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DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
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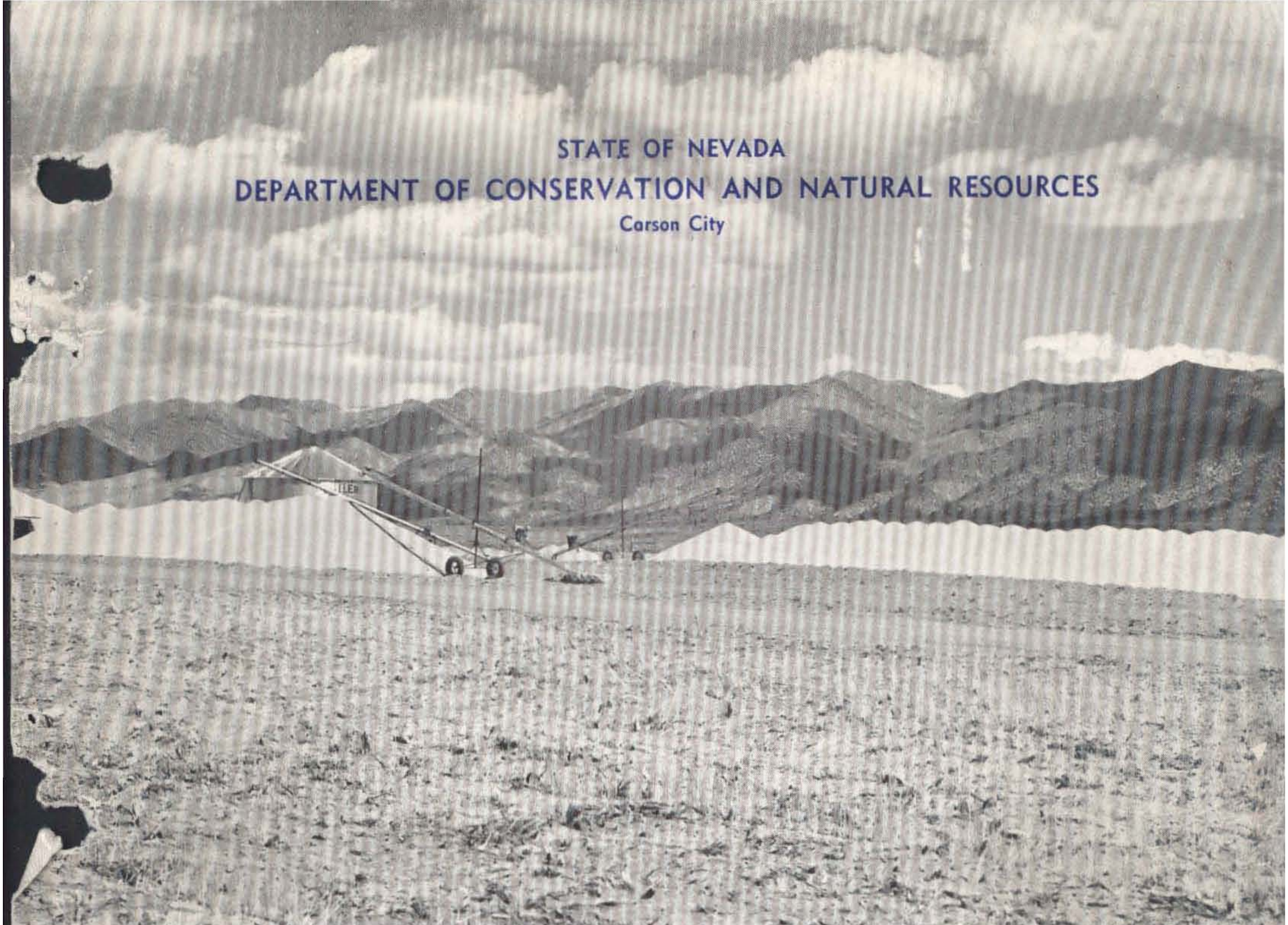

Diamond Valley—View of stored grain and Diamond Mountains

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 6

GROUND–WATER APPRAISAL OF DIAMOND VALLEY, EUREKA AND ELKO COUNTIES, NEVADA

By
THOMAS E. EAKIN
Geologist

Price $1.00

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

FEBRUARY 1962

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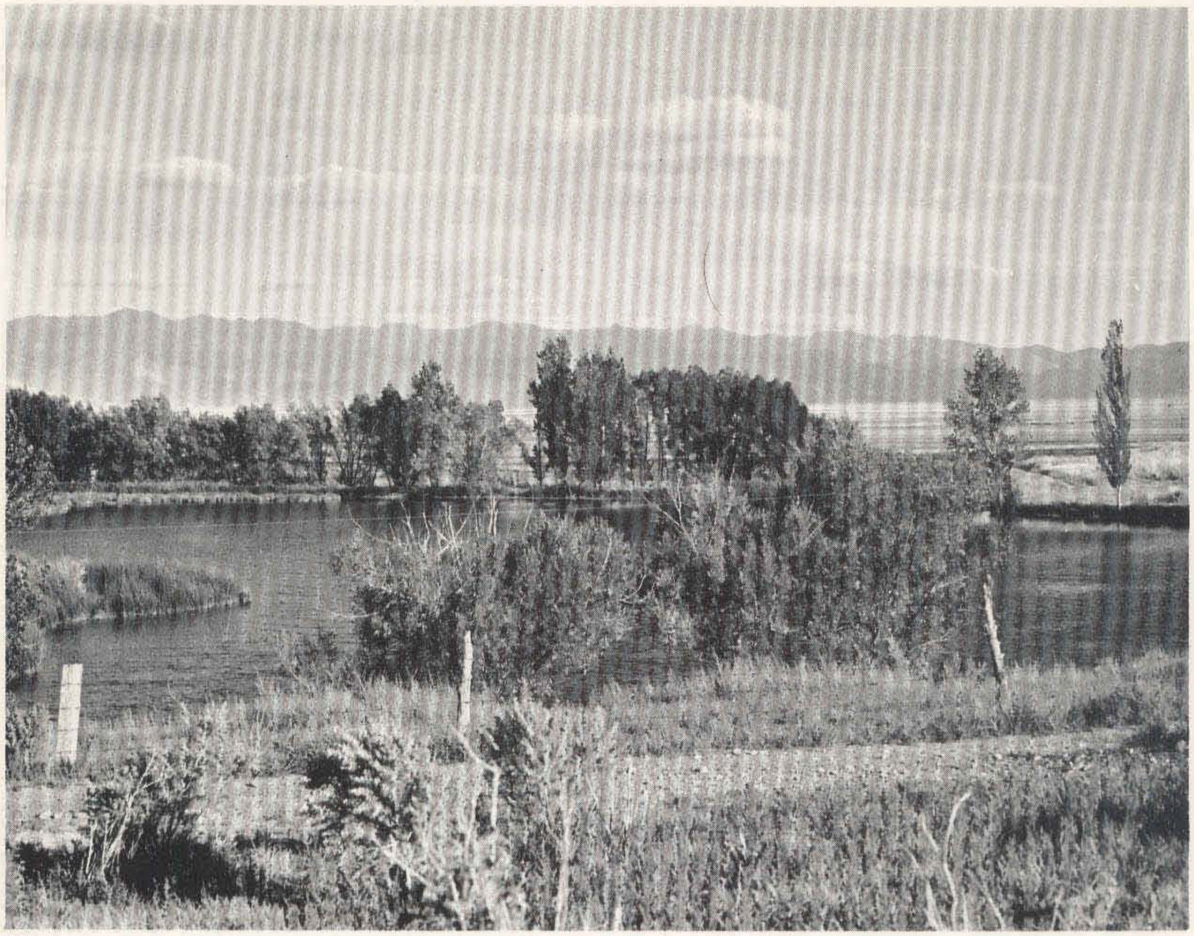

SHIPLEY HOT SPRINGS

View east of Shipley Hot Springs pool in T. 24 N., R. 52 E. Discharge is reported to be about 15 cfs. Water is used largely for irrigated meadows. Diamond Mountains are in the background.

COVER PHOTOGRAPH

View northeast from sec. 1, T. 21 N., R. 53 E. showing part of stored grain produced in 1961 in Diamond Valley. Central part of Diamond Mountains, in the latitude of the Maggini ranch, in the background.

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U. S. Department of the Interior

February

1962

FOREWORD

This is the sixth in the series of ground-water reconnaissance reports which were initiated by the 1960 legislature. The potential of the state's ground water basins is well set forth in this report as indicated by the recent ground water development in Diamond Valley. The report indicates that considerable development can continue without over-pumping.

It is the hope of this Department that the legislature will continue support of this reconnaissance program so that in time we will have information as to the ground water resources of all of the valleys in Nevada.

As the use of ground water increases in the various valleys, more detailed ground water studies will be carried on under the general cooperative program with the U. S. Geological Survey.

This report, as well as the others in this series, have been printed in this office under the direction of Mrs. Alta Thiex, Administrative Assistant.

Hugh A. Shamberger, Director
Department of Conservation and
Natural Resources

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GROUND-WATER APPRAISAL OF DIAMOND VALLEY

EUREKA AND ELKO COUNTIES, NEVADA

by

Thomas E. Eakin

SUMMARY

The results of this reconnaissance indicate that the average annual ground-water discharge by natural processes is on the order of 23, 000 acre-feet. This estimate is believed to be reasonable and compatible with information developed for other valleys of Nevada where more extensive studies have been made. The estimate of natural discharge provides an initial guide for the amount of ground water that may be withdrawn annually on the basis of permanent development. The estimate can be re-evaluated at such time as a great many more data can be obtained and economic or other conditions warrant.

The estimate of average annual ground-water recharge, based on precipitation and altitude zones, is about 70 percent of the estimate of discharge. It has been found that the estimates of recharge may vary widely from the estimates of discharge for a specific valley although the estimates in general are in reasonable agreement. To the extent that the estimate of recharge for Diamond Valley is correct, the estimate of perennial yield, based on the estimate of discharge, is optimistic. However, available information suggests that the estimate of discharge probably is more reliable and therefore it is given the principal weight in this reconnaissance.

The amount of ground water in storage has been estimated to be on the order of 15, 000 acre-feet per foot of saturated thickness in the valley fill within a 100, 000-acre area south of the playa. On the same basis, the upper 100 feet of saturated valley fill would contain about 1, 500, 000 acre-feet in storage. This latter amount, which is equivalent to 65 times the estimated average annual discharge, is indicative of the very large amount of ground water in reserve for maintaining pumping withdrawals during protracted periods of drought.

The few chemical analyses of ground water that are available suggest that the ground water in the newly developed area generally is of a calcium-bicarbonate type and suitable for irrigation. However, additional analyses are needed to identify local differences in quality. This information probably is needed even more in Diamond Valley than in some other areas because a wide variety of crops are being used to test the capabilities of the valley.

The development of new lands by means of pumped irrigation wells began in 1949 in Diamond Valley. A small acreage was irrigated for several years. In

1958 a few additional wells were drilled, but substantial development began in 1960. By September 1961 about 85 irrigation wells had been drilled. Many of these wells were not in operation during the 1961 irrigation season, but may represent the approximate number of wells that will be operating during the 1962 irrigation season.

The water has been used to irrigate principally small grains with smaller acreages of potatoes and alfalfa. The principal area of development is in T. 21 N., R. 53 E. and T. 22 N., R. 54 E. To date, most wells have developed water from sand and gravel in the upper 200 feet of the valley fill. Yields for individual wells of 1,000 to 2,500 gpm commonly have been reported.

It is estimated very roughly, that about 5,000 acre feet of water was pumped during the 1961 irrigation season, and several times that amount may be pumped next year.

Information suggests that the pumpage has resulted in some decline of water levels in the newly developed areas, and this should be expected. However, available data are not sufficient to determine the area and extent of the decline with any degree of precision.

INTRODUCTION

The present development of ground water for irrigation in Diamond Valley is an example of the general effort in Nevada to develop additional water supplies for irrigation. Throughout the State additional development is needed not only for irrigation, but also for public supply and other uses.

The increasing interest in ground-water development has resulted in a substantial demand for information on ground-water resources throughout the State. Recognizing this need, the State Legislature enacted special legislation (Chap. 181, Stats. 1960) for beginning a series of reconnaissance studies of the ground-water resources of Nevada. The authorization and funding was continued in the 1961-62 biennium. 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.

The emphasis of these reconnaissance studies is to provide as quickly as possible a general appraisal of the ground-water resources in valleys or areas where published information is not available. For this reason each reconnaissance is limited severely in time, field work for each area generally averaging about two weeks.

Additionally, the Department of Conservation and Natural Resources has established a special report series to expedite the publication of the results of these reconnaissance studies. Figure 1 shows the areas for which reports have been published in this series. A list of the previous reports is given at the end of this report. The present report is the 6th in the reconnaissance series. It describes the physical conditions of Diamond Valley and includes observations of the interrelationship of climate, geology, and hydrology as they affect ground-water resources. It includes also a preliminary estimate of the average annual natural recharge to and discharge from the ground-water reservoir.

The investigation was made under the administrative supervision of Omar J. Loeltz, district engineer in charge of ground-water studies in Nevada. The writer wishes to acknowledge his appreciation to personnel of the district office for constructive discussions and review, relative to this report, all of which have been most helpful.

H. G. Winchester, of Nevada Division of Water Resources, accompanied and assisted the writer in the field for several days. Roger Lyman of the district office also assisted in the collection of field data on wells. The field assistance of Messrs. Winchester and Lyman materially expedited the field phase of this reconnaissance.

Special thanks are due to W. T. Stuart and D. G. Metzger of the Geological Survey for permission to draw upon the draft of their report dealing with mining hydrology in the vicinity of the Fad shaft near Eureka.

The well drillers, equipment suppliers, farmers, and ranchers in Diamond Valley were most helpful in supplying information which was valuable in this study.

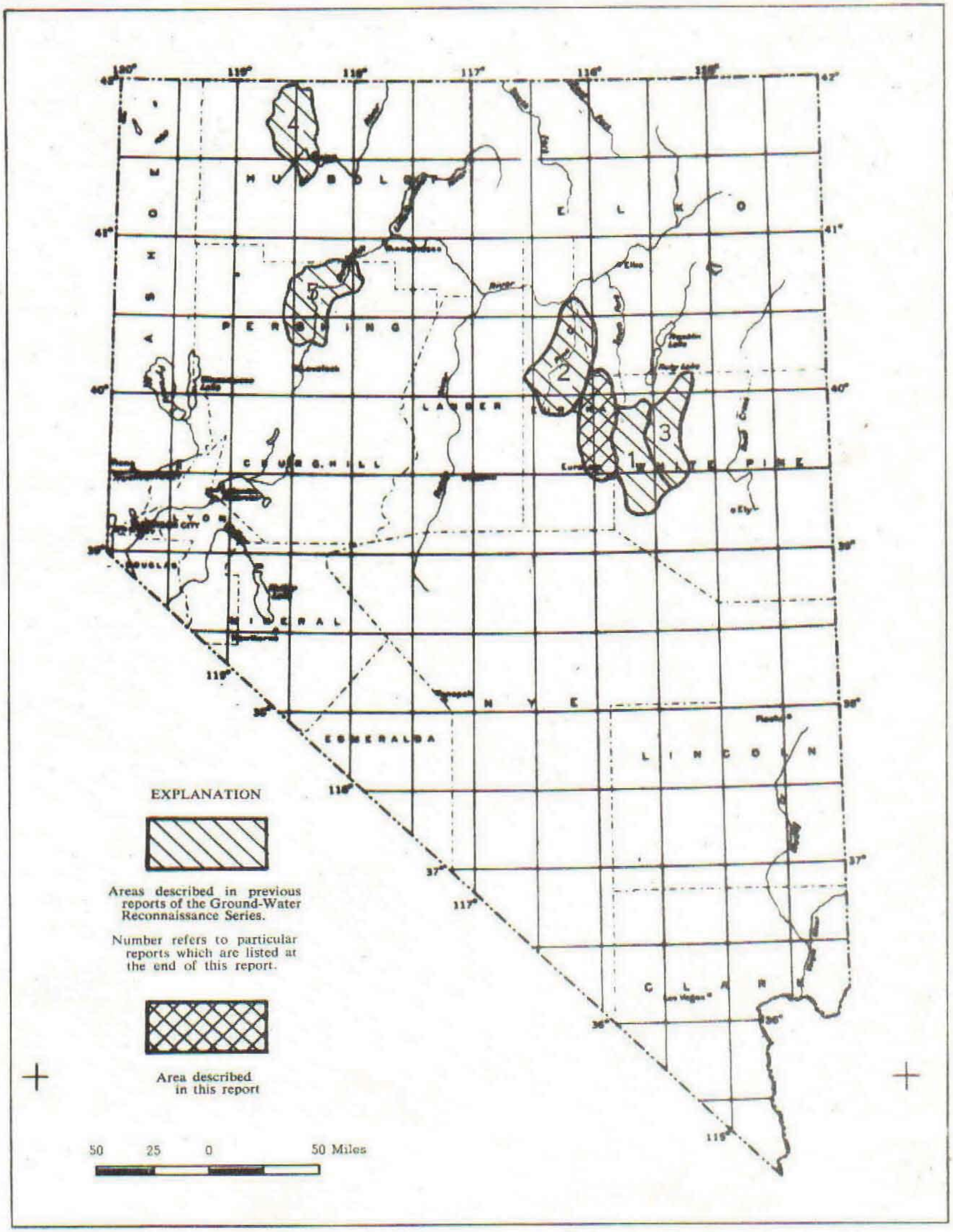

Figure 1.—Map of Nevada showing areas described in previous reports of the Ground-Water Reconnaissance Series and in this report.

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Location and General Features

Diamond Valley, in east-central Nevada, lies within an area enclosed by lat 39°27' and 40°15' N., and long 115°47' and 116°12' W. It is principally in Eureka County but its northern end extends about 8 miles into southwestern Elko County.

The valley extends northward ab out 56 miles from the latitude of Pinto Summit on U.S. Highway 50. Its maximum width is about 20 miles in the latitude of township 22 north. Its average width is somewhat more than 12 miles. The total area within the drainage divide is about 700 square miles.

The lowest part of the valley is at an altitude of about 5, 770 feet in the playa at the north end of the valley. South Diamond Peak in the Diamond Mountains, with an altitude of 10, 614 feet, is the highest point.

Principal access to the valley is by transcontinental U.S. Highway 50 which goes through Eureka and the southern part of the valley. State Highway 20 which joins U.S. Highway 50 about 3 miles northwest of Eureka, traverses part of the west side of the valley and connects with U.S. Highway 40 at Carlin 89 miles and Elko 112 miles to the north. State Highway 46, a graded and gravel road, traverses the east side of the valley connects with U.S. Highway at Elko by way of Huntington Valley. Between Eureka and Thompson Ranch in Diamond Valley, State Highway 46 is being rerouted in the area of development. Additional roads or trails are being constructed to provide access to the newly developed land in the south-central part of the valley. Gravel or graded roads and trails permit access to other parts of the valley during good weather. The Eureka-Nevada railroad, completed in 1875 but now abandoned, connected Eureka with the transcontinental railroads at Palisade on the Humboldt River. The roadbed follows an alinement roughly parallel to State Highway 20.

Economic Development

Mining was the principal economic factor in the area. Mines near Eureka have produced silver, lead, gold, copper and zinc which, according to Couch and Carpenter (1943, p. 60), represented a gross yield of more than 52 million dollars (1, 837, 615 tons) during the period 1866 to 1940. Some additional mining in the past has been carried out at the Mount Hope mine on the west side of the valley and in the Diamond district at the north end of the Diamond Mountains.

During the past 20 years, efforts to develop a substantial new ore body by the Fad shaft resulted in a mine dewatering problem that as yet has not been solved economically.

The Fad shaft was sunk to a depth of somewhat more than 2, 250 feet (altitude, 4, 655) in the late 1940's. According to Stuart and Metzger (written communication, 1961), the maximum pumping rate during the sinking of the shaft was less than 2, 000 gpm (gallons per minute). However, after a drift was started toward the ore body, a sudden increase in flow was developed that was greater than the pumping capacity and the pumping station was drowned.

Additional pumps were installed and renewed efforts to dewater the shaft area began in the spring of 1948. Over a period of several months the pumping rate was increased to 8,000 gpm and the water level was lowered to within 170 feet of the 2,250-foot level. Further increase of the pumping rate to 9,000 gpm resulted in removing fine material from the fissure conduits and provided better, freer hydraulic connection with the shaft. After this, a pumping rate of 9,000 gpm only maintained a water level 400 feet above the 2,250-foot level. During the 8 or 9 months period of pumping about 6,000 acre-feet of ground water was pumped from the Fad shaft.

In December 1952 W. T. Stuart and D. W. Metzger of the U.S. Geological Survey conducted a pumping test of the Fad shaft and a general study of the region to evaluate the magnitude of the dewatering problem.

In 1954 the T. L. shaft, about one mile northwest of the Fad shaft, was sunk to a depth of 1,037 feet. Although water was encountered in considerable amounts, it was possible to handle it. In 1958, mining through the T. L. shaft was terminated for economic reasons. Stuart (Stuart and Metzger, written communication, 1961) indicates that apparently 8,500 acre-feet of water was pumped from the T. L. shaft during the period August 1954 to March 1958.

The interest in possible oil development during the last 15 years in central and eastern Nevada resulted in the drilling of a number of exploratory wells to determine subsurface conditions. In 1956 the Shell Oil Company drilled an exploratory well to a depth of 8,042 feet (Campbell and Hebrew, 1957 p. 1125), in sec. 30, T. 23 N., R. 54 E. Reportedly this well penetrated 7,485 feet of valley fill (including undifferentiated Tertiary strata) before entering Paleozoic rocks.

Raising livestock has provided a continuing base for the economy of the valley for many years. Cattle have been fed principally on the range, supplemented by native hay from meadows and pastures. Meadows have been supplied mainly with water from spring discharge, the water being "developed" to the extent that ditches are used to distribute the water in the meadow area.

In the 1940's, additional water was developed by the construction of flowing wells on the Romano ranch for irrigation. In 1949 several flowing wells were drilled on the Flynn ranch and the water was used for irrigation. In 1949 also, two wells were drilled in T. 22 N., R. 54 E. in an effort to develop land under the Desert Entry act.

Renewed effort to develop public land for irrigation began in 1958. From 1948 to September 1961, about 85 wells have been drilled for irrigation of newly developed land. It may be too early to say that this development will be a permanent success, but certainly the effort and expenditure of funds being applied to the development of these lands suggest that the development will be a real test of the possibility of developing new land for irrigation in this part of Nevada. One might say that the effort warrants full available assistance from the agencies interested in the further development of Nevada.

Climate

The climate of east-central Nevada generally is semiarid in the valleys, but in the higher mountains may be subhumid. In the valleys, precipitation and humidity are generally low and summer temperatures, wind movement, and evaporation rates are high. Precipitation is very irregular but generally is least on the floors of the valley and greatest in the higher mountains. Winter precipitation occurs as snow and is moderately well distributed over several months. Summer precipitation commonly is localized as thundershowers. The range in temperature is large, both daily and seasonally. The growing season is relatively short.

Precipitation has been recorded at Eureka since 1888, but the record has been broken during the periods 1894-1901, 1919-21, and 1943-52 and only partial records were obtained during 1888, 1890, 1892, 1893, and 1960. The average monthly and annual precipitation for the period of record at Eureka, according to records of the Weather Bureau, is given in table 1. Additionally, the average monthly and annual precipitation are listed for Austin about 70 miles west of Eureka; Fish Creek Ranch, 15 miles south of Eureka, and Jiggs, 70 miles northeast of Eureka. The records show that precipitation varies considerably from month to month and year to year. The maximum and minimum recorded monthly and annual precipitation at Eureka is shown in table 2. Regional precipitation was below average during the period 1951-60. Table 3 lists recorded annual precipitation for Austin, Eureka, Fish Creek Ranch and Jiggs during the period 1951-60. As shown in the table, annual precipitation was above the long-time average in only 3 of 10 years at Austin, 1 of 7 at Eureka, 3 of 10 at Fish Creek Ranch, and 1 of 10 at Jiggs.

Table 1.--Average monthly and annual precipitation in inches, at four stations in the region of Diamond Valley (from published records of the U.S. Weather Bureau)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Austin 1/	1.17	1.18	1.46	1.60	1.45	0.73	0.54	0.53	0.50	0.84	0.79	1.10	11.89
Eureka 2/	1.11	1.08	1.49	1.33	1.49	.86	.73	.66	.66	.89	.66	.82	11.78
Fish Creek Ranch 3/	.47	.25	.56	.56	.58	.39	.47	.43	.56	.40	.63	.55	5.85
Jiggs 4/	1.17	1.05	1.23	1.50	1.44	.83	.54	.49	.61	1.08	.93	1.23	12.10

1/ Altitude, 6,543 feet. Location, sec. 19, T. 19 N., R. 44 E. Period of record: 1877-79, 1890-98, 1900-1908, 1911-60 (continuing). Partial record in 1880, 1888, and 1889.

2/ Altitude, 6,550 feet. Location sec. 13, T. 19 N., R. 53 E. Period of record: 1889, 1891, 1902-18, 1922-30, 1939-42, 1953-60 (continuing). Partial record in 1888, 1890, 1892-94, 1919-21.

3/ Altitude, 6,050 feet. Location, sec. 10, T. 16 N., R. 53 E. Period of record: 1943-60 (continuing).

4/ Altitude, 5,450 feet. Location, sec. 4, T. 29 N., R. 56 E. Period of record: 1910-42, 1946-60 (continuing). Partial record 1943, 1945. Station first known as Skelton, name changed to Hylton in 1913 and to Jiggs in 1945. Location changed: 1 mile south prior to August 1952, and 3 miles south-southeast prior to May 1945, from present location.

Table 2. --Maximum and minimum monthly and annual precipitation, in inches, at Eureka for period of record (1888-1960 discontinuous). (from published records of the U. S. Weather Bureau).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Maximum	1.51	1.22	1.67	3.04	2.16	2.31	1.75	2.66	0.92	2.50	1.81	2.31	23.86
Minimum	.70	.18	.84	.22	.32	.96	.81	.34	.00	.55	.42	.79	6.13

Table 3. -- Annual precipitation, in inches, for four climatological stations in the region of Diamond Valley, 1951-60 (from published records of the U.S. Weather Bureau)

Year	Austin	Eureka	Fish Creek Ranch	Jiggs
1951	11.38	--	5.66	10.36
1952	10.34	--	5.76	10.12
1953	6.73	7.36	2.17	8.11
1954	9.92	9.09	4.66	6.74
1955	e 12.12	e 10.48	e 7.68	13.59
1956	12.30	6.33	2.77	10.62
1957	12.70	e 14.54	e 9.77	11.27
1958	e 8.98	6.83	e 5.66	7.60
1959	e 5.90	7.67	e 5.49	8.78
1960	8.49	--	e 6.08	9.24

e/ estimated by Weather Bureau.

Generally, precipitation in Diamond Valley averages 8 inches or less on the valley floor. The average precipitation is greater on the mountains which drain to the valley floor. In the most favorable higher parts of the Diamond Mountains the maximum average annual precipitation may exceed 20 inches.

The climatic summary of records of temperature at Eureka, prior to 1931, show an average annual temperature of 47.4°F. A current average is not given because of incomplete records since 1931. However, it seems likely that the earlier average of about 47°F probably approximate the long-time average. The extremes of temperature for the period of record are 110° and -26°F.

The records of temperature at Fish Creek Ranch show an average annual temperature of 42.2°F for the 16 years ending 1960. The extremes of temperature for the period of record are 98° and -34°F.

Comparison of the two records suggest that temperatures at the Fish Creek Ranch generally are somewhat lower than at Eureka. This may be due to the differences in topographic location of the two stations. Eureka is in a canyon on the flanks of the mountains. Fish Creek Ranch is on the floor of Fish Creek Valley. If this relationship is significant, the area of irrigation in Diamond Valley, which also is on the valley floor, may have a shorter growing season than that at Eureka.

Recent Weather Bureau records list freeze dates rather than killing frost dates. The dates are listed for the last spring minimum and the first fall minimum for temperatures of: 32°F or below, 28°F or below, 24°F or below, 20°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 are given for each temperature group. Table 4 lists the number of days between the last spring minimum and the first fall minimum of the three principal temperature groups for Eureka and Fish Creek Ranch as available during the period 1951-60. For the 7-year period of correlative record 1953-59, the average at Fish Creek Ranch is consistently shorter than at Eureka for each temperature group. The apparent relative shortness of the growing season in Diamond Valley suggests that this will be one of the important factors in the long-time success of irrigation in the valley. Because of the importance of length of growing season, it would seem prudent to establish stations for obtaining precipitation and temperature data in the principal area of irrigation as a future aid in estimating the length of growing season.

Table 4.--Freeze data for Eureka and Fish Creek Ranch stations 1951-60

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

	Number of days between temperatures of:					
	32°F or below		28°F or below		24°F or below	
Year	Eureka	Fish Creek Ranch	Eureka	Fish Creek Ranch	Eureka	Fish Creek Ranch
1951	--	9	--	81	--	94
1952	--	44	--	87	--	142
1953	111	3	128	69	129	89
1954	96	48	115	70	150	98
1955	108	7	117	82	143	88
1956	109	11	109	58	133	135
1957	95	28	96	35	96	121
1958	93	2	134	98	140	139
1959	27	8	112	79	131	121
1960	--	87	--	87	--	141
10-year average		25		75		117
Average for 1953-59	91	15	116	70	117	113

Physiography and Drainage

Diamond Valley is an intermontane valley in the central part of the Great Basin section of the Basin and Range Province of Fenneman (1931, p. 328). It is roughly elliptical, elongate in a northerly direction.

Its southern end terminates in the Fish Creek Range, several miles south of Eureka. The Diamond Mountains form the east boundary of the valley and connect with the Fish Creek Range on the south. The Sulphur Springs Range, Whistler Mountain, and Mahogany Boy Range form the west boundary of the valley. The valley is closed at the north end by the Diamond Hills which connect the Diamond Mountains with the Sulphur Springs Range in the vicinity of Baily Mountain.

Diamond Peak, T. 20 N., R. 55 E., is the highest point in the area with an altitude of 10,614 feet. Most of the crest altitudes of the Diamond Mountains are 9,000 feet or higher. Prospect Peak, south of Eureka, is 9,571 feet above sea level. Most of the crest altitudes of the Sulphur Springs Range are between 7,000 and 7,500 feet.

Devil's Gate Gap, between Whistler Mountain and Mahogany Boy Range, is a topographic low which permits drainage, both surface and subsurface, into Diamond Valley from Antelope, Kobeh, and Monitor Valleys.

Railroad Pass in the northeast part of the valley was an outlet for drainage from Diamond Valley into Huntington Valley in Pleistocene time. The altitude of the divide in Railroad Pass is now about 125 feet above the playa in the valley.

The large playa or alkali flat at an altitude of about 5,770 feet, which occupies the floor of the valley north of the latitude of the Romano and Thompson Ranches, is the lowest part of the valley, the floor of the valley rises southward. Near the airport, about 20 miles south of the edge of the playa, the altitude is 5,945 feet. Thus, the average gradient is about 9 feet per mile. The south part of the floor of the valley has been somewhat modified by stream channels and Pleistocene lake features.

Beaches and slopes are prominent locally in the vicinity of Railroad Pass, northwest of the Romano Ranch, and elsewhere. Shoreline features are best developed at altitudes between 5,860 and 6,040 feet. These features were developed in late Pleistocene time.

Physiographically, the valley may be divided into three parts: the mountain, the alluvial apron, and the valley floor.

The mountains are areas of erosion and are characterized by steep slopes. (See photographs 1 and 2.) Canyons commonly are deeply incised, especially in the Diamond Mountains. The streams draining the mountains not only carried off excess water from the heavy precipitation but also transported weathered rock and soils. As they discharged from the canyons, they dumped much of their load thereby forming alluvial fans. As the alluvial fans expanded, they merged with adjacent fans to form the alluvial apron. (See photograph 3)

The alluvial apron was formed principally during Pleistocene time when runoff from the mountains was much greater than in Recent time. The surface slopes of the alluvial apron commonly have gradients of 200 to 500 feet per mile. In Recent time the reduced runoff from the mountains has resulted in less sediment being transported from the mountains. This, in turn, has resulted in some dissection of parts of the alluvial apron below the mouths of canyons.

The valley floor occupies the central part of Diamond Valley. It includes the playa and the lowland area to the south that generally lies below an altitude of 6,000 feet. The playa is a nearly flat surface covering an area of almost 50,000 acres. The lowland area south of the playa has a northward gradient generally less than 10 feet per mile. Where the valley floor merges with the alluvial apron gradients increase gradually but ordinarily do not exceed 100 feet per mile.

The valley lowland south of the playa has been modified by streams flowing from the mountains in the southeast and south part of the valley, by Slough Creek which drains a large area to the west and southwest of Diamond Valley, and by earlier formed beaches, bars and spits developed by currents in late Pleistocene lakes of Diamond Valley. These modifications have produced bluffs and channels which have a local relief of 10 to 25 feet. Some of the channels contain well-developed oxbows which commonly are features associated with perennial streams having relatively low gradients.

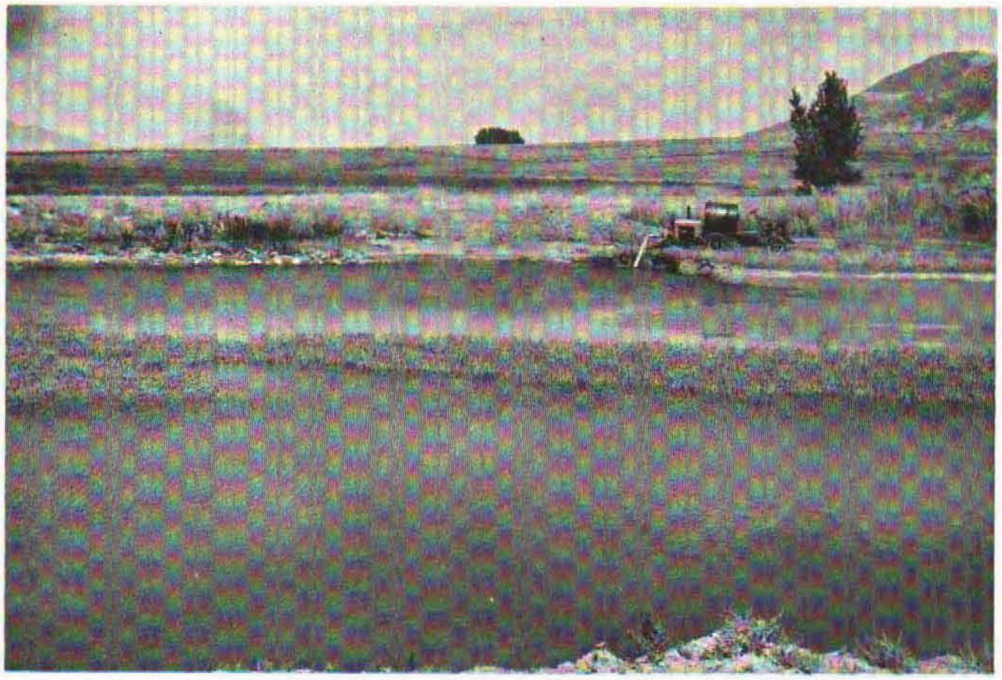
Present-day streams are principally confined to a few of the canyons in the mountains, and discharge to the alluvial apron or valley lowland only during periods of spring or flood runoff.

GENERAL GEOLOGY

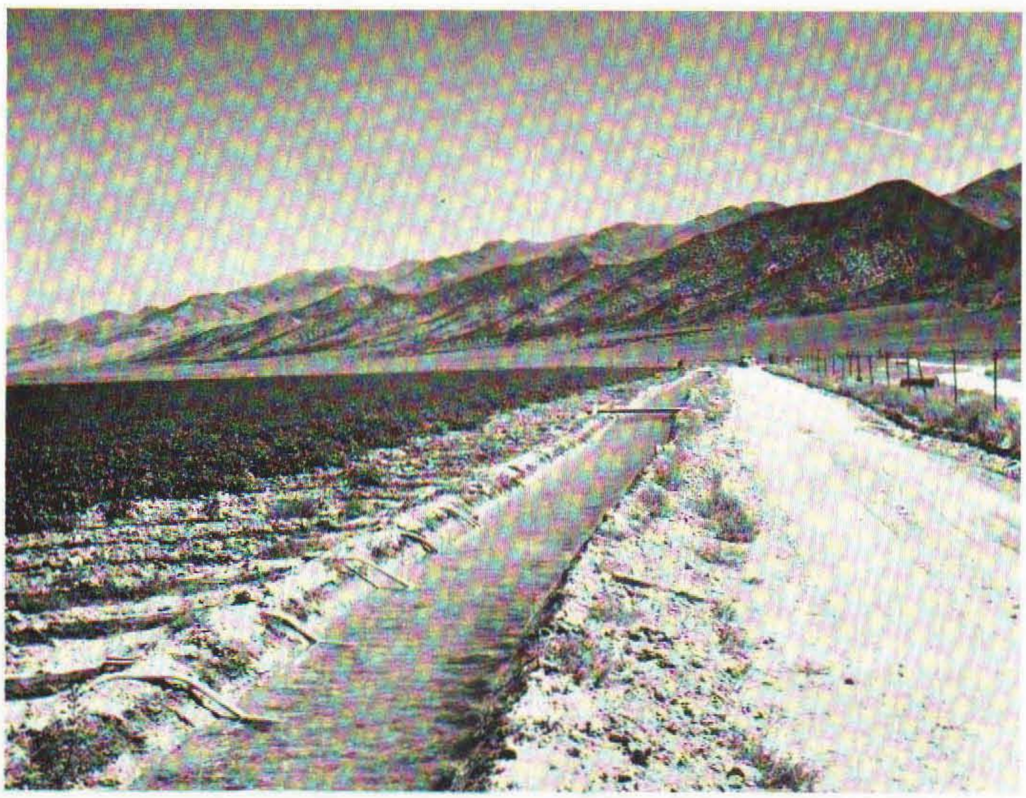
The rocks of Diamond Valley may be divided into two major units, the bedrock and the valley fill, on the basis of their general relation to topography and ground water.

The bedrock includes: rocks of Paleozoic age consisting principally of dolomite, limestone, and lesser amounts of shale, sandstone (or quartzite), and conglomerate; fresh-water limestone, conglomerate, silt, sandstone and grit of Early Cretaceous age; intrusive rocks of Late Cretaceous or early Tertiary age; extrusive lavas and associated pyroclastics of Tertiary age. These rocks crop out in the mountains and underlie the valley fill.

The valley fill includes clay, silt, sand, gravel, evaporites, and probably fresh-water limestone and pyroclastics deposited under subaerial and lacustrine conditions. It is construed that the valley fill also includes deposits of Cenozoic age and probably is several thousands of feet thick beneath the floor of Diamond Valley. Plate 1 shows the general distribution of bedrock and valley fill in Diamond Valley.



Photograph 3. Main spring pool at Thompson Ranch. Note portable pumping plant used to supply field of alfalfa in left middle distance. Alfalfa is irrigated by sprinkler system.



Photograph 4. View north in T. 21 N., R. 54 E. showing main ditch, siphons and furrow irrigation of potato field.

Bedrock in the Mountains

The bedrock in the mountains have been extensively studied in the Eureka area by Nolan, Merriam, and Williams (1956). Merriam and Anderson (1942) reported on an extensive reconnaissance survey of the R oberts Mountains which lie just west of and connect with the Sulphur Springs Range. Dott (1955) discussed the Pennsylvanian stratigraphy of the northern part of the Diamond Mountains. Carlisle, Murphy, Nelson, and Winterer (1955) reported on the Devonian stratigraphy of the Sulphur Springs Range. Nolan (1943) and Roberts, Hotz, Gilluly, and Ferguson (1958) have discussed broad aspects of Paleozoic formations and structure. Currently Lehner, Tagg, Bell, and Roberts (written communication, 1961) of the Geological Survey are completing a reconnaissance of Eureka County as part of the cooperative program between U.S. Geological Survey and the Nevada Bureau of Mines. These and other studies, both published and unpublished, provide a good reference framework on which to consider the bedrock formations in Diamond Valley.

Valley Fill

The valley fill of Diamond Valley has not been studied to an appreciable extent. Generally, however, it may be considered as the detritus, derived from the surrounding mountains and adjacent region, that underlies the present area of the valley lowland and contiguous alluvial apron and that is unconsolidated or only partially consolidated.

Regnier (1960) studied in Pine Valley to the west of the Sulphur Springs Range and describes the Cenozoic geology and anmes several Tertiary formations that might not be too dissimilar from deposits of Tertiary age which are included as valley fill in Diamond Valley. Also, Humphrey (1960) in his study of the White Pine Mining District describes two Tertiary formations that are exposed in the alluvial apron of Newark Valley. Typically the Tertiary formations described by Regnier and Humphrey contain a substantial proportion of pyroclastic material associated in part with shale, sandstone and conglomerate, but which include diatomite and fresh-water limestone. They also include vitric or welded tuff that may be closely related to the ignimbrites described in other areas of central Nevada. Ignimbrites are volcanic rocks generally considered to be deposited as a gaseous cloud and have some characteristics of both lava flows and pyroclastic rocks.

The maximum thickness of the valley fill, as here used, is not known. The thickness is substantial in some places as is indicated by the exploratory well drilled by the Shell Oil Company in 1956. This exploratory well, in sec. 30, T. 23 N., R. 54 E., is reported by Campbell and Hebrew (1957, p. 1, 246) to have penetrated 7,485 feet of valley fill and undifferentiated Tertiary strata before entering Paleozoic rocks.

The configuration of the bottom of the valley fill is determined by the pre-Tertiary bedrock surface upon which the valley fill was deposited. The bedrock surface was irregular when Tertiary deposition began and was deformed further to its present shape by structural activity during Cenozoic time.

Although the present shape of the pre-Tertiary bedrock surface is not known in detail the general form of the surface is suggested by recent reconnaissance regional gravity studies, which includes Diamond Valley, made by Mabey and others.

Plate 2 shows contours of the simple Bouguer anomaly in milligals as reported by Mabey (written communication, 1961) for the Diamond Valley part of the area investigated.

The gravity low in Diamond Valley is produced by a density contrast between the Cenozoic rocks and the generally more dense older rocks. The amplitude of the anomalies is dependent upon the density contrast and the thickness of the Cenozoic valley fill. The gravity anomaly in Diamond Valley is about 40 milligals and the Shell exploratory well shows that the valley fill is 7,485 feet at the well site. Thus, as an approximation, it can be assumed that each milligal of anomaly indicates about 200 feet of fill. This assumption requires a density contrast between the Cenozoic fill and the underlying bedrock of about 0.4 gram per cubic centimeter. Density contract of this order has been found to be a good approximation in most of the Basin and Range province (Mabey, written communication, 1961).

In general then, the basin in which the valley fill occurs in Diamond Valley apparently is an elongate trough about parallel to the surficial configuration of the valley, with the deeper part being somewhat closer to the Diamond Mountains than to the Sulphur Springs Range. This approximation is adequate for most purposes of the investigation of ground water at this time. At a later time, when more well data are available, and when a comprehensive investigation is warranted, it also may be desirable to conduct detailed gravity or other geophysical surveys to aid in more closely defining the configuration of the bottom of the valley fill.

Stratigraphy

The stratigraphy in the vicinity of Diamond Valley is summarized in the Appendix for those readers who may wish to examine the descriptions. Descriptions of Paleozoic and Mesozoic rock units in the mountains surrounding Diamond Valley are adapted from Nolan, Merriam, and Williams (1956). The descriptions of Cenozoic strata are adapted from Regnier (1960, p. 1191) and Humphrey (1960, p. 41-46). The Tertiary stratigraphic names are those used by Regnier and Humphrey and are not necessarily those of the U.S. Geological Survey. The description of Tertiary formations are given only to illustrate the types of Tertiary lithology that might be penetrated in drilling below Quaternary sediments in Diamond Valley.

Geologic History

The geologic history of an area provides a convenient outline of the sequence of events that have occurred. This sequence is an aid to obtaining a better understanding of the physical controls on the movement and occurrence of ground water.

Much additional investigation is needed to define the details of the geologic history of central Nevada, especially the Cenozoic history. The following outline of events is therefore highly generalized and approximate only.

1. Deposition of dolomite, limestone, sandstone, shale, and minor amounts of coarser clastic sediments during Paleozoic time. Development of a "linear swell" or positive area in Early or Middle Ordovician time and renewed in Late Devonian to Permian time. The swell had a marked effect on the lithologic character of the sediments and also resulted in several angular unconformities within the Paleozoic rock sequence.

2. Intensive diastrophism in one or more periods, including folding related extensive thrust faulting, accompanied by erosion from highland areas and continuing through much of Mesozoic time.

3. In Early Cretaceous time, erosion of highland areas and deposition in lowland areas of the Newark Canyon formation, consisting of fresh-water limestone, conglomerate, grit, sandstone and silt.

4. Emplacement of rocks in Late Cretaceous and early Tertiary time, probably accompanied by folding and high-angle faulting. The largest exposure is the Tertiary andesitic intrusive which forms the core of Whistler Mountain.

5. Extrusion of lavas and pyroclastic rocks in Tertiary and Quaternary time. Principal exposures in Diamond Valley are southeast of Eureka and scattered outcrops on the east flank of the Sulphur Springs Range north of the Siri Ranch.

6. Deposition in Tertiary and Quaternary time of pyroclastic rocks and lavas as well as diatomite, limestone, shale, sandstone and conglomerate, most of which are buried in Diamond Valley beneath the Quaternary deposits of the alluvial apron and the valley floor.

7. Faulting and folding intermittently during Cenozoic time. That involving the Quaternary lavas resulted in essentially the present day form of Diamond Valley.

8. Erosion in the mountains and deposition in the valley during Pleistocene time. Sedimentation occurred under subaerial and lacustrine environments. Sediments range in size from clay to gravel and locally include evaporites. One or more lakes occupying the valley in late Pleistocene time resulted in the formation of beaches and spits which are still prominently preserved, as in the vicinity of Railroad Pass, and near the ranches along the west side of the valley. These remnants occur principally between altitudes of about 5,880 and 6,040 feet.

9. Since the last Pleistocene lake, alternating periods of aridity and humidity, which probably resulted in alternation of shallow lakes and dry lake conditions in the present playa area. Streams flowing to the playa area from the south during the more humid periods dissected or removed late Pleistocene beach features in the south part of the valley. These streams probably were perennial for relatively long periods to permit the development of meander scrolls along the drainage ways in the valley floor. Concurrent dissection of stream channels crossing the alluvial apron, and deposition of relatively fine-grained sediments or evaporites, principally in the playa area.

Water-Bearing Properties of the Rocks

The oldest rocks in Diamond Valley are of Paleozoic age and are exposed principally in the mountains. They consist chiefly of limestone and dolomite with lesser but substantial amounts of shale and sandstone or quartzite. Consolidated rocks of these types usually have low primary permeability--that is, the openings present at the time of deposition were small or have been filled. However, the rocks in central Nevada have been substantially folded, faulted, weathered and otherwise altered and locally contain many secondary openings, mainly joints. These fractures, which locally have been enlarged by solution, have created a substantial secondary permeability that locally is quite important with respect to movement of ground water in the bedrock. Studies by Stuart (1955, p. 11 and Stuart and Metzger, written communication, 1961) indicate that formations or parts of formations such as the Eldorado Dolomite, Hamburg Dolomite, and the Geddes, Goodwin and Antelope Valley Limestones are capable of transmitting water in moderate to large quantities at least locally, as in the area of the Fad shaft near Eureka. In the same reference, Stuart indicates that formations such as the Dunderberg Shale, Secret Canyon Shale, and Prospect Mountain Quartzite are relatively impermeable and normally would transmit small to negligible amounts of ground water. Additionally, Shipley Hot Springs (T. 22 N., R. 52 E.) and other principal pool springs at ranches along the east and west sides of the valley are located near bedrock outcrops and probably are supplied to a substantial extent by water moving through secondary openings in bedrock formations of Paleozoic age.

Paleozoic rocks underlie the valley fill at varying but usually substantial depths. However, the degree to which they would yield water to wells is not known.

The limestone, conglomerate, silt, sandstone, and grit comprising the Newark Canyon Formation of Cretaceous age is consolidated and may be expected to transmit only small to negligible quantities of water through fractures. The known distribution of this formation is generally above the regional zone of saturation, but perched water may move through fractures to supply small springs in the mountains in the area of outcrop west of Diamond Peak.

The Tertiary and Quaternary volcanic rocks generally should be capable of transmitting only small supplies of water through fractures, especially the lavas. The amount of water so transmitted probably is only sufficient to maintain small springs locally in the mountains.

The Tertiary and Quaternary deposits that form the valley fill probably span nearly the complete range of sedimentary and pyroclastic rock types and includes evaporites. The proportion of the various rock types cannot yet be evaluated with the data at hand. Although these deposits differ greatly from place to place in their capacity for storing ground water, collectively they store a large volume of water.

A large part of the valley fill probably has a relatively low permeability and therefore will not yield water readily to wells. However, the valley fill also contains sand and gravel strata which are quite permeable and which are capable of yielding water freely to adequately constructed wells. Examples of these strata are shown by the logs of most of the irrigation wells in T. 21 N., R. 53 E. (see table 8). It will be noted that most of these wells are less than about 200 feet deep. As the valley fill may have a maximum thickness of several thousand feet, it can be assumed that the known distribution of permeable sand and gravel strata probably represents only a small fraction of the total volume of the valley fill.

GROUND-WATER APPRAISAL

General Conditions

Ground water in Diamond Valley is presumed to originate largely within the drainage basin, supplemented to a limited but unknown extent by surface and subsurface flow through Devil's Gate, south of Whistler Mountain. Precipitation as snow or rain on the flanks of the Diamond Mountains and the mountain mass at the south end of the valley, and to a lesser extent the Sulphur Springs Range, undoubtedly supplies most of the water that recharges the ground-water reservoir. Precipitation on the alluvial apron at times may be of such intensity, duration, and distribution as to result in recharge to the ground-water reservoir. The valley floor south of the playa commonly is underlain by permeable deposits between the land surface and the water table. This suggests favorable conditions for some recharge from the melting of snow on the valley floor, from moderate to heavy precipitation of adequate duration, or from streamflow on the valley floor.

Some surface and subsurface flow enters Diamond Valley through Devil's Gate from the large drainage area to the west that includes Antelope, Monitor, and Kobeh valleys. Ordinarily the amount of water coming through the gap is small, but in years of very large runoff from the west, streamflow through Devil's Gate might be at a substantial rate for limited periods. The long-time average recharge to the ground-water reservoir in Diamond Valley from this source probably is small.

The valley fill is the principal ground-water reservoir. The bedrock also contains a considerable volume of ground water, as shown by the studies of Stuart and Metzger (written communication, 1961). The degree to which ground water in the bedrock and in the valley fill is hydraulically connected is not yet known. However, on a valley-wide basis, the connection probably is good, although it may be localized.

The amount of ground water in storage in the valley fill is substantial and is many times the volume represented by the average annual recharge to and discharge from the valley fill.

Ground water is discharged from Diamond Valley by transpiration of phreatophyte vegetation and evaporation through the soil where the water table is at or relatively near the land surface. Ground water discharged from the springs along east and west sides of the valley and marginal to the playa is finally discharged from the valley by transpiration of vegetation and evaporation from the soil and free-water surface of ponds or wet meadows.

The water table in the valley fill generally is within a few feet of the land surface in the area of the playa and its immediate vicinity. Numerous small gravity springs and seeps marginal to the playa testify to the shallow depth to water in this area. Springs also occur along the lower edge of the alluvial apron, principally in Tps. 23 and 24 N. on the west and east sides of the valley. Most of the larger springs, such as Shipley Hot Spring and the main spring at Thompson Ranch, have artesian heads. (See photographs 2 and 3). That artesian conditions are operative in these areas is further supported by the flowing wells on the Romano Ranch. Discharge from the artesian springs and upward leakage in the vicinity has resulted in a shallow water table in the meadow areas down-gradient from the springs.

The water table generally increases in depth from the playa area to the mountains. In the valley lowland, the altitude of the water table rises gradually from 5,770 at the playa to about 5,870 feet in the vicinity of well 20/53-21ad1. Irregularity of the land surface results in considerable variation in the depth to water. Commonly though the depth to water in many of the irrigation wells ranges from 10 to 60 feet.

Under long-time natural conditions, the amount of recharge to a given ground-water system is balanced by the amount of water discharged from that system. For any particular year recharge and discharge probably will not be equal, but will involve a change in the amount of ground water in storage. Many data, which are not collected in these reconnaissance investigations, are required to make reasonably accurate estimates of ground-water recharge or discharge. However, crude estimates of recharge and discharge can be made on the basis of the long-time average rainfall and evapotranspiration, and are useful for those concerned with water development and management. The methods used in this report to estimate average annual recharge and discharge are the same as those used in prior reports of this reconnaissance series.

Estimated Average Annual Recharge

An estimate may be made of the average annual recharge to the ground-water reservoir 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 annual precipitation ranges between specified limits are delineated on a map, and a percentage of the precipitation is assigned to each zone which represents the estimated probable average recharge from the average annual precipitation of that zone. The degree of reliability of the estimate so obtained, of course, is related to the degree to which the values approximate the actual longtime average precipitation and the degree to which the assumed percentages represent the long time average recharge from that zone. Neither of these factors is known precisely enough to assure a high degree of reliability for any one valley. However, the method permits application of a system from valley to valley, and has proved useful for reconnaissance estimates. Additionally, experience suggests that in many areas the estimates probably are relatively close to the actual long-time average annual recharge.

The precipitation map of Nevada (Hardman and Mason, 1949, p. 10) was compared to the topographic map used as the base for plate 1. Precipitation zones were modified slightly to fit the better controlled topographic map. The division between the zones of less than 8 inches and 8 to 12 inches of precipitation was delineated at the 5,800-foot contour south of T. 24 N. and the 6,000-foot contour north of T. 23 N., between the 8 to 12 inches and 12 to 15 inches of precipitation at the 7,000-foot contour, between 12 to 15 inches and 15 to 20 inches of precipitation at the 8,000-foot contour, between the 15 and 20 inches and the over 20 inches of precipitation at the 9,000-foot contour. The valley floor area between the 5,800- and 6,000-foot contours south of T. 24 N. was included in the zone of 8 to 12 inches of precipitation because of the somewhat permeable character of the deposits between land surface and the water table in that area, as shown by several well logs, which would favor recharge resulting from snow or localized high-intensity rains in this area.

The average precipitation assumed for the respective zones beginning with the zone of less than 8 inches is 7 inches (0.58 foot), 10 inches (0.83 foot), 13.5 inches (1.12 feet), 17.5 inches (1.46 feet), and 21 inches (1.75 feet).

The average annual recharge, estimated as a percentage of the average annual precipitation for each zone, is as follows: less than 8 inches, 0 percent; 8 to 12 inches, 3 percent; 12 to 15 inches, 7 percent; 15 to 20 inches, 15 percent; and over 20 inches, 25 percent.

Table 5 summarizes the computation. The approximate average annual recharge, in acre-feet (column 5) for the zone of 15 to 20 inches of precipitation is obtained by multiplying the area of the zone, in acres, (column 2) by the average precipitation (column 3) by the percentage of recharge (column 4) divided by 100, and rounding the product. Thus, for the 15- to 20-inch precipitation zone: $17,000 \times 1.46 \times 15 \div 100 = 3,700$ acre-feet. Estimates of the recharge for the other zones are computed in a similar manner.

The estimated average annual recharge from precipitation, as shown in table 5, is on the order of 16,000 acre-feet. This is substantially less than the estimated average annual discharge of 23,000 acre-feet, which is discussed in the following section. The reason for the large difference between these estimates was not determined.

It was noted, however, that the ground-water discharge on the west side of the valley in Tps. 23 and 24 N. appeared to be relatively large, considering the relatively limited drainage area westward to the topographic divide of the Sulphur Springs Range. Recharge in this part of Diamond Valley in part may be supplied from areas beyond the topographic divide; that is, from the upper part of the drainage area of Garden Valley. However, there are no data to confirm this and at best it can be only a hypothesis until a more detailed investigation can be made.

Table 5.--Estimated average annual ground-water recharge from precipitation in Diamond Valley

(1) Precipitation zone (inches)	(2) Approximate acreage of zone	(3) Estimated average annual precipitation	(4) Percent recharge	(5) Approximate recharge (acre-feet) (2x3x4÷100)
20+	3,000	1.75	25	1,300
15-20	17,000	1.46	15	3,700
12-15	63,000	1.12	7	4,900
8-12	245,000	.83	3	6,400
8-	127,000	.58	--	----
Total				(16,300)
		Rounded		16,000

Estimated Average Annual Discharge

Ground water is ultimately discharged from Diamond Valley by transpiration of water-loving vegetation (phyreatophytes) and by evaporation from soil and free-water surfaces. Discharge by springs eventually is discharged from the valley by the above processes. Thus, an estimate of natural discharge of ground water may be made by evaluating the amount of water that is evaporated and transpired.

Ground water discharge by wells and consumptively used for cultivated crops or evaporated in the irrigation process would be in addition to the natural discharge. Some of the water pumped for irrigation probably returns to the ground-water reservoir and, thus, would not be removed from the ground-water system. Ground water pumped from wells for irrigating crops is discussed in a later section.

Table 6 summarizes the estimates of discharge by transpiration of phreatophyte vegetation and related evaporation from soil and free-water surfaces. Rates of use are adapted from studies of evapotranspiration of certain phreatophytes made by Lee (1912) and White (1932) in the Great Basin and by Young and Blaney (1942) in Southern California. Rates of use were assigned on the basis of vegetative types, density, and depth to water table.

Table 6.--Estimated average annual natural ground-water discharge from Diamond Valley

Process of discharge	Area (acres)	Approximate discharge (acre-feet per year)
Native vegetation:	47,000	14,100
Principally greasewood, rabbitbrush, saltgrass in varying proportions; density moderate to low but locally moderate to heavy; depth to water ranges from a few to about 20 feet, averaging about 10 feet below land surface. Average annual use about 0.3 foot.		
Meadow and pasture grasses:	5,600	8,900
Mixed grasses, depth to water 0 to 5 feet. Largely irrigated by discharge from springs and shallow ground water. Excludes that part supplied by streamflow and direct precipitation. Includes about 4,600 acres with an estimated average annual ground-water use of about 1.25 feet, and about 1,000 acres of meadow, which normally is flooded with water discharged from springs, estimated average annual use of 3 feet.		
Playa area:		
(Ground-water discharge not estimated)	49,000	---
Total:		23,000+

The areas of phreatophytes and playa and consequently the principal areas of discharge are largely in the northern part of the valley floor. The principal areas of native meadow and pasture are alined along the east and west margins of the valley floor in the latitude of Tps. 23 and 24 N. The greasewood, rabbitbrush, and salt grass areas are generally distributed as a band marginal to the playa.

The shallow water table in the playa area indicates that some ground water is being evaporated. However, the average annual rate of evaporation of a not known. Therefore, no estimate is given in table 6, although evaporation is a few thousand acre-feet a year might occur. A recommendation to investigate the rate of evaporation of ground water from playas was made previously (Eakin, 1960, p. 19). Data from such investigations would be of valuable assistance in making reconnaissance and more detailed estimates of discharge in other valleys of Nevada which contain playas.

Perennial Yield

The perennial yield of the ground-water system is ultimately limited by the average annual recharge to and discharge from the system. It is the upper limit of the amount of water that can be withdrawn for an indefinite period of time from a ground-water system without permanent depletion of the stored water. The average recharge from precipitation and the average discharge by evapotranspiration, discharge to streams, and underflow from a valley are measures of the natural inflow to and outflow from the ground-water system.

In an estimate of perennial yield, consideration should be given to the effects that ground-water development by wells may have on the natural circulation of 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 by wells usually would be offset eventually by a reduction of the natural discharge. In practice, however, it is difficult for well discharge to reduce fully the natural discharge, except when the water table can be lowered quickly to a level that eliminates both ground-water outflow and evapotranspiration in the areas 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.

As a preliminary measure of the long-term perennial yield of Diamond Valley, the estimate of average annual discharge is used. Thus, the estimated annual discharge of about 23,000 acre-feet also is considered to be the preliminary estimate of the perennial yield. On the one hand, this may be a conservative estimate to the extent that additional ground water is discharged by evaporation from the playa area. But, on the other hand, the estimate may be too high, because the estimated average ground-water recharge of 16,000 acre-feet may be more nearly correct. It is apparent then that the upper limit of the perennial yield of the natural ground-water system may be several thousand acre-feet more or less than the 23,000 acre-feet here estimated.

Movement

Ground water in general moves from areas of recharge to areas of discharge.

From the areas of recharge in the mountains the ground water moves slowly (perhaps on the general order of a few feet or a few tens of feet a year) toward the area of discharge which surrounds the playa in Diamond Valley.

Figure 2 shows generalized water-level contours of the ground water in the principal area of recent development south of the playa. It will be noted that the altitude of the contours decrease northward which indicates general movement toward the playa area. The northward swing of the contours on the east side indicates movement of ground water from the Diamond Mountains. Control is meager on the west side, but there is a suggestion of some movement of ground water from the mountains on the west side of the valley also. Pumping during the irrigation season of 1961 has modified the natural contours to some extent as is suggested by the irregularity of some individual contours, such as the 5,860-foot contour. No attempt has been made in this investigation to determine the precise effect of the pumping. This would require instrumental leveling to obtain close altitude control for well-measuring points and more detailed information of conditions prior to the time of measurements in September 1961. However, it appears that effects of pumping in the vicinity of the pumped wells locally may have amounted to several feet. It is not known whether these effects represent a "permanent" lowering of water level in the specific areas or whether full recovery from the pumping season had not occurred at the time of measurement.

Movement of ground water also is indicated by fluctuations in the water surface of the ground-water reservoir.

Figure 3 shows the fluctuation of water-levels in 2 wells during the period 1947-61. These hydrographs are based on occasional measurements and thus do not show details of fluctuations. However, they do show longer-term trends. Under natural conditions the water level fluctuates in response to storage changes and other factors in the ground-water reservoir, the storage changes in response to the relative balance between recharge and discharge. Fluctuations due to changes in storage commonly are small in areas relatively distant from areas of recharge or discharge. The hydrograph of well 21/53-5cb1 is generally representative of a small range of fluctuation of this type. The decline in the 1960-61 period may be, in part, a response to recent pumping. The location of well 22/54-34ab1 is close to ground-water recharge from the Diamond Mountains. Accordingly, its natural range of fluctuation would be expected to be greater than that for well 21/53-5cb1. It may be that most of the magnitude of decline in water levels in this well is a response to the drought periods of the last 10 years. It seems likely too that at least some of the decline may be induced by pumping, but the magnitude can not be estimated from present information.

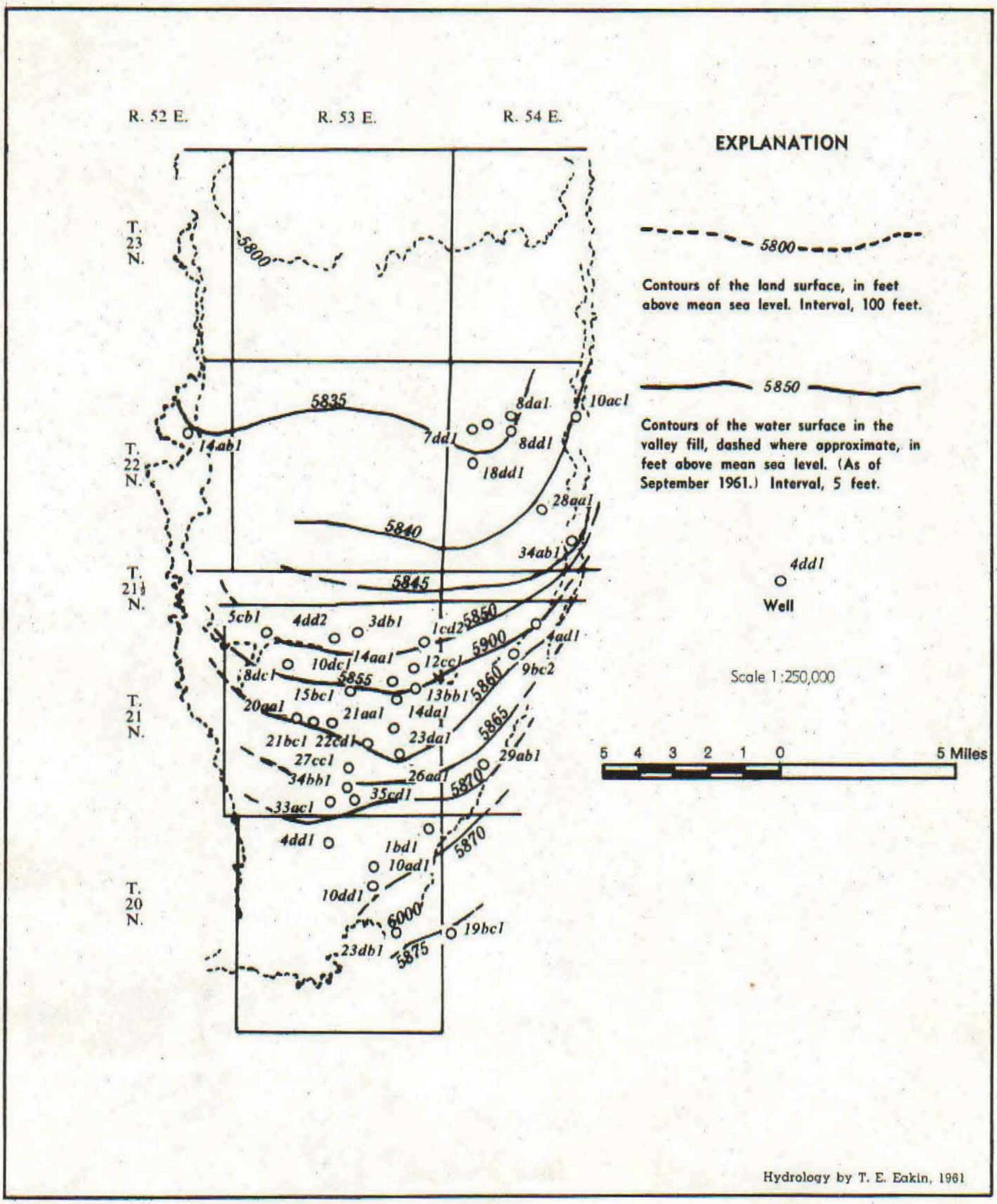


Figure 2. Sketch of principal area of ground-water pumping in Diamond Valley, showing generalized water-level contours.

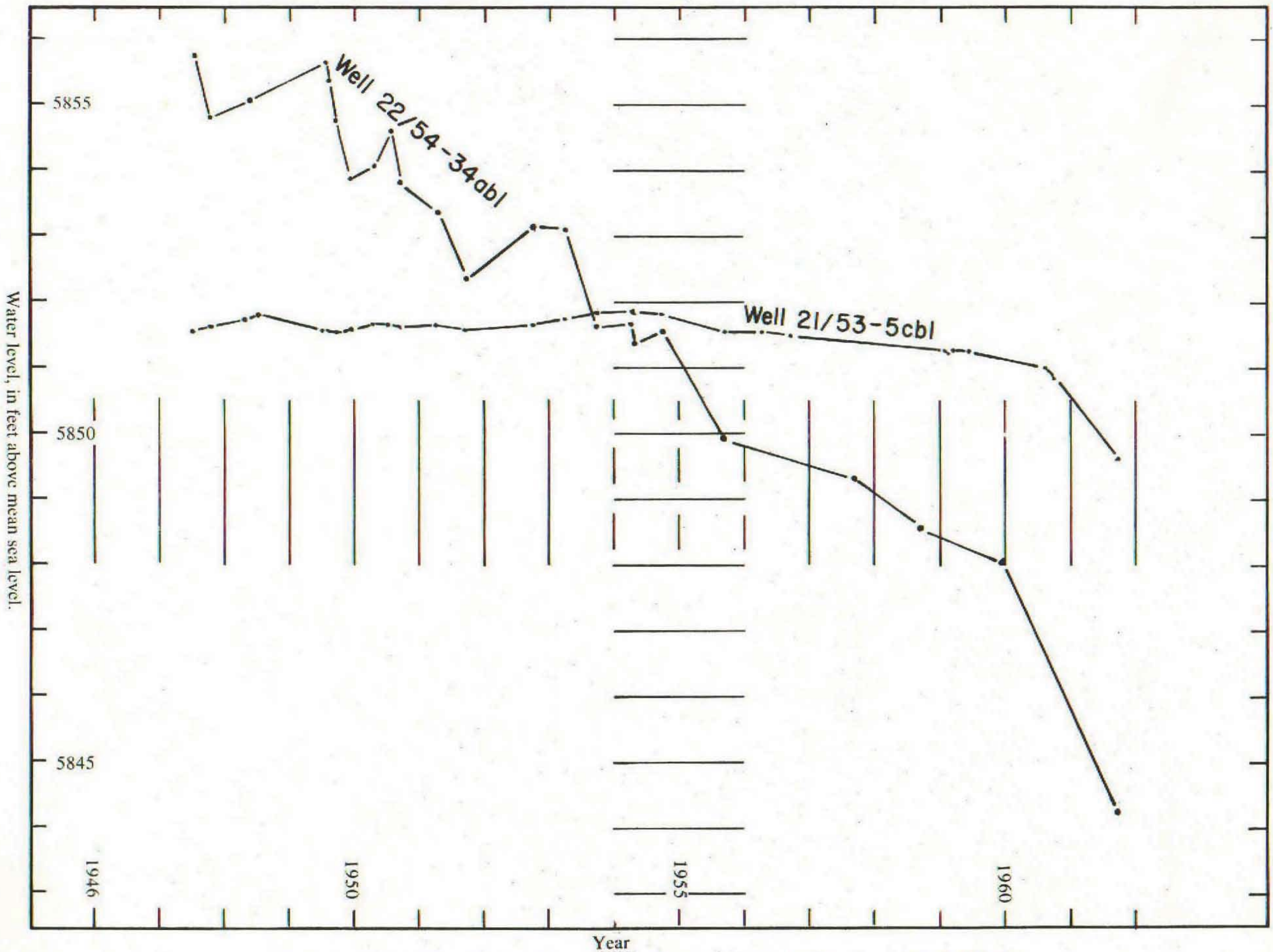


Figure 3. Hydrographs of two wells, in Diamond Valley, showing fluctuations of water level, 1947–61.

The relation of the movement of ground water in valley fill to the movement of ground water in bedrock is not known in detail. Investigations (Stuart and Metzger, written communication, 1961) of the mining hydrology in the vicinity of the Fad shaft, 1.4 miles west-southeast of Eureka, has shown substantial complexity of ground-water movement in the bedrock formations, but that, in general, the movement of ground water is northward. It is logical to expect that the detailed movement from the bedrock to the valley fill also is complex but, in the overall sense, that it functions as part of a single gross hydrologic system in Diamond Valley.

Storage

A large amount of ground water is stored in the valley fill in Diamond Valley. It is many times the volume of the annual ground-water recharge and discharge. Some concept of the magnitude of the ground water in storage may be obtained by the following calculation: The surface area of the valley fill lying below the 6,000-foot contour south of the playa is on the order of 140,000 acres. If it is assumed that only about 100,000 acres of this is the surface area beneath which the valley fill is saturated, and if a value of 15 percent is assumed as the specific yield (drainable pore space) of the saturated fill, then about 15,000 acre-feet of ground water is theoretically available from storage for each saturated foot of thickness of valley fill. This is equivalent to about 65 percent of the estimated average annual ground-water discharge under natural conditions. On this basis, the amount of ground water in storage in a 100-foot thick section of the valley fill, for the area cited, would be equal to about 1.5 million acre-feet or 65 times the natural annual discharge from the ground-water reservoir.

In addition to the water in the valley fill, there is an unknown amount of groundwater stored in the bedrock. Thus, it is evident that the total amount of ground water in storage is many times the average annual recharge to and discharge from the ground-water system in Diamond Valley. The water so stored provides a reserve for maintaining an adequate supply for pumping during protracted periods of drought or for limited periods of high demand under emergency conditions. This reserve further increases the reliability of ground water as a dependable source of irrigation supply and is an important asset in semi-arid regions where surface-water supplies are widely variable from year to year.

Quality

The chemical quality of ground water in interior valleys generally varies considerably as the water moves through the ground-water system. In general, the concentration of dissolved chemical constituents normally is low in the areas of recharge. As the water moves toward areas of discharge it is in contact with rock materials which have different solubilities. The extent to which the water dissolves chemical constituents from the rock materials is governed in large part by the solubility, volume, and distribution of the different rock materials, the time the water is in contact with the rocks, and the temperature and pressure in the ground-water system. In the areas of natural discharge, the ground water is evaporated or transpired, processes which tend to concentrate dissolved chemical constituents in the remaining ground water.

Although no samples of water were collected for analysis during this investigation, several analyses were made during the investigation of the mining hydrology in the Eureka region by Stuart and Metzger (written communication, 1961). Table 7 lists analyses for water from two wells, the Fad shaft, one spring, and surface-water flow in Devil's Gate.

Of these analyses only the sample of surface water in Devil's Gate has a dissolved-solids content in excess of 500 ppm (parts per million). The surface-water sample was collected during a period of low flow. Some of this water probably infiltrates to the ground-water reservoir but the quantity is small and thus probably affects the quality of this ground water only in a small area to the east and north of Devil's Gate.

The two analyses of ground water indicate that the quality of ground water in the southern part of Diamond Valley generally is of a bicarbonate type and that it is suitable for irrigation.

Table 7. --Chemical analyses of selected samples of water from Diamond Valley

Location	Date collected	Constituents: Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Specific conductance (Micromhos at 25°C.)	Hardness as $CaCO_3$: Total	Noncarbonate	Dissolved solids	Percent sodium	pH
Fad shaft (19/53-15bd) a/	1-21-53	11	.02	52	26	8.3	1.4	--	238	38	10	0.0	2.6	.06	467	236	42	267	7	7.8
Surface water at Devil's Gate (20/52-26A) a/	4-10-54	21	.47	41	94	1,020	98	35	834	918	800	1.0	.8	1.8	5,370	489	0	3,440	78	8.3
Well (20/53-15cb1) b/	6- 6-49	27	.75	37	14	-	-	-	247	16	25	-	-	.2	-	-	-	294	-	8.4
Well (22/54-34ab1) a/	3-10-54	37	.18	78	36	27	5.5	-	356	77	16	.6	5.5	.12	709	342	51	458	14	7.4
Shipley Hot Spr. (24/52-23da) a/	9-18-52	40	.01	57	21	29	5.9	0	279	35	21	.2	.0	.26	540	228	0	346	21	7.2

a/ Analyses by Geological Survey, U. S. Department of the Interior.
b/ Analyses by Twining Laboratories, Fresno, Calif. for Eureka Corporation, Ltd.

Although the analyses are suggestive of the chemical quality of ground water in the principal area of present development, they should not be relied upon as representing the quality of all ground water in this area because the samples were collected from points adjacent to the area of development.

The analyses also do not represent the chemical quality of ground water in and adjacent to the playa which extends northward from the north part of T. 23 N. Because ground water is discharged by evapotranspiration adjacent to and in the playa area, it would be expected that the ground water here would have a higher dissolved-solids content than the water in the southern part of the valley.

The chemical quality of water from the Fad shaft, which is from bedrock formations, is generally similar to the analyses of ground water from the valley fill. This similarity tends to support the idea that the ground water in the bed-rock and valley fill are a single gross hydrologic system in Diamond Valley. This is in agreement with general hydrologic and geologic principles for the occurrence and movement of water in interior valleys.

It would appear to be desirable to obtain and analyze samples of water from various parts of the valley, including the area of principal development. The data so obtained would be valuable not only to better determine the character of water with respect to suitability for various crops, but also, would be of substantial assistance in further defining ground-water hydrology of Diamond Valley.

Development

Prior to about 1940, development of ground water in Diamond Valley largely involved the utilization of spring discharge for the production of hay from meadows and pasture land. The larger springs so used are located on ranches near the east and west sides of Diamond Valley principally in Tps. 23 and 24 N.

In about 1943, drilling on the Romano Ranch resulted in the development of several flowing wells. The wells generally were less than 200 feet deep and the combined flow of six wells was about 600 gallons per minute. Over the years the flow gradually diminished and now may be on the order of 200 gpm.

The water from these wells was used for irrigation of meadow and pasture. The water also was used to flood brush land. During the winter, the water would freeze and kill the brush. The water further was used to leach the land of salts. The combined effect of these two processes resulted in increasing the acreage of meadow or pasture land.

In the late 1940's several wells with small flows, were drilled on the Flynn ranch, and the water was used for irrigation of meadows.

In 1949, public land withdrawals were made by Wm. and A. L. Jones and R. Stucki. Three irrigation wells were drilled of which two were successful, the largest yield about 1,200 gpm. Irrigation from these wells has continued for several years. (See photograph 4.)

Two additional irrigation wells were drilled in 1958 on public land withdrawals in T. 22 N., R. 54 E. However, the principal development began in 1960 and substantial drilling has continued through September 1961. During the summer season of 1961 about 50 pumped wells were used during all or part of the summer season in the areas where ground water is the only irrigation supply. Photograph 5 is representative of irrigation well installations in the valley. Photograph 6 shows a type of sprinkler system used to a limited extent.

Data are not available to make a firm estimate of the amount of water pumped for irrigation during 1961. However, a crude estimate, based on few data and incomplete information relating to acreage irrigated, number of wells pumped, and approximate average pumping, suggest that withdrawal apparently was within the range of 4,000 to 7,000 acre-feet, and probably was about 5,000 acre-feet.

Drilling continued through the summer and in September about 85 wells had been completed. It is expected that most of these will be equipped for production by next summer. Apparently additional irrigation wells will be drilled during the fall and winter.

The recent well development has been accompanied by increased efforts to develop or better utilize water on the older ranches. A well was drilled and equipped for relatively large production at the Romano Ranch. Additional development of springs has been and continues to be carried out to improve control and use of water. On the Thompson Ranch, about 56 acres of alfalfa are being irrigated by sprinklers, the water being pumped from the main spring pool.

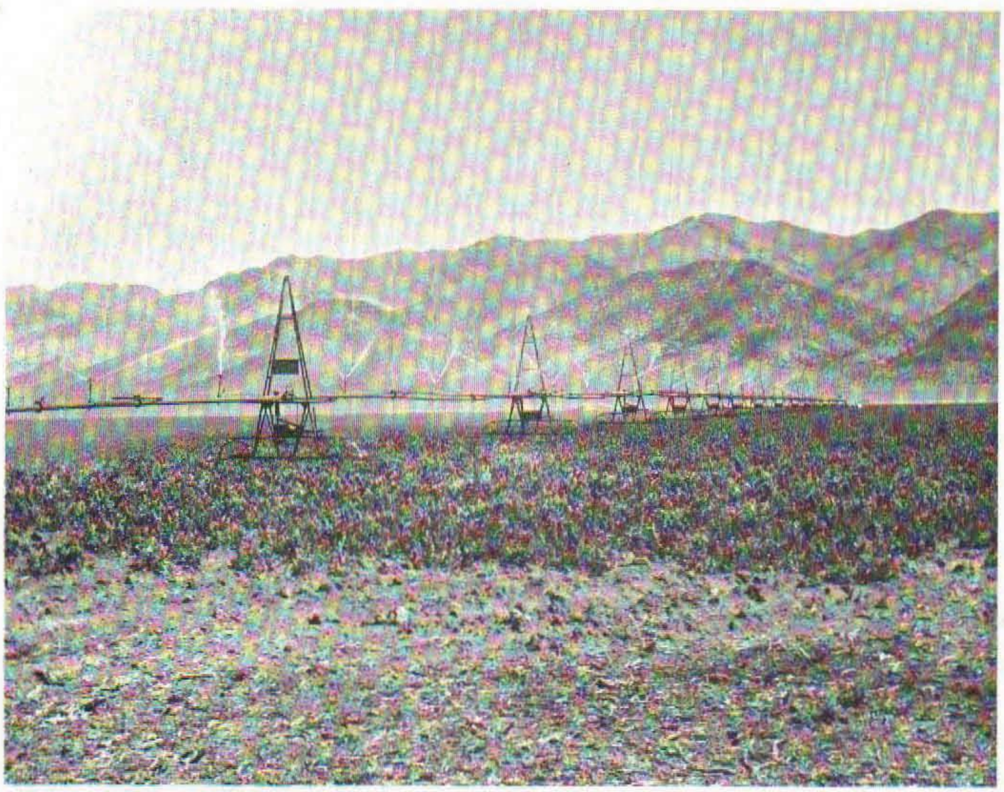
On the basis of development activity during the past year, and which is continuing at present, it appears that the summer of 1962 will be the first full season of large-scale irrigation pumpage in Diamond Valley.

Proposals for Additional Studies

In compliance with the request of Hugh A. Shamberger, Director, Department of Conservation and Natural Resources, State of Nevada, suggestions for special studies that are listed below are recommended for obtaining needed basic data and for obtaining a better understanding of the factors that influence or control ground water in Diamond Valley and similar areas in Nevada. These studies are separate from the normal areal investigations that commonly are needed after the development of ground water in a given area becomes substantial.

1. A detailed study of artificial withdrawal of ground water and discharge from principal springs during the irrigation season of 1962:

Photograph 5. View northwest showing typical well installation in Diamond Valley in field of small grain. Discharge from well goes directly into aluminum pipe which, in turn, is connected with sprinkler lines.



Photograph 6. View of "valley" sprinkler in 160-acre field of potatoes. Sprinkler line is self-propelled by hydraulic action. Line is connected with well at one end and rotates around well which is in the center of the quarter section.

It is expected that the summer of 1962 will be the first year of full scale irrigation pumpage in Diamond Valley. It is vitally important to obtain a firm determination of pumpage early in the history of a valley in which substantial development is taking place, as it will provide a firm reference on which to analyze the effects of intensive pumpage after 5 and 10 years of development. Obviously too, an early record of annual withdrawal will provide useful data to the farmers and ranchers of the valley and will aid in obtaining a better understanding of the ground-water resource on which their farming is based.

The study would include making pumping tests, discharge measurements of springs and wells at different times during the irrigation season, and obtaining water-level measurements during the irrigation season together with additional data required to estimate total ground-water withdrawal for irrigation in the valley. In order to obtain the necessary data field work on this study probably should be ready to begin by April 15, 1962.

2. An investigation of the microclimate of the lower part of Diamond Valley. This study was proposed previously in the report on Long Valley (Eakin, 1961, p. 27-28). It is repeated here because the current development of Diamond Valley makes it desirable to obtain information that can be used directly in the area.

An investigation of this type, although not entirely related to ground-water resources, is necessary for resolving certain water-resources problems, and additionally, it would have considerable economic value to irrigation interests.

The investigation would be directed toward the study of temperature variations with respect to topography, location, orientation, and exposure, in closed or nearly closed valleys. A second objective would be a similar study on the distribution of precipitation within the same area. Together the data would be valuable in explaining variations in the length of the growing season in different parts of a closed valley. Valuable information could be obtained also on direct precipitation as a partial water supply for cropland in various topographic positions in a closed valley.

3. A detailed study of the chemical character of water in Diamond Valley. This investigation would be useful not only for determination of the suitability for use for a wide variety of crops that may be tested in the valley, but also, for providing data in further defining the ground-water hydrology of the area.

4. Geophysical surveys of Diamond Valley. The results of a segment of a reconnaissance gravity survey are shown in plate 2 and are briefly discussed in this report. The data very broadly indicate the gross form of the valley fill, which includes Tertiary deposits. Better definition of the configuration of the subsurface contact between the bedrock and valley fill could be obtained by a detailed gravity survey. However, this would require more

control data from additional deep wells such as the Shell oil test. The deep wells would be required to provide more data on lithology, porosity, permeability and gravity of the valley fill and to provide positive control points on the position of the bedrock.

Magnetic and seismic surveys also may provide valuable data to define further the physical environment of Diamond Valley.

The time which geophysical surveys of the above types may be undertaken is dependent upon the availability of control data of and the economic need for comprehensive data on the ground-water hydrology of the valley.

DESIGNATION OF WELLS

The wells in this report are designated by a single numbering system. The number assigned to the 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 usually consists of three units. The first unit is the township north 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 one or two lower case letters, the first of which designates the quarter section, the second, the quarter-quarter section, and, finally, a number designating the order in which the well was recorded in the smallest subdivision of the section. The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest and southeast quarters and quarter-quarters of the section.

For example, well number 21/53-4dd1 indicates the first well recorded in the southeast quarter of the southeast quarter of sec. 4, T. 21 N., R. 53 E.

Owing to limitation of space, wells on plate 1 and figure 2 are identified only by the section number, quarter section and quarter-quarter section letters and serial number. The township in which the well is located can be ascertained by the township and range numbers shown at the margin of plate 1 and figure 2.

Wells listed in table 8 are shown either on plate 1 or figure 2.

Table 8.--Records of selected wells in Diamond Valley

19/53-8ab1. Owner, formerly A. C. Florio. Altitude 6,110 feet. Drilled stock well; casing diameter 6 inches. Equipped with cylinder pump and internal combustion engine. Measuring point, top of pipe clamp at land surface. Depth to water below land surface 178.3 feet, September 28, 1960. (Also prior water level measurements).

19/53-12C1. Owner, Irene Anderson. Altitude 6,440 feet. Dug domestic well; casing diameter 2 1/2 feet; depth of well 7.6 feet. Temperature 46°F. Measuring point, top of concrete curb which is 2.4 feet above land surface. Depth to water below land surface 5.49 feet, March 9, 1961.

20/53-1bd1. Owner, Mr. Mahacheck. Altitude 5,955 feet. Drilled irrigation well; depth of well 181 feet. Equipped with turbine pump and internal combustion engine. Measuring point, access tube on west side of pump, about 0.2 foot above land surface. Depth to water below land surface 81.83 feet, September 12, 1961.

20/53-4dd1. Owner, not determined. Altitude 5,928 feet. Drilled irrigation well; concrete casing, 13 inches in diameter. Equipped with turbine pump and diesel engine. Depth of well 180 feet, reported. Measuring point, 1-inch hole in pump base which is at land surface. Depth to water, below land surface, 56.5 feet, September 13, 1961.

20/53-10ad1. Owner, Mrs. Michael Mahacheck. Altitude, 5,994 feet. Drilled irrigation well; casing diameter 16 inches, depth 180 feet. Measuring point, top of casing, about 1 foot above land surface. Depth to water, below land surface, 72.54 feet, September 13, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	6	6
Gravel, loose coarse, and sand	27	33
Gravel, medium to coarse, and sand	9	42
Gravel, tight, coarse, and sand	18	60
Gravel, medium, with sand	11	71
Gravel, cemented	2	73
Gravel, loose, coarse sand	10	83
Gravel, loose, coarse, water-bearing	15	98
Gravel, partly cemented	4	102
Gravel, loose, coarse, water-bearing	29	131
Gravel streak, cemented	2	133
Gravel, medium to small	16	149
Gravel streak, cemented	2	151
Gravel, medium to fine	12	163
Gravel, good coarse, water-bearing	20	183
Total depth		183

20/53-10dd1. Owner, Joseph A. Mahacheck. Altitude, 5,953 feet. Drilled irrigation well; steel casing diameter 16 1/4 inches, depth 200 feet. Measuring point, top of casing, about 1 foot above land surface. Depth to water below land surface, 79.97 feet, September 13, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	6	6
Gravel, coarse, sand, silt	26	32
Gravel, medium to coarse, with sand	9	41
Gravel, coarse, tight, and sand	21	62
Gravel, sand and clay	6	68
Gravel, cemented, and clay	2	70
Gravel, loose	9	79
Gravel, loose, coarse, water-bearing	16	95
Gravel, partly cemented	3	98
Gravel, loose, coarse, water-bearing	29	127
Gravel, partly cemented	2	129
Rock, coarse, and smaller gravel	17	146
Gravel, partly cemented	2	148
Gravel, partly cemented, clay	5	153
Gravel, medium fine to coarse	8	161
Lime, cemented, gravel streak	1	162
Gravel, fine to medium	18	180
Lime, cemented, gravel streak	2	182
Gravel, medium to fine loose	14	196
Lime, cemented, gravel streak	2	198
Gravel, loose medium to fine	2	200
Total depth		200

20/53-15B1. Owner, not determined. Altitude, 5,951 feet. Dug stock well; casing diameter 48 inches; depth 99 feet. Equipped with cylinder pump and windmill. Measuring point, top of 4- by 4-inch timber at land surface. Depth to water below land surface, 77.2 feet. September 13, 1961. (Also prior water-level measurements.)

20/53-21ad1. Owner, Elaine B. Johnson. Altitude, 5,970 feet. Drilled irrigation well; casing diameter 16 inches; depth 213 feet. Measuring point, top of casing about 1 foot above land surface. Depth to water below land surface, 100.95 feet, September 15, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	5	5
Gravel, medium to fine	10	15
Clay, soft	15	30
Clay, hard gray	2	32
Clay, light colored	25	57
Gravel, partly cemented	5	62
Gravel, cemented	30	92
Gravel, large washed, loose	10	102
Gravel, clean, large, water-bearing	10	112
Gravel, coarse, and sand	46	158
Clay, brown	4	162
Gravel, partly cemented	20	182
Semi-sandstone, fine grained	5	187
Clay and gravel mixed	13	200
Gravel, tight cemented	13	213
Total depth		213

20/53-23db1. Owner, not determined. Altitude, 6,030 feet. Drilled stock well; casing diameter 6 inches. Equipped with cylinder pump and windmill. Measuring point, 1/8-inch hole in casing, about 1 foot above land surface. Depth to water below land surface, 134.23 feet, September 12, 1961.

20/53-29B1. Owner, Lions Club, Eureka. Altitude, 5,988 feet. Drilled stock well; casing diameter 6 inches; depth 142 feet. Equipped with jet pump and electric motor. Perforated from 112-142 feet. Well reported to have been bailed at 40 gpm. Temperature reported as 40°F. Measuring point, top of casing which is 0.7 foot above land surface. Depth to water below land surface, 103.9 feet, August 28, 1956. (Also prior water-level measurements.) Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil, brown	6	6
Sand, gravel, brown, clay	14	20
Clay, sandy, blue-gray	50	70
Clay, brown, sand and gravel	66	136
Sand and gravel, water-bearing	6	142
Total depth		142

20/54-19bc1. Owner, not determined. Altitude, 6,070 feet. Unused drilled well; casing diameter 8 3/4 inches; depth 189 feet. Measuring point, top of casing, about 3 feet above land surface. Depth to water below land surface, 168.07 feet, September 12, 1961.

21/53-1bd1. Owner, not determined. Altitude, 5,882 feet. Drilled irrigation well; casing diameter 16 inches. Equipped with turbine pump. Measuring point, top of casing which is about 1 foot above land surface. Depth to water below land surface, 32.40 feet, September 13, 1961.

21/53-1cd2. Owner, not determined. Altitude, 5,886 feet. Drilled irrigation well; casing diameter 16 inches. Measuring point, top of casing which is 0.5 foot above land surface. Depth to water below land surface, 36.58 feet, September 13, 1961.

21/53-3cd1. Owner, Katherine Veatch. Altitude, 5,883 feet. Drilled irrigation well; casing diameter, 16 inches; depth 182 feet. Equipped with turbine pump and diesel motor. Measuring point, 1-inch hole in pump base which is about 0.5 foot above land surface. Depth to water below land surface, 37.80 feet, September 13, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	5	5
Sand and gravel	41	46
Clay	37	83
Sand and gravel	32	115
Clay	15	130
Sand and gravel	26	156
Clay	5	161
Sand and gravel	8	169
Clay	4	173
Sand and gravel	9	182
Total depth		182

21/53-3db1. Owner, Sam Dick. Altitude, 5,883 feet. Drilled irrigation well; casing diameter, 16 inches; depth, 182 feet. Equipped with turbine pump and diesel motor. Measuring point, 1-inch hole in pump base, about 1 foot above land surface. Depth to water below land surface, 38.24 feet, September 13, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	5	5
Sand and gravel	27	32
Sand layers and clay	50	82
Sand and gravel	30	112
Gravel with clay layers	20	132
Sand (fine) layers and soft clay	30	162
Sand and gravel	20	182
Total depth		182

21/53-4dd1. Owner, C. Clayton Cooper. Altitude, 5,885 feet. Drilled irrigation well; casing diameter 16 inches; depth 182 feet. Equipped with turbine pump and diesel motor. Discharge reported as 2,160 gpm. Temperature reported as 58°F. Measuring point, 1-inch hole in pump base which is about 1 foot above land surface. Depth to water below land surface, 34.10 feet, September 12, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	5	5
Sand, dry and gravel	31	36
Clay, soft	11	47
Sand, fine	3	50
Clay, soft	13	63
Sand and gravel	28	91
Clay, soft	3	94
Sand and gravel with small clay layers	88	182
Total depth		182

21/53-4dd2. Owner, C. Clayton Cooper. Altitude, 5,886 feet. Drilled irrigation well. Equipped with turbine pump and internal combustion engine. Measuring point, top of 1-inch hole in pump base which is about 1 foot above land surface. Depth to water below land surface, 37.59 feet, September 12, 1961.

21/53-5cb1. Owner, formerly A. C. Florio. Altitude, 5,879 feet. Dug and drilled stock well; casing diameter 4 feet; depth 42 feet. Equipped with cylinder pump and windmill. Measuring point, top of steel plate over casing which is 1.5 feet above land surface. Depth to water below land surface, 30.89 feet, September 12, 1961.

Water levels, in feet, below land surface

Date	Water level	Date	Water level	Date	Water level
June 17, 1947	28.94	Sept. 11, 1951	28.92	Feb. 3, 1959	29.27
Oct. 27	28.90	Oct. 1, 1952	28.86	Feb. 16	29.23
Apr. 25, 1948	28.78	Mar. 3, 1953	28.76	Mar. 3	29.23
June 15	28.72	Sept. 15	28.69	Mar. 17	29.23
June 17, 1949	28.92	Mar. 8, 1954	28.61	Apr. 1	29.24
Sept. 13	28.98	Apr. 8	28.65	Apr. 14	29.22
Dec. 16	28.94	Sept. 16	28.68	Apr. 28	29.25
Mar. 17, 1950	28.83	Aug. 29, 1955	28.96	May 11	29.26
June 19	28.85	Mar. 26, 1956	28.93	July 1, 1960	29.50
Sept. 16	28.90	Aug. 28	29.00	Oct. 1	29.65
Mar. 15, 1951	28.87	Jan. 21, 1959	29.21	Sept. 12, 1961	30.89

21/53-8dc1. Owner, Alfred Farley. Altitude, 5,896 feet. Drilled irrigation well; casing diameter 13 inches; depth 192 feet. Temperature reported as 59°F. Measuring point, top of casing, about 1 foot above land surface. Depth to water below land surface, 42.12 feet, September 12, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	5	5
Sand	7	12
Sand and gravel with clay layers	72	84
Sand, gravel and clay layers	79	163
Gravel	6	169
Clay, soft	10	179
Gravel	13	192
Total depth		192

21/53-10dc1. Owner, not determined. Altitude, 5,892 feet. Drilled irrigation well; casing diameter 13 inches. Measuring point, top of casing which is 0.5 foot above land surface. Depth to water below land surface, 41.87 feet, September 13, 1961.

21/53-12cc1. Owner, not determined. Altitude, 5,895 feet. Drilled irrigation well; casing diameter, 16 inches. Equipped with turbine pump and diesel motor. Measuring point, top of 1-inch hole in pump base which is 1 foot above land surface. Depth to water below land surface, 41.70 feet, September 13, 1961.

21/53-13bb1. Owner, Ruthel DuBose. Altitude, 5,897 feet. Drilled irrigation well; casing diameter, 16 inches; depth 182 feet. Equipped with turbine pump. Discharge reported as 2,300 gpm with a drawdown of 57 feet. Measuring point, top of casing which is at land surface. Depth to water below land surface, 42.23 feet, September 13, 1961.

21/53-14aa1. Owner, Betty Sue Murphy. Altitude, 5,898 feet. Drilled irrigation well; casing diameter, 16 inches; depth 182 feet. Equipped with turbine pump and internal combustion engine. Discharge reported as 2,350 gpm with a drawdown of 57 feet. Depth to water below land surface reported April 15, 1961 as 42 feet.

21/53-14da1. Owner, Melvin S. Murphy, Altitude, 5,900 feet. Drilled irrigation well; casing diameter, 16 inches; depth 182 feet. Discharge reported as 1,480 gpm with a drawdown of 74 feet. Temperature reported as 58°F. Depth to water below land surface 44.51 feet. Measuring point, top of casing which is at land surface. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	4	4
Sand, dry and gravel	14	18
Clay, soft	8	26
Sand and gravel	18	44
Clay, soft	12	56
Sand, black and gravel	48	104
Clay, soft, gray	18	122
Sand, fine	14	136
Clay, soft	4	140
Sand and gravel	8	148
Clay	4	152
Gravel and coarse sand	4	156
Clay	3	159
Gravel and coarse sand	11	170
Clay	6	176
Sand and gravel	6	182
Total depth		182

21/53-15bc1. Owner, Vida Cooper. Altitude, 5,900 feet. Drilled irrigation well; casing diameter 16 inches; depth 182 feet. Discharge reported as 2,250 gpm with a drawdown of 68 feet. Equipped with a turbine pump and diesel engine. Temperature reported as 58°F. Depth to water below land surface, 43.27 feet, September 13, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	5	5
Sand, dry and gravel	20	25
Sand and clay layers	21	46
Gravel and sand	23	69
Clay, soft	22	91
Gravel, big, coarse	11	102
Sand, fine	14	116
Sand and gravel with small clay layers	66	182
Total depth		182

21/53-20aa1. Owner, not determined. Altitude, 5,930 feet. Drilled irrigation well; casing diameter 16 inches; depth 196 feet. Measuring point, top of casing which is 0.5 foot above land surface. Depth to water below land surface, 70.83 feet, September 12, 1961.

21/53-21aa1. Owner, Faye Cannedy. Altitude, 5,910 feet. Drilled irrigation well; casing diameter 16 inches; depth 182 feet. Equipped with turbine pump and diesel engine. Discharge reported as 2,410 gpm with a drawdown of 50 feet. Depth to water below land surface reported as 48 feet, March 15, 1961.

21/53-21bc1. Owner, not determined. Altitude, 5,917 feet. Drilled irrigation well; casing diameter 16 inches. Measuring point below top of casing which is 1.5 feet above land surface. Depth to water below land surface 59.25 feet, September 12, 1961.

21/53-22cd1. Owner, not determined. Altitude, 5,910 feet. Drilled stock well; casing diameter 6 inches. Equipped with cylinder pump and windmill. Measuring point, top of coupling on 6-inch casing. Depth to water below land surface, 50.35 feet, September 13, 1961. (Also prior water-level measurements.)

21/53-22dc1. Owner, Louis Heller. Altitude, 5,910 feet. Drilled irrigation well; casing diameter 16 inches; depth 117 feet. Discharge reported as 1,750 gpm with a drawdown of 26 feet. Temperature reported as 58°F. Depth to water below land surface, 47.6 feet, June 7, 1960. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	4	4
Sand, dry, and gravel	13	17
Clay, soft	3	20
Sand and gravel	40	60
Clay, soft	11	71
Sand, black, very fine	7	78
Sand and gravel, water-bearing	39	117
Total depth		117

21/53-23da1. Owner, Dewey F. Murphy. Altitude, 5,905 feet. Drilled irrigation well; casing diameter 17 inches; depth 166 feet. Equipped with a turbine pump and an internal combustion engine. Discharge reported as 2,040 gpm with a drawdown of 27 feet. Measuring point, lip of 1 1/4-inch pipe which is 0.5 foot above land surface. Depth to water below land surface, 49.88 feet, September 13, 1961. Temperature reported as 58°F. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	12	12
Gravel, dry; and sand	10	22
Clay	6	28
Sand, dry	18	46
Clay, gray, blue, soft	54	100
Sand	6	106
Clay, soft	4	110
Gravel, clean, water-bearing	12	122
Sand and gravel with some clay layers	19	141
Clay, soft	11	152
Gravel	14	166
Clay		166
Total depth		166

21/53-26aa1. Owner, not determined. Altitude, 5,910 feet. Drilled irrigation well; casing diameter 13 inches. Measuring point, top of casing which is at land surface. Depth to water below land surface, 50.64 feet, September 13, 1961.

21/53-26ba1. Owner, Delma Kibbe. Altitude, 5,910 feet. Drilled irrigation well; casing diameter 16 inches; depth 176 feet. Equipped with a turbine pump and a diesel engine. Discharge reported as 2,250 gpm with a drawdown of 61 feet. Depth to water below land surface 54 feet, November 11, 1960. Temperature reported as 58°F. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	4	4
Sand, dry, and gravel	28	32
Clay, soft, gray	18	50
Clay, soft, black	11	61
Sand, black, medium to fine	14	75
Clay, soft, gray	20	95
Sand, very fine	4	99
Clay, soft	7	106

Material	Thickness (feet)	Depth (feet)
Sand and gravel, water-bearing	37	143
Clay, soft	11	154
Sand, medium	11	165
Gravel, water-bearing	9	174
Clay, white	2	176
Total depth		176

21/53-27cc1. Owner, Clifford Fisher. Altitude, 5,915 feet. Drilled irrigation well; casing diameter 16 inches; depth 151 feet. Equipped with a turbine pump and a diesel engine. Discharge reported as 2,480 gpm with a drawdown of 49 feet. Measuring point, top of 1-inch hole in pump base which is 0.5 foot above land surface. Depth to water below land surface, 54.40 feet, September 12, 1961. Temperature reported as 59°F. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	4	4
Sand, dry	11	15
Clay, soft	6	21
Clay, soft, blue	21	42
Sand, medium	13	55
Clay	10	65
Gravel, water-bearing	12	77
Clay	2	79
Sand and gravel	70	149
Clay	2	151
Total depth		151

21/53-33ac1. Owner, not determined. Altitude, 5,920 feet. Drilled irrigation well; casing diameter 13 inches; depth 118 feet. Equipped with turbine pump and diesel engine. Reported depth to water when drilled, 56 feet. Discharge reported as 2,400 gpm with a drawdown of 37 feet.

21/53-33dd1. Owner, not determined. Altitude, 5,922 feet. Drilled irrigation well; casing diameter 13 inches; depth 118 feet. Equipped with a turbine pump and a diesel engine. Depth to water below land surface reported as 56 feet when drilled.

21/53-34bb1. Owner, not determined. Altitude 5,922 feet. Drilled irrigation well; casing diameter 13 inches. Measuring point, top of casing which is 0.5 foot above land surface. Depth to water below land surface 57.13 feet, September 13, 1961.

21/53-35cd1. Owner, Ola G. Gullett. Altitude, 5,922 feet. Drilled irrigation well; casing diameter 18 1/4 inches; depth 195 feet. Casing perforated 150 feet to 195 feet, 1/8-inch by 7/8-inch perforations. Equipped with a turbine pump. Discharge reported as 1,640 gpm with a drawdown of 42 feet. Measuring point, top of casing which is 0.5 foot above land surface. Water level below land surface, 51.62 feet, September 13, 1961. Temperature reported as 54°F. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	4	4
Sand, fine; and small gravel	11	15
Sand, coarser; and small gravel	10	25
Clay, gray	3	28
Gravel, fine; conglomerate	4	32
Gravel	8	40
Clay, gray	4	44
Gravel, fine	8	52
Clay, brown	23	75
Gravel, fine	5	80
Clay, gray	5	85
Clay and gravel mixture	1	86
Sandstone, brown	9	95
Gravel, fine, water-bearing	5	100
Clay, gray	6	106
Gravel, small, water-bearing	3	109
Clay	8	117
Gravel, coarse	5	122
Clay	9	131
Gravel	1	132
Gravel and clay mixture	8	140
Gravel	1	141
Clay	4	145
Gravel	3	148
Gravel and clay mixture	2	150
Sand and gravel, water-bearing	45	195
Total depth		195

21/54-4ad1. Owner, W. A. Jones. Altitude, 5,893 feet. Drilled irrigation well; casing diameter 12 inches; depth 120 feet. Equipped with a turbine pump and a diesel engine. Discharge estimated at 1,000 gpm. Pumpage for 1951 estimated at 100 acre-feet. Measuring point, slot in casing which is 0.7 foot above land surface. Depth to water, 38.25 feet, September 13, 1961. (Also prior water level measurements). Driller's log:

Material	Thickness (feet)	Depth (feet)
Clay, gray-green	28	28
Clay, sandy, some pebbles	17	45
Gravel and clay, stratified	35	80
Gravel, some coarse	8	88
Clay, yellow	5	93
Hard pan and cemented gravel	27	120
Total depth		120

21/54-9bc2. Owner, not determined. Altitude, 5,881 feet. Drilled stock well; casing diameter 6 inches. Equipped with cylinder pump and windmill. Measuring point, top of casing which is 2.75 feet above land surface. Depth to water below land surface 87.22 feet, September 13, 1961.

21/54-29cb1. Owner, Raymond Labarry. Altitude, 5,955 feet. Drilled stock well; casing diameter 8 inches; depth 130 feet. Equipped with cylinder pump and windmill. Measuring point, top of casing collar which is 0.4 foot above land surface. Depth to water below land surface, 87.22 feet, September 13, 1961. (Also prior water level measurements). Driller's log:

Material	Thickness (feet)	Depth (feet)
Soil	5	5
Clay and gravel	90	95
Sand and gravel	5	100
Clay and gravel	25	125
Sand and gravel	5	130
Total depth		130

22/52-14ab1. Owner, formerly A. C. Florio. Altitude, 5,862 feet. Dug stock and observation well; casing diameter 60 inches; depth 50 feet, later caved to a depth of 34.4 feet. Depth to water below land surface, 37.27 feet, September 16, 1950. (Also prior water level measurements). Well dry, December 18, 1959.

22/54-7dd1. Owner, Mr. Maddox. Altitude, 5,843 feet. Drilled domestic well; casing diameter 4 inches; depth 192 feet. Equipped with pump and internal combustion engine. Measuring point, top of casing which is 0.4 foot above land surface. Depth to water below land surface 12.87 feet, September 14, 1961.

22/54-8cc1. Owner, Louis L. Pollard. Altitude, 5,842 feet. Drilled domestic and irrigation well; casing diameter 10 inches; depth 154 feet. Discharge reported as 550 gpm. Measuring point, top of casing which is 1.7 feet above land surface. Depth to water below land surface, 12.31 feet, September 14, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Sand and gravel	28	28
Shale or sandy clay	22	50
Clay, blue, and sand	30	80
Shale	18	98
Clay, blue	10	108
Sand and gravel, water-bearing	12	120
Shale, sandy	7	127
Shale and gravel	16	143
Gravel, water-bearing	9	152
Shale, blue	2	154
Total depth		154

22/54-8ad1. Owner, Owen Pollard. Altitude, 5,843 feet. Drilled irrigation well; casing diameter 14 inches; depth 155 feet. Discharge reported 1,200 gpm with a drawdown of 50 feet. Measuring point, top of casing which is 1.4 feet above land surface. Depth to water below land surface, 9.10 feet, September 14, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Sand and gravel	21	21
Clay, blue, black	33	54
Sand, light colored	26	80
Gravel, with clay layers	46	126
Gravel and sand	14	140
Gravel, coarse	15	155
Total depth		155

22/54-8dd1. Owner, Louis Pollard. Altitude, 5,842 feet. Drilled irrigation well; depth 222 feet. Equipped with pump and internal combustion engine. Discharge reported as 1,100 gpm with a drawdown of 45 feet. Measuring point, slot in casing which is 0.5 foot above land surface. Depth to water below land surface, 9.25 feet, September 14, 1961.

22/54-10ac1. Owner, not determined. Altitude, 5,849 feet. Drilled stock well; casing diameter 6 inches. Measuring point, top of casing which is 1.2 feet above land surface. Depth to water below land surface, 9.88 feet, September 13, 1961. (Also prior water level measurements).

22/54-18dd1. Owner, Beverly Holmes. Altitude, 5,852 feet. Drilled irrigation well; casing diameter 12 inches; depth 222 feet. Discharge reported as 350 gpm with a drawdown of 47 feet. Depth to water below land surface, 15.98 feet, September 14, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Sand and gravel	25	25
Sandy clay	28	53
Sand	9	62
Clay	4	66
Sand and gravel	4	70
Clay, blue	25	95
Sandstone, soft	10	105
Sandy clay	10	115
Sandstone	5	120
Clay	18	138
Sandstone	7	145
Clay	5	150
Sandy clay	16	166
Sand	4	170
Clay	7	177
Sand	13	190
Clay	27	217
Sand	5	222
Total depth		222

22/54-28aa1. Owner, Oscar Carroll. Altitude, 5,855 feet. Drilled domestic and irrigation well; casing diameter 12 inches; depth 184 feet. Equipped with centrifugal pump. Discharge reported as 1,000 gpm. Measuring point, top of casing which is 0.75 foot above land surface. Depth to water below land surface, 13.53 feet, September 14, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Loamy soil	3 1/2	3 1/2
Hard pan	1 1/2	5
Sand	2	7
Shale, sandy	5	12
Shale, hard	4	16
Sand, hard	4	20
Muck	2	22
Sand, shale, clay	3	25
Sand, water-bearing	2	27
Mud, blue	9	36
Mud, black	8	44
Shale, sandy	6	50
Mud, blue	5	55
Sand, mud	4	59
Sand	5	64
Sand	3	67
Mud, blue	2	69
Sand	4	73
Shale, sticky	2	75
Sand	2	77
Shale, hard, blue	2	79
Sand	2	81
Sand and gravel	2	83
Sand	12	95
Sand and shale	5	100
Gravel, shale	1	101
Sand	6	107
Shale	3	110
Sand	3	113
Sand and shale	27	140
Sand and gravel	16	156
Gravel, small	4	160
Sand, gravel and rock	24	184
Total depth		184

22/54-34ab1. Owner, not determined. Altitude, 5,882 feet. Drilled stock well; casing diameter 6 inches; depth 50 feet. Equipped with cylinder pump and windmill. Measuring point, top of casing which is 2.4 feet above land surface. Depth to water below land surface, 40.13 feet, September 14, 1961. Chemical analysis. Temperature 54°F.

Water levels, in feet, below land surface

Date	Water level	Date	Water level	Date	Water level
June 17, 1947	28.67	June 19, 1950	29.80	Apr. 8, 1954	33.03
Oct. 27	29.60	Sept. 16	30.60	Sept. 16	32.82
May 6, 1948	29.33	Mar. 15, 1951	31.03	Aug. 29, 1955	34.49
June 17, 1949	28.73	Sept. 11	32.07	Sept. 6, 1957	35.05
July 8	29.02	Oct. 1, 1952	31.23	Sept. 5, 1958	35.82
Sept. 12	29.62	Mar. 3, 1953	31.30	Dec. 18, 1959	36.37
Dec. 16	30.51	Sept. 15	32.75	Sept. 14, 1961	40.13
Mar. 17, 1950	30.31	Mar. 10, 1954	32.71		

23/52-13bb1. Owner, L. Reitman Cattle Co. Altitude, 5,815 feet. Drilled irrigation well; casing diameter 14 inches; depth 157 feet. Equipped with a turbine pump and a diesel engine. Discharge reported as 700 gpm with a drawdown of 14 feet. Depth to water below land surface, 4.89 feet, September 15, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Gravel	14	14
Clay	8	22
Gravel	14	36
Clay	28	64
Gravel	2	66
Clay	12	78
Sandstone	2	80
Clay	8	88
Gravel	34	122
Clay	16	138
Gravel	6	144
Conglomerate	8	152
Limestone, tan colored	5	157
Total depth		157

25/53-5cb1. Owner, Joe Flynn. Drilled irrigation well; casing diameter 6 inches; depth 150 feet. Flowing well. Yield reported June 28, 1949, 25 gpm. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil, brown	10	10
Clay, blue	24	34
Clay, gray; small gravel	33	67
Clay, brown; small rock, water-bearing	8	75
Clay, brown; small rock, water-bearing	2	77
Clay, red; fine rock, water-bearing	6	83
Clay, gray; fine rock	2	85
Clay, red; fine rock; increasing water with depth	20	105
Clay, black; sand	12	117
Clay, brown; sand	33	150
Total depth		150

25/54-9db1. Owner, Ted Thompson. Dug stock and observation well; diameter 60 inches; depth 35 feet. Equipped with cylinder pump and windmill. Measuring point, top of 2-inch by 8-inch cribbing which is 1.0 foot above land surface. Depth to water below land surface, 32.57 feet, June 17, 1947; 33.30 feet, October 27, 1947; 33.14, May 6, 1948.

23/52-13ca1. Owner, formerly A. C. Florio. Drilled well; casing diameter 13 inches; depth 58 feet. Flowing well. Yield estimated June 16, 1947 as 115 gpm, September 15, 1961, 115 gpm.

23/52-13ca2. Owner, formerly A. C. Florio. Drilled stock and irrigation well; casing diameter 6 inches; depth 176 feet. Flowing well. Measured flow of 88 gpm, September 15, 1961. Driller's log:

Material	Thickness (feet)	Depth (feet)
Top soil	15	15
Clay, blue	20	35
Clay, blue-gray, sandy; small gravel	25	60
Clay, gray, sandy	25	85
Clay, light gray, sandy	6	91
Gravel streak, loose	2	93
Gravel, loose; pinkish clay	4	97
Gravel, coarse; sand; pink clay	28	125
Sand; gravel; clay	20	145
Sand, coarse and gravel streak	2	147
Clay, pink; sand; gravel	29	176
Gravel, cemented		176
Total depth		176

26/53-12db1. Owner, Ted Thompson. Altitude, 5,783 feet. Dug stock and observation well; diameter, 5 feet by 9 feet; depth 13 feet. Equipped with cylinder pump and windmill. Measuring point, top of 2- by 8-inch cribbing which is 3.5 feet above land surface. Depth to water below land surface, 9.39 feet, June 17, 1947; 10.95 feet, October 27, 1947; 9.77 feet, May 6, 1948; 9.10 feet, September 14, 1961.

26/54-15cd1. Owner, Bureau of Land Management. Altitude, 5,779 feet. Dug stock well; diameter 5 feet by 7 feet; depth, 9.5 feet. Equipped with cylinder pump and windmill. Measuring point, top of 2- by 12-inch sill which is 2.5 feet above land surface. Depth to water below land surface, 8.29 feet, October 27, 1947; 7.41 feet, May 6, 1948; 6.23 feet, September 14, 1961.

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Appendix--Generalized Stratigraphy of Diamond Valley and Vicinity

After Nolan, Merriam, and Williams (1956), Regnier (1960, p. 1191), and Humphrey (1960, p. 41-46).

Age	Formation	Lithology	Thickness
Quaternary	Alluvium	Unconsolidated sand, gravel, silt, and clay in fanglomerate; stream, lake, beach, playa, and dune deposits	0-200 or 300
		Unconformity	
Middle Pliocene to middle Pleistocene	Hay Ranch Formation of Regnier	Fanglomerate, conglomerate, sandstone, clay, and limestone. Some vitric tuff mostly, altered to zeolite	Possibly several thousand feet
		Slight angular unconformity	
Pliocene and (or) Pleistocene	Belmont Fanglomerate of Humphrey	Chiefly unbedded gravel fanglomerate	?
		Unconformity	
Early Pliocene	Carlin Formation of Regnier	Tuffaceous sandstone and conglomerate, vitric tuff, shale, limestone, and diatomite. (not present in Pine Valley)	600+
		Slight angular unconformity	
Late Miocene and (or) Pliocene	Lake Newark Formation of Humphrey	Bedded rhyolite tuff and coarser pyroclastics; in part lacustrine	430
		Unconformity	
Late Miocene or early Pliocene	Palisade Canyon Rhyolite of Regnier		500
		Slight angular unconformity	

Age	Formation	Lithology	Thickness (feet)
Late Miocene	Raine Ranch Formation of Regnier	Lapilli tuff, volcanic breccia, lava flows, vitric tuff, diatomaceous shale, and limestone	2,000
Slight angular unconformity			
Late Oligocene (?) or early Miocene (?)	Safford Canyon Formation of Regnier	Tuffs, tuffaceous conglomerate, and sandstone	700
Slight angular unconformity			
Oligocene (?)	Rand Ranch Formation of Regnier	Sandstone and conglomerate	1,700
Erosional unconformity			
Eocene	Illipah Formation of Humphrey	Fresh-water limestone, conglomerate, and interbedded tuff	1,500±
Unconformity			
Early Cretaceous	Newark Canyon Formation	Heterogeneous assemblage of fresh-water limestone, conglomerate, silt, sandstone, and grit	1,800
Unconformity			

Age	Formation	Lithology	Thickness (feet)
Permian	Carbon Ridge Formation	Heterogeneous, predominately calcareous rocks including abundant bedded sandy limestone; many beds of brown, yellow, or purple sandstone near base	1,750
Early and Middle Pennsylvanian	Ely Limestone	Massive bedded blue-gray limestone with some sandstone and rarely conglomerate beds near base . . .	1,500
Late Mississippian	Diamond Peak Formation	Quartzite with large but varying portions of shale, conglomerate, and limestone; abundant fossils . .	420
Late Mississippian	Chainman Shale	Black shale with some thin beds of sandstone, Rather siliceous in Diamond Mountains	5,000
	Unconformity		
Early Mississippian	Joana Limestone	Dense, porcelaneous limestone, coarsely crystalline limestone locally conglomeratic, nodular cherty limestone, black platy shale, thin quartzite or sandstone beds, and subordinate black chert . . .	0-135

Age	Formation	Lithology	Thickness (feet)
Mississippian and Devonian	Pilot Shale	Platy generally calcareous shale, tan to black in color on fresh fracture; approaches 1,000 feet in thickness in Pancake Range	420
Middle and Late Devonian	Devils Gate Limestone	Thick-bedded gray to blue-gray hard, dense, brittle limestone; few thinner beds of platy, flaggy limestone; some dolomite or dolomitic limestone near base; divided into Hayes Canyon and Meister members . . .	1,200
Early and Middle Devonian	Nevada Formation	Dominantly dolomite but appreciable thickness of sandstone and limestone; divided into five members inwhich a sandstone unit and a dominantly limestone unit separate three dolomite units; members, younger to older, are Bay State Dolomite, Woodpecker Limestone, Sentinel Mountain Dolomite, Oxyoke Canyon Sandstone, and Beacon Peak Dolomite Members	2,900

Unconformity

Age	Formation	Lithology	Thickness (feet)
Silurian	Lone Mountain Dolomite	Characteristically heavy-bedded to massive finely granular to coarsely saccharoidal light-gray dolomite; some beds of corase crinoidal dolomite near base	1,500-2,200
		Unconformity	
Late Ordovician	Hanson Creek Formation	Dark-gray to black dolomite, intensely fractured and brecciated in Eureka area; mostly limestone and calcareous shale in Roberts Mountains. .	300+
		Unconformity	
Middle and Late (?) Ordovician	Eureka Quartzite	Typically vitreous fine-to medium-grained sugary gleaming white quartzite, much fractured, brecciated, and locally recrystallized.	500-
		Unconformity	
Pogonip Group (eastern facies), composed of Antelop Valley Limestone, Ninemile Formation, and Goodwin Limestone			
Early and Middle Ordovician	Antelope Valley Limestone	Thick-bedded or massive medium of light-blue-gray fine-grained limestone; tends to be flaggy or platy, with argillaceous partings, in upper part . . .	430
Early Ordovician	Ninemile Formation	Platy, thin-bedded fine-grained to porcelaneous olive-green or greenish blue limestone. Some light-gray crystalline, sandy limestone, limy sandstone, and shale partings . .	540
Early Ordovician	Goodwin Limestone	Dominantly well-bedded, fairly massive light-gray to blue-gray limestone; much very fine grained, asphanitic, locally platy light-gray to white chert in lower 350 feet . . .	1,000±

Age	Formation	Lithology	Thickness (feet)
Late Cambrian	Windfall Formation	Includes, in descending order: Bullwhacker Member, thin-bedded platy sandy or shaly limestone between units characterized by massive limestone (400 feet); and Catlin Member, massive limestone beds and thinner sandy or silty limestone beds (250 feet)	650
Late Cambrian	Dunderberg Shale	Approximately equal thicknesses of shale and zones of interbedded shale and thin nodular, lenticular limestone beds	265
Middle and Late Cambrian	Hamburg Dolomite	Mostly composed of light-to medium-dull-gray coarsely crystalline dolomite, porous and vuggy, considerable local variation in bedding, texture, color, and composition	1,000
Middle Cambrian	Secret Canyon Shale	Includes: Clarks Spring Member, thin-bedded fine-grained silty blue-gray limestone with prominent yellow and red argillaceous partings (425-450 feet); lower shale member, argillaceous shale with little interbedded limestone; unweathered shale is massive blocky siltstone with little or no fissility (200-225 feet)	650
Middle Cambrian	Geddes Limestone	Well bedded, flaggy blue limestone with thin shale partings and some nodular black chert	330

Age	Formation	Lithology	Thickness (feet)
Middle Cambrian	Eldorado Dolomite	Massively bedded carbonate rock, ranging from nearly pure limestone to nearly pure dolomite; common type is light-gray rather coarsely crystalline dolomite, generally textureless but locally porous and vuggy; considerably modified by hydrothermal alteration . .	2,500±
Early Cambrian	Pioche Shale	Commonly micaceous sandy shale; includes some sicaceous sandstone quartzite and white and black limestone beds	400-500
Early Cambrian	Prospect Mountain Quartzite	White to gray fairly well sorted quartzite; micaceous sandy shale interbeds make up less than 5 percent of formation and tend to be more numerous in lower part . .	1,500±

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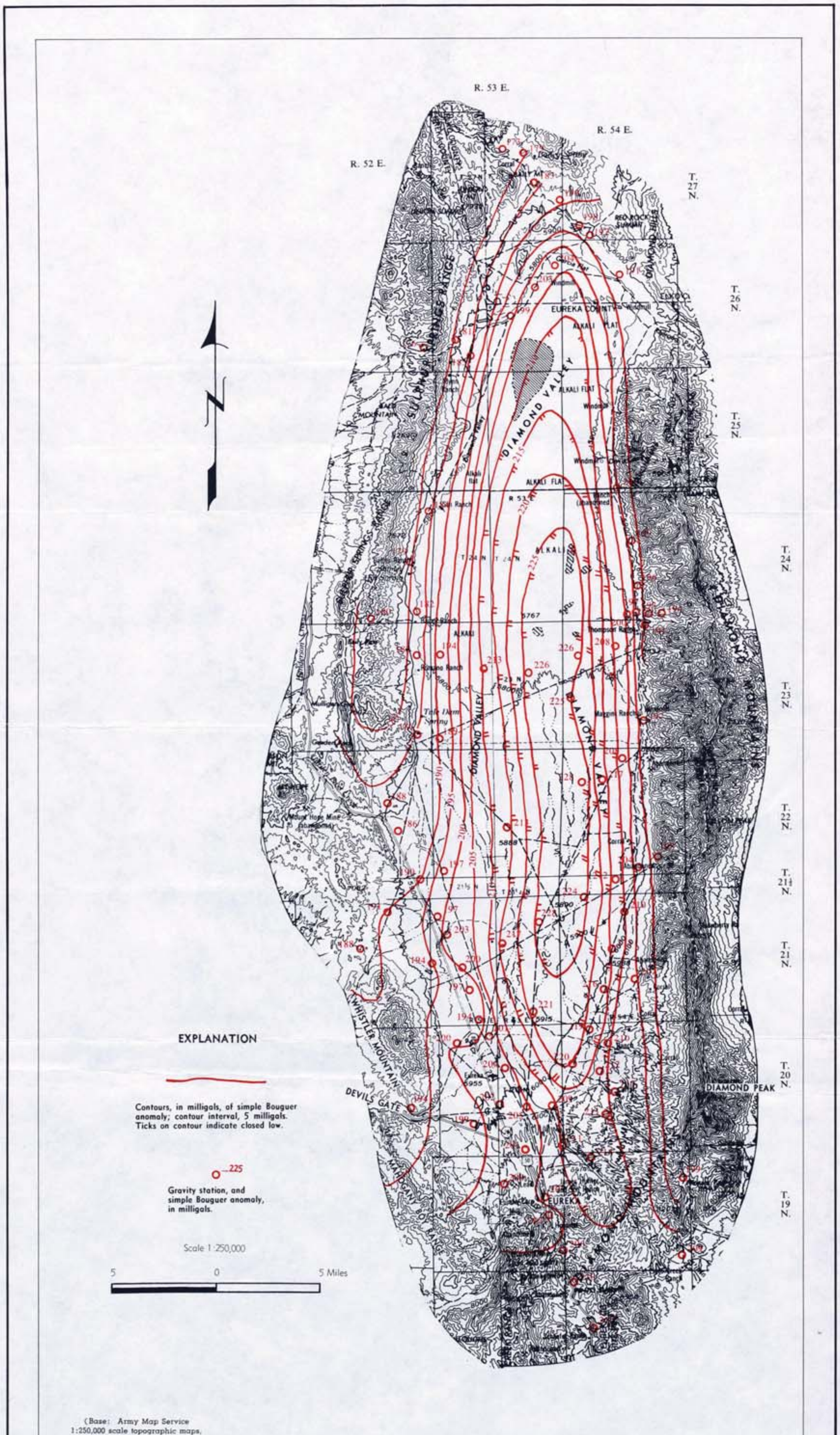

(Base: Army Map Service 1:250,000 scale topographic maps, Elko (1958), Ely (1959), Millett (1959), and Winnemucca (1958)).

Geophysical data by D. R. Mabey, 1961

PLATE 2. MAP OF DIAMOND VALLEY, SHOWING GENERALIZED CONTOURS OF SIMPLE BOUGUER ANOMALY.

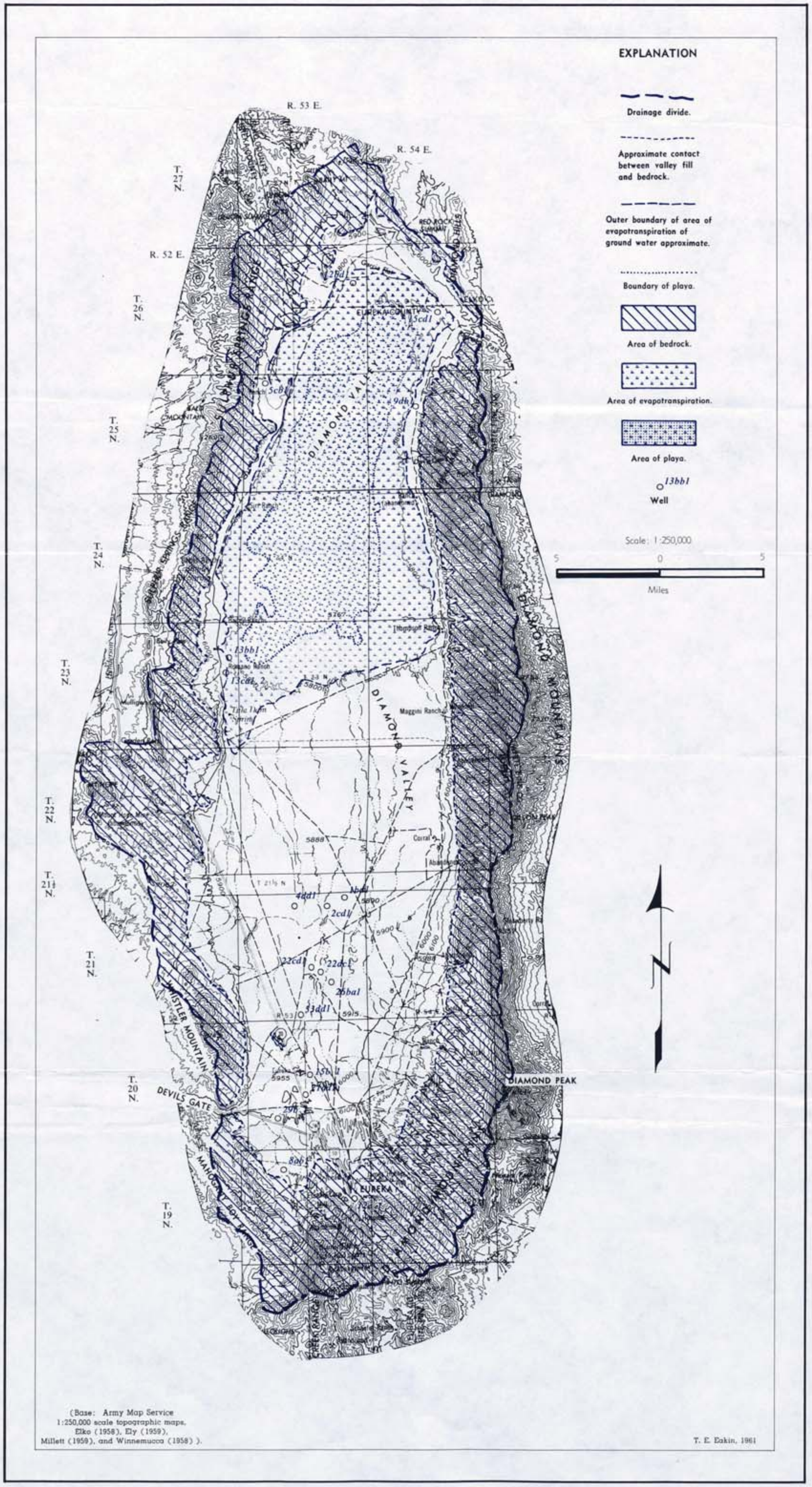

PLATE 1. MAP OF DIAMOND VALLEY, EUREKA AND ELKO COUNTIES, NEVADA
SHOWING AREAS OF BEDROCK, VALLEY FILL, PLAYA, AND EVAPOTRANSPIRATION, AND LOCATION OF WELLS.