STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Carson City

Evaporation pond for concentrating lithium on Clayton Valley playa.

WATER RESOURCES – RECONNAISSANCE SERIES
REPORT 45

WATER–RESOURCES APPRAISAL OF CLAYTON VALLEY–STONEWALL FLAT AREA, NEVADA AND CALIFORNIA

By
F. Eugene Rush

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

MAY 1968

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View of Clayton Valley playa looking westward toward Silver Peak.

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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 45th report prepared by the staff of the Nevada District Office of the U.S. Geological Survey. These 45 reports describe the hydrology of 112 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.

Elmo J. DeRicco
Director

May 1968

Department of Conservation
and Natural Resources

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WATER-RESOURCES APPRAISAL OF THE CLAYTON VALLEY-STONEWALL FLAT AREA, NEVADA AND CALIFORNIA

By F. Eugene Rush

SUMMARY

The report area is in south-central Nevada and south-easten California and lies south of Tonopah, Nevada, and north of Death Valley. The area covers about 2,000 square miles and is composed of six valleys. They are parts of three major hydrologic systems that apparently terminate in Clayton Valley, Sarcobatus Flat, and Death Valley.

Table 1 summarizes the hydrology of the valleys. Evapotranspiration is the dominant type of natural discharge from Clayton Valley; in the other valleys, subsurface outflow generally dominates. Clayton Valley has the highest water-development potential, with 20,000 acre-feet of natural discharge as yet undeveloped.

The estimated recharge to Ralston and Stonecabin Valleys, as presented in Reconnaissance Series report 12, has been drastically reduced from 16,000 acre-feet per year in each valley to 5,000 acre-feet per year. Subsurface inflow to Alkali Spring Valley of this report has been reduced accordingly to an estimated total of 5,500 acre-feet per year. The estimated perennial yields of Ralston and Stonecabin Valleys are considered to remain at 2,500 and 2,000 acre-feet, respectively.

Table 1.--Hydrologic summary

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

	Clayton Valley	Alkali Spring Valley	Lida Valley	Stonewall Flat	Oriental Wash	Grapevine Canyon
Approximate growing season (days)	150-180	140-180	140-180	140-180	140-180	150-180
Valley area (sq mi)	518	320	535	342	172	158
Surficial drainage character	(a)	(a)	(b)	(a)	(b)	(b)
Surface-water runoff from mountains	3,500	400	1,300	400	1,000	500
Ground-water recharge from precipitation	1,500	100	500	100	300	50
Subsurface inflow	18,000	5,500	200	--	0	500
Preliminary estimate of perennial yield	22,000	3,000	350	100	150	400
Preliminary estimate of transitional storage reserve[1]	450,000	30,000	600,000	350,000	180,000	0
Present ground-water development (rounded)	2,000	40	30	minor	10	10

Revised estimate of inflow to the report area from Ralston and Stonecabin Valleys is 5,500 acre-feet per year.

1. Total acre-feet.

a. Internal drainage.

b. External drainage.

INTRODUCTION

Purpose and Scope of the Study

Ground-water development in Nevada has shown a substantial increase in recent years. A part of this increase is due to the effort to bring new land into cultivation. The increasing interest in ground-water development has created a substantial demand for information on ground-water resources throughout the State.

Recognizing this need, the State Legislature enacted special legislation (Chapter 181, Statutes of 1960) for beginning a series of reconnaissance studies of the ground-water resources of Nevada. As provided in the legislation, these studies are being made by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. This is the 45th report prepared as part of the reconnaissance studies (fig. 1).

During the course of the earlier ground-water studies, little information on surface-water resources was presented. Later the reconnaissance series was broadened to include preliminary quantitative evaluations of the surface-water resources in the valleys studied.

The objectives of the reconnaissance studies and this report are to (1) describe the hydrologic environment, (2) appraise the source, occurrence, movement, and chemical quality of water in the area, (3) estimate average annual recharge to and discharge from the ground-water reservoir, (4) provide preliminary estimates of perennial yield and transitional storage reserve, and (5) estimate present and evaluate potential water development in the area.

The field work was done during January 1967.

Location and General Features

The area discussed in this report is in southwestern Nevada and southeastern California (fig. 1) and includes parts of Esmeralda and Nye Counties, Nevada, and Inyo County, California. The area is about 80 miles long in a north to south direction and has a maximum width of about 60 miles, and is approximately enclosed by lat 37°00' and 38°00' N, long 116°45' and 118°00' W. (fig. 1). The names Clayton and Alkali Spring Valleys are well-established names for these valleys shown on plate 1. The other four valley names used in the report and shown on plate 1 may not coincide with those of all other workers in the area but were selected to meet the needs of this report. The areas of the six valleys discussed in this report are: Clayton Valley, 518 square miles; Alkali Spring Valley, 320 square miles; Lida Valley, 535 square miles; Stonewall Flat, 342 square miles; Oriental Wash, 172 square miles; and Grapevine Canyon, 158 square miles.

The principal communities are Goldfield at the southern end of Alkali Spring Valley, Silver Peak in Clayton Valley, and Lida in Lida Valley. Goldfield has an estimated population of about 150; Silver Peak's population probably is between 50 and 75; and Lida is even smaller.

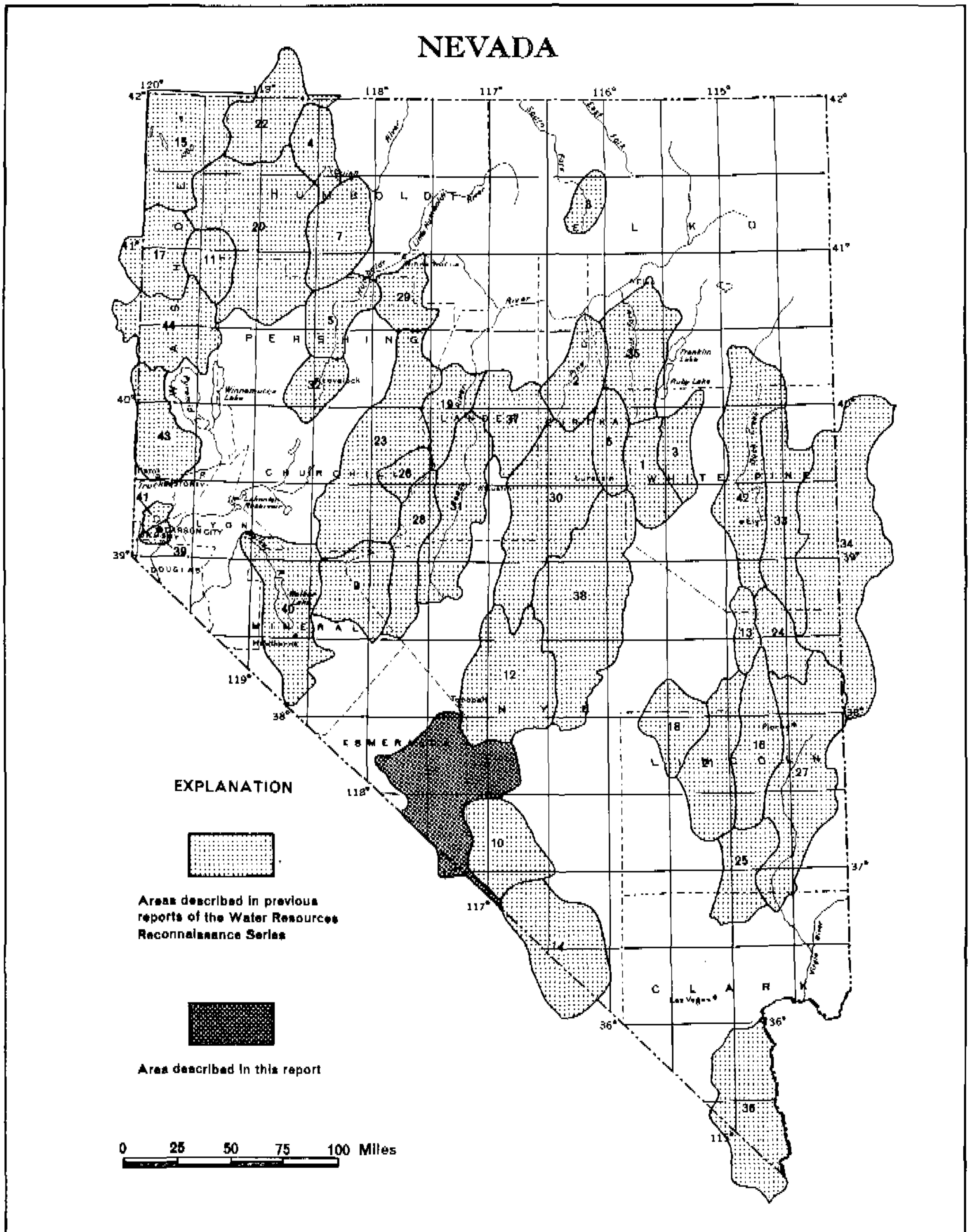

Figure 1.—Area described in this report and others in previous reports of the Water Resources—Reconnaissance Series

Previous Work

One of the earliest hydrologic references to the report area is by Mendenhall (1909). He described the wells and springs in southern Clayton Valley, Western Lida Valley, Oriental Wash, and Grapevine Canyon. Meinzer (1917) described the geology of Clayton and Alkali Spring Valleys. Later, Malmberg and Eakin (1962) and Eakin (1962) described the hydrology of Sarcobatus Flat and Ralston and Stonecabin (east of Ralston Valley) Valleys and their relation to the hydrology of the report area. Eakin and others (1963) described a regional flow system which includes part of the report area. Meinzer (1922) and Snyder and others (1964) published maps which show the maximum extent of lakes of Pleistocene age and which include this area. Phalen (1919) and Dole (1912) described the playa and the associated salt deposits of Silver Peak Marsh (playa) in Clayton Valley. Ball (1907) in his geologic reconnaissance described several springs and a well in the area.

Geologic maps have been published by several workers: Ransome (1909) and Searls (1948) of the Goldfield area, Anderson and others (1965) of Stonewall Flat and surrounding mountains, and Albers and Stewart (1965) of Esmeralda County.

Spurr (1906) described the ore deposits of the Silver Peak area. Summaries of mining and mineral resources were compiled for Nye County and the entire State by Kral (1951) and Lincoln (1923), respectively. Myrick (1963) described the railroads that served the early mining communities.

Historical Sketch

The history of the report area is essentially that of mining. The first important mineral strike was made near Silver Peak in 1863; however, maximum production of gold, silver, and lead was not achieved until the period of 1908-15. Three important discoveries were made in 1866 at Tokop in the Gold Mountain area (T. 8 S., R. 42 E.), Palmetto in the Palmetto Mountains (T. 5 S., R. 39 E.), and Hornsilver (location uncertain) in the Slate Ridge area (T. 7 S., R. 42 E.). In 1867 a discovery was made at Montezuma on the western slopes of Montezuma Peak (T. 3 S., R. 41 E.), and in 1871 at Lida (T. 5 S., R. 40 E.). Montezuma is not shown on plate 1.

At the turn of the century and for a period of about 20 years, many new discoveries were made at Goldfield (in 1903), Klondike (T. 1 N., R. 42 E.), Divide (T. 1 N., R. 42 E.), and at several less productive sites in the mountains of the area. Mining activity was at its peak during the periods 1905-18 (at Silver Peak and Goldfield) and 1933-40 (at Palmetto, Lida, and Divide). According to Lincoln (1923), Goldfield had a population of 8,000 in 1905 and 20,000 in 1908. For the period 1903-21 the production of gold, copper, and silver at Goldfield was valued at $85 million.

As Goldfield grew, more water was needed to supply mills, for fire protection, and for domestic use. A 47-mile pipeline system was constructed to carry water from several springs near Lida, across the northern part of Jackson Flat, to Goldfield (Meinzer, 1917, p. 151). Poorer quality water from Alkali Spring and wells on the southeastern edge of Alkali Spring Valley playa were used to supplement flow in the pipeline and wells when the Lida supply was inadequate. A present resident of Goldfield indicated that the Lida system ruptured, due to freezing in abnormally cold weather during the winter of 1919, and was not used after that event. Wells at Goldfield have been exclusively used since 1919.

Numbering System for Hydrologic Sites

The numbering system for hydrologic sites in this report is based on the rectangular subdivision of the public lands, referenced to the Mount Diablo base line and meridian. It consists of three units: The first is the township north (N) or south (S) 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. The section number is followed by a letter that indicates the quarter section and quarter-quarter section where applicable, the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 2S/40-18da is the well recorded in the NE$\frac{1}{4}$ SE$\frac{1}{4}$ section 18, T. 2 S., R. 40 E., Mount Diablo base line and meridian.

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

HYDROLOGIC ENVIRONMENT

Physiography and Drainage

The report area is in the southern part of the Great Basin section of the Basin and Range physiographic province of Fenneman (1931). The bordering mountains trend generally northward and are separated by valleys that are commonly 10 to 15 miles wide.

Clayton and Alkali Spring Valleys and Stonewall Flat, as shown on plate 1, are topographically closed valleys. Lida Valley drains to a playa in the southeastern part of the valley, which could overflow to Sarcobatus Flat. Lida Valley and Stonewall Flat are separated by a low, almost imperceptible, alluvial divide. Oriental Wash and Grapevine Canyon both drain southwestward to Death Valley. An irregular line of hills, Mount Jackson Ridge, divides Lida Valley into two parts; the northern part, called Jackson Flat, drains to the southern part through a wash which breeches Mount Jackson Ridge in T. 5 S., R. 41½ E.

The valleys are bounded by low- to medium-altitude mountain ranges, as shown on plate 1. The highest peaks are in the Silver Peak Range, the Palmetto Mountains, and the Grapevine Mountains. The crests of the first two ranges are above an altitude of 9,000 feet; the latter above 8,500 feet. Present topographic relief is largely the result of movement along many faults, some of which are shown on plate 1, and volcanic activity. Table 2 summarizes the topography and drainage of the valleys.

Three major geomorphic units are recognized in the area: Complexly folded and faulted mountain ranges, valley floors, and aprons or intermediate slopes between the mountains and the valley floors. The alluvial aprons include both alluvial fans and pediments. Pediments are erosional surfaces cut on bedrock but commonly are mantled with a veneer of alluvium ranging in thickness from a few to several tens of feet. By contrast, the alluvial fans are underlain by thick deposits of alluvium deposited by streams where they leave the mountains.

Pediments have formed in many parts of the report area. For example, pediments occur in much of the area shown as alluvium in the Weepah Hills on plate 1 and in the alluvial area between Mount Jackson Ridge and the southwestern extensions of the Goldfield Hills in Tps. 4 and 5 S., Rs. 42 and 43 E.

Table 2.--Summary of topography and drainage

	Clayton Valley	Alkali Spring Valley	Lida Valley	Stonewall Flat	Oriental Wash	Grapevine Canyon
Mountain area (square miles)	259	134	249	182	99	126
Valley-fill area (square miles)	259	186	286	160	73	32
Average altitude of consolidated rock-alluvium contact (feet)	5,200	5,500	5,400	5,300	4,900	4,800
Type of stream drainage	(a)	(a)	(b)	(a)	(b)	(b)
Playa altitude (feet)	4,270±	4,825±	c4,600+	d4,600+	--	4,100±
Maximum relief (feet)	5,000	3,400	4,400	3,700	5,200	4,600

a. Internal drainage.

b. External drainage.

c. A second playa, near the town site of Ralston is at an altitude of about 4,700 feet.

d. Two small playas are located to the east and southeast of this large playa.

-9-

Snyder and others (1964) prepared a map that shows Pleistocene lakes in Clayton, Alkali Spring, and Lida Valleys, Stonewall Flat, and Grapevine Canyon. The lakes essentially were confined to the vicinity of present playas and did not develop gravel bars or other large depositional features.

Geologic Units and Structural Features

Rocks of the report area are divided into three gross lithologic units: consolidated rocks, older alluvium, and younger alluvium. This division is based largely on their hydrologic properties; however, the hydrologic properties of all three types may vary widely with differences in their physical and chemical properties. The areal extent of the units is shown on plate 1. The geology is based principally on the Esmeralda County geologic map of Albers and Stewart (1965) and on aerial-photo and drillers'-log interpretations.

Consolidated rocks form the mountain masses and underlie the younger and older alluvium (collectively, valley fill) at depth. The consolidated rocks are composed mostly of volcanic rocks, associated shallow intrusives, and carbonate and associated sedimentary rocks. The volcanic rocks and intrusives are mostly Tertiary in age, whereas the carbonate and associated sedimentary rocks are mostly Paleozoic.

Albers and Stewart (1965) mapped carbonate rocks in all the ranges of the report area in Esmeralda County. Kral (1951) indicates that carbonate rocks were encountered in mines at Stonewall Mountain (T. 5 S., R. 44 E.). Anderson and others (1965) published a generalized geologic map of Stonewall Flat and the surrounding mountains which shows that Paleozoic and older rocks occur in the Cactus Range but whether these rocks include carbonate rocks, as might be assumed, is not known. In most ranges, outcrops of carbonate rocks are a small part of the total rocks mapped; however, with depth the proportion of carbonate rocks probably increases. In Nevada carbonate rocks commonly contain fractures and solution channels and locally may be moderately permeable, and therefore capable of transmitting water through mountain blocks from one basin to another.

Older alluvium is Pliocene(?) and Pleistocene in age (Albers and Stewart, 1965) and is composed mostly of gravel and sand formed from debris washed from the adjacent mountains. These deposits underlie the fans and much of the valley floors; they are characteristically unconsolidated to semiconsolidated, dissected, poorly sorted, and commonly somewhat deformed.

Younger alluvium is late Pleistocene and Recent in age (Albers and Stewart, 1965). In contrast to older alluvium, it generally is unconsolidated, undissected, moderately well sorted, and undeformed. It is composed of sand, silt, and clay deposited by the principal streams on the valley floor. Younger alluvium includes the lake and playa deposits and alluvial-fan deposits. The coarse-grained material of the younger alluvium probably is more porous and more permeable than the older alluvium.

In Clayton Valley, beneath the playa, thick beds of salt have accumulated. Dole (1912) described the source of the salt deposits, the method of exploration, and the commercial possibilities of the playa. (Dole called the playa Silver Peak Marsh.) Well 2S/39-12c penetrated four salt beds totaling a thickness of 26 feet in the upper 130 feet of alluvium (table 16). The log of well 2S/40-18da lists 61 feet of salt in the upper 154 feet of alluvium. The thickest bed recorded is 32 feet, encountered from a depth of 122 to 154 feet. These beds probably are both younger and older alluvium.

Most of the economically available ground water in the report area is stored in the younger and older alluvium which comprise the valley-fill reservoir.

Faults were mapped by Albers and Stewart (1965) and others inferred by the writer from aerial photos. Only those that form boundaries between lithologic units or cut the valley-fill reservoir are shown on plate 1.

Climate

Air masses that move across this part of Nevada characteristically are deficient in moisture. The valleys are arid, whereas the higher mountains are subhumid and receive more precipitation, especially in the winter. Thunderstorms provide most of the precipitation during the summer. A further discussion of precipitation is included in the Precipitation Section of this report.

Temperature data have been recorded at five nearby stations; table 3 and figure 2 summarize the freeze data for these stations. Because killing frosts vary with the type of crop, temperatures of 32°F, 28°F, and 24°F are used as indicators of the length of growing season.

Table 3.--Length of period above temperatures of 32°, 28°, and 24°F

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

Station[1]	Period of record (years)	Minimum recorded (days)			Maximum recorded (days)			Average (days)		
		32°F	28°F	24°F	32°F	28°F	24°F	32°F	28°F	24°F
Dyer	1950, 1953-65	94	101	112	150	178	188	121	143	163
Goldfield	1948-51, 1959-63	88	138	172	179	201	238	129	172	214
Sarcobatus	1948-60	110	151	173	196	221	247	160	187	216
Tonopah	1948-53	88	114	146	160	201	237	129	161	188
Tonopah Airport	1955-65	116	131	170	174	200	237	150	176	200

1. For station locations, see table 4.

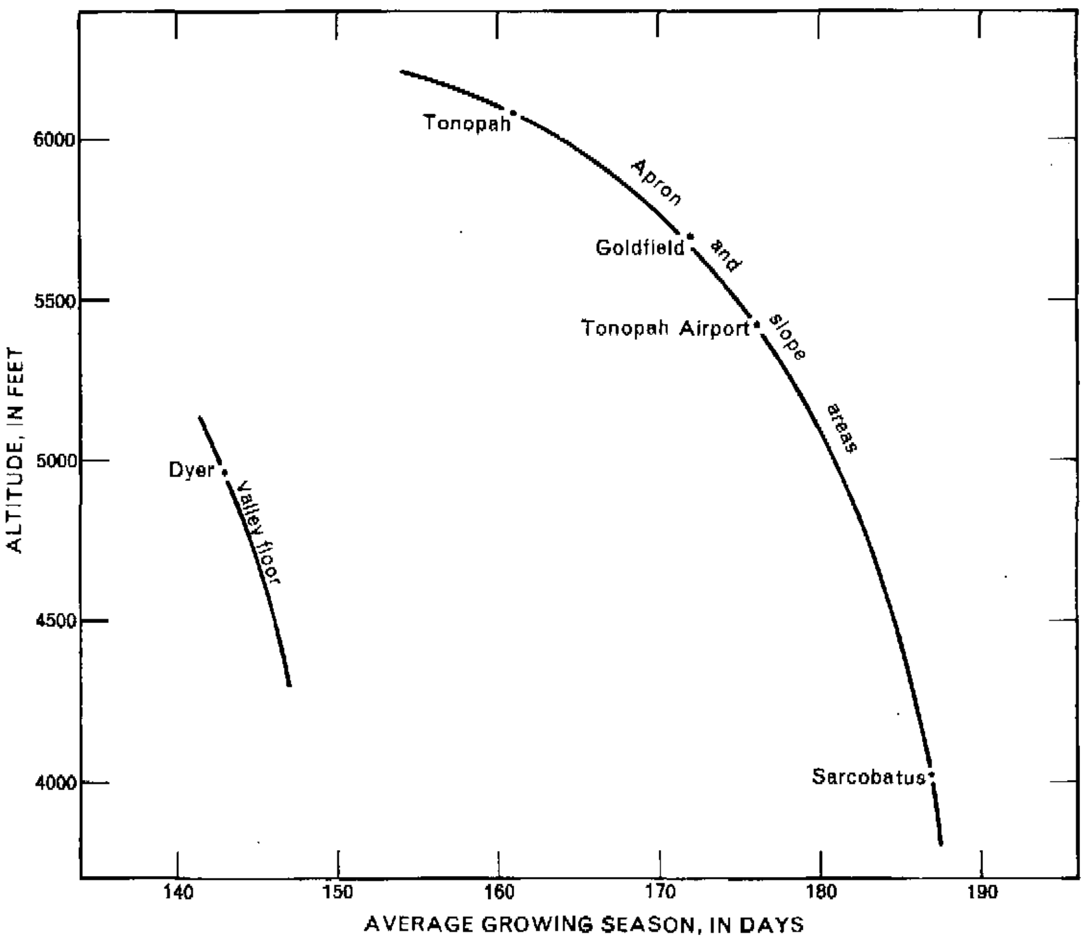

Figure 2.—Generalized relation of altitude and location to the length of growing season between 28°F killing frosts

Length of the growing season is controlled in large part by elevation of the station in relation to the adjacent valley floor and its latitude. The topography of the area favors the nighttime flow of heavy, cool air toward the lower parts of topographically-closed valleys in the summer when there is little wind movement and causes thermal inversions.

Figure 2 shows the generalized relation of altitude to growing season. Two curves are shown: one, for apron and slope areas where there are adjacent lower-lying areas, to which cool air can drain during nights. This curve represents data for Goldfield, Sarcobatus, Tonopah, and Tonopah Airport. The other curve, drawn parallel to the first curve, represents data for Dyer, which is near the bottom of Fish Lake Valley where cool air collects.

Available data suggest that on the lower parts of the valley floors the average length of the growing season, based on a killing-frost temperature of 28°F, probably is about 140 days in Alkali Spring and Lida Valleys, Stonewall Flat, and Oriental Wash, and about 150 days in Clayton Valley and Grapevine Canyon. Alluvial slopes several hundred feet higher than the lower parts of the adjacent valley floors may have an average of about 180 days. Houston (1950) stated that the growing season for the Tonopah-Goldfield area averages 144 days. For any one year, the length of the growing season may vary from these averages as much as 40 days.

VALLEY-FILL RESERVOIRS

Extent and Boundaries

Younger and older alluvium of the valleys, as shown on plate 1, form the valley-fill reservoirs that are the principal source of ground water in the area. Few deep wells have been drilled in the area; therefore little is known about the thickness of the valley-fill reservoirs. In Clayton Valley, well 3S/39-11a (tables 14 and 16) was drilled to a depth of 1,820 feet, but no bedrock was reported. In Lida Valley, the owner of well 5S/43-17c reports that consolidated rock was encountered at a depth of 600 feet. The reservoirs beneath the valley floors probably are at least 500 feet thick in most valleys, and at the center of Clayton and Alkali Spring Valleys and Stonewall Flat they probably are several times as thick. Although bedrock reportedly was encountered in wells at shallower depths, these wells were near the bedrock-alluvium contact where the valley-fill reservoir is generally thin.

External hydraulic boundaries are formed by the consolidated rocks (pl. 1) that underlie and form the sides of the valley-fill reservoirs. These lateral boundaries are leaky to varying degrees. Further, the carbonate rocks may contribute moderate amounts of recharge from the mountains to the valley-fill reservoir by subsurface flow.

The principal internal hydraulic boundaries are the faults that cut the valley fill in the several valleys (pl. 1), and lithologic changes. The extent to which these barriers impede ground-water flow probably will not be determined until substantial ground-water development occurs.

Regional Ground-Water Flow

Figure 3 shows diagrammatically the regional ground-water flow as determined by the water-level data in the study area. Three "sinks," or terminal discharge areas are identified: (1) a system which terminates in Clayton Valley, (2) a system which generally terminates in Sarcobatus Flat, adjoining the southeast edge of the report area, and (3) a system which terminates in Death Valley, southwest of the report area.

Clayton Valley apparently receives substantial ground-water flow from Big Smoky Valley. In addition, part of the ground-water flow from Ralston and Stonecabin Valleys

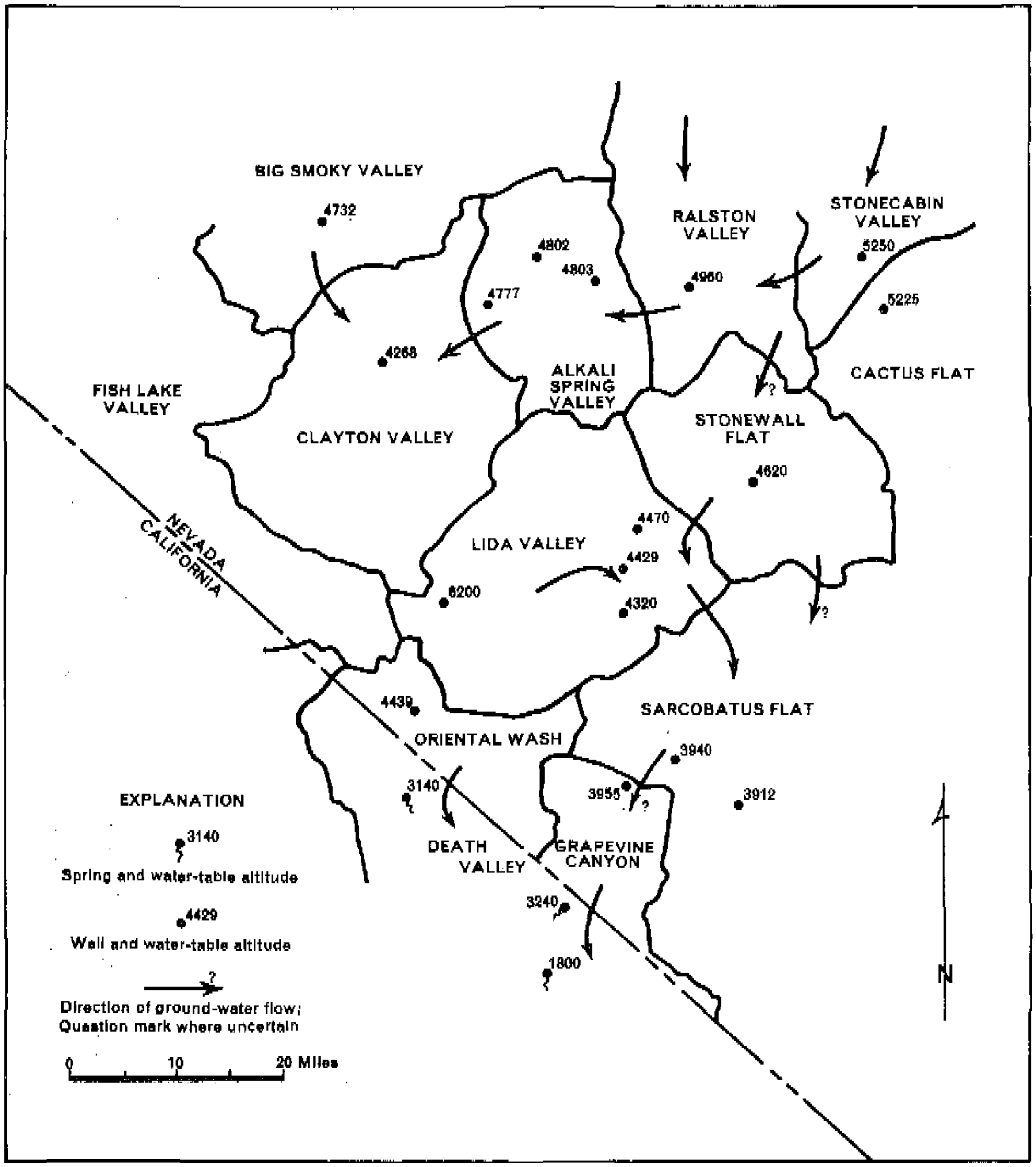

Figure 3.—Generalized map of intervalley ground-water flow as interpreted from water-level data

probably moves westward through Alkali Spring Valley to Clayton Valley.

Sarcobatus Flat apparently receives underflow from Lida Valley, Stonewall Flat, and possibly from areas to the northeast including Cactus Flat and Ralston and Stonecabin Valleys.

Oriental Wash and Grapevine Canyon drain southwestward to Death Valley, as shown in figure 3. Many other areas outside the report area drain to Death Valley, but their consideration is beyond the scope of this reconnaissance.

INFLOW TO THE VALLEY-FILL RESERVOIRS

Precipitation

Precipitation data have been recorded for 11 stations in or near the project area and are summarized in table 4. Two of the stations, Goldfield and Lida, are in the report area.

Most of the stations have not been in operation for more than about 20 years; therefore, no long-term regional variations can be identified. However, agreement among several stations suggests local trends and indicates that in general above normal precipitation occurred during the period 1906-16 and droughts occurred in some parts of the area within the period 1923-37.

The precipitation pattern in Nevada is related principally to the topography; the stations at the highest altitudes generally receive more precipitation than those at lower altitudes. However, this relation may be considerably modified by local conditions. The valley floors of the report area probably receive an average of about 3 to 5 inches of precipitation per year. The alluvial aprons of the area, generally ranging in altitude from about 4,500 to 5,500 feet, probably receive an average annual precipitation of from 4 to 6 inches. The highest mountain areas may have an average annual precipitation of 15 inches or more.

Ground-Water Recharge, Including Revisions for Ralston and Stonecabin Valleys

On the valley floors, where precipitation is small, little precipitation directly infiltrates into the ground-water reservoirs. Greater precipitation in the mountains provides most of the recharge. Water reaches the ground-water reservoirs by seepage loss from streams on the alluvial apron and by underflow from the consolidated rocks. Most of the precipitation is evaporated before infiltration and some adds to soil moisture.

A method described by Eakin and others (1951, p. 79-81) is used to estimate the potential recharge in this report. The method assumes that a percentage of the average annual precipitation may recharge the ground-water reservoirs.

Precipitation at any given altitude in the central Nevada region has been revised downward since the estimates of recharge

Table 4.--Summary of average annual precipitation of nearby stations

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

Station	Location	Altitude (feet)	Period of record (years)	Average annual precipitation (inches)
Coaldale	2N/37-8 (24 miles NW of Silver Peak)	4,646	1941-64	3.31
Deep Spring College	28 miles WSW of Lida	5,225	1948-66	5.03
Dyer	4S/36-5 (22 miles WSW of Silver Peak)	4,975	1948-66	4.38
Goldfield	3S/42-2	5,700	1906-66	5.43
Lida	5S/40-36	6,100	1912-18	10.29
Montgomery Maintenance Station	1N/33-5 (40 miles WNW of Silver Peak)	7,100	1949-66	6.80
Oasis Ranch	5 miles SSE of Dyer	5,106	1903-19	4.75
Sarcobatus	8S/44-2 (3 miles SE of Scottys Junction)	4,020	1941-61	3.24
Tonopah	2N/42-2	6,093	1907-53	4.98
Tonopah Airport	3N/44-31 (8 miles E. of Tonopah)	5,426	1954-66	3.86

made by Eakin (1962) in Reconnaissance Series report 12 for Ralston and Stonecabin Valleys of 16,000 acre-feet per year each. The revised estimates are appended to table 5.

Table 5 shows the values used to estimate precipitation and ground-water recharge in the area. Estimates of recharge for the valleys are less than 1 percent of the estimates of total precipitation. These percentages are less than the amounts usually found by this method for desert valleys of the central Nevada region, estimated elsewhere to be as much as 5 percent (Rush and Everett, 1964 and 1966) of estimated total precipitation. The lower amounts of recharge computed for this report area are due to the general lack of large areas above 7,000 feet altitude rather than to a change in the precipitation-altitude relation. Furthermore, the regions north and south of this central Nevada area generally have more precipitation at any given altitude.

Runoff

By D. O. Moore

Runoff in the report area is derived from precipitation within the drainage area. On the valley floor and on the lower mountains where precipitation is small, little streamflow occurs. Most of the streamflow originates in the higher mountains and then only during periods of large precipitation.

Only the major mountain streams flow to the playas or from the valleys and then only during periods of large runoff. The estimated average annual flow was determined at several places by a channel-geometry method being developed by Walter Langbein of the U.S. Geological Survey. The sites were selected along major drainageways, and are shown on plate 1. The estimated flows are listed in table 6. The estimated quantities are very small even in the larger washes.

A crest-stage gage has been maintained at 4S/42-13d (pl. 1) on a wash draining a 0.6 square-mile area. The only flow occurring there since its installation in October 1963 was on August 15, 1965, when the maximum flow was estimated to be about 8 cfs (cubic feet per second). Eight miles north, at Goldfield, the recorded precipitation for the period was as follows:

Table 5.--Estimated average annual precipitation and ground-water recharge

Precipitation zone (altitude in feet)	Area (acres)	Estimated annual precipitation: Range (inches)	Average (feet)	Average (acre-feet)	Estimated recharge from precipitation: Percentage of precipitation	Acre-feet per year
CLAYTON VALLEY						
Above 9,000	680	>15	1.5	1,000	15	150
8,000-9,000	7,040	12-15	1.1	7,700	7	540
7,000-8,000	32,300	8-12	.8	26,000	3	780
Below 7,000	292,000	<8	.5	150,000	minor	--
Total (rounded)	332,000	--	--	180,000	--	1,500
ALKALI SPRING VALLEY						
Above 7,000	3,560	>8	.8	2,800	3	85
Below 7,000	201,000	<8	.5	100,000	minor	--
Total (rounded)	205,000	--	--	100,000	--	100
LIDA VALLEY						
Above 8,000	2,170	>12	1.1	2,400	7	170
7,000-8,000	14,300	8-12	.8	11,000	3	330
Below 7,000	326,000	<8	.5	160,000	minor	--
Total (rounded)	342,000	--	--	170,000	--	500
STONEWALL FLAT						
Above 8,000	100	>12	1.1	110	7	10
7,000-8,000	2,220	8-12	.8	1,800	3	50
Below 7,000	217,000	<8	.5	110,000	minor	--
Total (rounded)	219,000	--	--	110,000	--	100

Table 5.--continued

Precipitation zone (altitude in feet)	Area (acres)	Estimated annual precipitation: Range (inches)	Estimated annual precipitation: Average (feet)	Estimated annual precipitation: Average (acre-feet)	Estimated recharge from precipitation: Percentage of precipitation	Estimated recharge from precipitation: Acre-feet per year
			ORIENTAL WASH			
Above 8,000	1,860	>12	1.1	2,000	7	140
7,000-8,000	8,060	8-12	.8	6,500	3	200
Below 7,000	100,000	<8	.5	50,000	minor	--
Total (rounded)	110,000	--	--	58,000	--	300
			GRAPEVINE CANYON			
Above 8,000	160	>12	1.1	180	7	10
7,000-8,000	1,110	8-12	.8	890	3	30
Below 7,000	95,500	<8	.5	48,000	minor	--
Total (rounded)	96,800	--	--	49,000	--	50
			RECOMPUTED ESTIMATES FOR RALSTON AND STONECABIN VALLEYS[1]			
			RALSTON VALLEY			
Above 9,000	1,400	>15	1.5	2,100	15	320
8,000-9,000	26,600	12-15	1.1	29,000	7	2,000
7,000-8,000	105,000	8-12	.8	84,000	3	2,500
Below 7,000	488,000	<8	.5	240,000	minor	--
Total (rounded)	621,000	--	--	360,000	--	5,000
			STONECABIN VALLEY			
Above 9,000	3,000	>15	1.5	4,500	15	680
8,000-9,000	25,000	12-15	1.1	28,000	7	2,000
7,000-8,000	89,000	8-12	.8	71,000	3	2,100
Below 7,000	496,000	<8	.5	250,000	minor	--
Total (rounded)	613,000	--	--	350,000	--	5,000

1. Revised from the estimates shown by Eakin (1962), table 4.

Table 6.--Estimated average annual flow in drainageways at selected sites

Valley[1]	Location	Estimated average annual flow (acre-feet per year)
Lida Valley	5S/41½-36b	20
	6S/42-8d	30
	4S/43-15a	25
	5S/43-6d	30
	5S/43-21b	60
Oriental Wash	8S/40-23b	30
Grapevine Canyon	10S/42-20a	20

1. No estimates were made in Alkali Spring and Clayton Valleys or Stonewall Flat.

August 1965	Precipitation (inches)
9	0
10	Trace
11	0.31
12	Trace
13	.10
14	.12
15	.49
16	.25
17	.02
18	.69

The small rains prior to August 15 probably produced some runoff which wetted the alluvium underlying the stream channel. As a result, less of the runoff resulting from the precipitation on August 15 infiltrated as it flowed toward the gage, producing a larger flow than if no rains had preceded the major event. On August 18 a larger rainfall was recorded at Goldfield but only a minor flow occurred at the gage, indicating that the storm was localized in the Goldfield area and its effect was not felt at the gage site.

The amount of average annual runoff from the mountains that reaches the valley-fill reservoirs has been estimated using a precipitation-altitude method described by Eakin, Moore, and Everett (1965) and devised by Riggs and Moore (1965). An altitude-runoff relation developed during the study of Statewide runoff (Lamke and Moore, 1965) also was used in this study.

The estimated mean annual runoff to the valley-fill reservoir area is summarized in table 7. Only about 22 percent of the report area is assumed to contribute to runoff. Occasional runoff may be locally developed on alluvial fans and lowlands but generally this type of runoff is so erratic in frequency and duration that it has little value to economic development.

Subsurface Inflow

Subsurface inflow is of two types: (1) underflow from the consolidated rocks of the mountains to valley-fill reservoirs that originates locally as infiltrated precipitation in the mountains, and (2) intervalley flow of ground water. Intervalley flow through consolidated

Table 7.--Estimated average annual runoff

	Runoff area (acres)	Estimated average annual runoff (acre-feet)
Clayton Valley:		
Montezuma Peak, Clayton Ridge, and Palmetto Mountains	53,000	1,700
Silver Peak Range, Weepah Hills, and Paymaster Ridge.	37,000	1,800
Total (rounded)	90,000	3,500
Alkali Spring Valley	27,000	400
Lida Valley	77,000	1,600
Stonewall Flat	31,000	400
Oriental Flat	44,000	1,000
Grapevine Canyon	24,000	500

rocks or alluvium has been described in a previous section and is shown in figure 3. Underflow to the valley fill from consolidated rocks of the mountains is a direct contribution to recharge of the valley-fill reservoir and is included in the estimated average annual recharge computed in table 5. No direct means are available to evaluate this underflow, but it is assumed that it is a moderately small part of the total recharge to each valley.

As stated in the section on Regional Ground-Water Flow, ground water flows into the area from Big Smoky Valley to Clayton Valley, from Ralston and Stonecabin Valleys to Alkali Spring Valley and possibly in part to Stonewall Flat, and from Sarcobatus Flat to Grapevine Canyon. Within the area, ground water flows from Alkali Spring Valley to Clayton Valley and from Stonewall Flat to Lida Valley. Estimates of the inflow are presented below.

The flow from the southern part of Big Smoky Valley to Clayton Valley was computed by a preliminary budget for the southern part of Big Smoky Valley, as follows:

	Acre-feet per year
<u>INFLOW</u>:	
Average annual recharge from precipitation	16,000
Average annual ground-water inflow from Ione Valley (not shown on pl. 1).	2,500
Total (rounded) (1)	18,000
<u>OUTFLOW</u>:	
Evapotranspiration	4,600
Other	minor
Total (rounded) (2)	5,000
<u>IMBALANCE</u>: (1) - (2)	13,000

The imbalance probably is due to ground-water flow mostly through carbonate rocks from Big Smoky Valley to Clayton Valley and is considered a measure of its magnitude. Ground water flows through alluvium and consolidated rocks can be computed by means of a form of Darcy's law:

$$Q = 0.00112\ TIW$$

in which *Q* is the quantity of flow, in acre-feet per year; *T* is the coefficient of transmissibility, in gallons per day per foot; *I* is the hydraulic gradient, in feet per mile;

W is the width of the flow section, in miles, and factor 0.00112 converts gallons per day to acre-feet per year. The average water-table gradient between Big Smoky Valley and Clayton Valley is about 40 feet per mile and assuming an effective flow width of 5 miles, would require a coefficient of transmissibility of about 60,000 gpd (gallons per day) per foot.

Subsurface inflow to Clayton Valley from Alkali Spring Valley (fig. 3) is computed by difference in the Alkali Spring Valley water budget (table 10) to be 5,000 acre-feet per year. Thus, the estimated total subsurface inflow to Clayton Valley from Big Smoky and Alkali Spring Valleys is about 18,000 acre-feet per year.

Ground-water inflow from Ralston and Stonecabin Valleys is shown to be moving to Alkali Spring Valley and possibly in part to Stonewall Flat (fig. 3). For the purposes of computation, all the flow is assumed to move into Alkali Spring Valley. The subsurface flow from Ralston and Stonecabin Valleys is computed as the difference between the excess of recharge over discharge. The recomputed average annual recharge to each valley is 5,000 acre-feet (table 5), or a total of 10,000 acre-feet for both valleys. The average annual natural discharge from the two valleys by evapotranspiration totals about 4,500 acre-feet (Eakin, 1962, p. 14). The difference of about 5,500 acre-feet per year is assumed to be the inflow to Alkali Spring Valley.

To make the outflow computation for Stonewall Flat, T is assumed to be about 10,000 gpd per foot (the transmitting alluvium probably is fine-grained), I about 10 feet per mile, and W about 2 miles, as estimated for the narrows near Ralston Townsite. The computed flow is about 200 acre-feet per year.

Malmberg and Eakin (1962, p. 17) indicated that ground water may be flowing from Sarcobatus Flat to Grapevine Canyon through the alluvium and underlying consolidated rocks near Bonnie Claire. They estimated that the inflow to Grapevine Canyon area might be about 500 acre-feet per year. Additional reconnaissance of the Bonnie Claire area indicates that probably no ground water is flowing through alluvium from Sarcobatus Flat to Grapevine Canyon because water levels in wells indicate a ground-water divide in the alluvium near Bonnie Claire. This does not eliminate the possibility of ground-water flow through consolidated rocks from Sarcobatus Flat to Grapevine Canyon of 500 acre-feet per year, however.

OUTFLOW FROM THE VALLEY-FILL RESERVOIR

Surface Water

Outflow of surface water is limited to minor amounts of surface water that flow from the valleys in drainage-ways. This type of flow occurs only from Lida Valley to Sarcobatus Flat, and from Oriental Wash and Grapevine Canyon to Death Valley. Outflow from Lida Valley was not estimated, but flow data for other sites in Lida Valley, listed in table 6, indicate that it probably averages no more than about 100 acre-feet per year. The estimated average annual surface-water outflows for Oriental Wash and Grapevine Canyon are 30 acre-feet and 20 acre-feet, respectively (table 6).

Ground Water

Evapotranspiration

In areas of shallow ground water, discharge occurs by evaporation from soil and by transpiration of plants that root to the water table. These plants that tap ground water are called phreatophytes. Plate 1 shows the areas of phreatophytes in Clayton and Alkali Spring Valleys. Only minor amounts of evapotranspiration occur in the other valleys. The principal phreatophytes are saltgrass, rabbitbrush, greasewood, and saltbush. Table 8 summarizes the estimated evapotranspiration of ground water from these areas. The rates used are modified from the work done in other areas by Lee (1912), White (1932), and Young and Blaney (1942).

Pumpage from Wells

Ground water is pumped from wells for industrial, public supply, domestic, and stockwatering use (table 14). Goldfield has a public-supply water system that includes three wells. Well 3S/42-11b is the main source of water, and wells 3S/42-2c and 3S/42-10a are standby wells.

In Clayton Valley, Foote Mineral Company pumps water from wells on the playa. The water is pumped into evaporation basins where minerals are concentrated and lithium is extracted. No irrigation wells are in the area. Table 9 summarizes the pumpage for the area.

In Lida Valley, water is hauled to Gold Point, because no local spring or well supply is available.

Table 8.--Estimated average annual evapotranspiration of ground water[1]/

[Phreatophyte areas shown on plate 1]

Areas of phreatophytes and playas	Area (acres)	Depth to water (feet)	Evapotranspiration: Acre-feet per acre	Evapotranspiration: Acre-feet (rounded)
	CLAYTON VALLEY			
Bare soil (playa)				
Standing water (free-water surface)	1,000	--	5.0	5,000
Very shallow ground water	14,000	0-1	1.0	14,000
Shallow ground water	4,000	1-5	.25	1,000
Subtotal	a 19,000	--	--	20,000
Greasewood and saltbush	5,000	10-40	.2	1,000
Saltgrass, rabbitbrush, and tules	3,000	0-10	1.0	3,000
Total (rounded)	27,000	--	--	b24,000
	ALKALI SPRING VALLEY			
Greasewood and rabbitbrush	3,500	30-50	.1	350
Bare soil (playa)	4,500	40-50	c --	--
Saltgrass, willow, and cottonwood	2	1-10	1.0	2
Total (rounded)	9,300	--	--	400

1. Only minor amounts of ground water are discharged by evapotranspiration in Lida Valley, Stonewall Flat, Oriental Wash, and Grapevine Canyon. Most of the discharge is associated with small springs and is not included in the table.

a. Meinzer (1917, p. 144) estimated the area of the playa as 25,000 acres. This estimate of 19,000 acres was made from aerial photographs and field checked at widely scattered points.

b. Meinzer (1917, p. 145) estimated the total discharge at "several thousand acre-feet a year."

c. Depth to water probably too large for any measurable evaporation from the playa.

Table 9.--Summary of estimated net well pumpage in 1966

[All quantities in acre-feet per year]

Valley	Industrial	Public supply	Domestic	Stock-watering	Total (rounded)
Clayton Valley	a 2,000	--	10	10	2,000
Alkali Spring Valley	--	b 20	10	10	40
Lida Valley	--	--	10	10	20
Stonewall Flat	--	--	--	--	minor
Oriental Wash	--	--	--	10	10
Grapevine Canyon	--	--	--	--	minor
Total	2,000	20	30	40	2,100

a. Foote Mineral Company reports a gross pumpage of 3,000 acre-feet in 1966, but they assume about a third of the pumpage returns to the ground-water system by infiltration from their evaporation ponds.

b. Based on a consumption of 100 gallons per day per person by an estimated population at Goldfield of 150.

Springs

In the mountains of the area, small springs issue from consolidated rocks. In most valleys their combined discharge is minor; they support small areas of willow, rabbitbrush, and wildrose. Much of their flow seeps back into the ground and reenters ground-water storage. Table 15 presents data on selected springs.

The largest springs in the area probably are Waterworks Springs (2S/39-22a) at Silver Peak in Clayton Valley. Dole (1912, p. 5) and Meinzer (1917, p. 143) report the flow of Waterworks Springs as 350,000 gallons per day (about 240 gpm). Later in Meinzer's report (1917, p. 153) he also reports the flow as 500+ gpm. If the smaller figure is correct, the average annual flow of these springs probably is about 400 acre-feet. The springs are in part utilized by the public-supply system at Silver Peak, but most of the water is consumed by phreatophytes in a nearby swampy, saltgrass area. This discharge is included in the estimates of evapotranspiration in table 8. The net consumption of spring flow by the public-supply system probably is about 10 acre-feet per year.

In Alkali Spring Valley, Alkali Spring (1S/41-26a) flows about 50 gpm at 140° F. The spring flows into a small stockwatering pond. Some of the water is consumed by stock, some is evapotranspired (the loss is accounted for in table 8), but most percolates back into the ground and recharges the ground-water reservoir. The stock consumption and associated losses from ponded water are estimated to be no greater than 10 acre-feet per year.

In Lida Valley, Meinzer (1917, p. 151) described several springs near Lida. Their flow was piped 30 miles northeast to Goldfield where it was used as the public supply and for milling. The dependable supply from these springs was reported to be about 450 acre-feet per year. After 1919, the pipe line was not operated again. A very brief inspection of a few of these springs indicates that their flow is now only a fraction of the flow reported by Meinzer. Most of the flow seeps back into the ground and percolates to the water table; some supports small areas of phreatophytes. The few residents of Lida use spring 5S/40-36a (table 15) for domestic supply, probably consuming less than 10 acre-feet per year.

In Grapevine Canyon, about a mile northeast of Scottys Castle, Staininger's Springs (11S/43-6b) had a flow of about 200 gpm in the spring of 1967, or about 300 acre-feet per year. Ball (1907, p. 20) described the springs as having a flow of about 600,000 gallons per day (about 700 acre-feet per year). In addition several small springs and seeps, called Grapevine Springs (Mendenhall, 1909, p. 31), 11S/42-3a,b, are about 3 miles west of Scottys Castle. The combined flow of these springs is not known, but is probably only a fraction of the flow of Staininger's Springs, or perhaps 100 acre-feet per year. These two groups of springs probably drain Grapevine Canyon and perhaps some additional adjoining areas. Perhaps 10 acre-feet of springflow per year is utilized at Scottys Castle, some is discharged by a few acres of phreatophytes near and downstream from the springs, but most seeps back to the water table where it flows in the subsurface to Death Valley.

Subsurface Outflow

Subsurface outflow through consolidated rocks and (or) alluvium occurs from Lida Valley to Sarcobatus Flat and from Oriental Wash and Grapevine Canyon to Death Valley. Outflow also occurs from Alkali Spring Valley to Clayton Valley (previously described as subsurface inflow of 5,000 acre-feet per year to Clayton Valley) and from Stonewall Flat to Lida Valley (previously described as subsurface inflow of 200 acre-feet per year to Lida Valley). Because of virtually no surficial natural discharge from Lida Valley, Stonewall Flat, and Oriental Wash, subsurface outflow probably is the principal means of discharge.

For Lida Valley, because of no phreatophyte discharge in the valley and because of water-table gradients all recharge is assumed to be discharged as subsurface outflow to Sarcobatus Flat. The estimated average annual recharge consists of 500 acre-feet from precipitation (table 5) and 200 acre-feet of underflow from Stonewall Flat, or a total of 700 acre-feet. Malmberg and Eakin (1962, p. 16) indicate that as much as 2,300 acre-feet of recharge to Sarcobatus Flat may be derived by subsurface inflow from tributary valleys. The conclusion reached in this reconnaissance is that about 700 acre-feet of inflow is supplied from Lida Valley. In addition, the possibility exists for some ground-water flow from Ralston and Stonecabin Valleys through Stonewall Flat to Sarcobatus Valley (fig. 3). Future studies may help refine the flow net and quantities of flow involved.

Because no direct estimate is made, the underflow from Oriental Wash is assumed equal to the ground-water recharge, which has been estimated to be about 300 acre-feet per year (table 5).

In Grapevine Canyon, Grapevine and Stainingers Springs flow about 400 acre-feet per year. (See Springs.) Under native conditions, most of the flow would seep back to the water table and would be discharged westward to Death Valley from the area by underflow. Therefore, the natural underflow out of the canyon is nearly equal to the spring flow, or about 400 acre-feet per year.

GROUND-WATER BUDGETS

For natural conditions and over the long-term, assuming that long-term climatic conditions remain reasonably constant, ground-water inflow to and outflow from an area are about equal. Thus, a ground-water budget can be used (1) to compare the estimates of natural inflow to and outflow from each valley, (2) to determine the magnitude of errors in the two estimates, provided that one or more elements are not estimated by difference, and (3) to select a value that, within the limits of accuracy of this reconnaissance, represents both inflow and outflow. This value in turn is utilized in a following section of the report to estimate the perennial yield of each area. Table 10 presents water budgets for each area and shows the reconnaissance value selected to represent both inflow and outflow.

For Clayton Valley, because neither the inflow figure nor outflow figure is considered more accurate, the average of the two is used for the value to represent both inflow and outflow. For Stonewall Flat, the inflow value is selected as probably being the more accurate of the two and for Grapevine Canyon, the outflow is selected for the same reason.

Table 10.--Preliminary ground-water budgets

[All estimates in acre-feet per year and rounded]

Budget elements	Clayton Valley	Alkali Spring Valley	Lida Valley	Stonewall Flat	Oriental Wash	Grapevine Canyon
INFLOW:						
Ground-water recharge from precipitation (table 5)	1,500	100	500	100	300	50
Subsurface inflow (p. 24-27)	18,000	5,500	200	--	--	500
Total (rounded) (1)	20,000	5,500	700	100	300	500
NATURAL OUTFLOW:						
Evapotranspiration (table 8)	24,000	400	minor	--	--	minor
Springs (p. 31-32)	a 10	minor	10	--	--	a 10
Subsurface outflow (p. 32-33)	0	b 5,000	b 700	200	b 300	400
Total (rounded) (2)	24,000	5,500	700	200	300	400
IMBALANCE:						
Excess of outflow over inflow (2) - (1)	4,000	(c)	(c)	100	(c)	-100
VALUES SELECTED TO REPRESENT INFLOW AND NATURAL OUTFLOW	22,000	5,500	700	100	300	400

a. Most of the spring discharge is included in evapotranspiration estimate or as subsurface outflow.

b. Computed to be the difference between total recharge minus the estimated elements of discharge.

c. Imbalance is 0 because some elements of budget were determined by difference.

CHEMICAL QUALITY OF WATER

As part of the present study, 16 water samples were analyzed in a field-office laboratory to make a general appraisal of the suitability of the water for domestic and agricultural use and to define the general chemical quality of the water. The analyses are listed in table 11.

The samples were analyzed for the principal anions and cations, except sodium and potassium, which were computed by difference. Fluoride, iron, manganese, arsenic and nitrate were not determined, although they are important ions and affect the suitability of water for domestic use. Boron, critical to agricultural use, was not determined.

For agricultural use the ground water analyzed was fair to poor in quality, as classified by the Salinity Laboratory (U.S. Dept. Agriculture, 1954) (table 11). For drinking purposes, most of the water samples are marginal as to quality. Most samples had undesirable concentrations of chloride, exceeding 250 ppm (parts per million), sulfate (more than 250 ppm), or total dissolved solids, as reflected by specific conductance of more than about 750 micromhos (U.S. Public Health Service, 1962). The sample from the Goldfield supply system had a specific conductance of 702 micromhos which is within the recommended limits. The water used for public supply at Silver Peak is highly mineralized (spring 2S/39-22a, table 11).

Because only a small number of wells and springs could be sampled, conclusions as to the general quality of water should not be drawn from the data in table 11. Both better quality and poorer quality water probably occurs in the valleys.

In areas of evapotranspiration the mineral content of water generally is high, as in Clayton Valley. This is not the case, however, in Alkali Spring Valley. Water from well 1S/41-4c on the playa, which is surrounded by greasewood that is transpiring ground water, had a specific conductance of only 1,730 micromhos, compared to a water sample from well 2S/40-17a on the playa in Clayton Valley, which had a specific conductance of 242,000 micromhos. A conductance of 1,730 micromhos suggests a mineral content of about 1,000 ppm. Generally, this would be a low concentration, if this were the principal area of natural discharge. The low mineral content confirms the preliminary conclusion that subsurface flow is occurring through the valley (fig. 3), that flushes the dissolved-mineral matter westward to Clayton Valley rather than allowing it to accumulate and concentrate in Alkali Spring Valley.

Table 11.--Chemical analyses of water from selected sources

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

Location	Date of collection	Source type	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus Potassium (K)	Bicarbonate (HCO_3)	Chloride (Cl)	Sulfate (SO_4)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Salinity hazard	Alkalinity hazard	RSC	Water type	Rock source
				Parts per million (upper number), equivalents per million (lower number)										Some factors affecting irrigation quality[1]				
CLAYTON VALLEY																		
1S/40-25a(?)	1-19-67	Spring	98	--	--	--	--	--	--	--	--	39,300	--	Very high	--	--	--	Siltstone(?)
2S/39-22a	1-19-67	Waterworks Spring	64	a154	a59	a340	a207	a774	a55	--	--	2,820	--	Very high	--	--	--	Limestone
2S/40-17a	1-19-67	Well	--	--	--	--	--	--	--	--	--	242,000	--	Very high	--	--	--	Alluvium
3S/39-11a	1-19-67	Well	--	--	--	--	--	--	--	--	--	2,650	--	Very high	--	--	--	Alluvium
ALKALI SPRING VALLEY																		
1N/41-26a	10-21-13	Well	--	a 17 0.85	a 9 0.74	a125 5.43	a212 3.48	a 44 1.24	a120 2.50	--	--	--	--	(b)	(c)	Marginal	Mixed	Alluvium
1N/42-34c	1-18-67	Well	59	16 0.80	5.6 0.46	78 3.41	166 2.72	24 0.68	61 1.27	63	0	459	8.1	Medium	Low	Marginal	Sodium bicarbonate	Alluvium
1S/41-4c	1-19-67	Well	55	--	--	--	--	--	--	--	--	1,730	--	High	--	--	--	Alluvium
1S/41-26a	1-18-67	Alkali Spring	140	46 2.30	4.6 0.38	349 15.2	348 5.70	68 1.92	492 10.2	134	0	1,840	8.1	High	High	Not suitable	Sodium sulfate	Volcanic rock
3S/42-11b	1-19-67	Well	59	--	--	--	--	--	--	--	--	702	--	Medium	--	--	--	Alluvium(?)
LIDA VALLEY																		
4S/43-33a	1-18-67	Well	64	--	--	--	--	--	--	--	--	806	--	High	--	--	--	Alluvium
5S/40-36a	1-15-67	Carter Spring	--	58	28	34	261	40	61	261	47	595	8.1	Medium	Low	Safe	Calcium magnesium	--
5S/40-36c	1-22-67	Well	--	178 8.88	81 6.70	46 1.98	234 3.84	277 7.81	284 5.91	780	588	1,780	8.0	High	Low	Safe	Mixed	Alluvium
5S/43-17c	1-15-67	Well	--	41 2.05	24 1.99	99 4.30	222 3.64	.28 0.79	185 3.91	202	20	773	8.0	High	Low	Safe	Mixed	Alluvium
STONEWALL FLAT																		
2S/43-36c	1-19-67	Willow Spring	--	--	--	--	--	--	--	--	--	418	--	Medium	--	--	--	Consolidated rock
5S/44-5b	1-18-67	Stonewall Spring	69	--	--	--	--	--	--	--	--	281	--	Medium	--	--	--	Consolidated rock
GRAPEVINE CANYON																		
8S/43-32b	1-18-67	Well	64	--	--	--	--	--	--	--	--	771	--	High	--	--	--	Alluvium
11S/43-6b	1-20-67	Staininger Spring	77	9.6 0.48	2.4 0.20	149 6.47	238 3.90	47 1.33	92 1.92	34	0	734	8.1	Medium	Medium	Not suitable	Sodium bicarbonate	Alluvium

1. Descriptive terms are for water applied to good soils requiring little or no leaching and having favorable drainage characteristics.

a. From Meinzer (1917, p. 154).

b. Probably high.

c. Probably medium.

THE AVAILABLE WATER SUPPLY

Sources of Supply

The available ground-water supply of the six valleys in the Clayton Valley-Stonewall Flat area consists of two interrelated entities: (1) the perennial yield, or the maximum amount of natural discharge that economically can be salvaged over the long term by pumping; and (2) the transitional storage reserve (defined below).

Perennial Yield

The perennial yield of each of the six valleys is shown in table 12. In Clayton and Alkali Spring Valleys, most of the ground-water evapotranspiration could be salvaged by properly located wells in or near the areas of discharge. However, in Clayton Valley water quality might be a limiting factor for agricultural use.

In Alkali Spring and Lida Valleys, Stonewall Flat, and Oriental Wash, from which subsurface outflow is the dominant means of discharge, the amount of salvable discharge is difficult to determine. The possibility of salvaging all or part of the outflow by pumping is uncertain. For the purposes of this reconnaissance it is assumed that the subsurface geohydrologic controls might permit salvage of about half the outflow by partly dewatering the valley-fill reservoir. In Grapevine Canyon, nearly all the natural discharge, that is, all the flow of Grapevine and Stainingers Springs can be salvaged.

Transitional Storage Reserve

Transitional storage reserve has been defined by Worts (1967) as the quantity of water in storage in a particular ground-water reservoir that can be extracted and beneficially used during the transition period between natural equilibrium conditions and new equilibrium conditions under the perennial-yield concept of ground-water development. In the arid environment of the Great Basin, the transitional storage reserve of such a reservoir 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 part of the total ground-water resource that can be taken from storage; it is water that is available in addition to the recharge.

Table 12.--Estimated perennial yield

Valley	Perennial yield[1] (acre-feet)	Remarks
Clayton Valley	22,000	Assumes salvage of nearly all natural discharge. Water quality poor, but suitable for mineral extraction.
Alkali Spring Valley	3,000	Assumes salvage of evapotranspiration losses and about half the subsurface outflow.
Lida Valley	350	Assumes salvage of about half the subsurface outflow.
Stonewall Flat	100	Do.
Oriental Wash	150	Do.
Grapevine Canyon	400	Assumes salvage of all the flow of Grapevine and Staininger Springs, which mostly becomes subsurface outflow.

1. Salvable supply based on estimates in table 10.

Most pertinent is the fact that no ground-water source can be developed without causing storage depletion. The magnitude of depletion varies directly with the distance of development from any recharge and discharge boundaries in the ground-water system. Few desert valleys have well-defined recharge boundaries, such as live streams or lakes; many, however, have well-defined discharge boundaries, such as areas of evapotranspiration.

To compute the transitional storage reserve of the six valleys in the report area, several assumptions are made: (1) wells would be strategically situated in, near, and around the areas of natural discharge so that these natural losses (subsurface outflow and evapotranspiration) could be reduced or stopped with a minimum of water-level drawdown in pumped wells; (2) a perennial water level 50 feet below land surface would curtail virtually all evapotranspiration losses from ground water; (3) over the long term, pumping would cause a moderately uniform depletion of storage throughout most of the valley fill, except in playa deposits (mostly clay) where the transmissibility and storage coefficients are small; (4) the specific yield of the valley fill is 10 percent; (5) the water levels are within the range of economic pumping lift for the intended use; (6) the development would have little or no effect on adjacent valleys or areas; and (7) the water is of suitable chemical quality for the intended use.

Table 13 presents the preliminary estimates of transitional storage reserve, based on the above assumptions. For each of the six valleys the estimated storage reserve is the product of the area beneath which depletion can be expected to occur, average thickness of the valley fill to be dewatered, and specific yield.

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 $\underline{Q}$ is the pumping rate, in acre-feet per year, and $\underline{t}$ is the time, in years, to exhaust the transitional 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.

Table 13.--Preliminary estimates of transitional storage reserve

[All quantities rounded]

Valley	Area of depletion (acres) (1)	Thickness to be dewatered (feet) (2)	Transitional storage reserve 1/ (acre-feet) (1) x (2) x 0.10
Clayton Valley	a 90,000	50	b 450,000
Alkali Spring Valley	80,000	c 10	80,000
Lida Valley	d 120,000	50	600,000
Stonewall Flat	70,000	50	350,000
Oriental Wash	35,000	50	180,000
Grapevine Canyon	--	0	e

1. Assumes a specific yield of 10 percent.

a. Excludes alluvial areas in Weepah Hills and Paymaster Canyon and those isolated areas mostly in the eastern halves of T. 2 S., R. 40 E., and T. 3 S., R. 40 E., and southwestern part of T. 2 S., R. 41 E.

b. Excludes playa deposits now being pumped for mineral extraction.

c. Water level in 1967 about 40 feet in phreatophyte areas (table 8).

d. Excludes the alluvial area between Goldfield Hills and Mount Jackson Ridge.

e. No mining of ground water is necessary to salvage most of the natural discharge of the area (Grapevine and Staningers Springs).

Using the above equation and the estimates for Clayton Valley as an example (transitional storage reserve 450,000 acre-feet, table 13; perennial yield 22,000 acre-feet, table 12) 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 40 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 virtually all the pumpage would be derived 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 22,000 acre-feet per year that originally flowed from around the sides of the valley to areas of natural discharge would ultimately flow directly to pumping wells.

To meet the needs of an emergency or other special purpose requiring ground-water pumpage in excess of 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 be reduced to the perennial yield as soon as possible. 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.

FUTURE DEVELOPMENT

The only significant water development in the area in 1966 was in Clayton Valley where about 2,000 acre-feet was evaporated for mineral extraction (table 9). This leaves an estimated 20,000 acre-feet per year of salvable water to be consumed for industrial and agricultural use, if water of suitable quality exists in areas favorable for farming. The low altitude of Clayton Valley favors a longer growing season than the higher, adjoining valleys. The best area, hydrologically, for development of the ground-water resources probably is in T. 3 S., R. 39 E., because of its proximity to the largest phreatophyte-discharge area and because of its shallow-to-moderate depths to water. Because the scope of this study excluded test drilling, the hydrologic evaluation of this area is tentative. Before any large-scale development is undertaken, test drilling should be done to evaluate the aquifer characteristics, depth to water, and particularly the water quality for the intended use. An evaluation of soil suitability also is beyond the scope of this study.

Alkali Spring Valley, having a yield of possibly 3,000 acre-feet per year, contains water that might be suitable for irrigation. However, static water levels are no less than 30 feet and might be 50 feet or more in areas having soils suitable for farming. Whether large-capacity wells could be developed is not known.

The depths to water in 1966 in Lida Valley, Stonewall Flat, and Oriental Wash probably were in excess of 200 feet. Ground water in these areas probably would be economically developed only for some industrial uses or for public-supply inasmuch as pumping lifts would exceed present economic limits for most types of agriculture. Moreover, the estimated perennial yields are inadequate (100-350 acre-feet) for any significant farming development.

The springs near Lida in Lida Valley probably could be redeveloped as they were when their flow was piped to Goldfield (Meinzer, 1917, p. 151). To determine their present potential, each spring would have to be visited, the flow measured, the quality of the water determined, and development costs ascertained. In Grapevine Canyon, maximum development of Grapevine and Stainingers Springs would utilize most of the perennial yield of the area.

SELECTED WELL AND SPRING DATA AND WELL LOGS

Selected well data are listed in table 14, selected spring data in table 15, and selected drillers' logs of wells are listed in table 16. Most of the well data and logs are from the files of the Nevada State Engineer.

Data in table 14 were selected to include most of the wells in the area. Table 15 includes data on the larger springs that were visited as part of the field work. Table 16 contains logs for only a few wells.

Table 14.--Selected well data

Use: M, mining; S, stock; T, test; P, public supply; D, domestic; U, unused; O, observation

Location 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	Remarks
						CLAYTON VALLEY					
2S/39-12c	Foote Mineral Company	1966	500	12	M	--	4,450	5-30-66	8	9001	
-14b	Do.	1965	125	6	M	--	4,290	2- 3-65	18	8364	
-15d	Do.	1965	50	6	M	--	--	2- 5-65	14	8365	
-25b	Do.	1966	400	6	T	--	--	5-28-66	2	9000	
2S/40-18da	Do.	1964	700	10	M	600/296	4,267	3-26-64	4	8334	
-18db	Do.	1964	500	10	M	800/296	4,267	6-19-64	4	8333	
3S/39-11a	Do.	1965	1,820	12	M	--	4,280	5-28-65	4	8529	
-16c	--	--	--	--	S	--	4,325	1-19-67	44.75	--	
-35cc	--	--	--	--	S	--	4,396	1-19-67	117.80	--	
4S/38-10d	Fish Lake Livestock Co.	1958	185	--	S	--	5,241	1958	dry	4520	
-11a	Do.	1958	245	6	S	15/--	5,000	12- 9-58	215	4518	
						ALKALI SPRING VALLEY					
1N/41-26a	Gottschalk Well	--	--	--	-	--	--	10-21-13	61	--	(a)
1N/42-34c	Klondike	--	160	50x70	S	--	4,940	10-22-13	148	--	(a)
								1-18-67	138.01	--	
1S/41-4c	U.S.G.S., no. 3	1965	72	1½	O	--	4,825	1-19-67	45.70	--	First water at 67 feet.
-18a	U.S.G.S., no. 2	1965	72	1½	O	--	4,825	1-19-67	47.62	--	(b)
1S/42-10a	Dodge Construction Co., Ramsey Well	1950	310	6	S	300/--	4,990	5-29-50	210	1345	(c)
								2-15-58	197.40		
								10-11-62	197.45		

Table 14.--continued

Location 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	Remarks
3S/42-2c	City of Goldfield	--	45	60	P	25/--	5,710	1-18-67	25.19	--	Standby well
-10a	Do., Rabbit Spring Well	--	90	--	P	--	5,900	1-18-67	7	--	Standby well
-11b	City of Goldfield	--	440	8	P	50/4	5,800	3- 6-65 1-18-67	31 91.41	8817	
					LIDA VALLEY						
4S/43-33a	Ralston well	--	--	10	S	--	4,780	1-18-67	309.50	--	
5S/43-17c	Lida Junction Service	1958	604	10,8,6	D	25/--	4,690	9-10-58	365?	4270	Depth to water reported by driller. First water 476 feet.
								1-18-67	241		Depth to water reported by owner
6S/43-5c	--	--	--	8	S	--	4,610	1-18-67	289.51	--	
					STONEWALL FLAT						
4S/45-8c	Desert well[b]	--	--	--	--	--	4,690	--	110	--	Reported by Ball (1907, p. 83).
					ORIENTAL WASH						
7S/40-27c	Roosevelt Well	--	--	8	S	--	4,514	1-20-67	75.42	--	
					GRAPEVINE CANYON						
8S/43-32b	--	--	--	--	U	--	4,220	1-18-67	264.69	--	

a. Reported by Meinzer (1917, p. 148).
b. Meinzer (1917, p.148) reports a water level in a nearby well on the playa of 47.5.
c. Meinzer (1917, p. 148) reports a water level in a nearby well at 221 feet.

Table 15.--Selected spring data

Use: P, public supply; U, unused; S, stock; D, domestic; I, Irrigation

Location number	Owner or name	Altitude (feet)	Rock type	Yield (gpm)	Use	Remarks
			CLAYTON VALLEY			
1S/40-25a(?)		4,350	Siltstone	<25	U	Two springs; discharge at edge of playa
2S/39-22a	Waterworks Springs	4,200	Limestone	240	P	Yield as reported by Meinzer (1917, p. 143) and Dole (1912, p. 5) Temperature of water ranges from 70° to 120°F
			ALKALI SPRING VALLEY			
1S/41-26a	Alkali Spring	5,020	Volcanic rock	40	S	Hot water; was piped to Goldfield for milling
			LIDA VALLEY			
5S/40-36a	Carter Spring	6,400	--	30	D,S	
6S/40-22d	Stateline Spring	6,960	Limestone	--	S	Was piped to Stateline Mill (7S/41-26b)
(near Lida)	Lida spring supply	--	--	300±	--	Used at Goldfield until 1919, Meinzer (1917, p. 151)
			STONEWALL FLAT			
2S/43-36c	Willow Spring	5,950	Consolidated rock	<1	S	
5S/44-5b	Stonewall Spring	5,800	do.	10	S	
			ORIENTAL WASH			
9S/41-7b	Sand Spring	3,140	Alluvium	1	S	In Death Valley
9S/41-18a	Little Sand Spring	3,020	do.	<1	S	In Death Valley
			GRAPEVINE CANYON			
11S/43-6b	Staininger Springs	3,200	Alluvium	200	D,I	Water used at Scottys Castle, 1 mile west. Waring (1915, p. 375) estimates the flow as 10 gpm. Ball (1907, p. 20) estimates the flow as about 600,000 gpd (400 gpm)
11S/42-3a,d	Grapevine Springs	2,800	Consolidated rock	>20	--	Located 3 miles west of Scottys Castle

Table 16.--Selected drillers' logs of wells

CLAYTON VALLEY

2S/39-12c

Material	Thickness (feet)	Depth (feet)
Clay, brown	14	14
Salt, layers	14	28
Mud, blue, and chunks of salt	30	58
Salt, firm	6	64
Clay, blue, with sand streaks	16	80
Salt	2	82
Clay, blue	44	126
Salt	4	130
Clay, blue, firm	82	212
Sand	14	226
Gypsum-like material, hard	18	244
Clay, hard	4	248
Sand	20	268
Clay, sandy, blue, soft	38	306
Clay, blue, hard	22	328
Sand	14	342
Clay, blue	48	390
Sand	6	396
Clay, blue	22	418
Sand	24	442
Clay, blue	18	460
Gypsum-like material, hard	15	475
Clay, blue, with sand streaks	25	500

2S/39-25b

Material	Thickness (feet)	Depth (feet)
Clay, brown, wet	12	12
Clay, brown, hard	12	24
Clay, gray, soft	36	60
Sand	4	64
Clay, gray, hard	16	80
Sand, fine	3	83
Clay, gray, and gravel	37	120
Sand	3	123
Clay, gray, and rock	117	240
Sand, fine	6	246
Clay, gray, and gravel	44	290
Rock	12	302
Clay, gray, with sand streaks	32	334
Rock and shale	66	400

2S/40-18da

Material	Thickness (feet)	Depth (feet)
Clay, brown	12	12
Salt	13	25
Sand, hard	30	55
Salt, hard	2	57
Clay, sandy, blue, hard	21	78
Clay, soft	4	82
Salt, crystalline	14	96
Clay, dark brown, sticky	9	105
Rock, loose; some gypsum	17	122
Salt	32	154
Clay, brown, sticky	132	286
Sand, blue, fine, with some pumice	12	298
Clay, brown, soft	32	330
Sand, blue, fine	8	338
Clay, brown	47	385
Rock and gypsum, hard	15	400
Sand, soft, with pumice	32	432
Clay, brown, soft	73	505
Gravelly clay, brown, hard	10	515
Gravel and sand	19	534
Clay, gravelly, gray, soft	36	570
Clay, gray, hard	14	584
Rock and gypsum	10	594
Sand, gravelly	6	600
Rock and gypsum	25	625
Clay and shale	75	700

Table 16.--continued

Material	Thickness (feet)	Depth (feet)
3S/39-11a		
Sandy silt with clay	25	25
Gravel	5	30
Clay	5	35
Gravel and sand	25	60
Clay	8	68
Sandstone and gravel	22	90
Sandstone, tuffaceous	15	105
Clay, sand, and gravel	45	150
Sandstone and gravel	25	175
Clay	15	190
Sandstone	13	203
Clay	7	210
Sand and gravel	17	227
Silt	3	230
Sand, conglomerate, and sandstone	40	270
Clay, sand, and gravel	125	395
Sand	25	420
Sand, silty, with clay	10	430
Sand, medium to coarse	20	450
Clay and fine sand	55	505
Gravel, sandy	5	510
Clay and silty sand	50	560
Sand and gravel	15	575
Clay	3	578
Gravel, sandy	22	600
Clay and fine sand	55	655
Sand, coarse	5	660
Clay, silt, and sand	155	815
Sand and gravel	7	822
Silt, sand, and gravel	38	860
Gravel, volcanic	5	865
Silt, sand, and gravel	30	895
Gravel, coarse	8	903
Silt, sand, and gravel	192	1,095
Sand and gravel	10	1,105
Silt, blue-gray	15	1,120
Sand and gravel	5	1,125
Silt, sand, and gravel	40	1,165
Gravel	5	1,170
Silt, light brown	12	1,182
Gravel	3	1,185
Silt, sandy, light brown	50	1,235
3S/39-11a cont.		
Gravel, sandy	10	1,245
Silt, sand, and gravel	240	1,485
Sand and gravel beds alternating with sandy silt beds	335	1,820
4S/38-11a		
Gravel and boulders	70	70
Clay, yellow, and gravel	100	170
Clay, red, and gravel	75	245
ALKALI SPRING VALLEY		
1S/42-10a		
Soil, sandy	1	1
Clay and gravel	179	180
Clay, yellow, and sand	30	210
Clay and water-bearing gravel	100	310
3S/42-11b		
Clay and boulders	136	136
Gravel and boulders	4	140
Clay and boulders	25	165
Boulders, sand, and gravel	13	178
Clay, gravelly, blue	57	235
Sand and gravel	2	237
Clay, blue	63	300
Sand and gravel	12	312
Clay, blue	20	332
Sandstone, sand, and gravel	20	352
Clay, blue	38	390
Sand, fine	3	393
Shale, brown	47	440
LIDA VALLEY		
5S/43-17c		
Gravel, rock, and sand	40	40
Conglomerate	436	476
Sand, fine	4	480
Conglomerate, very hard	100	580
Conglomerate, soft, weathered	20	600
Rock, very hard	4	604

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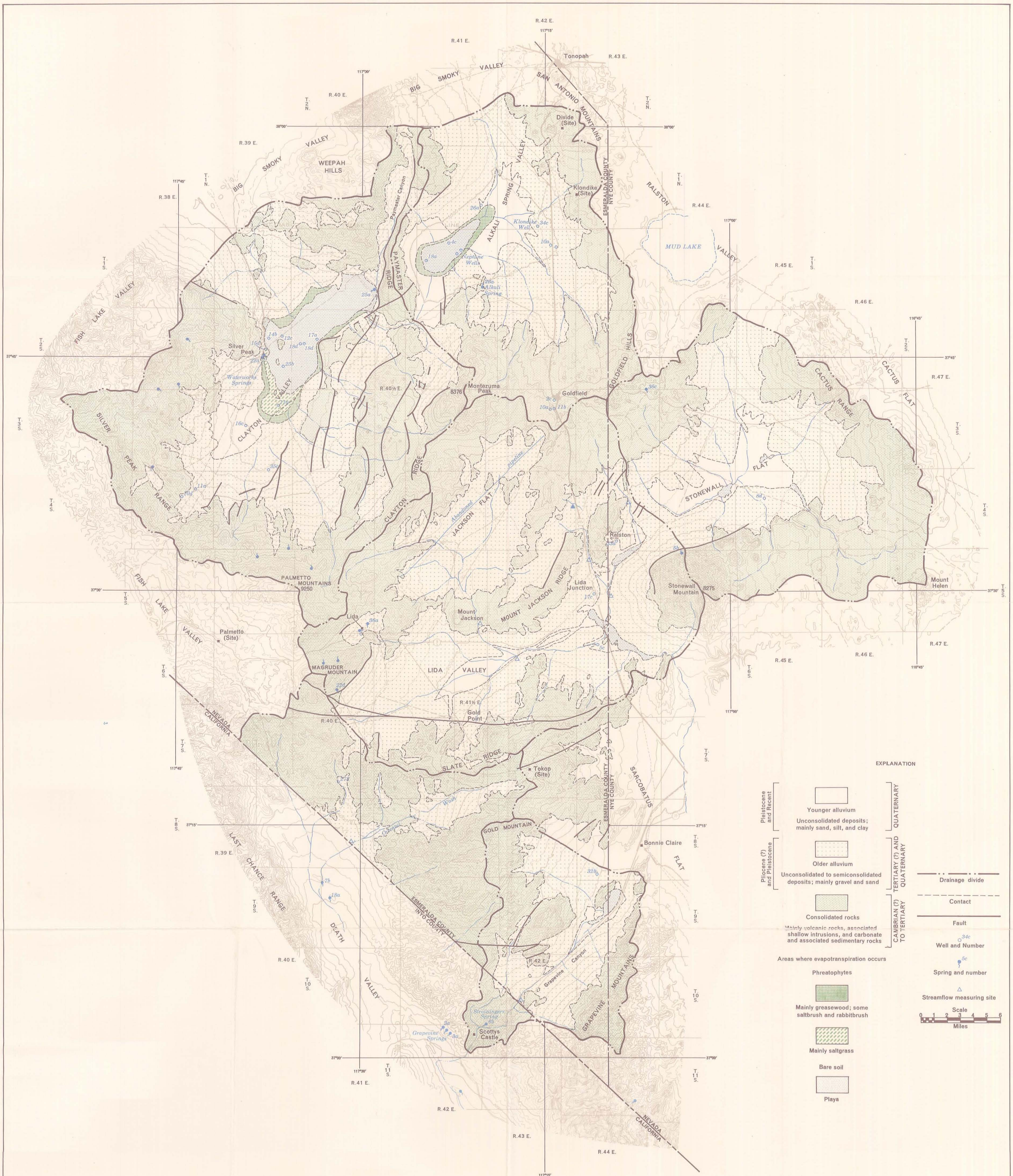
LIST OF PREVIOUSLY PUBLISHED REPORTS IN THIS SERIES

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, Massacre Lake, Mosquito, Boulder, Surprise, Coleman, Guano
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, Virgin, Continental Lake, Gridley Lake
23	Dixie, Fairview, Eastgate, Cowkick, Stingaree, Pleasant, Jersey
24	Lake
25	Coyote Spring, Kane Spring, Muddy River Springs
26	Edwards Creek
27	Lower Meadow, Spring (near Panaca), Panaca, Clover, Patterson, Eagle, 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, Newcomb Lake, Dry, Red Rock, Bedell Flat, Antelope, Warm Springs, Cold Spring, Lemmon, Spanish Springs, Sun
44	Smoke Creek Desert, San Emidio Desert, Pilgrim Flat, Painters Flat, Skedaddle Creek, Dry (near Sand Pass), Sano

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES



Base from Army Map Service 1:250,000 series; Death Valley, 1961; Goldfield, 1958; and Tonopah, 1956

Hydrology by F. Eugene Rush, 1967; geology adapted from Albers and Stewart (1965) and Anderson and others (1965)

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF THE CLAYTON VALLEY—STONEWALL FLAT AREA, ESMERALDA AND NYE COUNTIES, NEVADA AND INYO COUNTY, CALIFORNIA