 feet. Its southern boundary is arbitrarily chosen at the Nevada-California boundary, although some data in this report and on plate 1 are from the southern (California) part of the valley.

Jean Lake Valley ranges in altitude from about 2,780 feet to about 6,840 feet and the range of Hidden Valley is from about 2,990 feet to about 4,290 feet.

The areas of the playas as percentages of their total valley are: Mesquite Valley, 2.1 percent; Ivanpah Valley (Nevada), 2.3 percent; Ivanpah Valley (Nevada and California), 2.7 percent; Jean Lake Valley, 2.1 percent; and Hidden Valley, 0.8 percent.

Lithologic Units

A generalized geologic map of the area is shown on plate 1 and a summary of lithologic units and their characteristics is included in table 2. The major lithologic units portrayed are based mainly on hydrologic characteristics and include two broad groups--unconsolidated and consolidated rocks. Distribution and character of the consolidated rocks are taken from published geologic maps as credited on plate 1. The unconsolidated rocks were divided into two groups, conforming to Malmberg's classification of alluvial units in Pahrump Valley (1967); mapping was based mainly on aerial-photo textural characteristics.

Hydrologic characteristics of the lithologic units have been determined in part by structural deformation, which caused the

Table 2.--Lithologic units

	Geologic age		Lithologic unit	Thickness (feet)	General character and extent	Water-bearing properties
QUATERNARY	Holocene and Pleistocene	VALLEY FILL	Younger alluvium	0-100±	Unconsolidated lenses of gravel, sand, silt, and clay comprising fluvial, lacustrine, and eolian deposits; fluvial deposits commonly contain large-size gravel and boulders; composed mainly of material derived from bordering upland consolidated rocks and reworked older alluvium; unit thickest in valley troughs; probably mantles older alluvium over much of its extent. Present in all valleys.	The younger and older alluvium together form the valley-fill reservoir, the principal source of water for wells of the area. Yields water to domestic, irrigation, industrial, and public-supply wells; yields vary depending on character of sediments encountered by wells and range from about 5 to more than 1,000 gpm.
LATE TERTIARY AND QUATERNARY	Pleistocene and Pliocene	VALLEY FILL	Older alluvium	0-several thousand	Unconsolidated to semiconsolidated deposits of boulders, gravel, sand, silt, and clay exposed around margins of valley and buried at a generally shallow depth beneath younger alluvium; composed mainly of debris derived from bordering consolidated rock areas; unit thinnest in upland areas and thickest in valley troughs; mantles consolidated rock; limited surface exposure in Mesquite and Ivanpah Valleys; surficially absent in Jean Lake and Hidden Valley; probably present in subsurface in all valleys.	

Table 2.--Continued

Geologic age		Lithologic unit		Thickness (feet)	General character and extent	Water-bearing properties
PRECAMBRIAN TO CENOZOIC	Quaternary to Precambrian	CONSOLIDATED ROCKS[1]	Non-carbonate rocks[2]	--	Igneous, metamorphic, and sedimentary rocks; igneous rocks are mainly volcanic extrusions and occur most extensively in McCullough and Kingston Ranges; some intrusive bodies in Spring Mountains; metamorphic rocks mainly gneiss and quartzite in southern part of area; sedimentary rocks mainly shale around south-western edge of Mesquite Valley.	Unit generally untested by wells; yields minor amounts of water to springs; might yield small amounts of water to wells from fracture zones; considered poorest water-yielding unit in area.
	Permian to Late Precambrian		Carbonate rocks[2]	0-several thousand	Mainly limestone and dolomite[3]; structurally deformed; occur extensively in Spring Mountains and around west edge of Mesquite Valley; limited surficial occurrence around west edge of Jean Lake Valley; surficially absent in Hidden Valley; unit may occur extensively beneath valley-fill deposits.	Transmits water through fractures and solution cavities; interbasin subsurface flow may occur through these conduits; may be source of water in Goodsprings well field; yields water (less than 5 gpm) to several springs mainly in Spring Mountains.

1. Carbonate and noncarbonate rocks are interbedded and are not discreet geologic time units.

2. Generalized from Hewett, 1956.

3. According to Hewett (1956, p. 163), "nearly pure dolomite is more abundant in this (Ivanpah) quadrangle than pure limestone."

present orientation of sedimentary strata as well as secondary transmissive features, such as faults, fractures, fissures, joints, and related solution cavities. Structural deformation may have increased or decreased transmissivity depending on a variety of factors and conditions. Changes in transmissivity by structural deformation were mainly restricted to the consolidated rocks because much intensive deformation predates deposition of the unconsolidated rocks. However, deformation has also occurred as recently as the Quaternary Period (Hewett, 1956, p. 105-106) and effects on the water-bearing properties of the older alluvium may be important in localized areas.

VALLEY-FILL RESERVOIR

Extent and Boundaries

The valley-fill reservoir is composed of older and younger alluvium. Lateral extent of these alluvial units is shown on plate 1. There are at least two distinct valley-fill reservoirs in the report area because saturated alluvium of Mesquite Valley is separated from that of the other valleys. Ivanpah, Jean Lake, and Hidden Valleys may have independently functioning valley-fill reservoirs, but the thickness of alluvium connecting the valleys is presently unknown, and some combination of the three may be functioning together as a single ground-water system.

Maximum thickness of the valley-fill reservoirs may be several thousand feet (Bates, 1967, p. A86) in areas of the deeper valley-trough axes. According to the California Department of Water Resources (1964a, p. 221), at one place in Mesquite Valley it is at least 1,180 feet thick. Well logs for Ivanpah Valley (table 17) show the following: well 25/29-14c1 near Jean penetrated 450 feet of alluvium without encountering bedrock; well 27/59-8c1 near the Nevada-California border, about a quarter of a mile southeast of a carbonate rock (consolidated rock) outcrop apparently penetrated 600 feet through alluvium without encountering the consolidated rock valley floor; well 16/15-20J1 (Ivanpah Valley, Calif.) penetrated 735 feet of alluvium without intercepting consolidated rock; and well 16/15-12Q1 (Ivanpah Valley, Calif.), near Desert, penetrated 602 feet of alluvium before encountering consolidated rock. Therefore, maximum thickness of the valley-fill reservoir of Ivanpah Valley exceeds 735 feet and probably is actually much greater. Well logs for Jean Lake Valley do not provide the basis for a reasonable estimate of the maximum thickness of that valley-fill reservoir; one well, 25/60-8a1, encountered consolidated rock after 106 feet of drill penetration but the well was only about one-half mile from a consolidated rock outcrop. Well 24/61-28b1 in Hidden Valley penetrated consolidated rock at a depth of between 760 and 820 feet; therefore, maximum thickness of its valley-fill reservoir is at least that great.

The sides and bottoms of the valley-fill reservoirs are formed by the consolidated rocks. The consolidated rocks, particularly the carbonate rocks, probably contribute water to the valley-fill reservoirs by subsurface flow and, as discussed later in this report, may also provide avenues of subsurface leakage to adjacent valleys.

Depth to Water and Movement of Ground Water

Known depths to the zone of saturation below land surface in Mesquite Valley range from about 5 to more than 130 feet. The water table is shallow near the valley floor and deepens toward the mountains. The configuration of the water table generally conforms to that of the land surface; however, irregularities exist and the slopes are gentler than that of the land surface. Therefore, ground-water movement in Mesquite Valley is generally from the valley margins centripitally toward the playa area where it is discharged from the system by evapotranspiration; this natural discharge is discussed in more detail later in this report. From water-level contours shown on plate 1, which approximately depict the water table, flow gradients and general directions of ground-water movement within the valley-fill reservoir may be inferred.

Known depths to the water table of the valley-fill reservoir in Ivanpah Valley range from about 90 feet near the Nevada-California border to at least 365 feet near Jean. The few available data indicate that the water table is about 340 feet deep near the valley floor of Jean Lake Valley and ranges from about 600 to about 1,000 feet in the central part of Hidden Valley. In Hidden Valley, the depth to water in well 24/61-28b1 is about 350 feet greater than that in well 24/61-20d1, and the wells are only about a quarter of a mile apart. Water was first encountered in the valley fill at a depth of 617 feet in well 24/61-20d1; the static water level stabilized at a depth of 605 feet (altitude about 2,420 feet). Water was first encountered at a depth of 1,002 feet, apparently in consolidated rock, in well 24/61-28b1; static water level reportedly stabilized at a depth of 950 feet (altitude about 2,080 feet). These differences in water-bearing zones and water levels are assumed to be caused by the McClanahan fault, which apparently passes between the two wells and may create a barrier to the movement of water within the valley.

Movement of water in Ivanpah, Jean Lake, and Hidden Valleys is affected by and associated with subsurface leakage from the valleys to adjacent areas. Water movement within and out of these valleys is discussed in the section of the report, "Underflow between valleys."

CARBONATE-ROCK RESERVOIR

Carbonate rocks tend to form a fairly efficient storage and transmission medium for ground water where zones of structural weakness have been enlarged to form solution cavities. This fact, coupled with the locally intensive deformation of the carbonate rocks and their concentrated occurrence in the area of greatest precipitation (the Spring Mountains) may promote underflow through the carbonate rocks from Pahrump Valley to Mesquite Valley. Unfortunately, although some small (less than 5 gpm) springs do occur in the carbonate rock areas, few wells penetrate these rocks and they are localized; therefore, the flow system is not understood. The town of Goodsprings is supplied by a number of shallow wells, collectively referred to in this report as the Goodsprings well field, most of which are probably producing from carbonate rocks (Hewett, 1931, p. 7) but the total annual pumpage is only a few acre-feet. Hewett's (1931, p. 7-8) discussion of the Goodsprings well field suggests that this local flow system is structurally controlled and "that the water is drawn from a remote collecting area."

Although the water-yielding capabilities of the carbonate rocks of the area are practically untested, the general hydrologic characteristics of carbonate rocks requires that they be considered as a potential aquifer system which may facilitate interbasin ground-water flow within the region.

INFLOW TO THE VALLEY-FILL RESERVOIR

Precipitation

Precipitation is the source of virtually all water entering the hydrologic system of the report area. It recharges the valley-fill reservoir mainly as infiltration from runoff or as underflow from the consolidated-rock uplands. Precipitation as it relates to recharge and runoff is discussed in the two following sections of the report.

Precipitation throughout the area probably ranges from about 3 to 20 inches per year, on the basis of comparison with selected recorded data for adjacent areas (table 3). Most precipitation occurs during the winter and generally the amounts increase with altitude. Regional storms generally occur during the winter and summer storms typically occur as localized thundershowers.

Average monthly precipitation for six selected stations of the region (table 4) suggest seasonal trends that can be generally categorized as follows: a period of maximum wetness occurs during the winter months, which is mainly the result of Pacific storm systems. A wet period of lesser magnitude occurs during midsummer, which may be mainly the result of moist air systems moving in from the south. A season of maximum dryness occurs during middle and late spring, and a dry season of lesser magnitude occurs during late summer and early autumn.

Surface Water

General Conditions

Runoff in the Mesquite-Ivanpah Valley area is generated by high-intensity precipitation and is more frequent on the mountain blocks than on the lowlands. Minor amounts of surface flow occur locally in fairly short channel reaches from spring discharge. Occasional flow may occur locally on alluvial fans and playa areas in response to high-intensity precipitation from thunderstorms or from mountain snowmelt. This type of streamflow is so erratic in frequency and duration that it is difficult to use directly; however, it may provide a significant amount of recharge to the ground-water system. Most runoff infiltrates or is lost by evapotranspiration as it moves downstream. During periods of exceptionally high-intensity rainfall or during periods of rapid snowmelt, part of the flow occasionally reaches the playas where only negligible amounts are able to infiltrate to ground water; most is returned to the atmosphere by evaporation.

Table 3.--Summary of average annual precipitation at selected stations

/Summarized from published records of the U.S. Weather Bureau/

Station	Location[1]			Altitude (feet)	Period of record (years)		Average annual precipitation (inches)
	Sec.	T.	R.				
Boulder City	5	23 S.	64 E.	2,525	36 yrs.:	1931-66	5.22
Las Vegas Airport	34	20 S.	61 E.	2,162	30 yrs.:	1937-66	3.89
Lee Canyon Summit[2]	9	19 S.	56 E.	9,200	17 yrs.:	1945-53, 1955 1957-62, 1965	20.32
Mountain Pass	14	16 N. (Calif.)	13 E.	4,739	9 yrs.:	1956-64	6.78
Pahrump	14	20 S.	53 E.	2,669	8 yrs.:	1959-66	3.64
Red Rock Summit[2]	13	21 S.	57 E.	6,240	10 yrs.:	1945-54	10.62
Roberts Ranch[2]	34	20 S.	57 E.	6,100	8 yrs.:	1945-52	13.95
Searchlight	34	28 S.	63 E.	3,540	53 yrs.:	1914-36, 1938-42, 1945-66	7.71

1. Station locations shown in figure 2.

2. Storage-type precipitation gage.

Table 4.--Average monthly and annual precipitation, in inches, at selected stations

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

Station 1/	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Boulder City	0.63	0.52	0.51	0.41	0.17	0.06	0.49	0.57	0.49	0.38	0.44	0.58	5.22
Las Vegas Airport	.46	.33	.40	.28	.08	.04	.47	.44	.37	.26	.38	.38	3.89
Pahrump	.31	.49	.13	.34	.05	T.	.17	.26	.32	.22	.77	.57	3.64
Red Rock Summit	1.20	.73	1.39	.76	.41	.25	1.08	1.29	.48	1.14	.64	1.75	10.62
Roberts Ranch	1.30	1.26	1.84	.97	.49	.25	1.12	1.21	.60	1.49	.96	2.06	13.95
Searchlight	.86	.82	.68	.50	.20	.14	.96	1.17	.61	.49	.43	.80	7.71

1. See table 3 and figure 2 for station locations and period of record.

Runoff tends to increase in a downstream direction within the mountain blocks and decrease as it crosses the valley fill after leaving the mountains.

Estimated Runoff

By D. O. Moore

Runoff has not been recorded by gaging stations in the Mesquite-Ivanpah Valley area. However, the characteristics of runoff are similar to the infrequent and short duration flow at the gaging station, Las Vegas Wash at North Las Vegas, Nevada. Flows for this station are summarized in table 5. The relation between flow volume and flow duration is variable. The short-term record suggests that occurrence of runoff is also erratic with respect to season. Estimates of mean annual runoff shown in table 6 were made at specific points on the main ephemeral channels in the report area during the course of this investigation; the points are shown on plate 1.

The amount of runoff from the mountains that reaches the valley-fill reservoir cannot be computed directly because of the absence of streamflow data in the area. Therefore, methods as described by Moore (1968) were used to estimate runoff. These methods are based on use of altitude-runoff relations, which are adjusted for local differences in geology, precipitation, vegetation, and land slopes and by use of a channel geometry-runoff relationship. Estimates at several sites within the area were made using channel geometry; five are shown in table 6.

The estimated total mean annual runoff to the edge of the valley-fill reservoir is summarized in table 7.

Ground-Water Recharge

Ground-water recharge in the Mesquite-Ivanpah Valley area is derived mainly from precipitation within the area. A preliminary estimate of recharge in this area was made using a method described by Eakin (1951), which is based on the assumption that a percentage of the average annual precipitation ultimately reaches the ground-water reservoir. It is assumed that no recharge takes place from precipitation that falls below 5,000 feet, and the percentage of precipitation that reaches the zone of saturation increases with increasing altitude; above 8,000 feet 20 percent of precipitation is thought to reach the ground-water reservoir.

A precipitation map of Nevada prepared by Hardman (1965) shows that average annual precipitation is closely related to altitude. Therefore, an estimate of recharge for the area

Table 5.--Discharge and duration of flow in Las Vegas Wash at North Las Vegas, Nevada, June 1962-December 1965

Date	1962		1963		1964		1965	
	Discharge (acre-ft)	No. days of flow	Discharge (acre-ft)	No. days of flow	Discharge (acre-ft)	No. days of flow	Discharge (acre-ft)	No. days of flow
Jan.			0		0		0	
Feb.			0		0		0	
Mar.			0		0		0	
Apr.			1.2	2	0		41.3	3
May			1.4	2	0		0	
June	0		14.0	2	0		0	
July	0		0		0		0	
Aug.	8.7	11	0		0		0	
Sept.	0		181	2	0		0	
Oct.	0		0		0		0	
Nov.	0		0		0		34	1
Dec.	0		0		0		0	
Total	8.7	11	198	8	0		74.3	4

Table 6.--Estimated mean annual runoff at selected sites

Map designation (pl. 1)	Approximate location	Drainage name or area drained	Estimated mean annual runoff (acre-feet)
1	sec. 2, T.19 N., R.11 E. (California)	Part of Kingston Range	15
2	sec. 23, T.23 S., R.56 E.	Potosi Wash	180
3	sec. 25, T.24 S., R.58 E.	Goodsprings Valley	120
4	sec. 29, T.24 S., R.61 E.	Hidden Valley drainage	25
5	sec. 17, T.27 S., R.59 E.	Nevada-California border	Minor

Table 7.--Estimated average annual runoff

	Runoff area (acres)	Estimated average annual runoff (acre-feet per year)
Mesquite Valley		
Area in California	43,800	400
Area in Nevada	86,800	1,700
Total (rounded)	130,600	2,100
Ivanpah Valley (Nevada)	74,300	1,200
Jean Lake Valley	27,800	250
Hidden Valley	10,400	50

was computed using several altitude zones, their estimated average annual precipitation, inferred from Hardman's map, and an assumed percentage of average annual precipitation in each altitude zone that ultimately recharges the ground-water reservoir. Estimates of recharge are shown in table 8.

The estimated average annual precipitation on the report area is about 430,000 acre-feet and the estimated average annual recharge is about 3,100 acre-feet, or less than 1 percent of the total precipitation. Much of the recharge probably occurs by seepage loss as the streams cross the alluvial fans.

In this study, ground-water recharge estimates were made assuming that recharge divides are coincident with topographic divides. However, the Spring Mountains, northeast of Mesquite Valley, pose a special problem to this assumed location of the recharge divide. The mountains rise sharply in altitude beyond the Mesquite Valley surface-drainage boundary. The mountains include thick and extensive areas of carbonate rocks that probably are contiguous with those in Mesquite Valley. Therefore, some of the water recharged in the high mountains beyond the topographic boundary of Mesquite Valley may reach the valley by underflow through the carbonate-rock reservoir.

Table 8.--Estimated average annual precipitation and ground-water recharge

Altitude zone (feet)	Area (acres)	Estimated annual precipitation: Range (inches)	Average (feet)	Average (acre-ft)	Estimated recharge: Assumed percentage of precipitation	Acre-feet per year
MESQUITE VALLEY (Nevada part)						
Above 8,000	50	>20	1.8	90	20	20
7,000-8,000	1,000	15-20	1.5	1,500	15	220
6,000-7,000	7,980	12-15	1.1	8,800	7	620
5,000-6,000	22,320	8-12	.8	18,000	3	540
Below 5,000	123,200	<8	.5	62,000	--	--
Subtotal (rounded)	154,600			90,000		1,400
MESQUITE VALLEY (California part)						
Above 6,000	620	>12	1.1	680	7	50
5,000-6,000	2,790	8-12	.8	2,200	3	70
Below 5,000	136,900	<8	.5	68,000	--	--
Subtotal (rounded)	140,300			71,000		100
Total (rounded)	294,900			160,000		1,500
IVANPAH VALLEY (Nevada part)						
Above 8,000	30	>20	1.8	50	20	10
7,000-8,000	780	15-20	1.5	1,200	15	180
6,000-7,000	3,100	12-15	1.1	3,400	7	240
5,000-6,000	10,840	8-12	.8	8,700	3	260
Below 5,000	135,940	<8	.5	68,000	--	--
Subtotal (rounded)	150,700			81,000		700
IVANPAH VALLEY (California part)						
Above 7,000	370	>15	1.5	560	15	80
6,000-7,000	1,830	12-15	1.1	2,000	7	140
5,000-6,000	25,410	8-12	.8	20,000	3	600
Below 5,000	259,780	<8	.5	130,000	--	--
Subtotal (rounded)	287,400			150,000		800
Total (rounded)	438,000			230,000		1,500
JEAN LAKE VALLEY						
Above 6,000	460	>12	1.1	510	7	40
5,000-6,000	2,170	8-12	.8	1,700	3	50
Below 5,000	60,140	<8	.5	30,000	--	--
Total (rounded)	82,800			32,000		100
HIDDEN VALLEY						
Below 5,000	21,700	<8	.5	11,000	--	Minor

OUTFLOW FROM THE GROUND-WATER RESERVOIR

Evapotranspiration

In the report area, discharge of ground water by evapotranspiration is mainly restricted to Mesquite Valley. Springs in the mountains also discharge small quantities of ground water that are then lost by evapotranspiration. No natural evapotranspiration of ground water is known to occur in Ivanpah, Jean Lake and Hidden Valleys because the water level is deep.

Ground water is discharged in Mesquite Valley by evapotranspiration in areas of phreatophytes around the playa and evaporation from the bare soil of the playa. In the other three valleys, the depth to water probably is more than 50 feet, too great to support phreatophyte growth, except near springs in the mountains. Phreatophytes adjacent to the Mesquite Valley playa include Mesquite trees and several varieties of saltbush of genus Atriplex, which are reportedly phreatophytic under favorable conditions (Robinson, 1958, p. 32; Meinzer, 1927, p. 32-37; Jaeger, 1940, p. 49-54). Mesquite trees grow in a nearly continuous but irregular band around the outer margin of the playa where depth to water ranges from about 5 to 45 feet. Published estimates of the annual ground-water use rate of one species of mesquite, Prosopis velutina, in the Safford Valley, Arizona, range from 2.7 feet (Gatewood and others, 1950, p. 138) to 3.3 feet (Robinson, 1958, p. 38). These use rates apply to plants growing at 100 percent volume density, as defined by Gatewood and others (1950), and where the water level was less than 10 feet. Mesquite growth in Mesquite Valley occurs within an area of about 6,400 acres. The trees range in height from a few feet to about 20 feet. Their growth density varies from place to place and between individual plants. Their areal density, estimated from aerial photographs, ranges between 2 and 15 percent. The estimated use is shown in table 9.

Several varieties of saltbush associated with the mesquite and believed to be locally phreatophytic were tentatively identified as Atriplex conescens, A. torreyi, A. polycarpa (cattle spinach), and A. lentiformis. Density of the saltbush is highly variable and probably is controlled by a variety of factors, including soil conditions and depth to water. The above-mentioned species, as well as other varieties of saltbush and related desert plants, form the understory growth beneath and among the mesquite groves. Although certain varieties of saltbush, including the varieties tentatively identified, are conceded by several authorities to be phreatophytic under favorable conditions, their water-use rates are unknown. For purposes of this reconnaissance report,

Table 9.--Estimated average annual evapotranspiration of ground water in Mesquite Valley

Phreatophyte type or character of discharge	Area (acres)	Depth to water range (feet)	Estimated density (percent)	Estimated water use rate (feet per year)	Estimated ground-water discharge (acre-feet)
Mesquite	6,400	5-45	2-15	1-3 1/	1,000
Saltbush	6,000 2/	5-50	--	0.1	600
Bare soil evaporation	6,000 2/	4-10	--	0.1	600
Total (rounded)	--	--	--	--	2,200

1. As explained in text, the use rate of a 100-percent stand of mesquite probably varies from 1 to 3 feet, depending on variation in depth to the water table. The average use rate for the entire 6,400-acre area of varying density would therefore arithmetically equal about 0.156 feet per year.

2. Saltbush and bare soil evaporation areas do not completely coincide.

an estimated ground-water use rate of 0.1 foot per year was applied to the approximate area occupied by the varieties of saltbush believed to be existing as phreatophytes (table 9).

A fairly dense stand of scrubby saltbush of undetermined species covers an area about 8 miles long and 4 miles wide northwestward from the mesquite growth zone. The saltbush growth zone generally straddles the Nevada-California border. There the depth to water ranges from about 35 feet to about 130 feet. Approximately 15,000 acres, or 68 percent of the zone is characterized by water depths of less than 60 feet. Although the saltbush zone is excluded from the phreatophyte area in this report, this vegetation may be using some ground water. Beyond the saltbush zone, the vegetation is definitely xerophytic and consists of creosote bush, cactus, yucca, Joshua trees, and associated desert vegetation.

About 6,000 acres of bare soil of Mesquite Lake playa and adjacent areas discharges ground water. Ground-water levels range from about 4 to 10 feet beneath the land surface. The estimated evaporation is shown in table 9. The capillary fringe in this area commonly extends to within a few inches of the land surface where the soil texture becomes fluffy and larger pore spaces disrupt capillary action. The few inches of fluffy soil and loose windblown sand, as much as several feet thick on the playa, make vehicle travel hazardous. The fluffy texture of the playa is believed to be an indication of the evaporation of water that has moved upward through the playa deposits and precipitated its dissolved salt load during evaporation in the upper soil horizons.

Springs

Springs occur only in the upland consolidated-rock areas. Most of the known springs of the area are shown on plate 1. No measurements of flow were made but the flow of individual springs generally is estimated to be less than 5 gpm. Their cumulative annual discharge is small. The discharge of the springs is inadequate to sustain surface flow for any significant distance; the water either percolates into the alluvium or is lost by evapotranspiration.

Underflow Between Valleys

Underflow from Ivanpah, Jean Lake, and Hidden Valleys is indicated by the following evidence: (1) inferred directions of ground-water movement in the valley fill of Ivanpah Valley, (2) comparison of ground-water surface altitudes in the three valleys and with adjacent valleys, and (3) absence of natural discharge by evapotranspiration because of excessive depths to the saturated zone in the valleys.

Ground-water movement through the valley-fill reservoir in Ivanpah Valley is inferred to consist principally of two lateral directional components; one toward the longitudinal valley axis and the other parallel to the axis in a generally northward or slightly northeastward direction. The approximately located water-level contours shown on plate 1 suggest the axial directional component of movement and gradient magnitudes within the valley. Ground-water movement within Jean Lake and Hidden Valleys is less certain because of scanty well data.

Water levels in critical wells in all valleys, when compared with each other and with nearby wells in adjacent valleys suggest, with regard to head difference, the potential for intervalley underflow. Comparative data and inferred gradients between valleys are shown in table 10.

Figure 2 shows the inferred directions of ground-water underflow based on data shown in table 10. Estimated quantities are listed in table 11. The estimates were obtained by the difference between recharge-discharge estimates because direct determinations are impossible.

Pumpage and Development

The earliest use and development of water resources by white men in the report area probably were by explorers in the early 1800's and the immigrant travelers who followed later in the century who utilized spring water for drinking and bathing purposes. The first semipermanent development probably started in about 1856 when the Potosi mine was discovered by a party of Mormons (Hewett, 1931, p. 69). Mining development continued sporadically in the areas as the dominant industry until near the beginning of World War II. A few ranchers entered the region shortly after the advent of mining to introduce the livestock industry. They used water from springs and drilled wells for stock-watering and domestic purposes. However, ranching was severely limited by the sparse forage of the countryside. Mining, which required water for both the domestic needs of the miners and for milling of the ores, probably spurred most development of water resources during the early historic period.

The railroads were built early in the 20th century, and local water requirements for steam engines were met primarily by drilling wells along the route through Ivanpah Valley. Currently,

Table 10.--Inferred ground-water gradients between valleys

From			To				
Well	Valley	Approximate water-surface altitude (feet)	Well	Valley	Approximate water-surface altitude (feet)	Approximate distance between wells (miles)	Inferred gradient (feet per mile)
25/59-13bl	Ivanpah Valley	2,480	23/61-19dl	Las Vegas Valley	2,120	13	28
25/59-13bl	Ivanpah Valley	2,480	25/60-10dl	Jean Lake Valley	2,440	4	10
25/60-10dl	Jean Lake Valley	2,440	24/61-20dl	Hidden Valley	2,420	6	3
25/60-10dl	Jean Lake Valley	2,440	23/61-19dl	Las Vegas Valley	2,120	11	29
24/61-20dl	Hidden Valley (west of fault)	2,420	23/61-19dl	Las Vegas Valley	2,120	6.5	46
24/61-28bl	Hidden Valley (east of fault)	2,080	a 24/63-29al	Eldorado Valley	1,440	11.5	56

a. Well location not shown on plate 1 because of map area limitations.

Table 11.--Estimated underflow between valleys

Assumed underflow system	Estimated underflow (acre-feet per year)
Pahrump Valley to Mesquite Valley, by interflow through carbonate rocks from Spring Mountains . . .	a 700
Ivanpah Valley, California, to Ivanpah Valley, Nevada, through alluvium and (or) carbonate rocks at State line	b 800
Ivanpah Valley to Las Vegas Valley, mainly through carbonate rock system or possibly via Jean Lake Valley	c 1,500
Jean Lake Valley to Las Vegas Valley, possibly via Hidden Valley	d about 100
Hidden Valley to Las Vegas	e minor
Hidden Valley to Eldorado Valley	f minor

a. Assumed equal to the difference between evapotranspiration loss of 2,200 acre-feet (table 9) and recharge of 1,500 acre-feet (table 8).

b. Assumed equal to the recharge to Ivanpah Valley, California part (table 8).

c. Assumed equal to the total recharge to Ivanpah Valley (table 8).

d. Assumed equal to recharge to Jean Lake Valley (table 8).

e. Assumed equal to that part of recharge to Hidden Valley west of McClanahan fault.

f. Assumed equal to that part of recharge to Hidden Valley east of McClanahan fault.

many of the railroad wells are either abandoned or are used only for domestic purposes by the few remaining residents.

A few attempts at irrigation farming were made in Ivanpah Valley near the State line and in Hidden Valley. Several irrigation wells were drilled in the 1950's and some land was cleared, but no crops are known to have been produced, and the wells are now unused. Mesquite Valley has witnessed several moderately large-scale attempts at irrigation development, the earliest being around 1910 (California Dept. of Water Resources, 1964a, p. 224). The majority of the irrigation wells were drilled in the 1950's, although most of them are now unused or destroyed. The crops attempted throughout the years included cotton, castor beans, alfalfa, and native pasture. In 1967 one farm was beginning to grow sorghum.

The greatest concentration of wells is in Mesquite Valley, which has at least 60; Ivanpah Valley has about 20; Hidden Valley, 3; and Jean Lake Valley, 2. Selected well data are listed in table 17. The amount of pumped water consumed in Mesquite and Ivanpah Valleys is shown in table 12. Only minor amounts were pumped in Jean Lake and Hidden Valleys in 1966-67.

Water development in the area (table 12) is exclusively ground water because of the absence of perennial streams. In Ivanpah Valley the tourist industry mainly supports the town of Jean, the major water consumer. Jean Lake and Hidden Valleys remain undeveloped, except for a minor amount of livestock watering.

Success of agricultural development currently being initiated in Mesquite Valley and future expansion will depend on many factors including water quantity and quality, soil characteristics, and economic controls. Length of growing season is also an important criterion affecting decisions on the type of crop to be planted. A determination of expected growing season length depends on availability of temperature data for the area.

Temperature data are recorded at few nearby locations outside the report area. Approximate station locations are shown in figure 2. Since 1949, the U.S. Weather Bureau has been publishing freeze data for many of their temperature recording stations. Data for five of these stations in adjacent areas are summarized in table 13. Because killing frosts vary with the type of crop, temperatures of 32°F, 28°F, and 24°F are used to determine the number of days between the last spring minimum (prior to July 1) and the first fall minimum (after July 1). The temperatures at Pahrump station may roughly approximate those in the agricultural part of Mesquite Valley. However, the Pahrump station is located

Table 12.--Ground-water development and estimated average annual water consumption, 1966-67

Development location	Type development	Use	Estimated average use rate[1] (acre-feet per acre per year)	Acres	Crop	Estimated average annual consumption (acre-feet per year)
			MESQUITE VALLEY			
20/12-33d	well	irrigation	2.0	40	cotton	80
20/12-29d	well	irrigation	1.7	110	sorghum	190
20/12-34c, 19/12-11b	wells	irrigation	1.7	190	sorghum	320
19/12-2a	wells	irrigation	2.0	3	cotton	6
19/12-2a	wells	irrigation	3.3	40	alfalfa	130
19/12-22b	well	irrigation	3.3	40	alfalfa	130
19/12-22b	well	irrigation	2.0	10	cotton	20
19/12-16a	wells	irrigation	3.3	160	alfalfa	530
Throughout valley	wells	domestic	Est. 0.1 acre-foot per person annually (30 people)	--	--	3
Throughout valley	wells	livestock	Est. 15 gpd per head (est. 100-200 head)	--	--	2
Total (rounded)				600		1,400
			IVANPAH VALLEY (Nevada part)			
T. 24 S., R. 58 E.	Goodsprings wells	Goodsprings domestic and public supply	Est. 0.1 acre-foot per person annually (100 people)	--	--	10
T. 25 S., R. 59 E.	Jean wells	Jean domestic and public supply	Est. based on transient population (65 people) and pumpage rates (25,000-40,000 gpd)[2]	--	--	20
Throughout valley	wells	livestock	Est. 6 gpd per head (est. 100-200 head)	--	--	1
Total (rounded)				--	--	30

1. Crop use rate based on those developed by houston, 1950.
2. Reported by Jean Water Manager

Table 13.--Length of growing season between killing frosts that occur at 32°, 28°, and 24°F

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

Station[1]	Altitude (feet)	Period of record	Minimum recorded (days) 32°F	28°F	24°F	Maximum recorded (days) 32°F	28°F	24°F	Average (days) 32°F	28°F	24°F
Boulder City	2,525	1949-66	239	--	--	333	--	--	275	--	--
Las Vegas Airport	2,162	1949-66	224	236	277	285	313	365	254	278	311
Mountain Pass	4,739	1956-66	171	204	231	239	274	316	204	220	261
Pahrump	2,669	1959-66	166	207	243	251	265	321	195	230	267
Searchlight	3,540	1949-66	224	209	252	278	365	265	241	287	320

1. See table 3 and figure 2 for location.

above the valley floor, whereas the agricultural areas of Mesquite Valley are on the valley floor. Therefore, the growing season in Mesquite Valley might be expected to be slightly shorter than that indicated by the Pahrump station. The limited data available for the Pahrump station indicate that crops would experience temperatures above 28°F probably for a period of about 210 to 265 days. The lower areas of Ivanpah Valley probably have a growing season similar to that of lower Mesquite Valley.

Temperature extremes in the lower parts of the valleys of the report area can be expected to range approximately from near 10°F to about 115°F during most years.

The long-term future course of development depends on many factors, but several trends are indicated for the immediate future. Continued success of the Mountain Pass mining operation may increase requirements for water in mining operations in the area. The tourist industry seems to be on the increase and this probably will enlarge water requirements in Ivanpah Valley. Agriculture may become more successful in Mesquite Valley, which would bring about marked changes and greater water requirements there. Increased growth of the Las Vegas Metropolitan area conceivably could stimulate fringe suburban domestic development throughout the area.

No immediate possibilities for development of the erratic and unpredictable surface-water flows are foreseen. Ground-water reserves have historically borne the small development load and probably will continue to be the major source of local supply in the foreseeable future.

WATER BUDGET FOR NATURAL CONDITIONS

Over the long term and for natural conditions inflow to and outflow from an area are equal, provided the long-term climatic regimen remains nearly constant. The equilibrium condition is assumed to prevail for the study area--an assumption that may not be actually correct. If it is not correct, the amount of ground water in storage may be changing. Comparisons of annual estimates of recharge and discharge for all valleys are shown in table 14.

In all valleys, the estimated recharge and discharge are shown to be in balance because the subsurface interbasin flow was computed by the difference between the other recharge and discharge estimates. Data are not available to make direct estimates of the underflow quantities.

Table 14.--Estimated ground-water budget, in acre-feet per year, for natural conditions

Budget item	Mesquite Valley[1]	Ivanpah Valley (California)	Ivanpah Valley (Nevada)	Jean Lake Valley	Hidden Valley
ESTIMATED RECHARGE:					
Precipitation (table 8)	1,500	800	700	100	minor
Subsurface inflow (table 11)	700	none	800	(a)	(b)
Total (rounded)	2,200	800	1,500	100	minor
ESTIMATED DISCHARGE:					
Evapotranspiration (table 9)	2,200	none	none	none	none
Springs (p. 27)	minor	minor	minor	minor	minor
Subsurface outflow (table 11)	none	800	1,500	100+	minor
Total (rounded)	2,200	800	1,500	100	minor

1. California and Nevada parts not distinguished.

a. Possibility of some inflow from Ivanpah Valley.

b. Possibility of minor inflow from Jean Lake Valley.

CHEMICAL QUALITY OF WATER

General Characteristics

Analytical results of water samples collected by the Geological Survey and selected results from files of the California Department of Water Resources are included in table 15. The availability of analyses is areally biased, because the greatest intensity of water-quality sampling generally occurred in the areas of greatest development. There are no analyses available for Hidden Valley and only one for Jean Lake Valley. Most water sampled was from comparatively shallow aquifers; deeper aquifers may contain water of considerably different quality.

The dissolved-solids content of water is indicated in a general way by the measurement of specific conductance. The dissolved-solids content, in parts per million, commonly equals about two-thirds the specific conductance, in micromhos per centimeter at 25°C (abbreviated "micromhos"). Specific conductance of sampled well water in the area ranges from 464 to 19,200 micromhos; therefore, dissolved-solids content probably ranges from about 300 to more than 10,000 ppm.

The analytical results (table 15) permit the following generalizations about the chemical quality of ground water in the area: Water tends to be more highly mineralized in Mesquite Valley toward the area of natural discharge around the playa; and water of poor quality is commonly present around the lower part of Ivanpah Valley near the State line; the absence of phreatophytes in the State line area prohibits associating poor water quality in this area with the effects of concentration of salts by evapotranspiration.

According to well-owners' reports (Calif. Dept. of Water Resources, 1964a, p. 225), water at depths below 700 feet in Mesquite Valley was found to be of poor quality.

Suitability of Ground Water for Various Uses

According to the Salinity Laboratory Staff, U.S. Department of Agriculture (1954, p. 69-82), the most significant factors with regard to the chemical suitability of water for irrigation are the dissolved-solids content, the relative proportion of sodium to calcium and magnesium, the amount of bicarbonate relative to calcium and magnesium, and the concentration of substances that are toxic to plants. Dissolved-solids content commonly is expressed as "salinity hazard," and the relative proportion of sodium to calcium and magnesium as "alkalinity hazard." The amount of bicarbonate in excess of calcium and magnesium is referred to as

Table 14.--Chemical analyses of water from selected wells

[Field-office analyses by the U.S. Geological Survey, except where noted]

Salinity and alkalinity hazards: L, low; M, medium; H, high; V, very high

RSC: S, safe; M, marginal

Location	Date sampled	Temperature (°F)	Parts per million (upper number), equivalents per million (lower number): Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sodium (Na) plus Potassium (K)[1]	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Hardness as $CaCO_3$: Calcium, magnesium	Noncarbonate	Specific conductance (micromhos per cm at 25°C)	pH	Irrigation quality[2]: Salinity hazard	Alkalinity hazard	RSC
MESQUITE VALLEY																					
18/13-8Q1[3]	5- 7-54	66	149	99	322	19	--	316	0	364	615	3	1.6	0.35	780	521	2,940	7.6	V	L	S
			7.46	8.13	14.00	0.50	--	5.18	0.00	7.60	17.34	0.05	0.08	--							
19/12-2A1	1-22-67	--	60	42	--	--	21	252	0	138	11	--	--	--	321	114	638	8.1	M	L	S
			2.99	3.42	--	--	0.90	4.13	0.00	2.87	0.31	--	--	--							
19/12-2D1[3]	5-20-55	61	68	40	19	2.5	--	234	0	161	14	4	0.6	0.04	334	142	648	7.6	M	L	S
			3.39	3.29	0.82	0.82	--	3.84	0.00	3.35	0.39	0.06	0.03	--							
19/12-3B1[3]	5-20-55	61	66	45	24	4.3	--	290	0	139	10	5	0.4	0.16	350	112	714	7.4	M	L	S
			3.29	2.70	1.40	0.11	--	4.76	0.00	2.89	0.28	0.07	0.02	--							
19/12-4B1[3]	5-20-55	66	53	45	20	1.8	--	261	0	121	8	6	0.4	0.12	317	103	588	7.8	M	L	S
			2.64	3.70	0.87	0.05	--	4.28	0.00	2.53	0.23	0.09	0.02	--							
19/12-11D1[3]	5-20-55	66	56	40	14	2.3	--	229	0	124	9	3	0.5	0.10	304	116	568	8.0	M	L	S
			2.79	3.29	0.61	0.06	--	3.76	0.00	2.58	0.25	0.04	0.03	--							
19/12-11Q1[3]	5- 7-54	66	51	51	20	2.5	--	276	0	132	12	4	0.7	0.15	335	108	617	7.9	M	L	S
			2.54	4.26	0.88	0.06	--	4.54	0.00	2.75	0.34	0.07	0.04	--							
19/12-14D1[3]	5- 7-54	68	58	80	36	2.5	--	252	0	308	21	7	0.7	0.3	427	220	953	8.0	H	L	S
			2.90	6.64	1.58	0.06	--	4.14	0.00	6.42	0.59	0.11	0.04	--							
19/12-14E1[3]	5-20-55	54	36	48	112	3.6	--	232	0	130	151	0	0.6	0.24	288	98	998	7.6	H	L	S
			1.80	3.95	4.87	0.09	--	3.80	0.00	2.70	4.26	0	0.03	--							
19/12-14M1[3]	5-20-55	--	41	60	140	4.0	--	178	24	160	230	3	0.6	0.2	348	162	1,360	8.5	H	L	S
			2.05	4.93	6.08	0.10	--	2.92	0.80	3.33	6.49	0.05	0.03	--							
19/12-15R1	1-22-67	65	33	51	--	--	51	382	0	40	34	--	--	--	293	0	722	7.7	M	L	S
			1.65	4.20	--	--	2.20	6.26	0.00	0.83	0.96	--	--	--							
19/12-26H1[3]	9-11-53	--	84	74	240	10	--	234	0	466	254	3	1.2	0.44	508	316	1,950	8.0	H	L	S
			4.19	6.08	10.44	0.24	--	3.84	0.00	9.71	7.16	0.05	0.06	--							
19/12-26H2	1-22-67	--	59	49	--	--	127	252	0	194	152	--	--	--	348	141	1,220	8.0	H	L	S
			2.94	4.01	--	--	5.51	4.13	0.00	4.04	4.29	--	--	--							
19/13-19N1[3]	9-14-54	63	18	28	521	62	--	284	0	260	593	8	1.2	0.23	163	0	2,500	8.0	V	H	M
			0.90	2.35	22.65	1.59	--	4.65	0.00	5.42	16.73	0.13	0.06	--							
20/12-19F1[3]	9-14-54	68	61	37	18	2	--	214	0	128	17	22	0.1	0.15	307	131	565	8.0	M	L	S
			3.05	3.10	0.77	0.05	--	3.51	0.00	2.66	0.48	0.35	0.01	--							
20/12-33Q1[3]	9-14-54	68	48	37	19	1.8	--	238	0	89	7	4	0.1	0.10	275	80	511	7.8	M	L	S
			2.40	3.10	0.82	0.05	--	3.90	0.00	1.85	0.20	0.07	0.01	--							
24/58-26b1	1-21-67	62	58	30	--	--	--	236	0	--	30	--	--	--	267	73	611	--	M	--	S
			2.89	2.44	--	--	--	3.87	0.00	--	0.85	--	--	--							
25/57-5a1[3]	9-14-54	68	79	40	14	2	--	269	0	138	18	5	0.2	0.16	365	144	637	7.8	--	L	S
			3.95	3.34	0.63	0.05	--	4.41	0.00	2.87	0.51	0.08	0.01	--							
25/57-9a1	1-22-67	--	64	42	--	--	20	280	0	111	23	--	--	--	334	104	667	8.1	M	L	S
			3.19	3.48	--	--	0.88	4.59	0.00	2.31	0.65	--	--	--							
25/57-36b1	1-22-67	63	62	36	--	--	--	276	0	--	334	--	--	--	304	78	1,840	--	H	--	S
			3.09	2.98	--	--	--	4.52	0.00	--	9.70	--	--	--							
IVANPAH VALLEY																					
15½/15-20J1[3]	5- 8-54	75	24	9	129	8	--	109	0	38	175	6	2.0	0.25	89	0	845	8.1	H	L	S
			1.22	0.76	5.60	0.20	--	1.79	0.00	0.80	4.92	0.10	0.11	--							
15½/15-23N1[3]	9-14-54	68	28	22	43	5.5	--	189	0	39	28	10	1.0	0.20	161	6	464	7.3	M	L	S
			1.40	1.83	1.86	0.14	--	3.10	0.00	0.81	0.78	0.16	0.05	--							
16/14-1H1[3]	9-11-53	72	42	19	60	3.0	--	194	0	44	67	15	0.3	0.16	187	27	641	7.8	M	L	S
			2.10	1.56	2.61	0.08	--	3.20	0.00	0.92	1.89	0.24	0.02	--							
16/14-12Q1[3]	5- 8-54	--	25	19	83	4.7	--	156	0	38	96	19	1.4	0.20	143	15	643	7.9	M	L	S
			1.26	1.60	3.60	0.12	--	2.56	0.00	0.79	2.71	0.31	0.07	--							
16/14-23Q1[3]	5- 8-54	--	45	31	71	4	--	136	0	76	121	17	0.9	0.25	237	103	794	7.6	H	L	S
			2.25	2.53	3.10	0.10	--	2.68	0.00	1.58	3.42	0.27	0.05	--							
16/16-33L1[3]	5- 8-54	78	8	1.1	105	2.5	--	131	0	41	65	19	2.1	0.20	25	0	528	8.2	M	M	M
			0.40	0.09	4.58	0.06	--	2.15	0.00	0.86	1.83	0.30	0.11	--							
17/14-36M1[3]	5-21-55	--	99	28	4,600	45	--	134	7	629	6,800	0	2.3	3.8	312	190	19,200	8.2	V	V	S
			4.94	2.30	200.1	1.15	--	2.20	0.24	13.11	191.8	0.00	0.12	--							
27/59-8a1[3]	5-21-55	72	583	0	5,000	105	--	20	12	1,060	7,800	13	1.0	2.3	143	107	19,200	9.0	V	V	S
			29.1	0	217.5	2.69	--	0.32	0.40	22.07	220.0	0.21	0.05	--							
JEAN LAKE VALLEY																					
25/60-10d1	5-21-55	--	30	30	--	--	175	136	0	88	266	--	--	--	198	87	1,300	7.7	H	L	S
			1.50	2.46	--	--	7.60	2.23	0.00	1.83	7.50	--	--	--							

1. Computed by arithmetic difference, and reported as sodium.
2. Classification based on criteria stated by U.S. Salinity Laboratory Staff (1954, p. 75-82).
3. Analytical data from California Department of Water Resources (1956, p. 24-29).

residual sodium carbonate, or "RSC." Boron, which is necessary in small quantities for healthy plant growth, is toxic to plants when present in water in quantities only slightly exceeding the desirable amount. Table 15 shows that the analyzed ground water ranged widely in acceptability for agricultural use. The agricultural suitability of Mesquite Valley ground water is apparently greatest in areas away from the playa deposits and at shallow depths. Ivanpah Valley has excessively alkaline and saline water beneath the valley floor near the State line; water in that area is also typified by excessive boron.

Agricultural development in the study area may be influenced ultimately more by the chemical quality of the water than by the quantity of water available. In any event, evaluation of prospective agricultural development warrants careful consideration of the chemical quality of the water and the chemical and physical character of the lowland soils. This would help ensure compatability of soil and irrigation water with the type of crops planned.

Future recycling of ground water for intensive irrigation around the playa margins probably will degrade the chemical quality of the water, particularly if commercial fertilizers are used in substantial quantities and if the soil contains leachable salts.

Drinking-water standards recommended by the U.S. Public Health Service (1962) commonly are cited as limits for domestic use. Several of these standards are as follows:

Chemical constituent	Recommended maximum concentration (ppm)
Sulfate	250
Chloride	250
Fluoride	a 1.0
Nitrate	45
Total dissolved solids	500

a. Recommended upper control limits based on an average annual maximum daily temperature of about 75-78°F.

As indicated by table 15 and the above tabulation, water from several wells would be deemed unacceptable, because of sulfate, chloride, fluoride, and total dissolved-solids concentrations. No well water analyzed would be considered unacceptable because of excessive nitrate.

Hardness of water, which is mainly caused by calcium and magnesium, adversely affects suitability of water for domestic use, especially for cooking and washing, and may also be detrimental to certain industrial uses. The U.S. Geological Survey uses the following classification of water hardness:

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

Water analyzed from the study area generally ranges from hard to very hard.

Many well waters in and near the report area were not analyzed for their chemical quality, and the analytical procedures employed were not intended to determine the presence of many elements known to be toxic in excessive concentrations; also, bacteriological tests were not performed on any samples. To assure that the water is safe and acceptable for human consumption, water samples should be submitted to a reliable laboratory or to the Nevada Bureau of Environmental Health for appropriate analysis whenever domestic or municipal use is planned for a particular water supply.

The suitability of water for industrial use depends on the quality requirements of the industry. Water considered unacceptable for internal consumption by humans and animals might be desirable for industrial use.

THE AVAILABLE WATER SUPPLY

The available ground-water supplies of the four valleys of the area consist of two interrelated entities: (1)perennial yield, and (2) transitional storage reserve, which are described below.

Perennial Yield

Perennial yield of a ground-water reservoir may be defined as the maximum amount of water of usable chemical quality that can be withdrawn and consumed economically each year for an indefinite period of time. If the perennial yield is continually exceeded, water levels will decline until the ground-water reservoir is depleted of water of usable quality or until the pumping lifts become uneconomical to maintain. Perennial yield cannot exceed the natural recharge to an area and ultimately is limited to the maximum quantity of natural discharge that can be salvaged for beneficial use. Salvage of natural discharge implies diversion by pumping of ground water presently destined for areas of natural discharge. A method of accomplishing the diversion is the lowering of water levels in and near areas of natural discharge by scheduled depletion of storage according to the concept of transitional storage reserve (defined below).

Table 14 shows the estimated values of recharge and discharge for all valleys of the report area. The estimated total natural discharge from Mesquite Valley is by evapotranspiration, and amounts to 2,200 acre-feet per year. Because most of this probably could be salvaged, as described above, the perennial yield is considered to be about the same magnitude as that of natural discharge.

For Ivanpah, Jean Lake, and Hidden Valleys, virtually all the natural discharge is by subsurface outflow. The possibility of salvaging all or part of the outflow is dependent on the manner in which the flow moves out of the valleys. If the water is moving over a "spillway" or "lip," most could be salvaged by drawing down the water level below the outlet altitudes. However, if the outflow is dispersed vertically through permeable rock or occurs at considerable depth, only a small part of the natural discharge could be salvaged by pumping within the valleys. Because the salvable discharges probably lie somewhere between the limits set forth by these conditions, the preliminary estimates of perennial yield for Ivanpah, Jean Lake, and Hidden Valleys are assumed for reconnaissance purposes to be about one-half the annual recharge-discharge value for each valley, or about 700, 50, and a few acre-feet, respectively.

Transitional Storage Reserve

Transitional storage reserve has been defined by Worts (1967) as the quantity of ground water in storage in a particular basin that can be extracted and beneficially used during the transition period between equilibrium conditions in a state of nature and new equilibrium conditions under the perennial-yield concept of ground-water development. In the arid environment of the Great Basin and under the general design of Nevada water law, the transitional storage reserve of this area is the amount of stored water available for withdrawal by pumping during the nonequilibrium period of development or period of lowering water levels. Therefore, transitional storage reserve is a specific quantity of water available from ground water in storage; it is a quantity additional to that of perennial yield, but can be withdrawn on a once-only basis.

Ground-water development inherently involves storage depletion; the magnitude of depletion is commensurate with the volume of pumpage, the hydraulic characteristics of the aquifer, and locations of wells with respect to recharge and discharge boundaries. Desert valleys often have well-defined discharge boundaries, such as areas of evapotranspiration, but recharge boundaries, such as live streams or lakes, are uncommon.

Computation of transitional storage reserve for valleys of the report area was based on the following assumptions: (1) Development wells would be strategically located in, near, and around the areas of natural discharge so that any subsurface outflow losses could be reduced and any evapotranspiration losses stopped with a minimum of water-level drawdown in the pumped wells; (2) in general, water levels would be lowered to and stabilized at a minimum depth of 50 feet below the land surface in areas of phreatophyte growth, which would curtail virtually all evapotranspiration losses from the ground-water reservoir; (3) long-term pumping would cause a moderately uniform depletion of storage throughout the valley-fill reservoir, except in the very fine-grained playa deposits where transmissibility and storage coefficients are small and therefore storage depletion also would be small or occur over a very long period of time; (4) the specific yield of the valley fill is 10 percent; (5) water levels are within the range of economic pumping lift for the intended use; (6) the pumping development causes little or no effect on adjacent valleys and only small quantities of water are withdrawn from the adjacent consolidated-rock mountain masses; and (7) the water is of suitable chemical quality for the desired use. Table 16 presents the preliminary estimates of transitional storage reserve of the area, based on the above assumptions.

Table 16.--Estimated transitional storage reserve

Valley	Selected area of depletion (acres) (1)	Selected depletion (dewatered) thickness (feet) (2)	Transitional storage reserve (acre-feet) (1) x (2) x 0.1
Mesquite Valley	120,000	a 40	480,000
Ivanpah Valley (Nevada)	56,000	b 50	280,000
Jean Lake Valley	30,000	b 50	150,000
Hidden Valley	7,500	b 50	38,000

a. Minimum depth to water table about 10 feet.

b. Assumes 50-foot dewatering would salvage about half the subsurface outflow.

The manner in which transitional storage reserve augments the perennial yield has been described by Worts (1967) and in its simplified form is shown by the following equation:

$$Q = \frac{\text{Transitional storage reserve}}{t} + \frac{\text{Perennial yield}}{2}$$

in which Q is the pumping rate, in acre-feet per year, and t is the time, in years, to exhaust the storage reserve. This basic equation, of course, could be modified to allow for changing rates of storage depletion and salvage of natural discharge. The equation, however, is not valid for pumping rates less than the perennial yield.

Using the above equation and the estimates for Mesquite Valley as an example (transitional storage reserve 480,000 acre-feet, table 16; perennial yield 2,200 acre-feet, p.41) and using a pumping rate (Q) equal to perennial yield in accordance with the general intent of Nevada water law, the time (t) to deplete the transitional storage reserve is computed to be 440 years. At the end of that time, the transitional storage reserve would be exhausted, subject to the assumptions previously described.

What is not shown by the example is that in the first year of pumping virtually all the water would be supplied from storage, and very little, if any, would be derived by salvage of natural discharge. On the other hand, during the last year of the period nearly all pumpage would be derived from the salvage of natural discharge and virtually none from the storage reserve.

During the period of depletion the ground-water flow net would be substantially modified. The estimated recharge of 2,200 acre-feet per year that originally flowed from around the sides of the valley to areas of natural discharge would ultimately flow directly to the pumping wells.

To meet the needs of an emergency or other special purpose requiring ground-water pumpage in excess of the perennial yield for specified periods of time, the transitional storage reserve would be depleted at a more rapid rate than in the example given. The above equation can be used to compute the time required to exhaust the storage reserve for any selected pumping rate in excess of the perennial yield. However, once the transitional storage reserve was exhausted, the pumping rate should then be reduced to the perennial yield. Pumpage in excess of the perennial yield would result in an overdraft, and pumping lifts would continue to increase and stored water would continue to be depleted until some undesired result occurred.

NUMBERING SYSTEM FOR WELLS AND SPRINGS

Numbers assigned to Nevada wells in this report are based on the rectangular subdivisions of the public lands referenced to the Mount Diablo base line and meridian. Each number consists of three units; the first is the township south of the base line. The second unit, separated from the first by a slant, is the range east of the meridian. The third unit, separated from the second by a dash, designates the section number, which in turn is followed by a letter that indicates the quarter section. The quarter sections are designated counter clockwise in sequence beginning with "a" for the northeast quarter section. Following the letter, a number indicates the order in which the well or spring was recorded within the 160-acre tract. For example, well 25/57-5a1 is the first well recorded in the northeast quarter of sec. 5, T.25 S., R.57 E., Mount Diablo base line and meridian.

Numbers assigned to wells in California conform to the numbering system used in all ground-water investigations made by the U.S. Geological Survey in California. Rectangular subdivision of public lands in the California part of the report area is referenced north and east of the San Bernardino base line and meridian. Under the California numbering system, each section is divided into 40-acre plots which are lettered as follows:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Wells are numbered within each of these 40-acre plots according to the order in which they are located. For example, well 19/12-2A1 is the first well recorded in the 40-acre plot lettered A of sec. 2, T.19 N., R.12 E., San Bernardino base line and meridian.

Because of limitation of space, wells are identified on plate 1 only by the section number, quarter-section or quarter-quarter-section letters, and the number indicating the order in which the well or spring was located. Township and range numbers are shown along the margins of the plate.

Table 17.--Records of selected wells

Use: D, domestic, I, irrigation, M, municipal; S, stock; U, unused
Symbol preceding / designates original well use;
symbol following / designates current use
Yield and drawdown: Reported or from records of the Nevada State Engineer
State log number: Log number in the files of the Nevada State Engineer

Well number	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land-surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	State log number
				MESQUITE VALLEY						
18/13-8Q1[1/]	Greens Mill well	1933	80	(dug)	S/U	--	2,575	5- 7-54	41	--
			38	4x6 ft				1-22-67	dry	
18/13-12Q1	Bullocks well	--	56	(dug)	S/U	--	2,660	1916	52	--
			63	3x3 ft				1-22-67	dry	
18/13-23M1	Mesquite well	1960	--	8	S	--	2,650	1-22-67	79.15	--
19/12-2A1	P. Davin	--	105	9	D	--	2,610	1-23-67	a 27	--
19/12-2B1	P. Davin	--	--	--	I	500/73	2,615	--	--	--
19/12-2B2	P. Davin	--	--	--	I	500/73	2,610	--	--	--
19/12-2D1[1/]	R. E. Case	1953	600	14	I/U	800±/--	2,615	--	--	--
19/12-2M1[1/]	Abbott	1953	600	12	D/U	--	2,605	5-20-55	33.4	--
								6-14-62	32.8	
19/12-3B1[1/]	R. Davin	1954	60	--	I/U	--	2,620	5-10-55	39.8	--
19/12-3D2[1/]	--	1953	600+	--	I/U	--	2,620	5- 6-64	54.4	--
19/12-4B1[1/]	W. Hauk	1954	500-600	14	I/U	300/--	2,635	--	--	--
19/12-10B1[1/]	H. Hattendorf	1953	b 380	14	I/U	--	2,605	9-28-55	45.2	
19/12-11B1[1/]	W. P.Barrington	1953	600	--	I/U	--	2,595	9-28-55	31.4	--
								5-15-64	29.9	
19/12-11D1[1/]	H. Bruce	1953	600	--	I	--	2,600	6-14-62	38.0	--
								5- 6-64	37.8	
19/12-11Q1[1/]	B. Purcell	1930	35	(dug)	D/U	--	2,585	--	--	--
				4x4 ft						
19/12-13D1[1/]	W. Purcell	--	--	12	I/U	--	2,580	5-12-57	33.3	--
19/12-14C1[1/]	O. Lee	1958	400	--	I/U	--	2,585	5-20-58	33	--
								5- 5-64	33.4	

Table 17.--Continued

Well number	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land-surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	State log number
19/12-14D1[1/]	O. Lee	1935	50	8	D/U	---	2,585	5- 7-54	37.7	---
								9-14-54	38.0	
19/12-14D2[1/]	O. Lee	1930	42	---	D/U	---	2,585	5-20-55	37.5	---
19/12-14D3[1/]	O. Lee	1934	160	8	U	---	2,585	---	---	---
19/12-14D4[1/]	O. Lee	1952	800	14	I/U	---	2,587	5-20-55	38.5	---
								5- 5-64	37.9	
19/12-14E1[1/]	O. Lee	1952	1,050	12	I/U	---	2,580	5-20-55	38.5	---
								1-22-67	38.59	
19/12-14M1[1/]	H. Brockbank	1953	610	14	I/U	---	2,583	9-12-53	36.0	---
								5-20-55	35.4	
								5-14-62	35.3	
								5- 5-64	34.2	
19/12-14N2[1/]	W. E. Groom	1954	600	12-14	I,D/U	---	2,610	5-12-57	57.7	---
19/12-15N1[1,2/]	W. E. Groom	1954	1,000	12	I/U	---	2,610	5-12-57	56.5	---
19/12-15R1	---	---	---	(dug)	D/U	---	2,580	1-22-67	33.92	---
19/12-16A1	Morton Investment Co.	---	600	---	I	800	2,620	---	---	---
19/12-16H1	Morton Investment Co.	---	600	---	I	800	2,620	---	---	---
19/12-23G1[1/]	H. Reynolds	1955	493	16	I/U	---	2,580	9-28-55	28.2	---
19/12-23H1[1/]	H. Reynolds	1956	90	---	D	---	2,580	---	---	---
19/12-26H1[1/]	C. Clark	1952	100	10	D	---	2,610	9-11-53	48.0	---
19/12-26H2[1/]	C. Clark	---	60-67	6-8	D	---	2,600	1-22-67	48.04	---
19/12-26J1[1/]	C. Clark	1952	640	14	I/U	---	2,620	8-15-55	67.0	---
19/13-19L1[1/]	W. Spencer	---	---	---	---	---	2,555	---	---	---
19/13-19N1[1/]	W. Spencer	1949	25-29	---	D,S	---	2,550	5- 7-54	14.6	---
								1-22-67	15.20	
19/13-19Q1[1/]	Buzzard Roost well	---	---	12	S	---	2,550	5-10-61	9.8	---
								5- 6-64	9.0	
20/12-19F1[1/]	W. Hauk	1953	600-700	12-14	I/U	1,500/---	2,700	5- 7-54	126.4	---
								6-14-62	129.0	
								5- 6-64	129.4	
20/12-19H1	---	---	---	12	I/U	---	2,685	1-22-67	103.54	---
20/12-29M1[1/]	Wood	---	700	12	I/U	800/---	2,665	---	---	---

Table 17.--Continued

Well number	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land-surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	State log number
20/12-30B1[1/]	W. Hauk	--	--	--	--	--	2,680	5-14-59	107	--
								5-10-61	113	
20/12-33Q1[1/]	C. Luttig	1953	600-700	10-14	I	--	2,630	1-22-67	63.55	--
20/12-33Q2[1/]	--	--	--	--	I	--	--	--	--	--
20/12-34K1[1/]	W. C. Gibson	1955	400	12	I/U	--	2,630	5-20-55	41.8	--
20/12-34M1[1/]	W. Hauk	1955	600	14	I	--	2,630	5-20-55	52.1	--
								5- 6-64	53.7	
23/55-25b1	--	--	150	6	S/U	--	2,920	2-14-67	117.3	--
24/56-16c	M. Mello	1958	415	18	I/U	250/--	2,705	1-23-67	99.26	6343
24/56-25c	N. S. Company	1956	1,020	12	I/U	1,450/--	2,655	2- -56	53	6302
24/56-26d	N. S. Company	1955	925	14	I/U	1,250/--	2,655	12- -55	55	6303
25/57-5a[1/]	D. Battey	1920	60±	--	D	--	2,635	1-21-67	46.46	--
25/57-9a[1/]	R. Spurlock	--	--	--	D	--	2,640	1-23-67	a 52	--
25/57-9a	R. Spurlock	--	490	20	I	800/53	2,635	1-23-67	a 47	--
25/57-16d	--	--	--	6	D,I	--	2,600	--	--	--
25/57-22d	H. Smith	1960	250	20	I/U	500/--	2,620	4- -60	a 44	5140
25/57-26b	D. Smith	1962	305	14	I/U	--	2,650	1-22-67	49.98	6396
25/57-26d	H. Smith	1963	162	14	I/U	--	2,640	3- -63	a 33.30	7062
25/57-36d[1/]	--	--	--	(dug) 4x5 ft	S	--	2,640	1-22-67	49.95	--
				IVANPAH VALLEY						
15½/15-20K1[3/]	Molybdenum Corporation of America	1953	--	12	I,D	600/9	2,705	--	--	--
15½/15-20K2[3/]	Molybdenum Corporation of America	1965	860	12	I,D	250/20	2,705	--	a180±	--
15½/15-21K1	--	--	--	(dug)	U	--	--	3-14-67	Dry at 82 ft	--
15½/15-23N1	Murphy well	--	--	30	S	--	2,630	2-15-67	100.40	--
16/14-1H1[1/]	Jack Ruoff	1939	160	8	D	--	2,630	5-21-55	100.1	
16/14-23Q1[1/]	W. E. Smith	1953	544	10	D	--	3,060	8-15-53	515.0	--
16/15-6P1	Yates well	--	--	6	S	--	2,615	2-15-67	88.66	--

Table 17.--Continued

Well number	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land-surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	State log number
16/15-12Q1	Union Pacific Railroad	1943	609	16	D,I	---	2,801	3-14-67	271	--
16/16-33L1	Winnefield	---	650	---	D	---	3,070	3-14-67	a540	--
17/14-36M1[1]	Ray Smith	1937	was 1,600 now 800	8	S/U	---	2,665	3-14-67	131.78	--
23/61-19d1	--	---	800	12	U	---	2,675	2-15-67	552.5	--
24/58-26b1	--	---	---	8	S	---	3,760	1-21-67	54.05	--
25/59-13b1	P. A. Simon	1958	945	8	PS	150/--	2,840	9-11-58	365	4294
25/59-14a1	P. A. Simon	1949	646	12	PS	--	2,845	2-15-67	364.40	953
25/59-14b1	P. A. Simon	1958	640	8	I,D	---	2,890	1-15-48	350±	3840
25/59-14c1	Nevada Highway Dept.	1959	450	8-10	D	22/---	2,850	2-15-67	354.7	4989
26/59-16c1	Nevada Highway Dept.	---	---	8	D	---	2,635	2-15-67	115.7	---
27/59-8a	Calada Club	1954	635-650	12	D/U	--	2,612	1-21-67	89.55	--
27/59-8c1	E. J. Primm	1948	600	8	D	---	2,602	2-15-67	82.79	690
27/59-16a1	Primm Investment Co.	1955	555	12	D/U	---	2,760	---	---	2861
				JEAN LAKE VALLEY						
25/60-8a1	O. A. Paul	1962	140	10	U	---	2,790	---	Dry hole	6803
25/60-10d1	---	---	470	6	S	---	2,784	11-23-56	343.02	--
				HIDDEN VALLEY						
24/61-20d1	J. Wollenzein	1954	640	6	S	--	3,028	2-20-54	600	2516
24/61-28b1	F. D. Smith	1953	1,490	---	U	---	3,030	1953	950	2364
25/61-5a1	G. F. Wellington	1960	787	14	I/U	---	3,030	11-22-60	599	5658

1. Part or all data pertaining to this well was obtained from California Department of Water Resources files or publications.
2. Poor quality water below 700 feet.
3. Data furnished in part by Molybdenum Corporation of America.

a. Reported.
b. Originally drilled to 1,180 feet but back filled to 380 feet, poor quality water below 700 feet.

Table 18.--Available drillers' logs of wells

Material	Thickness (feet)	Depth (feet)
24/56-16c1		
Soil	30	30
Shell, hard	3	33
Soil and gravel	12	45
Shell, hard	3	48
Clay and gravel	14	62
Shell, hard	5	67
Clay and gravel	5	72
Shell, hard	2	74
Clay and gravel	19	93
Shell, solid, hard	15	108
Clay, red	8	116
Shell, hard	11	127
Clay, reddish, with sand and gravel streaks	83	210
Clay, sticky, red	50	260
Clay, light pink	25	285
Clay, light colored, and little sand	10	295
Shell, hard	3	298
Clay, red	12	310
Gravel, cemented	35	345
Gravel, cemented, with occasional soft streaks	70	415
24/56-25c1		
Soil	2	2
Clay	58	60
Rock and gravel, waterbearing	2	62
Clay, caliche	10	72
Boulders and gravel	3	75
Caliche	148	223
Sand and gravel	22	245
Caliche	145	390
Clay and gravel streaks	34	424
Caliche	161	585
Clay, fractured, with gravel	7	592
Clay, red	268	860
Sand, rock, and gravel	15	875
Sandstone	19	894
Clay, fractured, with gravel streaks	126	1,020
24/56-26d1		
Soil	3	3
Clay	41	44
Rock and gravel	3	47
Caliche	15	62
Gravel	2	64
Caliche	115	179
Rock	4	183
Caliche	97	280
Rock, chunky, and gravel	12	292
Caliche	191	483
Rock and gravel	3	486
Clay, red	29	515
Clay, red, and gravel streaks	40	555
Clay, sandy, red	59	614
Gravel, coarse	6	620
Clay, red	145	765
Gravel streaks and clay	32	797
Boulders and clay	63	860
Clay, fractured	30	890
Clay, hard, red	25	915
Gravel with streaks of clay	8	923
24/61-28b1		
Sand	5	5
Clay	5	10
Gravel	10	20
Boulders	10	30
Boulders and gravel	250	280
Rock, volcanic, black	105	385
Sand, black	15	400
Rock, black	102	502
Rock, volcanic, red	33	535
Sand, brown	15	550
Sand, hard, fine, brown	125	675
Sand, black	28	703
Sand, hard, black	57	760
Rock, red	5	765
Sand, black	45	810
Quartz and red rock	6	816
Quartz and black rock	4	820
Volcanic, black	150	970
Rock, volcanic, black and red	210	1,180
Sand, black	140	1,320
Lime, gray	170	1,490

Table 18.--Continued

Material	Thickness (feet)	Depth (feet)
25/57-22d1		
Rock, native, and gravel boulders	65	65
Boulders	8	73
Gravel, pea	5	78
Gypsum, white, and sand	46	124
Gypsum, hard	6	130
Gypsum, brown	3	133
Gypsum, hard	9	142
Clay and gypsum	10	152
Gypsum, hard	43	195
Clay, brown	12	207
Clay, sandy, brown	23	230
Clay and gypsum	20	250
25/57-26b1		
Topsoil	3	3
Caliche	5	8
Gypsum, hard	13	21
Clay, sticky	9	30
Gravel and sand streaks	25	55
Clay and gravel, and hard shell	72	127
Gravel	10	137
Boulders and clay	35	172
Sand, gypsiferous, with clay streaks	18	190
Clay, brown	12	202
Clay, gypsiferous, with streaks of gravel	58	260
Gravel and clay streaks	15	275
Clay, blue-green, and gravel	30	305
25/59-14c1		
Gravel, cemented	276	276
Gravel, cemented, brown	34	310
Gravel, cemented, brown, and sand	7	317
Gravel, cemented	2	319
Gravel, cemented, and sand	27	346
Gravel, cemented	19	365
Gravel, cemented, and sand	5	370
Gravel, cemented, and sand, water-bearing	5	375
Gravel, cemented	15	390
Clay, sandy, and gravel	5	395
Clay, sandy, water-bearing	15	410
Clay, sandy, and gravel	10	420
Clay, gravelly	17	437
Gravel and some clay	4	441
Clay	2	443
Gravel	7	450
25/60-8a1		
Clay and gravel	60	60
Gravel, cemented	46	106
Lava, black	34	140
25/61-5a1		
Gravel and clay	140	140
Cinders, red, water-bearing at 600 feet	467	607
Cinders, black	15	622
Clay and cinders	113	735
Cinders, water-bearing	25	760
Soapstone	10	770
Clay, red	15	785
Rock, black	2	787
27/59-8c1		
Clay, brown	40	40
Clay, yellow	45	85
Lime	10	95
Gravel, water-bearing	5	100
Lime	15	115
Gravel, water-bearing	5	120
Gravel, cemented, brown	45	165
Clay, red	10	175
Clay, brown, and gravel	55	230
Lime, hard, pink	60	290
Clay, red	10	300
Rock, basalt, broken	30	330
Lime, hard, pink	65	395
Gravel, cemented	70	465
Clay, brown, and gravel	30	495
Rock, lime, broken	15	510
Lime, hard, brown	20	530
Gravel, water-bearing	10	540
Clay, sandy, pink	35	575
Lime, hard and smooth, pink	15	590
Clay, brown	10	600

Table 13.--Continued

Material	Thick- ness (feet)	Depth (feet)
16/15-12Q1		
Sand and boulders	20	20
Sand, gravel, and boulders	35	55
Boulders, hard	5	60
Boulders and gravel	130	190
Boulders and cemented gravel	32	222
Boulders and gravel	81	303
Gravel and yellow clay	22	325
Rocks and gravel	50	375
Boulders and clay	47	422
Boulders and gravel	90	512
Rocks and clay	53	565
Boulders	17	582
Rock, fractured	20	602
Bedrock	7	609
16/15-20J1		
Sand and silt	2	2
Conglomerate, gray	153	155
Clay, red	20	175
Gravel and sand, water-bearing, 5-foot artesian rise	3	178
Clay, red	20	198
Lime, brown, water-bearing	2	200
Clay, red, and gravel	60	260
Conglomerate, brown	75	335
Shale, sandy, green	50	385
Slate, green, hard streaks	45	430
Clay, green	10	440
Shale, green, hard streaks	135	575
Conglomerate, hard (cut bit badly)	40	615
Clay, soft, sticky, green	5	620
Flint and conglomerate, hard	10	630
Gombo, tough, sticky	20	650
Clay, soft, sandy	5	655
Lime, hard, lavender	5	660
Gumbo, tough, sticky (bad at 675 feet)	30	690
Gravel, water-bearing	5	695
Clay, sticky	5	700
Sand and gravel, water-bearing	5	705
Sylvin shale	25	730
Conglomerate, possibly water-bearing	5	735

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Report No.	Valley
1	Newark (out of print)
2	Pine (out of print)
3	Long (out of print)
4	Pine Forest (out of print)
5	Imlay area (out of print)
6	Diamond (out of print)
7	Desert
8	Independence
9	Gabbs
10	Sarcobatus and Oasis
11	Hualapai Flat
12	Ralston and Stonecabin
13	Cave
14	Amargosa
15	Long, Surprise, Massacre Lake, Coleman, Mosquito, Guano, Boulder
16	Dry Lake and Delamar
17	Duck Lake
18	Garden and Coal
19	Middle Reese and Antelope
20	Black Rock Desert, Granite Basin, High Rock Lake, Summit Lake
21	Pahranagat and Pahroc
22	Pueblo, Continental Lake, Virgin, Gridley Lake
23	Dixie, Stingaree, Fairview, Pleasant, Eastgate, Jersey, Cowkick
24	Lake
25	Coyote Spring, Kane Spring, Muddy River Springs
26	Edwards Creek
27	Lower Meadow, Patterson, Spring (near Panaca), Panaca, Eagle, Clover, Dry
28	Smith Creek and Ione
29	Grass (near Winnemucca)
30	Monitor, Antelope, Kobeh
31	Upper Reese
32	Lovelock
33	Spring (near Ely) (out of print)
34	Snake, Hamlin, Antelope, Pleasant, Ferguson Desert (out of print)
35	Huntington, Dixie Flat, Whitesage Flat (out of print)
36	Eldorado - Piute Valley (Nevada and California)
37	Grass and Carico Lake (Lander and Eureka Counties)
38	Hot Creek, Little Smoky, Little Fish Lake
39	Eagle (Ormsby County)
40	Walker Lake, Rawhide Flats, Whiskey Flat
41	Washoe Valley
42	Steptoe Valley
43	Honey Lake, Warm Springs, Newcomb Lake, Cold Spring, Dry, Lemmon, Red Rock, Spanish Springs, Bedell Flat, Sun, Antelope
44	Smoke Creek Desert, San Emidio Desert, Pilgrim Flat, Painters Flat, Skedaddle Creek, Dry (near Sand Pass), Sano

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ILLUSTRATIONS

PHOTOGRAPHS

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

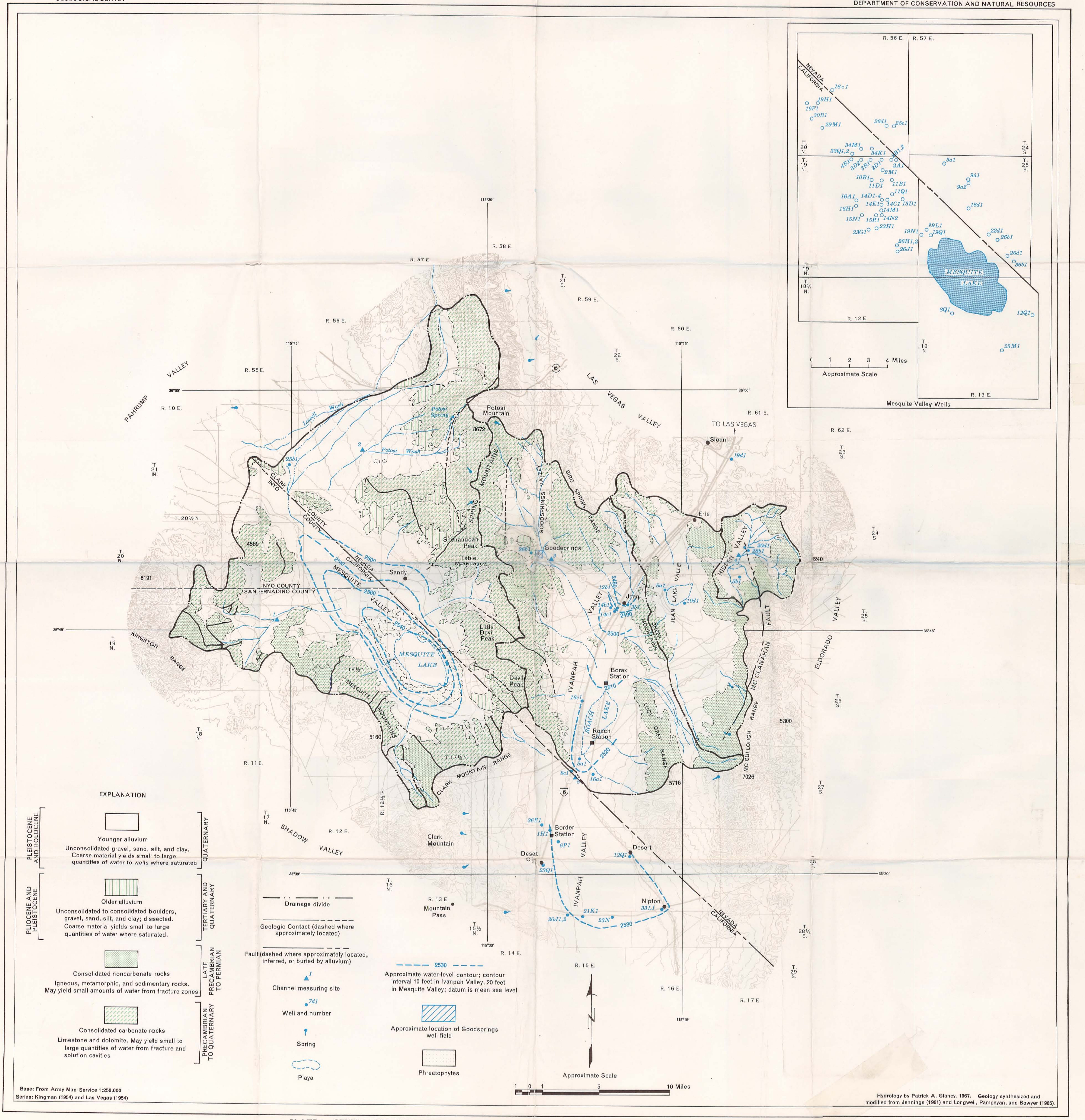

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF MESQUITE-IVANPAH VALLEY AREA, NEVADA AND CALIFORNIA