STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
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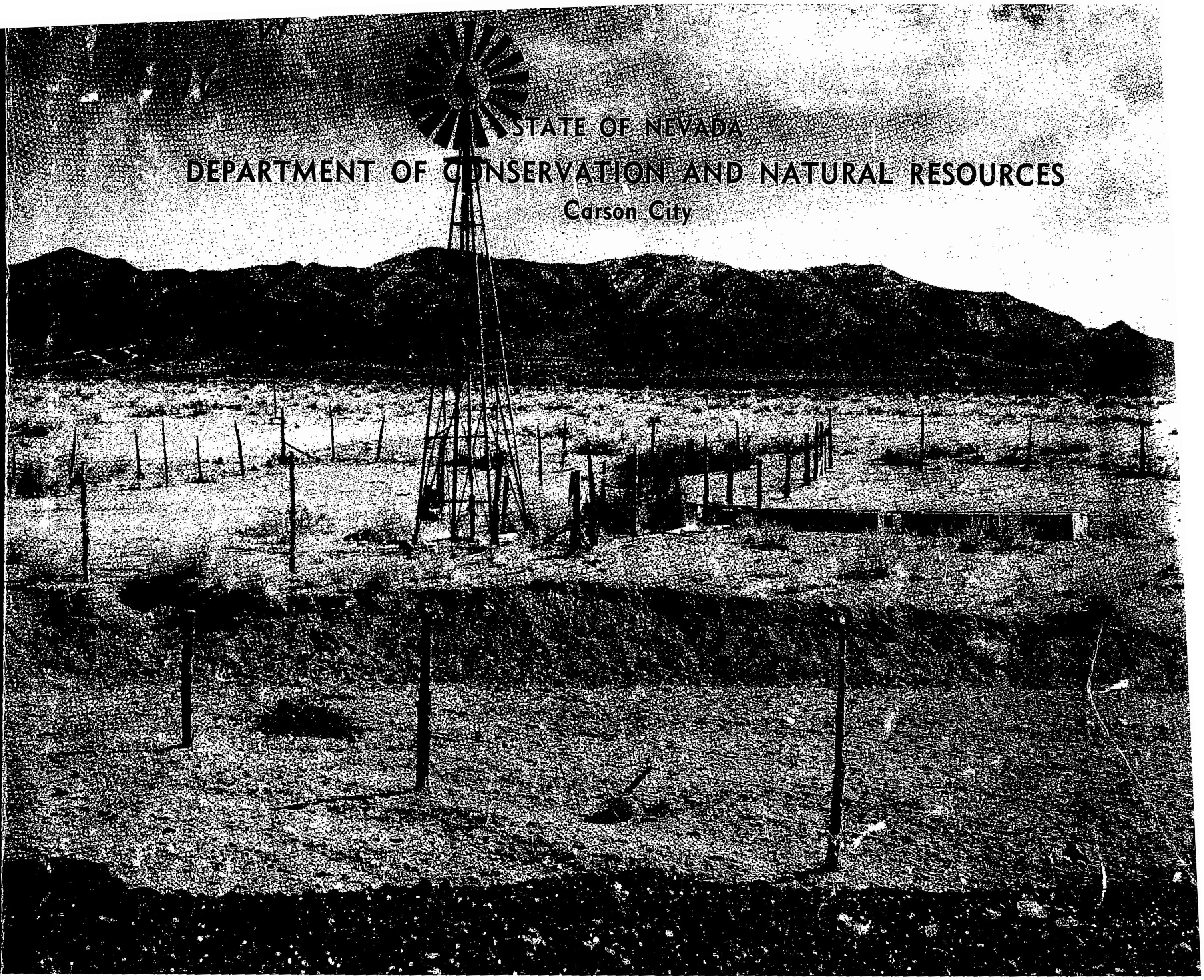

View of Bristol Wells

#253

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 16

GROUND-WATER APPRAISAL OF DRY LAKE AND DELAMAR VALLEYS, LINCOLN COUNTY, NEVADA

By
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PRICE $1.00

Prepared cooperatively by the
Geological Survey, Department of Interior

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FOREWORD

This is the 16th report in the series of reconnaissance ground-water studies which were initiated by action of the Legislature in 1960. In these sixteen reports, the ground-water resources of some nineteen valleys have been appraised and described.

The present appraisal of the ground-water resources of Dry Lake and Delamar Valleys in Lincoln County, Nevada, was made by Thomas E. Eakin, geologist, U. S. Geological Survey.

These reconnaissance ground-water resources studies make available pertinent information of great value to many State and Federal agencies. 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 ground-water resources of the areas on which reports are prepared.

Hugh Shamberger

Hugh A. Shamberger
Director
Department of Conservation
and Natural Resources

May, 1963

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by
Thomas E. Eakin

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SUMMARY

The results of this reconnaissance of Dry Lake and Delamar Valleys suggest that average annual ground-water recharge from precipitation may be on the order of 6,000 acre-feet. Ground water is discharged largely by underflow through bedrock from the valleys, most probably to the southwest or south toward Pahranagat Valley.

The substantial depth to water, in excess of 300 feet in the topographically lower parts of the valleys, precludes low-cost development of substantial supplies of ground water. However, this apparently adverse feature for usual water-supply purposes may be desirable from the standpoint of possible special testing purposes required in modern technology.

The area roughly including Tps. 1 S. to 2 N., R. 64 E. may be most favorable for eventual interception of most of the recharge which is principally supplied from the mountains to the east and north. Here, perennial yield might closely approach the average annual recharge. It should be pointed out, however, that the depth to water, ranging from about 400 feet to 700 feet or more, probably precludes development of substantial water supplies for most purposes because of the high cost of pumping.

INTRODUCTION

Ground-water development in Nevada has shown a substantial increase in recent years. Part of the increased development is due to the effort to bring new land into cultivation, part is due to the effort to supplement surface-water supplies, and part is due to the general increased demands for water. In any case, as efforts to develop ground water increase, there is a corresponding increase in demand for information on the ground-water resources throughout the State.

Recognizing this need, the State Legislature enacted special legislation (Chapt. 181, Stats. 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.

Interest in ground-water resources currently includes many areas and is extending to additional areas almost continuously. Thus, the emphasis of the reconnaissance studies is to provide as quickly as possible a general appraisal of the ground-water resources in particular valleys or areas where information is urgently needed. Ultimately, ground-water information will be available for practically all valleys of the State, at least at a reconnaissance level. For this reason each study is limited severely in time, field work for each area generally averaging about two weeks.

The Department of Conservation and Natural Resources has established a special report series to expedite publication of the results of the reconnaissance studies. Figure 1 shows the areas for which reports have been published in this series. A list of the titles of previous reports published in the series is given at the end of this report. This report is the sixteenth in the Reconnaissance Series.

The purpose of the Reconnaissance Series is to provide a general appraisal of the ground-water resources of virtually all valleys of the State for public information, and to provide a preliminary estimate of the amount of ground-water development that the areas might sustain on a perennial basis as an initial guide to possible requirements for administration of the areas under the State ground-water law.

The scope of this report is limited to a general description of the physical conditions of Dry Lake and Delamar Valleys, including observations of the interrelation of climate, geology, and hydrology as they affect ground-water resources; and possible movement of ground water between valleys is discussed. The report also includes a preliminary estimate of the average annual recharge to and discharge from the ground-water reservoir.

Location and General Features:

Dry Lake and Delamar Valleys are in central Lincoln County and lie within an area bounded by lat 37° 15' and 38° 28' N., and long 114° 33' and 115° W. The two valleys occupy a north-trending trough which is about 82 miles long and a maximum of about 20 miles wide between drainage divides. The combined area of the two valleys is nearly 1,300 square miles.

U. S. Highway 93 crosses the area in an eastward alinement about at the divide between Dry Lake Valley on the north and Delamar Valley on the south (fig. 2). Caliente lies along the highway about 20 miles east of the area.

A gravel road extends southward from U.S. Highway 93 to the former mining town of Delamar. State Highway 83 and improved roads connect formerly active mines on the western side of the Bristol Range with U.S. Highway 93 to the east in the vicinity of Pioche. Trails provide limited access to the lower parts of the valleys during fair weather.

The valleys are used principally for livestock range, although full use of the area may be somewhat limited by inadequate distribution of permanent watering points.

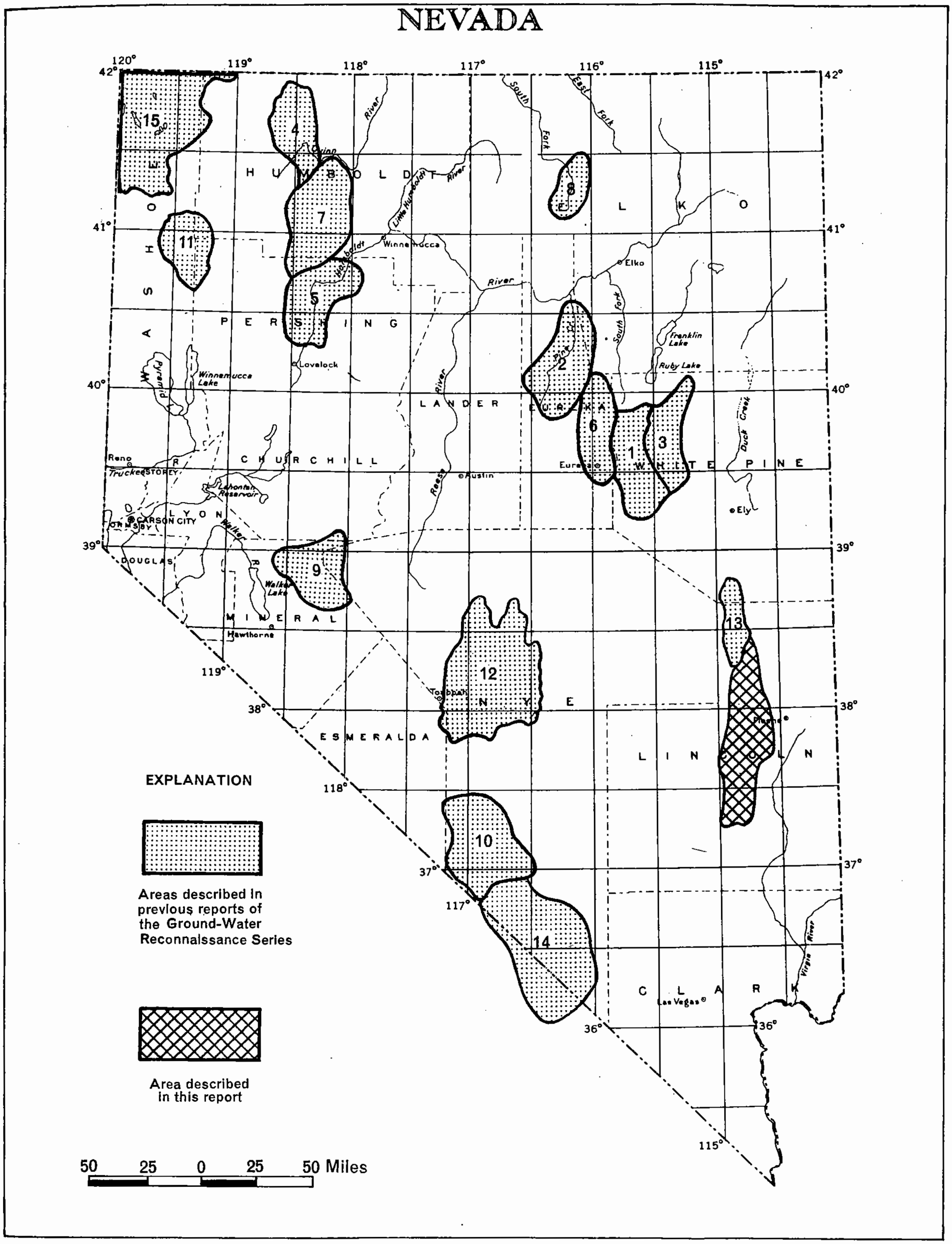


FIGURE 1. MAP OF NEVADA SHOWING AREAS DESCRIBED IN PREVIOUS REPORTS OF THE RECONNAISSANCE SERIES AND IN THIS REPORT.

Climate:

The climate of Dry Lake and Delamar Valleys is semi-arid. Precipitation and humidity generally are low, and summer temperatures and evaporation rates are high. Precipitation is irregularly distributed but generally is least on the valley floor and greatest in the mountains. Snow is common during the winter months and localized thundershowers provide much of the summer precipitation. The daily and seasonal temperature range is relatively large.

Records of precipitation are not available for Dry Lake and Delamar Valleys. However, the magnitude and distribution of precipitation in parts of the valleys probably are reasonably represented by the records for Alamo in Pahranagat Valley west of Delamar, and for Caliente and Pioche to the east (fig. 2). Table 1 lists the annual and the average monthly and average annual precipitation at Alamo, Caliente, and Pioche.

Maximum annual precipitation, in inches, during the period 1931-60 for Alamo, Caliente, and Pioche was 14.91 (1941), 18.73 (1941) and 22.38 (1941), respectively. Maximum monthly precipitation, in inches, for the same period was 6.15 (August 1945), 4.29 (October 1946), and 5.01 (August 1945), respectively. Minimum annual precipitation, in inches, for the respective stations was 1.23 (1956), 2.92 (1950), and 3.81 (1956). Minimum monthly precipitation has been zero a number of times at each of the stations.

Table 2 lists average monthly and annual temperature for the period 1931-60 at Alamo and Caliente and for the period 1939-60 at Pioche. Maximum and minimum temperatures recorded are: at Alamo, 115° F. on August 11, 1940, and -9°F. on January 21, 1937; at Caliente, 109°F. on June 22, 1948, and -31°F. on January 9, 1937; and at Pioche, 102°F. on June 22, 1954 and -5°F. on January 4, 1949.

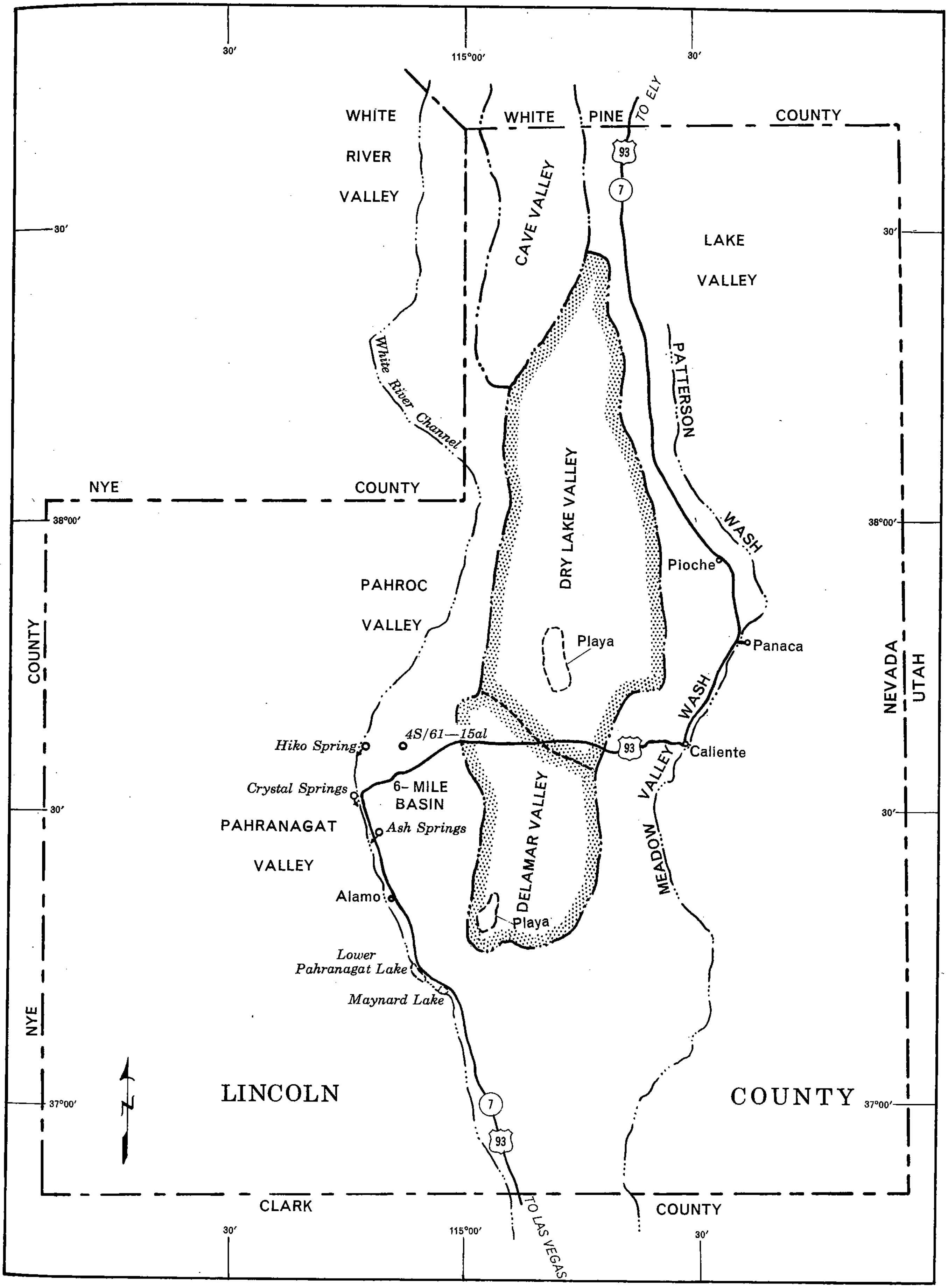


FIGURE 2. Sketch map showing relation of Dry Lake and Delamar Valleys to adjacent, areas

Table 1.--Summary of precipitation at Alamo, Caliente, and Pioche, Nev.

(from published records of the U.S. Weather Bureau)

Average monthly and annual precipitation, in inches, (1931-60)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
lamo	.70	.68	.68	.57	.45	.15	.73	.77	.32	.43	.43	.60	6.60
aliente	.83	.79	.85	.70	.56	.39	.76	.92	.49	.89	.75	.86	8.79
ioche[1]	1.55	1.26	1.46	1.19	.83	.33	.87	1.12	.69	1.18	.96	1.36	12.80

/ Average for 1939-60.

Annual precipitation, in inches, (1931-61)

ear	Alamo	Caliente	Pioche	Year	Alamo	Caliente	Pioche
931	9.60	9.49	--	1947	--	7.47	10.70
932	9.68	11.61	--	1948	2.75	5.23	8.39
933	7.29	8.16	--	1949	6.09	10.03	15.36
934	3.01	7.14	--	1950	5.32	2.92	7.14
935	5.58	9.43	--	1951	4.89	10.15	13.98
936	8.97	11.60	--	1952	6.88	11.52	16.32
937	6.30	6.84	--	1953	1.98	4.66	7.26
938	11.15	--	--	1954	5.96	9.31	13.28
939	7.42	9.41	10.05	1955	5.65	7.13	14.09
940	6.16	7.49	13.48	1956	1.23	4.78	3.81
941	14.91	18.73	22.38	1957	7.43	10.88	17.14
942	2.94	6.63	7.18	1958	6.47	8.13	15.51
943	--	11.70	16.08	1959	4.42	4.83	10.41
944	--	7.96	11.59	1960	6.02	9.77	12.85
945	10.65	11.60	20.60	1961	3.63	8.80	9.62
946	--	12.36	14.04				

Table 2.--Average monthly and annual temperature, in degrees Fahrenheit, at Alamo, Caliente, and Pioche, Nev. for the period 1931-60

(from published records of the U.S. Weather Bureau)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Year
amo	36.6	41.1	47.2	56.1	62.9	71.9	79.2	76.9	69.7	58.6	46.8	39.3	57.1
liente	30.4	36.0	43.7	52.2	60.2	68.5	75.9	73.9	65.9	54.1	41.5	33.5	52.9
oche[1]	29.5	33.6	39.3	48.6	57.0	66.3	73.9	71.7	64.8	52.8	40.3	34.0	51.0

Average for 1939-60.

Low humidity and high temperatures are favorable for high rates of evaporation. Pan evaporation recorded at Caliente since 1956 is listed in table 3. Evaporation from May through September accounts for most of the annual total and averages about 50 inches for the 6-year period of record.

The average growing season in Dry Lake and Delamar Valleys has not been determined. An approximation of the probable growing season may be obtained by reference to the nearby Upper Meadow Valley Wash, which is 20 miles east of this area. Houston (1950, p. 19) lists an average growing season of 157 days (May 2 to October 6), based on records at Caliente. Killing temperatures vary according to type of crop. In recent years Weather Bureau records list freeze data rather than killing frosts; the dates are listed for the occurrence of the last spring minimum and the first fall minimum for temperatures of 32°F. or below, 28°F. or below, and 16°F. or below. From these data the number of days between the last spring minimum and the first fall minimum occurrence for the respective temperature groups are given. The following tabulation lists the number of days for the three temperature groups recorded for the period 1952-61 at Alamo, Caliente, and Pioche.

Number of days between temperatures of:
(from published records of the U.S. Weather Bureau)

	32°F or below			28°F or below			24°F or below		
Year	Alamo	Caliente	Pioche	Alamo	Caliente	Pioche	Alamo	Caliente	Pioche
1952	177	183	173	212	208	210	227	227	232
1953	117	122	143	150	144	161	208	191	166
1954	219	151	136	230	206	176	257	210	177
1955	141	137	143	178	178	170	208	186	197
1956	134	151	152	183	--	163	202	204	204
1957	163	138	134	169	162	190	238	227	227
1958	173	134	178	176	152	179	222	191	224
1959	151	135	131	184	150	178	228	200	209
1960	144	141	144	164	189	164	198	205	204
1961	129	136	148	156	179	165	188	183	188
Average	154	142	148	180	174	175	217	202	180

Table 3.--Total evaporation at Caliente, Nev. (1956-61)

(from published records of the U.S. Weather Bureau)

Year	March	April	May	June	July	August	September	October	November
1956			7.42	[b]12.55	11.10	10.86	8.07	[b]4.65	2.05
1957	3.97	6.76	6.33	10.66	11.45	[b]11.60	7.54		
1958		[b]6.39	9.35	11.99	12.39	11.73	7.56	5.00	
1959		7.56	9.59	11.89	11.71	10.10	7.18		
1960			9.78	10.94	11.16	10.87	7.34	4.06	
1961		7.19	9.40	12.07	11.06	7.90	6.68	[b]4.07	
Average			8.64	11.67	11.48	10.51	7.39		

b/ Adjusted to full month by Weather Bureau.

Physiography and Drainage:

Dry Lake and Delamar Valleys occupy a surficially closed trough in the Great Basin section of the Basin and Range physiographic province of Fenneman (1931, p. 328). The north-trending trough is bounded on the east successively from the north by the Ely, Bristol, Highland Peak, and Delamar Ranges. A southwest-trending spur of the Ely Range forms the northwest boundary of Dry Lake Valley. The Pahroc (also Pahrock) Range bounds the central part of the trough on the west. On the southwest unnamed ranges, commonly with poorly defined drainage divides, comprise the boundary. The south end of Delamar Valley is separated from Pahranagat Valley by a low alluvial divide.

The highest point in the mountains enclosing Dry Lake and Delamar Valleys is Highland Peak with an altitude of about 9,500 feet. The crest of the Bristol and Highland Peak Ranges is more than 8,000 feet above sea level for a distance of about 12 miles. The crest of the mountains along the northwest and east sides has an altitude of more than 7,000 feet for a combined distance of about 42 miles. Elsewhere the crests are less than 6,000 feet above sea level, except for short segments whose altitudes are somewhat above 7,000 feet.

The lowest part of the trough of Dry Lake and Delamar Valleys is the playa or dry lake, in the southern part of Delamar Valley (see inside cover photograph) which has an altitude of slightly less than 4,400 feet. The altitude of the playa in Dry Lake Valley is somewhat less than 4,600 feet. Dry Lake and Delamar Valleys are separated by an alluvial divide whose saddle altitude is about 4,875 feet.

The trough of Dry Lake and Delamar Valleys is higher than those of White River and Pahranagat Valleys on the west and Meadow Valley Wash on the east, which are tributary to the Colorado River (fig. 2). In Dry Lake and Delamar Valleys the altitude decreases irregularly from about 5,400 feet at the latitude of Fairview Peak in the north to about 4,400 feet at the north end of the Delamar playa in a distance of about 55 miles, or an average decrease of 18 feet per mile. In the White River and Pahranagat Valleys to the west the altitude of the floor of the channel decreases from about 5,100 feet to 3,600 feet in the same distance, giving an average gradient of about 27 feet per mile. Similarily, in Meadow Valley Wash and in Lake Valley to the east, the altitude decreases from 5,900 feet to 3,900 feet in the same distance, giving an average gradient of about 36 feet per mile. Thus, the steeper gradients in the adjacent valleys result in the land surface altitude of the channels being substantially lower than the land surface altitude in the southern part of the trough of Dry Lake and Delamar Valleys. In fact, the playa in Delamar Valley is nearly 1,200 feet higher than the floor of Pahranagat Valley in the vicinity of Maynard Lake. The topographic positions and geology of these valleys largely control the occurrence and movement of ground water in the region. There are no perennial streams in Dry Lake and Delamar Valleys, and the gross physiographic features of most of the stream channels and washes probably were formed during periods of greater precipitation--probably in Pleistocene time. Present-day streamflow occurs for short periods only after high-intensity rains and from snowmelt runoff. Only runoff from high-intensity rains can provide large volumes of flow to cause local erosion and substantial transport of sediments in sufficient quantity to modify stream channels and washes.

The main channel along the axis of the northern part of Dry Lake Valley is contained between relatively steep banks about 25 feet below the general level of the valley. The floor of the channel is covered with white sage, and the soil is fine-grained as it is in adjacent parts of the valley floor. This feature suggests that flash-flood erosion in this channel is most uncommon. Farther south, channels draining the Highland Peak and Delamar ranges have somewhat steeper gradients. In this area flood flows occasionally transport relatively coarse gravel to the lower part of the alluvial apron. One example of this was noted along a wash crossing the trail about in sec. 22, T. 1 N., R. 65 E.

During Pleistocene time, lakes occupied the playa areas of Delamar and Dry Lake Valleys. Tschanz and Pampeyan (1961) mapped about 16 miles of beach or strand line along the west, south, and southeast sides of the Dry Lake playa, and about 14 miles along the equivalent segments of the Delamar playa. These represent the highest shore lines identified in these valleys.

Maximum depths of the Pleistocene lakes were on the order of 75 feet in Dry Lake Valley and perhaps 50 feet in Delamar Valley, according to Carpenter (1915, p. 65, 66). The surface areas of the lakes in Dry Lake and Delamar Valleys were about 30 and 16 square miles, respectively.

GENERAL GEOLOGY

The following discussion of geology is based largely on the reconnaissance geologic maps of Tschanz and Pampeyan (1961) and Tschanz (1960). Other reports that relate to the geology in and adjacent to Dry Lake and Delamar Valleys include those prepared by Westgate and Knopf (1932), Callaghan (1936, 1937), Reso and Croneis (1959), and Kellog (1960).

For the purposes of this report the rocks of Dry Lake and Delamar Valleys are divided into two general groups and further subdivided into four major units. The distribution of these four units is shown on plate 1. One group primarily represents bedrock in the mountains. It is divided into a Paleozoic carbonate unit and a Paleozoic clastic and Tertiary volcanic and clastic rock unit.

Tschanz (1960, p. 198) indicates that the total thickness of Paleozoic rocks exposed in northern Lincoln County is between 30,000 and 33,000 feet. As described, one may infer that carbonate rocks (limestone and dolomite) probably constitute about 60 percent of the total section. This is somewhat less than the 80 percent of carbonate rocks in a total section of about 30,000 feet noted by Kellog (1960, p. 189) in his study of the southern Egan Range, which is 10 to 15 miles northwest of the area. The second unit of the bedrock group includes Paleozoic shale, sandstone or quartzite, and conglomerate and Tertiary volcanic rocks, chiefly tuff and intravolcanic sedimentary rocks. Because of their importance to the ground-water hydrology of the region, the Paleozoic carbonate rocks are distinguished from Paleozoic clastic and Tertiary volcanic rocks on plate 1 as discussed subsequently in this report.

The second group is designated the valley fill and is divided into older and younger valley fill. The older deposit consists of unconsolidated to partly consolidated silt, sand, and gravel derived from adjacent highland areas, but also includes some rocks of volcanic origin. This unit was deposited largely under subaerial and lacustrine environments. Although data are not available, the maximum thickness of this unit probably is at least several hundred feet.

The younger valley fill includes clay, silt, sand, and gravel of Quaternary age and is largely restricted to stream channels and playa areas. As defined, this unit is relatively thin and probably is no more than a few tens of feet thick. The valley fill is underlain by bedrock, presumably similar in character to that exposed in the mountains.

Water-Bearing Properties of the Rocks:

The rocks of Paleozoic age generally have had their primary permeability, that is, permeability at the time of deposition, considerably reduced by consolidation, cementation, or other alteration. However, because they subsequently have been fractured repeatedly by folding and faulting, secondary openings have developed through which some ground water is transmitted. Further, fractures or joints in Paleozoic carbonate rocks locally have been enlarged by solution as water moves through them. Solution openings develop near sources of recharge where carbon dioxide carried by rain water penetrates the ground, where organic acids derived from decaying vegetation, or where otherwise derived acids may be carried by the water into contact with the carbonate rocks. Solution openings need not be restricted to the vicinity of present day recharge areas and outcrops of these rocks. Rather, they may occur wherever the requisite conditions have occurred anytime since the deposition of the carbonate rocks. The principal significance of solution openings is that they further facilitate movement of ground water through carbonate rocks.

Whether existing fractures or solution openings have extensive hydraulic connection or not is related to the overall geologic history of the rocks. In the absence of detailed information, ground-water movement through carbonate rocks in this region is assumed to occur both through fractures and solution openings. Certainly, the large quantity of ground water issuing from fractures and solution openings, such as those at Crystal and Ash Springs in Pahranagat Valley, is a dramatic demonstration that ground-water movement through Paleozoic carbonate rocks occurs in this region of Nevada.

The Paleozoic clastic rocks and the Tertiary volcanic and clastic rocks exposed in the mountains generally have little primary permeability. Secondary fractures probably are the principal means by which limited amounts of ground water are transmitted through them. Favorably disposed fractures in these rocks probably provide the network of openings through which water moves and is discharged at small springs in the mountains and which yield a few gallons per minute to wells penetrating these rocks. Under extremely favorable conditions the distribution of fracture openings in welded tuff, lava flows, or Paleozoic clastic rocks may permit the development of moderate yields of water from wells. However, these occurrences are likely to be so localized that the odds of a well encountering them are very small indeed.

The unconsolidated sand and gravel of the valley fill in Dry Lake and Delamar Valleys is capable of transmitting ground water freely. However, most of the valley fill probably is composed of deposits of fine sand and silt. Grains of this size generally have relatively low permeability and, where saturated, transmit water much more slowly than coarse sand and gravel. Deposits of silty clay and clay may transmit water so slowly to wells that they will not yield supplies adequate for stockwatering purposes. Various parts of the valley fill probably are moderately consolidated or cemented and this further reduces the capacity of these deposits to transmit useful supplies of water to wells.

GROUND-WATER APPRAISAL

Occurrence of Ground Water:

Ground-water recharge in Dry Lake and Delamar Valleys is derived principally from precipitation within the surficial drainage area of the valleys. In a general way, ground water moves from recharge areas in and bordering the mountains toward the central parts of the valleys, thence southward or southwestward to discharge through bedrock formations. This is in contrast with hydrologically closed valleys commonly found in the Basin and Range province. Carpenter (1915, p. 67) indicated that ground water in Bristol (Dry Lake) and Delamar Valleys probably finds an outlet in Pahranagat Valley. Snyder (1963, p. 400) refers to Dry Lake Valley as being a drained valley; that is, ground water moves out of the valley to discharge elsewhere.

In typical hydrologically closed valleys in the Great Basin, ground water is recharged from precipitation largely in the mountains enclosing the valley. Ground water moves from areas of recharge toward the ground-water reservoir in the valley fill underlying the central part of the valley. In or adjacent to the topographically lowest part of the valley, the water table, or upper surface of the zone of saturation, is within a few feet of land surface. Where the water table is close to land surface, ground water is discharged naturally by evaporation from the soil or from free-water surfaces and is transpired by plants (phreatophytes) which obtain most of their water from the zone of saturation or overlying capillary fringe.

Under long-term conditions in a hydrologically closed ground-water system, average annual recharge to the ground-water reservoir equals the average annual natural discharge. However, if a ground-water system in a topographically closed valley is hydrologically open, recharge from precipitation in the valley may be greater or less than the discharge within the valley. Where recharge from precipitation within the valley is greater than discharge in the valley, ground water must be discharging by underflow from the valley to an area eas of lower hydraulic head. Where the recharge from precipitation within alley is less than discharge in the valley, recharge in part must be entering valley from an area or areas beyond the topographic divide having a higher aulic head.

In addition to hydraulic controls, the water-bearing character of the rocks and their structure are important factors in the movement, or impedance to movement, of ground water. Where bedrock formations in the enclosing mountains are relatively impermeable, ground water normally is part of a closed hydrologic system in a topographically closed valley. Where the bedrock formations are at least locally permeable, the ground-water system may be hydrologically open. Winograd (1962, p. 110) has referred to this relationship in the vicinity of Yucca Flat in southern Nevada.

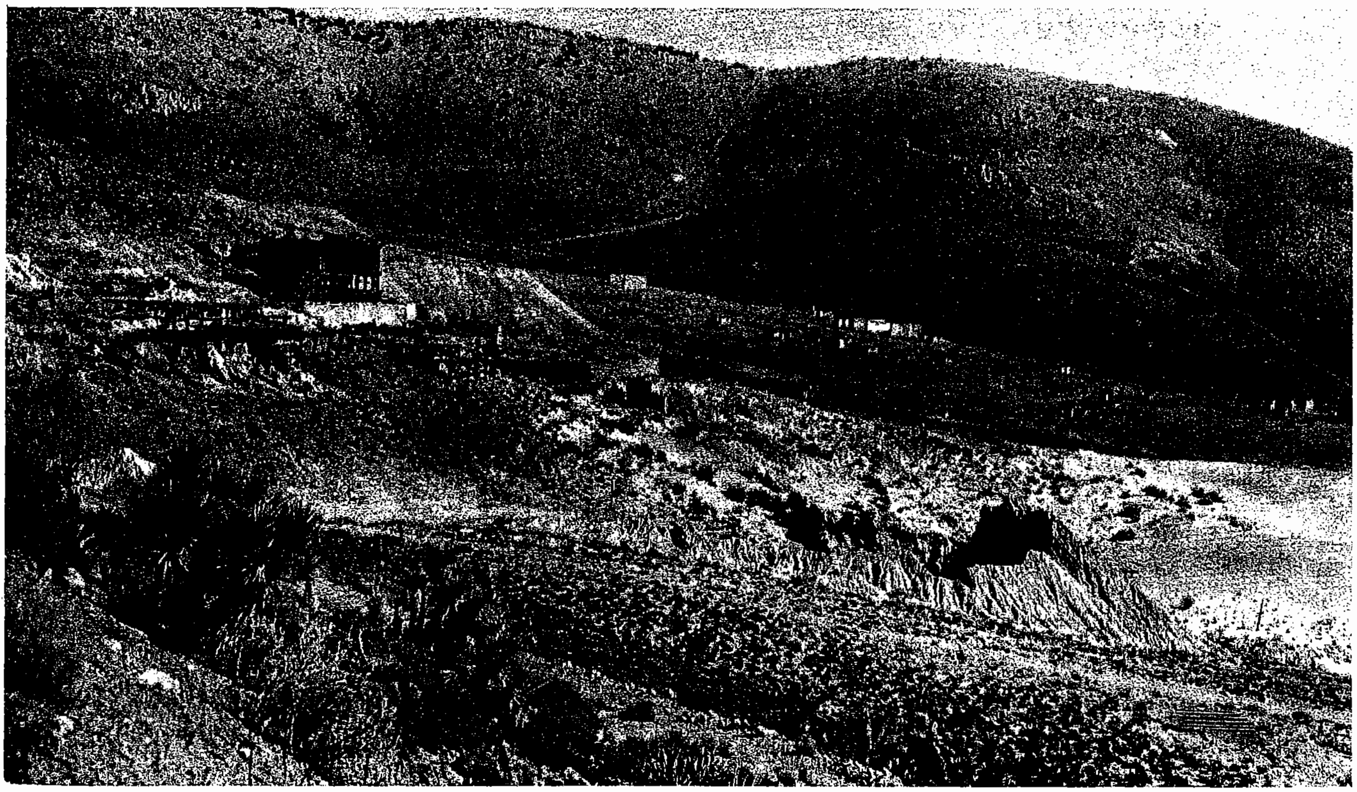
The chemical quality of the ground water is another factor that may be an aid in evaluating the nature of a ground-water system. Ordinarily, the concentration of chemical constituents shows considerable variation in different parts of a ground-water system. Generally, the concentration is least in areas of recharge and tends to be greatest in areas of natural discharge. Despite the normal variations that may be expected in the chemical constitutents in ground water in a given system, the character and concentration of one or more constituents may aid in identifying whether or not a given system is closed.

In summary, closed or open ground-water systems may be identified by the relationship of recharge to discharge within the valley, by potential hydraulic gradients between the reference valley and adjacent valleys, by the water-bearing character of geologic formations, including modifications by structural deformation, and by the chemical quality of the ground water with respect to that in adjacent areas.

In Dry Lake and Delamar Valleys, the principal areas of recharge are centered in the mountains along the northwest, northeast, and east sides of Dry Lake Valley. From the areas of recharge, ground water moves toward the central part of the valley. Along at least some of the stream canyons or washes ground water is not far below land surface, such as at Bristol wells (3N/65-21d3) (See cover photograph ~~and photograph~~ 3) and well 1N/65-2a1 where the depth to water is about 45 feet and 10 feet, respectively. Near the centers of the valleys the depths to water generally are substantial. For example, well 5N/64-14a1 is dry at a depth of about 240 feet, an altitude of roughly 5,385 feet; the depth to water in well 3N/64-20b1 is about 318 feet, altitude of about 4,820 feet; the depth to water in well 2N/64-3b1 is about 664 feet, altitude about 4,350 feet; and the depth to water in well 1N/64-24a1 is about 398 feet, altitude on the order of 4,300 feet.

In Delamar Valley, water for the mines and town of Delamar (photograph 4) was obtained from small springs and wells in the volcanic rocks in a nearby wash according to Callaghan (1937, p. 35). Callaghan further states that this supply was inadequate and that a well was drilled 900 feet deep in the alluvium of Delamar Valley which was dry throughout. The approximate well site is shown

Photograph 3. View east of stone cabin at Bristol Wells. Well 3N/65–21d2 is a short distance to the left of the cabin. The north end of the Bristol Range forms the skyline. Bristol Wells was an early water supply point for stock and travelers, it supported a small smelter operation and at least part of the water requirements of the Bristol Silver mine about 4 miles to the southeast, beyond the right side of the picture.



Photograph 4. View southeast of Delamar. Structure to left is remains of mill. Light colored band extending to right edge of picture is part of tailings. Wind action has heavily sculptured and removed a considerable volume of the tailings. In middle distance stone walls mark the principal area of Delamar townsite. Principal mining was in hill to left of left side of picture, although numerous prospect pits mark hill in background. Most of water supply for Delamar was brought in by pipeline from Meadow Valley Wash, 10 to 12 miles to the east.

/63-12a1 on plate 1. However, the details of drilling are not known. If the iterally did not encounter water throughout the full 900 feet, the water-level de in this area may be below about 3,700 feet, subject of course to the acy of land-surface altitude and the location of the well site.

The great depth to water below the playa areas of Dry Lake and Delamar Valleys precludes evapotranspiration losses from the ground-water reservoir in these valleys, except for extremely small amounts adjacent to scattered springs in the mountains. Inasmuch as the average annual ground-water recharge to Dry Lake and Delamar Valleys is estimated to be several thousand acre-feet per year (p. 34-37), and as no equivalent ground-water discharge by evapotranspiration occurs in the valleys, virtually all the ground water is discharged from the valleys by underflow through bedrock.

That ground water is discharged outside these valleys is further confirmed by the hydraulic gradients between Dry Lake and Delamar Valleys and adjacent valleys. As noted previously the altitude of the ground-water levels in Dry Lake and Delamar Valleys decreases southward along the axial part of the valleys. Available control points do not precisely define the altitude of the ground-water levels in the valleys. However, an apparent gradient is indicated by the water-level altitudes at the several drilling sites; that is, less than about 5,385 feet in sec. 14, T. 5 N., R. 64 E., about 4,820 feet at well 3N/64-20b1, about 4,350 feet at well 2N/64-3a1, and somewhat below about 3,700 feet at well 6S/63-12a1 in Delamar Valley. Thus, the hydraulic gradient is southward at more than 35 feet per mile in the northern part of Dry Lake Valley, and southward at somewhat more than 18 feet per mile from the north-central part of Dry Lake Valley to the central part of Delamar Valley.

Valleys to the east and west of Dry Lake and Delamar Valleys surficially drain to the Colorado River. Along the White River channel in Pahranagat Valley, Hiko Spring issues from about the alluvial-carbonate bedrock contact at an altitude of about 3,890 feet. About 5 miles south of Hiko Spring, Crystal Springs issue from limestone and alluvium at an altitude of about 3,815 feet. About 5 miles farther south in Pahranagat Valley, Ash Springs issue from limestone at the alluvial-bedrock contact at an altitude of about 3,610 feet. About 30 miles farther south in the vicinity of Lower Pahranagat and Maynard Lakes, at the south end of Pahranagat Valley, ground water in the alluvium is near land surface and is at an altitude of about 3,150 feet. Additionally, the depth to water in well 4S/61-15a1, about 6 miles east of Hiko Spring, is about 678 feet or an altitude of about 3,700 feet. Land surface along the White River channel and known water-level altitudes south of Maynard Lake along the White River channel are lower still. Maynard Lake is only about 10 miles southwest of the playa in Delamar Valley. Thus, ground water from Dry Lake and Delamar Valleys could discharge to Pahranagat Valley by underflow to the west, south, or southwest, based in terms of the potential hydraulic gradient.

Along Meadow Valley Wash to the east, land-surface altitude in the wash is above 4,000 feet northward from a point about 10 miles south of Caliente. The depth to water in the wash is generally within a few tens of feet below land surface;

erefore, the water-level altitude in Meadow Valley Wash probably is equal to higher than that in Dry Lake and Delamar Valleys at equivalent latitudes oughout most of their lengths. For most of the same distance, the mountain ea probably provides sufficient recharge to maintain a hydraulic divide tween the two areas. Thus, a major transfer of ground water between the wo areas does not seem likely.

In further considering ground-water discharge by underflow from Dry ake and Delamar Valleys, the Paleozoic carbonate rocks appear to be the most vorable rocks to transmit ground water. The springs in Pahranagat Valley emonstrate that ground water moves through solution openings and fracture ystems in some quantity, at least locally. Ground-water movement through milar Paleozoic rocks in Cave Valley, northwest of Dry Lake Valley, has een described in a previous report (Eakin, 1962). Drilling at the Nevada Test ite, about 75 miles southwest of this area, has shown that the Paleozoic carbon- te rocks transmit ground water more readily than do the Paleozoic clastic rocks nd Tertiary tuff (Winograd, 1962, p. 110). Thus, the Paleozoic carbonate rocks robably afford the best opportunity for ground-water movement between valleys in this area.

Plate 1 shows the surficial distribution of Paleozoic carbonate rocks in Dry Lake and Delamar Valleys. They are exposed most extensively along the east and northwest sides of Dry Lake Valley. Along the west and south sides of Delamar Valley, younger volcanic rocks crop out. However, Paleozoic carbonate rocks undoubtedly underlie the volcanic rocks in this area and, further, are exposed along White River channel in Pahranagat Valley and southward (Tschanz and Pampeyan 1961, and Bowyer, Pampeyan, and Longwell, 1958). Accordingly, the distribution of Paleozoic carbonate rocks in this area in favorable to the movement of ground water southward or southwestward from Dry Lake and Delamar Valleys to Pahranagat Valley.

If the Paleozoic carbonate rocks are capable of transmitting ground water by underflow from Dry Lake and Delamar, the converse may be true; that is, ground water may move into Dry Lake and Delamar Valleys from the north through carbonate rocks from valleys upgradient from Dry Lake and Delamar Valleys. This may be evaluated roughly as follows: In the northern part of Dry Lake Valley the lowest known water-level altitude is about 4,820 feet at well 3N/64-20b1. Higher water-level altitudes occur in White River Valley to the west and northwest; in Cave Valley to the northwest, and in Lake Valley to the north and east. However, the mountains enclosing the northern part of Dry Lake Valley are areas favorable to recharge from precipitation. Because they are areas of recharge, the water levels, in these mountain blocks also must be assumed to be areas of relatively high water levels. Thus, although actual water levels are not available in these areas, it is strongly inferred that ground-water divides occur beneath the mountains and thus provide hydraulic barriers to ground-water movement from adjacent valleys into the northern part of Dry Lake Valley. Similarly, it is inferred that a hydraulic divide exists in the Bristol and Highland Peak Ranges on the east side of Dry

Valley and provides a hydraulic barrier to ground-water movement en Dry Lake Valley and Meadow Valley Wash. The same condition prob- ccurs in the Delamar Range on the east and southeast sides of Delamar y, although this range probably receives less recharge from precipitation o the ranges to the north.

The mountains bordering the west side of Dry Lake and Delamar Valleys ently provide only meager recharge from precipitation. The amount prob- s not sufficient in magnitude or time to maintain a hydraulic barrier een Dry Lake and Delamar Valleys and White River and Pahranagat Valleys.

In summary most, if not all, of the ground-water recharged to Dry Lake Delamar Valleys is believed to be derived from precipitation within their cial drainage areas. Ground water moves from the areas of recharge rd the central part of the valleys, thence generally southward or south- westward. Ground water is discharged from the trough of Dry Lake and Delamar Valleys by underflow through Paleozoic carbonate rocks to areas downgradient from the trough; that is, most probably into Pahranagat Valley, southwest of Delamar.

The depth to water in the central part of the trough of Dry Lake and Delamar Valleys is deep--probably too deep for economic recovery of ground water for the usual uses in this region, except possibly for stock purposes. Depths to water in the lower parts of the valleys decrease from somewhat more than 300 feet in T. 3 N., R. 64 E., to about 400 feet in the south part of T. 1 N., R. 64 E., to possibly more than 1,000 feet beneath the playa area of Delamar Valley. Perched or semiperched ground water in the mountains and upper parts of the alluvial apron locally supply water to small springs and locally is at a sufficiently shallow depth to permit the development of small water supplies by wells, such as at Bristol wells and well 1N/65-2a1.

Estimated Average Annual Recharge:

The average annual recharge to the ground-water reservoir may be estimated as a percentage of the average annual precipitation within the valley (Eakin and others, 1951, p. 79-81). A brief description of the method follows: Zones in which the average precipitation ranges between specified limits are delineated on a map, and a percentage of the precipitation is assigned to each zone which represents the probable average recharge from the average precipitation for that zone. The degree of reliability of the estimate so obtained, of course, depends on the degree to which the values approximate the actual precipitation in the several zones, and the degree to which the assumed percentages represent the actual proportion of recharge to ground water. Neither of these factors is know precisely enough to assume a high degree of reliability of the recharge estimate for any one valley. However, the method has proved useful for reconnaissance estimates and experience suggests that in many areas the estimates probably are relatively close to the actual long-term average annual recharge.

The precipitation map of Nevada (Hardman and Mason, 1949, p. 10) has been adjusted (Hardman, oral communication, 1962) to the improved topographic base maps (scale 1:250,000) now available for the whole State. The base map for plate 1 of this report was prepared from the same series of topographic maps. The several zones of precipitation applicable to Dry Lake and Delamar Valleys are as follows: the boundary between the zones of less than 8 inches and 8 to 12 inches of precipitation was delineated at the 6,000-foot contour; between 8 to 12 inches and 12 to 15 inches, at the 7,000-foot contour; between 12 to 15 inches and 15 to 20 inches, at the 8,000-foot contour; between 15 to 20 inches and more than 20 inches at the 9,000-foot contour.

The average precipitation used for the respective zones, beginning with the zone of 8 to 12 inches of precipitation, is 10 inches (0.83 foot), 13.5 inches (1.12 feet), 17.5 inches (1.46 feet), and 21 inches (1.75 feet).

The percentages of the average precipitation assumed to represent recharge for each zone are: less than 8 inches, 0; 8 to 12 inches, 3 percent; 12 to 15 inches, 7 percent; 15 to 20 inches, 15 percent; and more than 20 inches, 25 percent.

Table 4 summarizes the computation of recharge for Dry Lake and Delamar Valleys. The recharge (column 5) for each zone is obtained by multiplying the figures in columns 2, 3, and 4. Thus, for the zone of 12 to 15 inches of precipitation in Dry Lake Valley the computed recharge is 16,000 (acres) times 1.12 (feet) times .25 (25 percent) = about 1,300 acre-feet. The estimated total average annual recharge to ground water in Dry Lake and Delamar Valleys is about 6,000 acre-feet.

Table 4.--Estimated average annual ground-water recharge from precipitation in Dry Lake and Delamar Valleys, Nev.

	Dry Lake Valley)				Delamar Valley			
(1) Precipitation zone (in inches)	(2) Approximate area of zone (acres)	(3) Average annual precipitation (feet)	(4) Percent recharged	(5) Estimated recharge (acre-feet) (2x3x4)	(2) Approximate area of zone (feet)	(3) Average annual precipitaion (feet)	(4) Percent recharged	(5) Estimated recharge (ac.-ft) (2x3x4)
20+	200	1.75	25	100	0	- -	- -	- -
15-20	3,200	1.46	15	700	0	- -	- -	- -
12-15	16,000	1.12	7	1,300	4,000	1.12	7	300
8-12	114,000	.83	3	2,700	35,000	.83	3	900
8 -	442,000	- -	0	- -	208,000	- -	0	- -
	575,400 about 900 sq. mi.	Estimated average annual recharge (rounded)		5,000	247,000 about 385 sq. mi.	Estimated average annual recharge (rounded)		1,000

Estimated Average Annual Discharge:

Only a very small amount of ground water is discharged from Dry Lake and Delamar Valleys by evaporation and transpiration. Areas where ground water evaporates from soil or from free-water surfaces or is transpired by vegetation are restricted to isolated areas adjacent to the few small springs. The largest of these occurs near the spring at the Meloy Ranch in the southern part of T. 5 N., R. 65 E. Discharge was estimated to be about 20 gpm in March 1963. The few wells in the valley are used largely to provide water for stock, and the total withdrawals are very small. In the past, Bristol wells have been used in part to supply water requirements for mine camps and travelers. Similarly, wells and springs in Cedar Wash were used for water supply at Delamar. However, neither of these supplies were adequate.

Because of the great depth to water, no large areas of evapotranspiration from ground water occur in the lower parts of Dry Lake and Delamar Valley. Most of the ground water apparently is discharged by underflow through bedrock from Dry Lake and Delamar Valleys, but the amount cannot be directly determined. However, to the extent that the estimate of ground-water recharge is correct, and because over a long period of time recharge equals discharge, ground-water discharge by underflow is about 6,000 acre-feet per year minus the small amount, probably less than a few hundred acre-feet discharged by wells and by evapotranspiration adjacent to spring areas.

Perennial Yield:

The perennial yield of a ground-water system is the amount of natural discharge that can be salvaged for beneficial use from the ground-water system. It is the upper limit of the amount of water that can be withdrawn economically from the system for an indefinite period of time without causing a permanent and continuing depletion of ground water in storage and without causing a deterioration of the quality of water. The average recharge from precipitation and streams, discharge by evapotranspiration, discharge to streams, and underflow from a valley are measures of the natural inflow and outflow from the ground-water system.

In an estimate of perennial yield, consideration should be given to the effects that ground-water development of wells may have on the natural circulation in the ground-water system. Development by wells may or may not induce recharge in addition to that received under natural conditions. Part of the water discharged by wells may re-enter the ground-water reservoir by downward percolation, especially if the water is used for irrigation. Ground water discharged from wells theoretically is offset eventually by a reduction of the natural discharge. In practice, however, it is difficult to offset fully the discharge from wells by a decrease in the natural discharge, except when the water table has been lowered to a level that eliminates both underflow and evapotranspiration in the area of natural discharge. The numerous pertinent factors are so complex that, in effect, specific determination of perennial yield of a valley requires a very extensive investigation, based in part on data that can be obtained economically only after there has been substantial development of ground water for several years.

The ground-water system in Dry Lake and Delamar Valleys, as presently understood, is such that economics probably is the controlling factor in the determination of perennial yield. The great depth to water in most of the valley more or less precludes large-scale withdrawals for most uses. Hydrologically, the saturated zone, or reservoir, underlying the floor of the valleys is the most likely area in which to develop substantial water supplies. At the depth of water indicated, the ground-water reservoir probably occurs largely in Tertiary rocks or in underlying Paleozoic carbonate rocks beneath the floor of the valleys.

Whether development occurs in the Tertiary or younger rocks of the valley fill or in the Paleozoic carbonate rocks, withdrawals for a long time would have to come largely from ground water in storage. The amount of stored ground water to be removed is many times the average annual recharge and undoubtedly would require many years of pumping. Pumping from storage would result in a lowering of water levels extending outward from the area of pumping farther and farther until the area of influence eventually would divert virtually all the water from areas of recharge to the area of pumping. After this was accomplished, pumping levels would tend to stabilize, providing that the average annual net withdrawals from pumping were equal to the recharge to the pumped area. The net withdrawals at that time would be equal to perennial yield. Thus, the perennial yield would be limited to the amount of inflow that could be diverted from the areas of recharge to the area of pumping influence.

Whether the magnitude of perennial yield ultimately equals total recharge to the valley depends upon the relative location of the area of pumping with respect to the several areas of recharge to the valley, the relation of the area of pumping with respect to the principal area of ground-water discharge or underflow from the valley, and the altitude of economic pumping levels with respect to altitude of natural discharge or underflow. In Dry Lake and Delamar Valleys, the costs of pumping relatively large quantities of ground water to modify appreciably the natural ground-water regimen to salvage all the natural discharge undoubtedly would be prohibitive for all but the most exceptional water requirements. However, to the extent that such development might occur, the area in and adjacent to Tps. 1 S. and 1 N., R. 64 E., is located favorably with respect to ground-water storage, and sufficient development might result ultimately in salvaging much of the discharge from Dry Lake Valley. However, it is conceivable that to salvage a large part of the estimated 6,000 acre-feet of average annual discharge from the valley, water levels might have to be drawn down as much as 1,500 feet below land surface.

d-Water in Storage:

The amount of ground water stored in the valley fill and underlying bed- in Dry Lake and Delamar Valleys is substantial. It is many times the age annual recharge to and discharge from the ground-water reservoir in these valleys. To the extent that ground water may be developed, the volume of ground water in storage provides a reserve for maintaining an adequate supply for pumping during protracted periods of drought or for temporary periods of high demand under emergency conditions. This reserve, in effect, increases the reliability of ground water as a dependable source of supply and is an important asset in semiarid regions where surface-water supplies vary widely from year to year.

Chemical Quality:

The chemical quality of the water in most ground-water systems in Nevada varies considerably from place to place. In the areas of recharge the chemical concentration of the water normally is very low. However, as the ground water moves through the system to the areas of discharge, it is in contact with rock materials which have different solubilities. The extent to which the water dissolved chemical constituents from the rock materials is governed in large part by the solubility, volume, and distribution of the rock materials, by the time the water is in contact with the rocks, and by the temperature and pressure in the ground-water system.

The following analysis of water from Bristol well was reported by Carpenter (1915, p. 30). Constituents are listed in parts per million.

Silica	(SiO_2)	49	Carbonate	(CO_3)	0.0
Iron	(Fe)	.7	Bicarbonate	(HCO_3)	187
Calcium	(Ca)	76	Sulfate	(SO_4)	71
Magnesium	(Mg)	33	Nitrate	(NO_3)	32
Sodium plus Potassium	(Na + K)	37	Chloride	(Cl)	110

- -

Total hardness as $CaCO_3$	325
Total solids	509

The analysis probably does not represent the typical chemical quality of ground water in Dry Lake Valley. However, it is somewhat suggestive of a mixed-water type found in the region. In some areas, ground water in Paleozoic carbonate rocks will contain a relatively high proportion of calcium magnesium, and bicarbonate due to solution of the carbonate rocks. As that water moves into Tertiary volcanic rocks or deposits derived from such rocks the proportion of sodium will increase partly by base exchange and partly by addition to the dissolved solids in the water until the water becomes a sodium-bicarbonate type. The relatively high chloride and nitrate in the analysis suggests local contamination, a condition that might well be expected from the local concentration of people and stock of the watering point when Bristol wells supplied water to the nearby mines and was the site of a small settlement and a smelter.

If it can be assumed that the analysis may be more or less representative of ground water in the lower part of Dry Lake Valley, with the exception of the high concentration of chloride and nitrate, the water would be suitable for domestic and stock purposes.

Development:

Small amounts of ground water from springs and wells are used to water livestock feeding on the range in Dry Lake Valley. Carpenter (1915, p. 66) reported that Bristol well (3N/65-21d1) formerly furnished the water supply for a smelter. He reported too, that several wells were dug in the vicinity and a small town sprung up around them. However, when Carpenter visited the area in 1912, only one well remained. This well had been in use to supply water to the traveling public and for miners at the Bristol mine a few miles east. The well could be pumped dry at that time during the filling of water tanks used to supply water at the mine. In October 1912 the well was 51 feet deep and water level was 43 feet below land surface. Seemingly the well has since been destroyed. There are three drilled wells in that area that are used to water stock. Reportedly, however, all three do not provide a sufficient supply to meet the needs.

Near Delamar, Carpenter (1915, p. 67) noted that water was piped from several springs, reported to be small seepages in the limestone and granite. Callaghan (1937, p. 35) also refers to the water supply of Delamar but refers to the earlier used springs and wells in a nearby wash as being developed in volcanic rocks. Carpenter also reported that well 6S/63-12a1, drilled 900 feet deep at the foot of the alluvial slope below Delamar, was dry. He further states that when the mine at Delamar was active, water supply was obtained from Meadow Valley Wash, which was pumped over the Meadow Valley Range (Delamar Range) through two 3 1/2-inch pipe lines.

Presently, ground water from wells and springs probably supplies less than 100 acre-feet per year and is used principally for watering stock in Dry Lake and Delamar Valleys. Development of ground water for irrigation probably would be prohibitive because of high pumping costs. Limited amounts of ground water could be developed, if the need were great enough.

The very substantial depths to water in the central parts of Dry Lake and Delamar Valleys, which makes the cost of development of ground water too high for usual purposes, may make the area attractive for some types of special testing or operation required in modern day technology. In turn, ground water probably could be developed to meet limited water requirements of such activities.

DESIGNATION OF WELLS

In this report the number assigned to a well is both an identification number and a location number. It is referenced to the Mount Diablo base line and meridian established by the General Land Office.

A typical number consists of three units. The first unit designates the township; "N" after the number identifies the township as north of the Mount Diablo base line; "S" after the number identifies the township as south of the Mount Diablo base line. The second unit, a number separated by a slant line from the first, is the range east of the Mount Diablo meridian. The third unit, separated from the second by a dash, is the number of the section in the township. The section number is followed by a lower case letter, which designates the quarter section, and finally, a number designating the order in which the well was recorded in the quarter section. The letters a, b, c, and d, designate, respectively, the northeast, northwest, southwest, and southeast quarters of the section.

Thus, well number 3N/64-20b1 indicates that this well was the first well recorded in the northwest quarter of sec. 20, T. 3 N., R. 64 E.

Wells on plate 1 are identified only by the section number, quarter section letter, and serial number. The township in which the well is located can be ascertained by the township and range numbers shown on the margin of plate 1. For example, well 3N/64-20b1 is shown on plate 1 as 20b1 and is within the rectangle designated as T. 3 N., R. 64 E.

Table 5.--Records of selected wells in Dry Lake and Delamar Valleys, Lincoln County, Nev.

1N/64-24a1. Owners R. Lytle, S. A. Hollinger, and A. Delmue. Drilled stock well; depth 515 feet, casing diameter 5 inches. Reported depth to water below land surface 398 feet, January 17, 1959. This well caved between 428 feet and 515 feet. Driller's log:

Material	Thickness (feet)	Depth (feet)
Clay	3	3
Gravel, sandy	12	15
Clay	45	60
Sand and gravel, stratified	29-	350
Sand, fine	70	420
Lime, cemented	8	428
Clay	87	515
Total depth		515

1N/65-2a1. Owner not determined. Dug well; depth 12 feet, diameter 48 inches. Reported depth to water 10 feet.

2N/64-3b1. Coyote well. Owner, Bureau of Land Management. Drilled stock well; depth 742 feet; diameter, 6 inches; casing perforated 702 to 742 feet with torch-cut 1/4- x 8-inch slots, 6 to the round. Equipped with pump jack and gasoline pump. Reported depth to water, 664 feet, March, 1963.

2N/65-6b1. Owner not determined. Abandoned drilled well; depth 376 feet. Dry.

3N/64-20b1. Owner Bureau of Land Management. Unused, drilled stock well; depth 380 feet, casing diameter 6 inches. Depth to water below land surface 304 feet, when drilled; measured depth to water 316.54 feet, Mar. 11, 196

3N/65-21d1. Bristol well. Destroyed dug stock and domestic well. Reported depth, 51 feet. Reported depth to water 43 feet.

3N/65-21d2. Bristol well. Drilled stock well; casing diameter, 8 inches. Equipped with pump jack. Reported depth to water about 45 feet.

3N/65-21d3. Bristol well. Drilled stock well; casing diameter, 6 inches. Equipped with windmill and cylinder pump. Reported depth to water, 45 feet.

3N/65-21d4. Bristol well. Drilled stock well; casing diameter, 5 inches. Equipped with pump jack and engine. Reported depth to water, 45 feet.

5N/64-14a1. Owner not determined. Drilled well; depth 239.5 feet. Dry.

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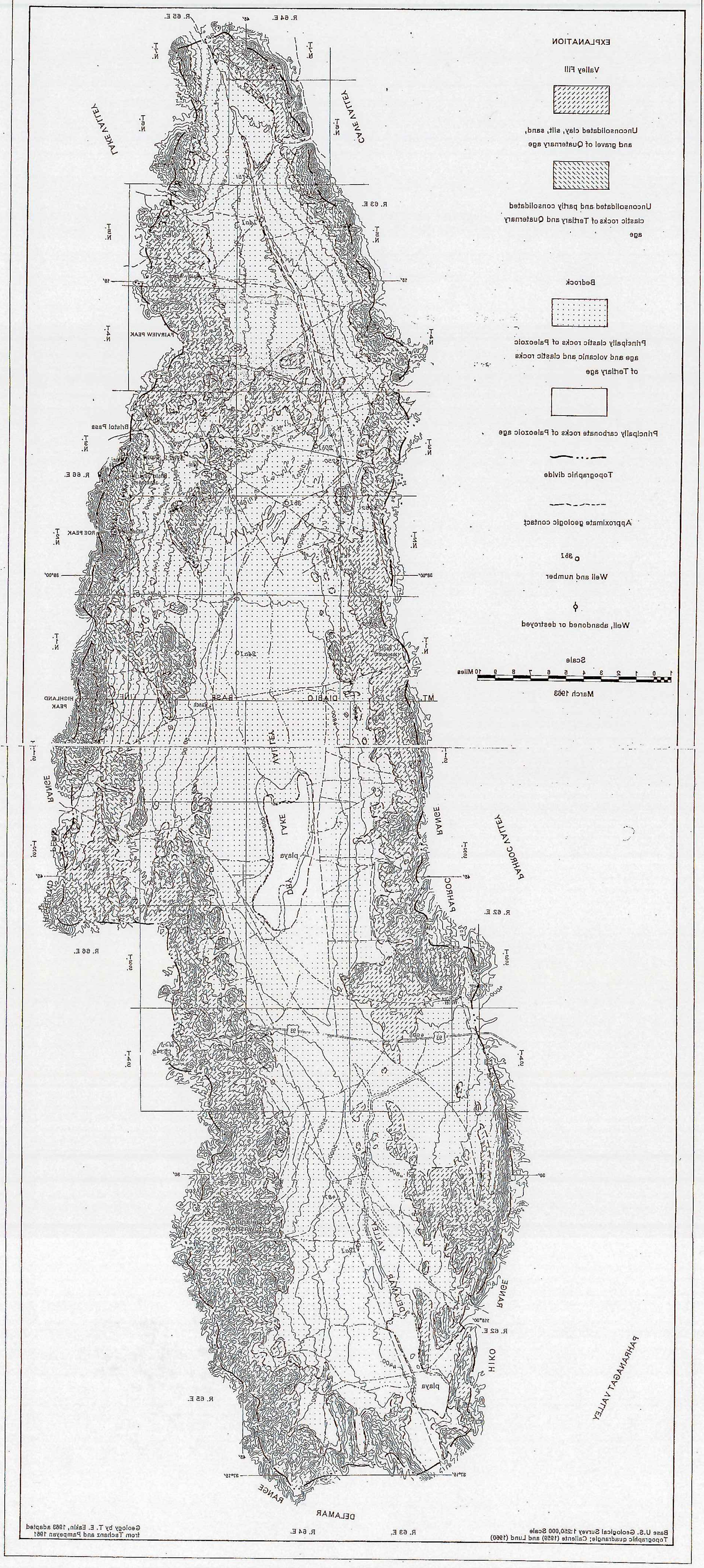
UNITED STATES DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES



Base U.S. Geological Survey 1:250,000 Scale
Topographic quadrangle; Caliente (1959) and Lund (1960)

Geology by T. E. Eakin, 1963 adapted from Tschanz and Pampeyan 1961

PLATE 1.—MAP OF THE DRY LAKE AND DELAMAR VALLEYS; LINCOLN COUNTY, NEVADA
SHOWING AREAS OF BEDROCK, VALLEY FILL, AND LOCATION OF WELLS