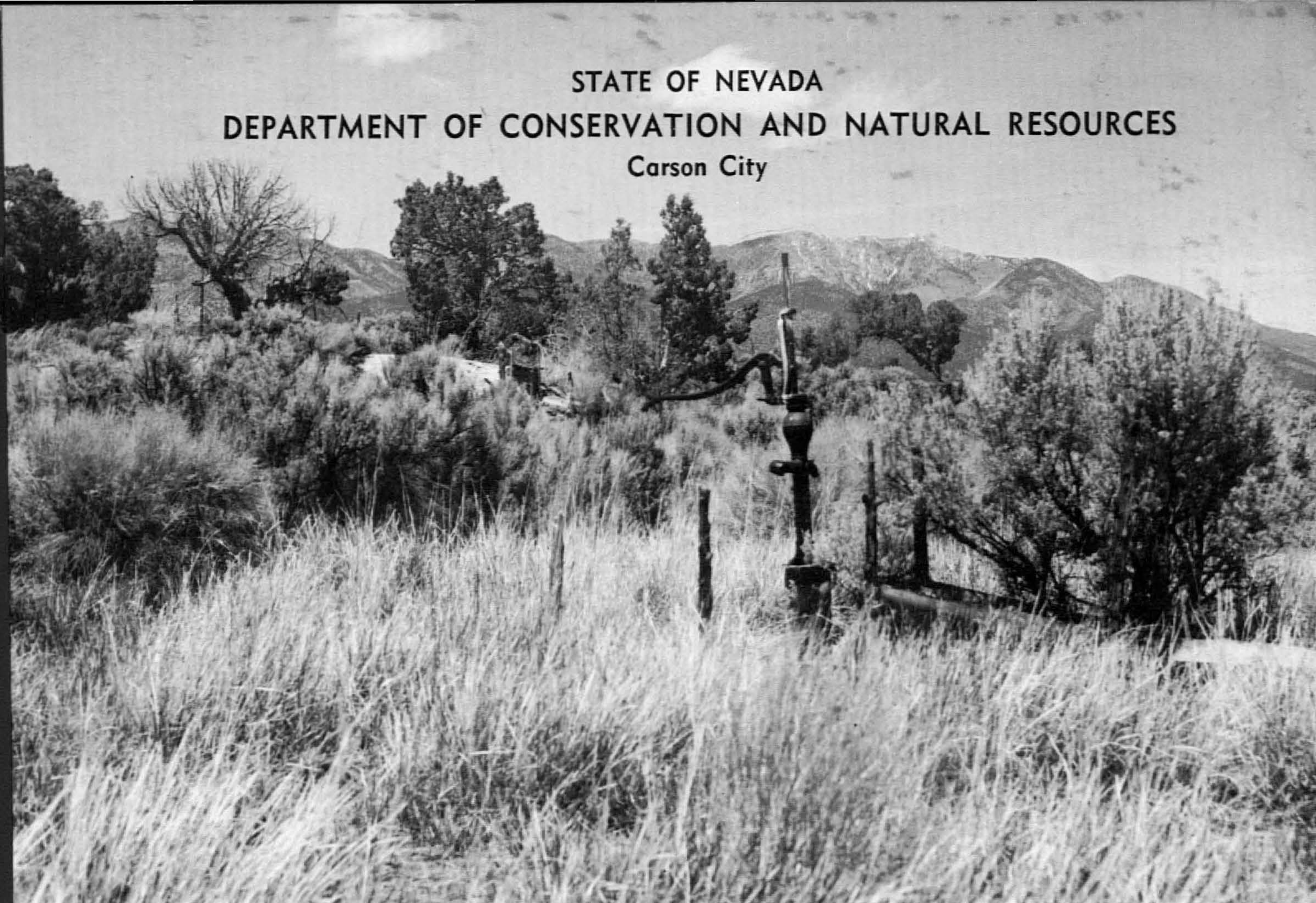
STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Carson City



View of Troy Peak

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 18

GROUND–WATER APPRAISAL OF GARDEN AND COAL VALLEYS, LINCOLN AND NYE COUNTIES, NEVADA

By

THOMAS E. EAKIN

Geologist

Price $1.00

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

JULY 1963

36 pages - 1 map - 7.16 / 8.16

Control works and earth fill dam in Garden Valley. View southwest of Control Works and dam in sec. 18, T. 2 N., R. 59 E. in Garden Valley. Dam was constructed to impound water from Little Cherry, Cottonwood and Pine Creeks for irrigation of land in Coal Valley at Oneota. Water was to be conveyed by a 4 to 5 mile ditch to points of proposed use. Dam was originally constructed in 1908. It was breached by high flows in 1909 and apparently 3 more times by 1916. Mr. L. Wadsworth reported that a flow of 3 to 4 cfs occurred at the dam in the spring of 1962.

COVER PHOTOGRAPH

View northwest of well 4N/58-23dl in Garden Valley. Heavy growth of phreatophytes around well reflect the shallow depth to water (10 feet) in this area. Grant Range and Troy Peak, altitude 11,312 feet, in background.

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FOREWORD

This report, the 18th in the series of reconnaissance ground-water studies which were initiated by action of the legislature in 1960, deals with the underground water resources of Garden and Coal Valleys in Nye and Lincoln Counties. The ground-water resources of some twenty-two valleys have been appraised in these eighteen reports.

The present appraisal was made by Thomas E. Eakin, geologist, U. S. Geological Survey.

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

Hugh A. Shamberger
Director
Department of Conservation
and Natural Resources

July, 1963.

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GROUND-WATER APPRAISAL OF GARDEN AND COAL VALLEYS, LINCOLN AND NYE COUNTIES, NEVADA

by

Thomas E. Eakin

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SUMMARY

The results of this reconnaissance of Garden and Coal Valleys suggest that the average annual recharge to the ground-water reservoir derived from precipitation within the drainage areas of the valleys may be on the order of 12,000 acre-feet. Ground-water discharge by evapotranspiration and by wells occurs largely in Garden Valley and is on the order of 1,500 to 2,000 acre-feet a year. Most of the discharge from the valleys is believed to be accomplished by underflow, largely through Paleozoic carbonate rocks, toward Pahranagat Valley. To the extent that the estimates of recharge and of discharge by evapotranspiration indicated above are correct, the discharge by underflow through bedrock is on the order of 10,000 acre-feet a year.

The relatively great depths to water in most of the central part of the valley floor of Garden and Coal Valleys precludes low cost development of water in these areas, although this adverse feature may be desirable for some special purpose.

The northern part of Garden Valley includes an area of relatively shallow ground water--that is, the depth to water is less than about 25 feet in the eastern part of T. 4 N., R. 58 E., and in the western and northwestern part of T. 4 N., R. 59 E. The shallow depth to water in this area offers the possibility of developing moderate quantities of ground water at a reasonable cost. Recent drilling in this area indicates the occurrence of relatively fine-grained deposits. Development of moderate supplies of ground water from such deposits requires careful attention to the construction and development of wells.

INTRODUCTION

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

Recognizing this need, the State Legislature enacted special legislation (Chap. 181, Stats. 1960) for beginning a series of reconnaissance studies of the ground-water resources of Nevada. As provided in the legislation, these studies are being made by the U. S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources.

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

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

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

The scope of this report is limited to a general description of some of the physical conditions of Garden and Coal Valleys, including observations of the interrelations of climate, geology, and hydrology as they affect ground-water resources. Possible movement of ground water between valleys is discussed. The report also includes a preliminary estimate of the average annual recharge to the ground-water reservoir and a discussion of the discharge from the valleys.

Acknowledgements

The author wishes to express his appreciation for the field assistance of Howard Ness in this study. Residents of the area were most kind and helpful in providing information. Special acknowledgement is due Mr. L. Wadsworth for taking much time and effort in providing information on the area which was most valuable in the preparation of this report.

Location and General Features of the Area

Garden and Coal Valleys are largely in western Lincoln County but extend northward about 10 miles into adjacent Nye County (fig. 1). They lie within an area bounded by about lat 37°29' and 38°16' N., and long 115°04' and 115°47' W. Garden Valley is west of Coal Valley; together they extend about 41 miles in a

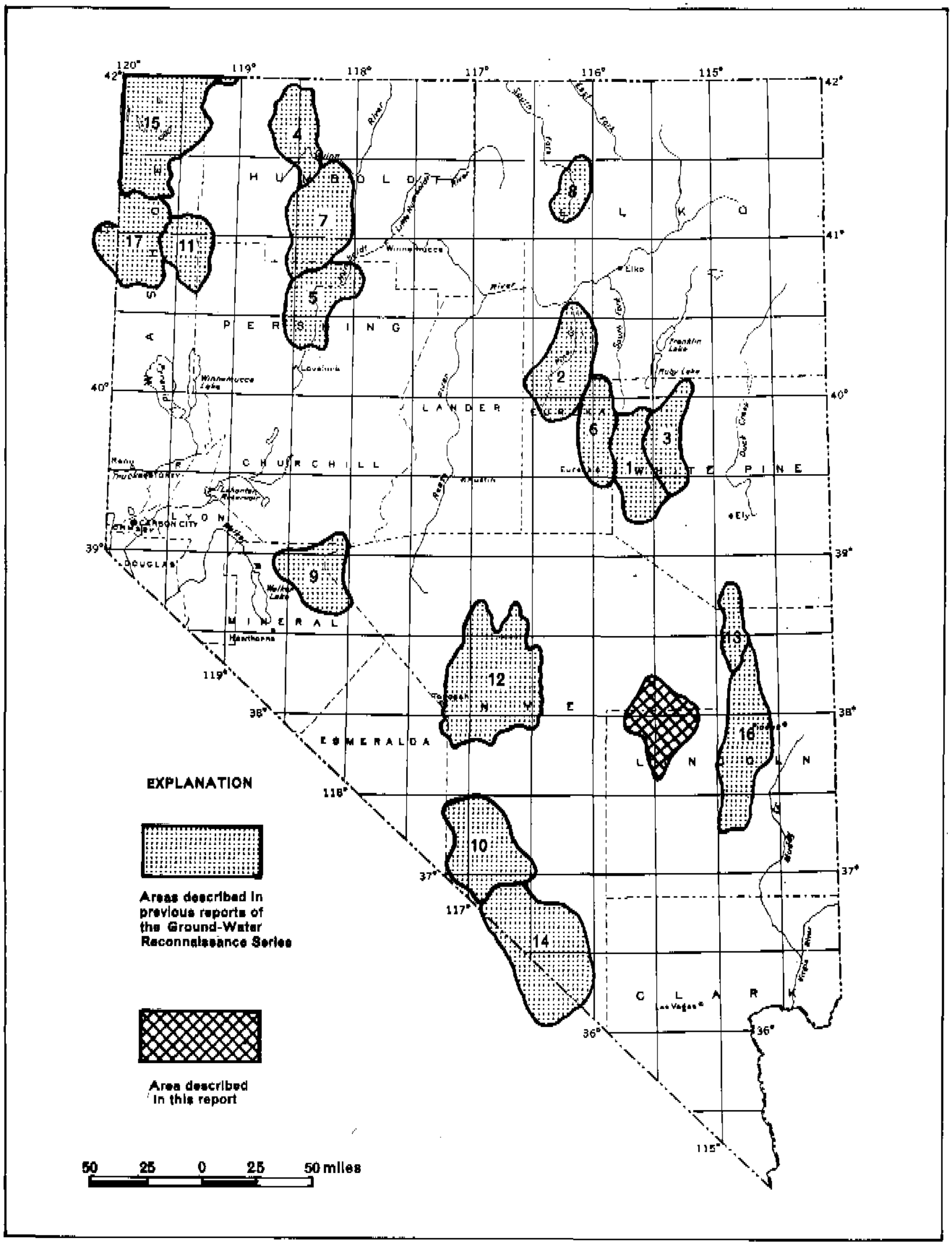

Figure 1. **MAP OF NEVADA**

showing areas described in previous reports of the ground-water reconnaissance series and the area described in this report.

north-south direction and 42 miles in an east-west direction. Their areas within the drainage divides are about 500 and 450 square miles, respectively.

The valleys are somewhat remote. Access to them is by graded roads and trails. Southern Coal Valley and Garden Valley can be reached by an improved road from the north end of Pahranagat Valley. Principal access to Garden Valley is by graded and partly graveled road from Sunnyside in White River Valley. Adaven is about 38 miles by road southwest of Sunnyside and is in the northwestern part of Garden Valley. Several graded roads and trails permit access to various parts of the valleys in good weather.

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

Climate:

The climate of the lowlands of Garden and Coal Valleys is semiarid. Precipitation and humidity ordinarily are low, and summer temperatures and evaporation rates are high. Precipitation is irregularly distributed within the valleys but generally is least on the valley floors and greatest in the mountains. Snow is common during the winter months and localized storms provide most of the summer precipitation. The daily and seasonal range in temperature is large.

Records of precipitation and temperature have been maintained since 1919 at Adaven (formerly Sharp) in northwestern Garden Valley. These records are published by the U. S. Weather Bureau. The average monthly and annual (1931-60) and annual precipitation (1913-61) are listed in table 1 for Adaven. The station at Adaven, at an altitude of about 6,250 feet, is in the canyon of Cherry Creek. The records may be affected somewhat by local influences of topography and exposure. Records for Alamo and Caliente for the same periods also are listed for general reference.

Table 1. --Summary of precipitation at Adaven, Alamo, and Caliente, Nev. (from published records of the U.S. Weather Bureau)

Average precipitation, in inches, 1931-60

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Adaven	1.51	1.57	1.43	1.17	.75	.51	.95	1.02	.61	.97	.85	1.27	12.67
Alamo	.70	.68	.68	.57	.45	.15	.73	.77	.32	.43	.43	.60	6.60
Caliente	.83	.79	.85	.70	.56	.39	.76	.92	.49	.89	.75	.86	8.79

Annual precipitation, in inches, 1931-61

Year	Adaven	Alamo	Caliente	Year	Adaven	Alamo	Caliente
1931	15.92	9.60	9.49	1947	6.51	--	7.47
1932	10.44	9.68	11.61	1948	8.99	2.75	5.23
1933	12.66	7.29	8.16	1949	11.67	6.09	10.03
1934	9.28	3.01	7.14	1950	7.79	5.32	2.92
1935	12.79	5.58	9.43	1951	9.49	4.89	10.15
1936	16.82	8.97	11.60	1952	15.77	6.88	11.52
1937	12.74	6.30	6.84	1953	6.83	1.98	4.66
1938	21.32	11.15	--	1954	16.09	5.96	9.31
1939	16.94	7.42	9.41	1955	19.09	5.65	7.13
1940	9.65	6.16	7.49	1956	4.42	1.23	4.78
1941	23.55	14.91	18.73	1957	14.24	7.43	10.88
1942	5.19	2.94	6.63	1958	16.42	6.47	8.13
1943	14.98	--	11.70	1959	8.45	4.42	4.83
1944	8.71	--	7.96	1960	11.59	6.02	9.77
1945	17.43	10.65	11.60	1961	12.47	3.63	8.80
1946	14.28	--	12.36				

Figure 2 is a graph of the cumulative departure from average annual precipitation for the period 1919-62. Downward trends of the graph indicate a year or succession of years when precipitation was below average; upward trends indicate a year or succession of years when precipitation was above average. Thus, it may be seen that below average precipitation generally occurred in the period 1922-29, 1941-44, 1946-53. Above average precipitation most prominently occurred during the period 1934-41. Additionally, above average precipitation occurred in the years 1945 and 46, 1954 and 55, and 1957 and 58. The record at Adaven illustrates that successions of years of above and below average precipitation are irregular in duration and frequency. This characteristic is well known to residents in the region.

Table 2 lists average monthly and annual temperature at Adaven, Alamo, and Caliente for the period 1931-60. Maximum and minimum temperatures recorded are: at Adaven, 100°F. on July 18, 1959, and July 19, 1960, and -20°F. on January 9, 1937; at Alamo, 115°F. on August 11, 1940, and -9°F. on January 9, 1937; and at Caliente, 109°F. on June 22, 1948, and -31°F. on January 9, 1937.

Low humidity and high temperature and wind movement favor high evaporation rates. Evaporation-pan data recorded at Caliente since 1956 are listed in table 3. Caliente is the station recording evaporation data nearest to Garden and Coal Valleys. These data should be considered only generally indicative of evaporation in Garden and Coal Valleys. As suggested by the record at Caliente, evaporation from May through September accounts for most of the annual total evaporation, and seasonal evaporation averages about 50 inches for the period of record.

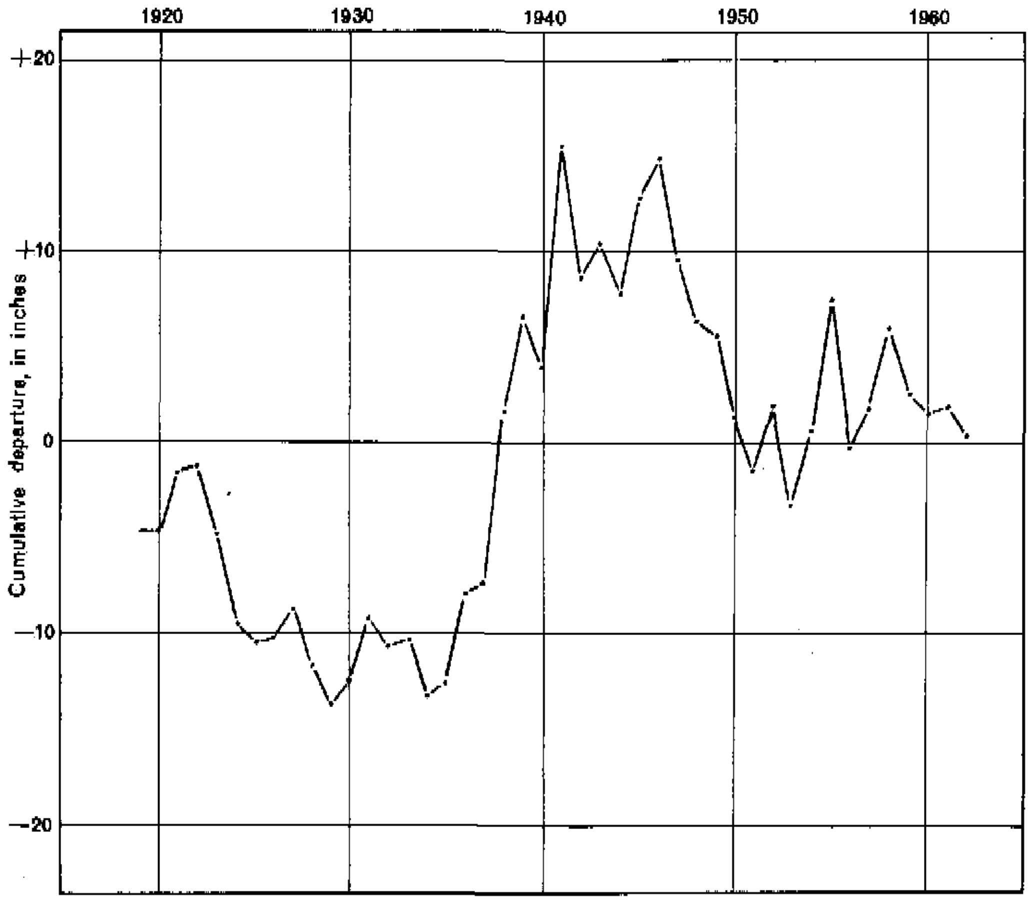

FIGURE 2. Graph of cumulative departure from average annual precipitation, at Adaven, Nevada for the period 1918 - 1962

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

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

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Adaven	29.1	31.4	37.6	46.2	53.8	62.6	70.2	68.3	61.8	50.4	39.1	32.5	48.6
Alamo	36.6	41.1	47.2	56.1	62.9	71.9	79.2	76.9	69.7	58.6	46.8	39.3	57.1
Caliente	30.4	36.0	43.7	52.2	60.2	68.5	75.9	73.9	65.9	54.1	41.5	33.5	52.9

Table 3. --Pan evaporation, in inches, at Caliente, Nevada, 1956-62

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

Year	March	April	May	June	July	August	September	October	Nov.
1956			7.42	b12.55	11.10	10.86	8.07	b4.65	2.05
1957	3.97	6.76	6.33	10.66	11.45	b11.60	7.54		
1958		b6.39	9.35	11.99	12.39	11.73	7.56	5.00	
1959		7.56	9.59	11.89	11.71	10.10	7.18		
1960			9.78	10.94	11.16	10.87	7.34	4.06	
1961		7.19	9.40	12.07	11.06	7.90	6.68	b4.07	
1962		7.93	8.27	10.93	11.52	11.41	7.50	4.53	

b/ Adjusted to full month by Weather Bureau

The growing season in Garden and Coal Valleys varies from year to year and with location within the valleys. Hardman and Mason (1949, p. 12) show that a narrow band along the alluvial slope on the west side of Garden Valley is in the "Upper Humboldt" growing season zone. Much of the lower part of Garden Valley is in the "Lower Humboldt" growing season zone, and much of the floor of Coal Valley is in the "Lahontan" growing season zone. As described by Hardman and Mason (p. 14-15), those zones are characterized as follows:

"Upper Humboldt Zone: This zone is entirely a ranching and grazing area because of low growing season temperatures and of the hazard to tender plants of killing frosts in the summer months. Cereal grains, one crop of alfalfa, and hardy vegetables can be grown in favorable locations. Meadow hay is the major harvested crop. Large areas are devoted to native pastures."

"Lower Humboldt zone: The growing season permits the production of cereal grains, alfalfa, clover, grasses, and hardy vegetables and fruits. Corn will not mature in average seasons and, except near the lower limit of the zone, only two cuttings of alfalfa are made. This zone covers the transition area from general farming to stock ranching."

"Lahontan Zone: The growing season in this zone permits three cuttings of alfalfa, the production of many vegetables and hardy fruits, and of early maturing varieties of corn."

In recent years the U.S. Weather Bureau records list freeze data rather than killing frosts; the dates are listed for the occurrence of the last spring minimum and the first fall minimum for temperatures of 32°F. or below, 28°F. or below, 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 occurrence for the respective temperature groups are given. The following tabulation lists the number of days for the first three temperature groups, recorded at Adaven, Alamo, and Caliente for the period 1952-61.

Number of days between the last spring minimum temperature and the first fall minimum temperature for Adaven, Alamo, and Caliente, for the period 1952-61

	32°F or below			28° F or below			24° F or below		
Year	Adaven	Alamo	Caliente	Adaven	Alamo	Caliente	Adaven	Alamo	Caliente
1952	147	177	183	213	212	208	222	227	227
1953	118	117	122	148	150	144	151	208	191
1954	126	219	151	136	230	206	176	257	210
1955	126	141	137	126	178	178	183	208	186
1956	150	134	151	163	183	--	193	202	204
1957	133	163	138	155	169	162	168	238	227
1958	135	173	134	177	176	152	179	222	191
1959	130	151	135	134	184	150	197	228	200
1960	138	144	141	164	164	189	198	198	205
1961	129	129	136	156	156	179	188	188	183
Average	133	154	142	157	180	174	186	217	202

Physiography and Drainage:

The Grant and Quinn Canyon Range on the west side of Garden Valley topographically dominate the area. Troy Peak, altitude 11,312 feet, is the highest point (photograph 1). Crest altitudes are higher than 9,000 feet for a combined distance of about 15 miles. The Worthington Mountains bound the southwest side of Garden Valley and connect with the Quinn Canyon Range by a bedrock and alluvial divide.

The arcuate Seaman Range bounds the east side of Coal Valley. At the northern end the Range curves northwestward, connects with the Golden Gate Range by a relatively low bedrock and alluvial pass. The northwestward trend continues and connects with the Grant Range.

On the south, the Worthington Mountains, and the Golden Gate and Seaman Range merge to form part of the mountain mass of Mt. Irish. The Golden Gate Range separates Garden and Coal Valleys through a series of mountains and saddles. The range is broken by a gap in T. 2 N., R. 59 E. through which surface water occasionally flows from Garden to Coal Valley.

Much of the floor of Garden Valley, which has a general slope toward the gap in T. 2 N., R. 59 E., lies at an altitude between about 5,100 and 5,600 feet. In Coal Valley much of the floor lies at an altitude of slightly less than 5,000 feet. This is about 1,000 feet higher than the floor of the north end of Pahranagat Valley, 8 to 10 miles to the south. In effect then, Garden and Coal Valleys are relatively high with respect to the land-surface altitude along the White River channel to the east. This differential apparently is an important factor in the occurrence and movement of ground water in these valleys.

During Pleistocene time, a shallow lake occupied the floor of Coal Valley. Several strand or beach lines still reflect different lake levels. Much of the water supplied to the Pleistocene lake probably was derived by runoff largely from the Garden Valley drainage area.

Present day runoff is much less than that in Pleistocene time. Streamflow occurs only in Little Cherry, Pine, and Cottonwood Creeks which drain parts of the Quinn Canyon and Grant Ranges. Even these creeks ordinarily do not flow perennially much beyond the contact of the bedrock and alluvial slope. Rather, the flow in short sections of the streams is maintained by spring discharge in the canyons. During short periods in the spring, runoff from these streams may extend into the normally dry channels in the central part of Garden Valley. When runoff conditions are exceptionally favorable, the flow in these channels extends across Garden Valley, through the gap in T. 2 N., R. 59 E., into Coal Valley. The occurrence of such flow in the early 1900's led to efforts to develop an irrigation area at Oneota in Coal Valley, a short distance south of the gap. The dam and control works shown in photograph 2 form a part of this development. However, the frequency of such flow apparently was too low to sustain irrigation. Significant amounts of runoff from most of the other streams result mainly from infrequent high-intensity storms.

GENERAL GEOLOGY

The following discussion of geology is based largely on a reconnaissance geologic map of Lincoln County prepared by Tschanz and Pampeyan (1961) and on a reconnaissance geologic map of northern Nye County by F. J. Kleinhampl (written communication, 1963).

In this report, the rocks of Garden and Coal Valleys are divided into two groups and further, each group is divided into two units. The distribution of the four units is shown on plate 1.

Kellog (1960, p. 189) in his study of the southern Egan Range noted that about 80 percent of the rocks in the Paleozoic section, which is about 30,000 feet thick, is limestone and dolomite. The southern end of the Egan Range is about 20 miles north of the Seaman Range. Tschanz (1960, p. 198) indicates that the total thickness of Paleozoic rocks exposed in northern Lincoln County is between 30,000 and 33,000 feet. As described by Tschanz, carbonate (limestone and dolomite) rocks probably comprise about 60 percent of the total section. Although the exposed thickness of Paleozoic rocks in Garden and Coal Valleys may not be as great; it is presumed that the total thickness of these rocks and the proportion of carbonate rocks in Garden and Coal Valleys is similar to those in the areas to the east and north.

On plate 1 the Paleozoic carbonate rocks are shown as one unit of the bedrock group because of their significance in the ground-water hydrology of the region. The second unit of the bedrock group includes Paleozoic shale, sandstone, quartzite, and conglomerate, and Tertiary volcanic rocks composed chiefly of welded tuff, but including tuff, lava flows, and some sedimentary units, which generally yield little water.

The second group of rocks is designated valley fill and is divided into two units--older and younger valley fill. The older unit consists of unconsolidated to partly consolidated silt, sand, and gravel derived from adjacent highland areas, but includes some rocks of volcanic origin. It ranges in age from Tertiary to Quaternary. The unit was deposited largely under subaerial and lacustrine environments. Although data are not available to determine the maximum thickness of the unit, it probably is at least several hundred feet thick and many exceed a thousand feet.

The younger valley fill unit includes unconsolidated clay, silt, sand, and gravel of late Quaternary age and on the map is represented only in Coal Valley where it is relatively fine-grained. Obviously, recent deposits along numerous channels are of Recent age. As defined, the unit probably is not more than a few tens of feet thick. The valley fill probably is underlain by bedrock similar to that exposed in the mountains.

Water-Bearing Properties of the Rocks:

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

Whether existing fractures or solution openings have extensive hydraulic connection is related to the geologic history of the rocks. In the absence of detailed information, ground-water movement through carbonate rocks in this region may occur both through fractures and solution openings. Certainly, the large quantity of ground water issuing from fractures and solution openings, such as those at Crystal and Ash Springs in Pahranagat Valley, is a dramatic demonstration that ground-water movement through Paleozoic carbonate rocks occurs in this region of Nevada.

Caves in the Worthington Mountains further attest to the fact that solution openings reach sizable proportions. The location of these caves suggest that they may have been formed largely, if not entirely, in the relatively recent geologic past, as the mountains have been in about their present form probably since late Pliocene to Pleistocene time.

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

The unconsolidated sand and gravel of the valley fill in Garden and Coal Valleys is capable of transmitting ground water freely. However, most of the valley fill probably is composed of deposits of fine sand and silt having relatively low permeability, and where saturated, transmit water much more slowly than coarse sand and gravel. Deposits of silty clay and clay may transmit water so slowly to wells that they will not yield supplies adequate for stock-watering purposes. Some of the valley fill probably is moderately consolidated or cemented which further reduces their capacity to transmit large supplies of water to wells.

GROUND-WATER APPRAISAL

Occurrence and Movement of Ground Water:

Ground water in Garden and Coal Valleys is derived largely from precipitation on the Quinn Canyon and Grant Ranges; lesser amounts are derived from precipitation on the Seaman Range and Worthington Mountains. Recharge from the Golden Gate Range is meager and largely occurs in the southern part of the range. In general, ground water moves from the recharge areas toward the lower parts of the valleys. The general movement in northern and central Garden Valley probably is southeastward from the Quinn Canyon and Grant Ranges toward Coal Valley. The movement in Coal Valley probably has a more southerly component. Ground-water movement from Garden Valley to Coal Valley and from Coal Valley to Pahranagat Valley probably occurs predominantly by underflow, and most likely is largely through Paleozoic carbonate rocks. This is in contrast with the hydrologically closed valleys commonly found in the Basin and Range Province.

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

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

In addition to hydraulic controls, the water-bearing character of the rocks are important factors in the movement, or impedance to movement, of ground water. Where bedrock in the mountains enclosing a topographically closed valley is relatively impermeable, ground water normally is part of a closed hydrologic system. Where the bedrock formations are at least locally permeable, the ground-water system may be hydrologically open.

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

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

In Garden Valley most of the recharge is derived from the Quinn Canyon and Grant Ranges on the northwest sides of the valley. From the areas of recharge ground water moves generally southeastward toward the Golden Gate Range which apparently has little or no effect as a recharge boundary in the northern two-thirds of the range. It is likely that ground water moves from Garden Valley into Coal Valley through the Golden Gate Range, possibly anywhere northwest from about the northern part of T. 1 N.

The depth to water below land surface is within a few tens of feet in the valley fill along the northwest side of Garden Valley, northward from T. 3 N. Southeastward, apparently the depth to water increases substantially, based on information for well 2N/59-22b1 near Oneota in Coal Valley. According to Carpenter (1915, p. 69), the well was dug to a depth of 250 feet without encountering water. Carpenter inferred that ground water, if it is escaping through the gap between Garden and Coal Valleys, has not filled the sediments in the gap to within 250 feet of land surface. If this hypothesis is correct, the depth to water in the northeastern part of T. 2 N., R. 58 E. should be at least 250 feet and possibly substantially more. This is supported indirectly by the fact that the depth to water in well 3N/58-15b1 reportedly is about 235 feet, altitude about 5,040 feet.

In southern Garden Valley, the reported depth to water in well 1S/57-3a1 is 570 feet, and is at an altitude of about 5,020 feet. The direction of movement from this point cannot be identified from the available information. If movement is lateral in the valley fill, it probably would be northeastward away from the Worthington Mountains to Coal Valley and thence southeastward. However, in the vicinity of the well ground-water movement might be downward into Paleozoic carbonate rocks, and the general direction of movement might be southeastward, provided that recharge derived from the southern part of the Golden Gate Range did not impose a hydraulic barrier to movement beneath the range in that direction.

In Coal Valley information on depth to water below land surface is even more meager. The previously mentioned well near Oneota indicates that the depth to water in that area is greater than 250 feet. Well 2S/60-1dl in upper Seaman Wash, about 5 miles southeast of the playa in Coal Valley, is dry at about 500 feet below land surface. Thus, the water level is below an altitude of about 4,400 feet. This suggests that the depth to water beneath the playa in Coal Valley may be below an altitude of 4,400 feet, or 500 feet below land surface. It is possible that the altitude of the water table in Coal Valley may approach the altitude of the water table in northern Pahranagat Valley, which is about 3,900 feet. If this assumption is correct, the depth to water beneath the southeastern part of the playa in Coal Valley may be on the order of 1,000 feet.

A well recently drilled by the Bureau of Land Management in the gap in the northeastern part of T. 2 S., R. 58 E., encountered water at a depth of about 110 feet, or at an altitude of about 5,775 feet. It is inferred that the water level is maintained by recharge from the basin southwest of the gap and that the depth to water in Coal Valley rapidly increases eastward with increasing distance from the gap.

Except for the northwest part of Garden Valley, depth to water apparently is too great for ground-water discharge by evapotranspiration from Garden and Coal Valley. Some ground water is discharged by phreatophytes along part of the lower alluvial slope northeastward from T. 3 N. in Garden Valley and along some channels near or in the mountains. However, the total quantity of ground-water discharge by evapotranspiration is only a small fraction of the estimated total recharge. To the extent that the estimated recharge and estimated discharge by phreatophytes are correct, the imbalance between the two (p. 18) must be discharged from the area by underflow through bedrock, most likely through Paleozoic carbonate rocks. A somewhat similar situation has been described for Cave Valley (Eakin, 1962) to the northeast, and for Dry Lake and Delamar Valleys to the east and southeast (Eakin, 1963). Deep water levels in Garden and Coal Valleys and other information led Carpenter (1915, p. 69) to state, "Any water that might collect in the unconsolidated sediments /of Coal Valley/ would be likely to find an underground passage through the bedrock formations into the unconsolidated material underlying Pahranagat Valley."

The ground water at shallow depth, which supplies a few shallow wells in the northwestern part of Garden Valley, apparently is semiperched. However, water levels in well 3N/58-15bl (water-level altitude about 5,040 feet) in the northern part of the valley and well 1S/57-3al (water-level altitude about 5,020 feet) in the southern part of Garden Valley may be representative of the water table in the main part of the valley fill.

To examine further the possibility of underflow through bedrock, consideration may be given to water-level altitudes in adjacent Pahrock Valley to the east and Pahranagat Valley to the south and southeast (fig. 3). The White River channel flows southward in these two valleys. Along the White River channel north of Coal Valley in the southeast part of T. 5 N., R. 60 E., the water-level altitude is about 5,100 feet or about 25 feet below land surface. Southeastward about 12 miles along the channel, the water-level altitude is about 4,835 feet, or about 217 feet below land surface in well 3N/62-8c1. Southeastward another 5 miles, the water-level altitude is about 4,770 feet, or about 253 feet below land surface in well 3N/62-35a1. Southward another 5 miles, a dry hole drilled to 800 feet by the Bureau of Land Management, indicates a water-level altitude below about 4,135 feet. In northern Pahranagat Valley, about 30 miles to the south-southwest, Hiko Spring is at an altitude of about 3,890 feet, and ground water in the valley fill of Pahranagat Valley west of the spring is near land surface at an altitude of about 3,860 feet. Thus, water levels along the White River channel east of Coal Valley have a generally southward gradient and, at equivalent latitudes, apparently are lower than water levels in Garden and Coal Valleys. Therefore, based on the potential hydraulic gradient, ground water from Garden and Coal Valleys probably moves toward White River valley.

In further consideration of the possibility of ground-water discharge by underflow from Garden and Coal Valleys, the Paleozoic carbonate rocks appear to be the most favorable rocks to transmit ground water. A number of the springs in upper White River valley issue from or adjacent to carbonate rocks. Hot Creek Springs, in the southern part of the valley, discharge at the rate of about 15 (cfs) cubic feet per second. These springs are only about 10 miles northeast of the north end of Garden Valley. The springs in Pahranagat Valley also demonstrate that ground water moves through solution openings and fractures in carbonate rocks. The combined discharge of Hiko, Crystal, and Ash Springs is on the order of 35 cfs. Hiko Spring is only about 10 miles south of the southern drainage divide of Coal Valley. Ground-water movement through similar Paleozoic carbonate rocks in Cave Valley, which is east of the White River valley and northeast of Coal Valley, has been described by Eakin (1962). Caves in the Worthington Mountains attest to the fact that solution openings occur in the Paleozoic carbonate rocks in this area. Drilling in the Nevada Test Site, about 80 miles south-southwest of Garden and Coal Valleys, has shown that the Paleozoic carbonate rocks commonly transmit ground water more readily than do the Paleozoic clastic rocks and Tertiary tuff (Winograd, 1962, p. 110). Thus, the Paleozoic carbonate rocks probably afford the best opportunity for ground-water movement between basins.

Plate 1 shows the surficial distribution of Paleozoic carbonate rocks in Garden and Coal Valleys. They are exposed extensively in Grant and Quinn River Ranges along the northwest part of Garden Valley, in the Worthington Mountains, in the Golden Gate Range, the northern part of the Seaman Range, and in the Mt. Irish area at the south end of Coal Valley. Elsewhere Paleozoic clastic and Tertiary volcanic rocks are exposed. However, in general, Paleozoic rocks underlie them, and carbonate rocks undoubtedly form a large proportion of the Paleozoic rocks in the area.

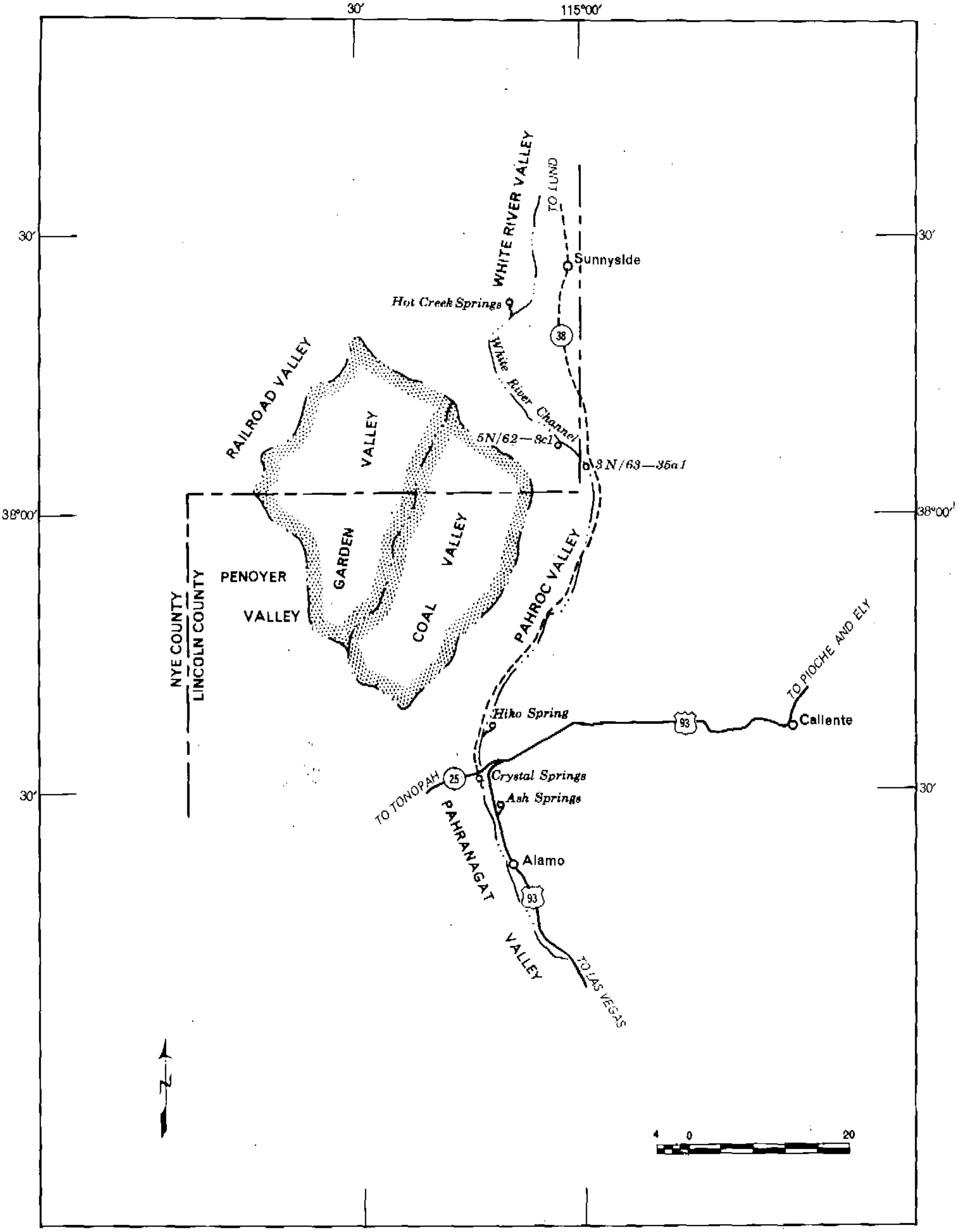

FIGURE 3. Sketch map showing relation of Garden and Coal Valleys to adjacent, areas

Carbonate rocks are exposed in Pahranagat Valley and southward (Tschanz and Pampeyan, 1961). Accordingly, the distribution of Paleozoic carbonate rocks in this area is favorable for the occurrence and movement of ground water southeastward from Garden and Coal Valleys to Pahranagat Valley.

If the Paleozoic carbonate rocks are capable of transmitting ground water from Garden and Coal Valleys, the converse may be true, that is, ground water may enter Garden and Coal Valleys through carbonate rocks from areas upgradient from them. Precipitation in the Grant and Quinn Canyon Ranges and in the Worthington Mountains supplies most of the recharge to Garden Valley and undoubtedly is sufficient to maintain a hydraulic divide between Railroad Valley to the northwest and Penoyer Valley to the southwest of Garden Valley. The floor of Railroad Valley is at an altitude of about 4,650 feet and the floor of Penoyer Valley is at an altitude of about 4,750 feet. To the north in upper White River Valley, water-level altitudes in the axis of the valley are higher than the deeper water levels in Garden Valley. For example, the water-level altitude of Hot Creek Springs in T. 6 N., R. 61 E. is about 5,150 feet, and in well 3N/58-15b1 in Garden Valley the water-level altitude is about 5,040 feet. However, about 20 miles due east of the well in Garden Valley the water-level altitude beneath White River channel apparently is about 4,800 feet. Thus, the potential gradient favors ground-water movement at depth more or less along the channel of White River. Additionally, recharge from the Grant Range in the latitude of the north end of Garden and Coal Valleys very likely imposes a hydraulic high southeastward across the north end of the valleys.

In summary, most or all of the ground-water recharge to Garden and Coal Valleys is believed to be derived from precipitation within their surficial drainage area. Ground water moves in the valley fill from the areas of recharge generally toward the topographically low parts of the valleys, and thence south or southeastward in the carbonate rocks toward Pahranagat Valley.

Estimated Average Annual Recharge:

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

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

The average precipitation used for the respective zones, beginning with the zone of 8 to 12 inches of precipitation, is 10 inches (0.83 foot), 13.5 inches (1.12 feet), 17.5 inches (1.46 feet), and 21 inches (1.75 feet). The percentages of the average precipitation assumed to represent recharge for each zone are: less than 8 inches, 0; 8 to 12 inches, 3 percent; 12 to 15 inches, 7 percent; 15 to 20 inches, 15 percent; and more than 20 inches, 25 percent.

Table 4 summarizes the computation of recharge for Garden and Coal Valleys. The recharge (column 5) for each zone is obtained by multiplying the figures in columns 2, 3, and 4. Thus, for the zone of 15 to 20 inches of precipitation in Garden Valley, the computed recharge is 15, 000 (acres) times 1.46 (feet) times 0.15 (15 percent) = about 3, 300 acre-feet. The estimated total average annual recharge to ground water is 10, 000 acre-feet to Garden Valley and 2, 000 acre-feet to Coal Valley.

Table 4. --Estimated average annual ground-water recharge from precipitation in Garden and Coal Valleys, Nev.

(1) Precipitation Zone (in inches)	GARDEN VALLEY				COAL VALLEY			
	(2) Approximate area of zone (acres)	(3) Average annual precipitation (feet)	(4) Percent recharged	(5) Estimated recharge (ac. ft.) (2x3x4)	(2) Approximate area of zone (acres)	(3) Average annual precipitation (feet)	(4) Percent recharged	(5) Estimated recharge (ac. ft.) (2x3x4)
20+	5,000	1.75	25	2,200	--	--	---	--
15-20	15,000	1.46	15	3,300	400	1.46	15	100
12-15	35,000	1.12	7	2,700	6,700	1.12	7	500
8-12	81,000	.83	3	2,000	65,000	.83	3	1,600
8-	180,000	--	--	--	219,000	--	--	--
	316,000 about 490 square miles	Estimated average annual recharge (rounded)		10,000	219,000 about 455 square miles	Estimated average annual recharge (rounded)		2,000

Estimated Average Annual Discharge:

Only a small amount of ground water is discharged from Garden and Coal Valleys by evapotranspiration. Ground water evaporates from the soil or is transpired by vegetation where water levels are within a few feet or a few tens of feet below land surface--that is, locally along some stream channels and spring areas and in 2,000 to 3,000 acres of relatively shallow ground water in northern Garden Valley. Most of the springs have a relatively small discharge which is subsequently discharged by evapotranspiration. Several springs in Cherry Creek Canyon provide a base flow for irrigation in the canyon and may have a combined discharge of as much as 2 cfs in some years. Most of this flow is evaporated or transpired in the irrigated fields and along the channel. Discharge by wells in Garden Valley provides water for stock and domestic supply at the ranches, but in aggregate it is small. Well 3N/57-16c1 provides some ground water for supplemental irrigation in relatively dry years.

The aggregate discharge of ground water by evapotranspiration from springs and phreatophyte areas and wells in the valleys probably does not exceed 1,500 to 2,000 acre-feet a year. Nearly all of this discharge occurs in Garden Valley.

Most of the ground water moving through Garden and Coal Valleys is discharged by underflow through bedrock, probably largely through Paleozoic carbonate rocks. To the extent that the estimate of total recharge for the two valleys is correct (12,000 acre-feet), ground-water underflow from the valleys through the carbonate rocks may average about 10,000 acre-feet a year.

Perennial Yield:

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

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

The ground-water systems in Garden and Coal Valleys, as presently understood, are such that economic considerations probably control the perennial yield. The substantial depth to water in much of Coal Valley and most of the lower part of Garden Valley more or less precludes large-scale withdrawals for most uses.

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

Whether the magnitude of perennial yield ultimately equals total recharge to the valley depends upon the relative location of the area of pumping with respect to the several areas of recharge to the valley, the relation of the area of pumping with respect to the principal area of ground-water discharge from the valley, and the altitude of economic pumping levels with respect to the altitude of water levels in areas of natural discharge. In Garden and Coal Valleys, the costs of pumping relatively large quantities of ground water to modify appreciably the natural ground-water system and salvage all of the natural discharge undoubtedly would be prohibitive for all but the most exceptional water requirements. However, to the extent that substantial development might occur, the area north of T. 3 N. may be situated most favorably. Here present water levels are relatively shallow and the area is located favorably for the interception of part of the recharge from the Grant Range north of Adaven. Interception of most of this recharge, however, may require that water levels be drawn down several hundred feet or more.

Ground Water in Storage:

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

Chemical Quality:

The chemical quality of the water in most ground-water systems in Nevada varies considerably from place to place. In recharge areas the chemical concentration of the water normally is very low. However, as the ground water moves through the system to discharge areas it comes into contact with soluble rock materials for long periods of time. 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 rock materials, by the time the water is in contact with the rocks, and by the temperature and pressure in the ground-water system.

No samples from Garden and Coal Valleys have been analyzed for chemical constituents. However, based on the general relation of quality of ground water to rock types, ground water that has traveled only a short distance in alluvium, that is, near sources of recharge, would tend to be low in dissolved solids. The predominant ions in ground water that has moved largely in Paleozoic carbonate rocks or alluvium derived from Paleozoic carbonate rocks usually are calcium, magnesium, and bicarbonate. Ground water that has moved in Tertiary volcanic rocks or detritus from volcanic rocks commonly have a sodium-bicarbonate character. Thus, ground water in the northwestern part of Garden Valley, northward from about Adaven, would be expected to have a relatively low dissolved-solids content and to be a calcium-magensium-bicarbonate type. Southward, opposite the Quinn Canyon Range, the dissolved-solids content might also be relatively low but the water probably would be a sodium-bicarbonate type due to the widespread occurrence of volcanic rocks in the mountains in that area.

Development:

At different times in the past, there has been considerable interest in developing parts of Garden and Coal Valleys for irrigation. In the early 1900's a substantial though unsuccessful effort was made toward an agricultural development at Oneota in Coal Valley. The basis of the development was a ditch system several miles long that was to carry the flow of Cherry, Cottonwood, and Pine Creeks from about the gap to the proposed farming area. An earth-filled dam in sec. 18, T. 2 N., R. 59 E., and diversion works provided some storage and control of the stream flow. The dam is breached, showing that fairly large flows reached this point since its construction. Among other possible problems, it is virtually certain that streamflow to the gap has not been of sufficient annual frequency and volume to maintain an irrigation economy.

In the mountains, Cherry, Cottonwood, and Pine Creeks provide water for irrigation of 100 acres or less. Irrigation is partly maintained by spring discharge that supports the low flow in segments of the streams. Irrigation along Cherry Creek has been the most successful in maintaining a continuous operation. In recent years, well 3N/37-16cl has been used for supplemental water requirements on the Uhalde Ranch.

Currently in northern Garden Valley, Messrs. L. and E. Wadsworth are planning to develop ground water for irrigation about in sec. 6, T. 4 N., R. 59 E. Three wells were drilled in May 1963--one 200 feet and the other two about 80 feet deep. On preliminary tests, the deep well yielded about 100 gallons per minute, and the shallow wells yielded considerably less.

The poor yields apparently are due largely to the rather fine-grained deposits encountered in that area. As the depth to water is shallow in this area, the Messrs. Wadsworth are considering the possibility of developing additional water by cutting a trench below the water table and pumping from it to augment the water from the wells.

The principal use of ground water in Garden and Coal Valleys has been to provide water for range stock. Currently, available supplies from wells and stock ponds do not provide an adequate distribution to utilize all the range. This probably is due in part to the relatively high cost of developing stock water where the depth to water is several hundred feet.

Several springs in the Quinn Canyon and Grant Ranges provide water for stock and other small quantity requirements. The springs along Cherry Creek which are used for irrigation may yield 1 to 2 cfs but probably fluctuate moderately or considerably in response to variations in recharge in the mountains. Elsewhere, most springs discharge relatively small quantities of water--on the order of a few gallons a minute or less.

Collectively, ground water discharged from wells and by evapotranspiration from spring and phreatophyte areas probably does not exceed about 2,000 acre-feet per year, most of which is discharged by springs in Cherry Creek Canyon.

Northern Garden Valley, where the depth to water is shallow, appears to be the most favorable area for development in terms of cost. The current effort toward development in that area suggests that fine-grained deposits may require special attention to construction and development of wells to obtain adequate yields. Furthermore, some of the soils in this area may not be entirely satisfactory for some crops. Moreover the length of growing season may restrict full production of some crops. It is possible that industrial uses would warrant the cost of developing the available supply.

In central and southern Garden Valley and apparently in most of Coal Valley, the depth to water is at least several hundred feet below land surface and locally may be as much as about 1,000 feet below. The cost of developing ground water from these great depths probably is excessive for most purposes. If, however, the need is great enough, small to moderate supplies probably could be developed in these areas. Further, the adverse feature of considerable depth to water might be favorable for some purposes.

DESIGNATION OF WELLS

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

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

Thus, well number 3N/58-15b1 indicates that this well was the first well recorded in the northwest quarter of sec. 15, T. 3 N., R. 58 E.

Wells on plate 1 are identified only by the section number, quarter-section letter, and serial number. The township and range in which the well is located can be ascertained by the township and range numbers shown on the margin of plate 1. For example, well 3N/58-15b1 is shown on plate 1 as 15b1 and is within the rectangle designated as T. 3 N., R. 58 E.

The land grid shown on the base maps does not always coincide precisely with surveyed township and section corners on the ground. Time is not available during reconnaissance studies to determine specific legal locations for all wells that would permit adjustment of the land grid shown on the map. Rather, wells are located on the map primarily with respect to relative position to topographic and geologic features, as this is most important in the interpretation of hydrologic features. In northern Garden Valley, the land grid shown on plate 1 apparently is somewhat shifted from the actual location. For example, Mr. L. Wadsworth reports that his recently drilled wells are in sec. 31, T. 5 N., R. 59 E. On the map the wells plot as being in the SE 1/4 sec. 6, T. 4 N., R. 59 E., which is used for the well number as this grid location is consistent with the topography, trails, and other wells in that area.

Table 5a.--Records of selected wells in Garden Valley, Lincoln and Nye Counties, Nevada.

1S/57-3a1. Owner, John Uhalde. Drilled stock well; depth 620 feet. Equipped with jack pump and gasoline engine. Depth to water below land surface reported to be 570 feet.

3N/57-16c1. Owner, John Uhalde. Drilled irrigation well; depth 92 feet; casing diameter 16 inches; casing perforated 43 feet to 92 feet. Equipped with turbine pump and diesel engine. Measuring point, hole in pump base which is 1 foot above land surface. Depth to water below land surface 33.1 feet, May 9, 1963. Driller's log:

Material	Thickness (feet)	Depth (feet)
Soil	20	20
Clay	23	43
Sand and gravel	5	48
Clay	7	55
Clay and gravel in streaks	15	70
Clay	15	85
Gravel	35	90
Bedrock	2	92
Total depth		92

3N/58-15b1. Owner, John Uhalde. Drilled stock well; depth 260 feet; casing diameter 6 inches; casing perforated 235 feet to 260 feet. Equipped with jack pump and gasoline engine. Reported depth to water below land surface 235 feet, January 20, 1960. Driller's log:

Material	Thickness (feet)	Depth (feet)
Soil	3	3
Boulders, cemented	52	55
Silt, sandy	45	100
Gravel, cemented	130	230
Clay	5	235
Sand and gravel	25	260
Total depth		260

4N/58-23d1. Owner, not determined. Drilled well; casing diameter 10 inches. Equipped with hand pump. Measuring point, top of casing which is 2 feet above land surface. Depth to water below land surface 14.8 feet May 9, 1963.

4N/58-36a1. Owner, Bureau of Land Management. Drilled stock well; casing diameter 10 inches. Equipped with gasoline engine. Measuring point, top of casing which is at land surface. Depth to water below land surface 24.3 feet, May 9, 1963.

4N/59-6d1. Owners, L. and E. Wadsworth. Drilled irrigation well; depth 200 feet; casing diameter 12 inches. Measuring point, top of casing which is 1 foot above land surface. Depth to water below land surface 8.9 feet, May 9, 1963. Driller's log:

Material	Thickness (feet)	Depth (feet)
Soil, fine-grained	10	10
Sand, white, fine) Sand, brown, fine)	70	80
Silt and clay (?)	120	200
Total depth		200

4N/59-6d2. Owners, L. and E. Wadsworth. Drilled irrigation well; depth 80 feet; casing diameter 12 inches. Depth to water 10 feet, May 9, 1963. Water under partial artesian pressure. Driller's log:

Material	Thickness (feet)	Depth (feet)
Soil, fine-grained	10	10
Sand, fine and brown	70	80
Total depth		80

4N/59-6d3. Owners, L. and E. Wadsworth. Drilled irrigation well; casing diameter 12 inches; proposed depth 80 feet. Well incomplete as of May 9, 1963.

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4N/59-8b1. Owners, L. and E. Wadsworth. Dug irrigation well; diameter 5 feet by 5 feet. Equipped with centrifugal pump. Measuring point, at land surface. Depth to water below land surface 12.3 feet, May 9, 1963.

5N/59-32d1. Owner, B. Paris. Dug stock well. Equipped with cylinder pump and gasoline engine. Measuring point, at land surface. Depth to water below land surface 57.7 feet, May 9, 1963.

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Table 5b.--Records of selected wells in Coal Valley, Lincoln County, Nevada.

2S/58-11a1. Owner, Bureau of Land Management, Murphy Gap well. Drilled stock well; reported depth 188 feet; casing diameter 8 inches. Measuring point, top of casing which is 0.5 foot above land surface. Depth to water below land surface 110.14 feet, May 8, 1963. Driller's log:

Material	Thickness (feet)	Depth (feet)
Gravel	50	50
"Rhyolite"	70	120
Sand, gravel	65	185
Tuff	3	188
Total depth		188

2S/60-1d1. (Upper Seaman Wash drainage.) Owner, not determined. Drilled unused well; casing diameter 6 inches. Well dry 499 feet below top of casing, May 8, 1963.

1N/59-4b1. Owner, not determined. Dug unused well; diameter 5 feet by 5 feet. Well caved and dry at 25 feet.

2N/59-22b1. Owner, not determined. Dug unused well; diameter 5 feet by 5 feet. Well caved and dry at about 25 feet. Carpenter (WSP-365, p. 69) reported well dug 250 feet without finding water.

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3.	Ground-Water Appraisal of Long Valley, White Pine and Elko Counties, Nevada. June 1961, by Thomas E. Eakin.
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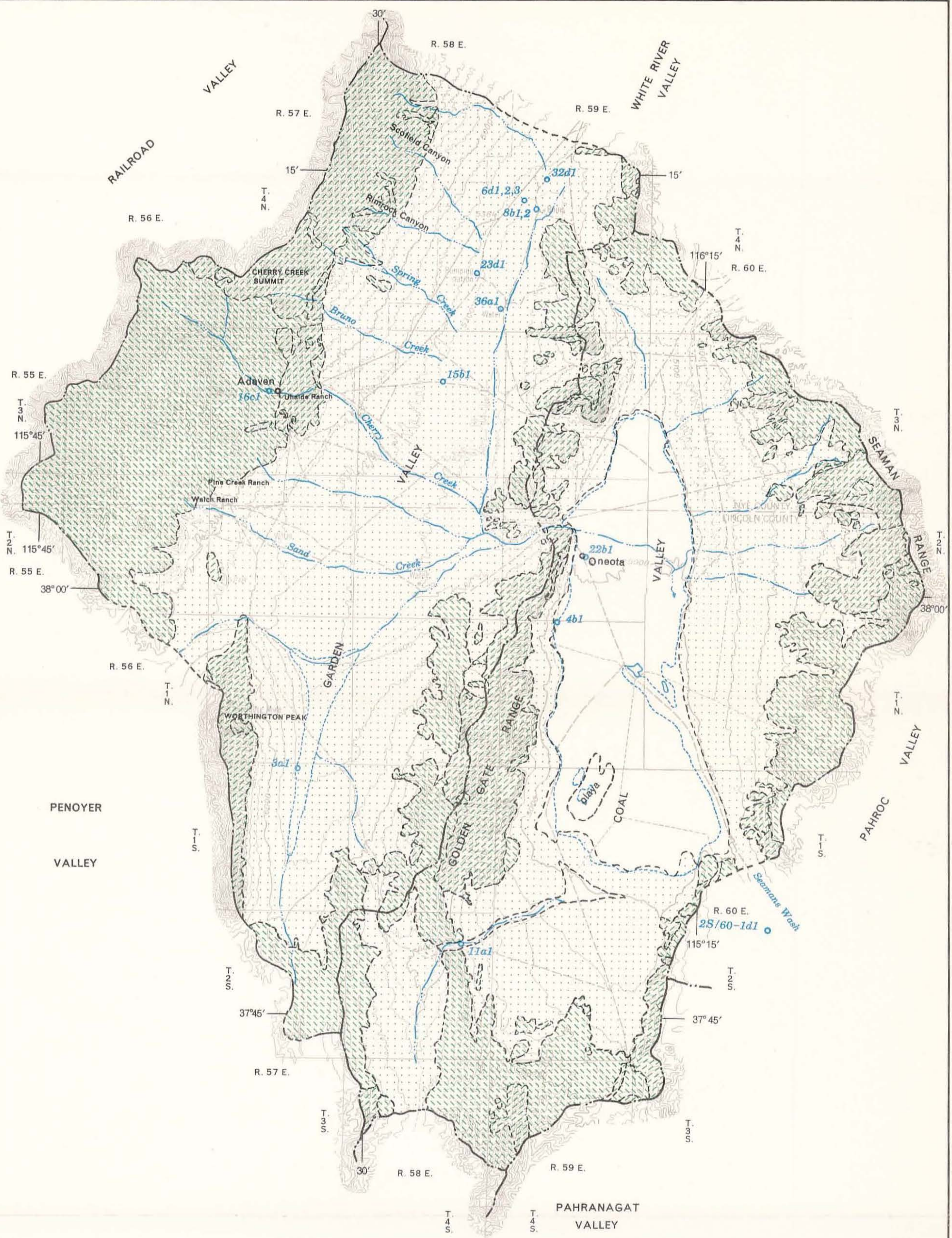
14. Ground-Water Reecurces of Amargosa Desert, Nevada-California. March 1963, by George E. Walker and Thomas E. Eakin.

15. Ground-Water Appraisal of the Long Valley-Massacre Lake Region, Washoe County, Nevada, by William C. Sinclair; also including a section on The Soils of Long Valley by Richard L. Malchow, May, 1963.

16. Ground-Water Appraisal of Dry Lake and Delamar Valleys, Lincoln County, Nevada. May 1963, by Thomas E. Eakin.

17. Ground-Water Appraisal of Duck Lake Valley, Washoe County, Nevada. June 1963. By William C. Sinclair.



EXPLANATION

Valley Fill

Unconsolidated clay, silt, sand, and gravel of Quaternary age

Unconsolidated and partly consolidated clastic rocks of Tertiary and Quaternary age

Bedrock

Principally clastic rocks of Paleozoic age and volcanic and clastic rocks of Tertiary age

Principally carbonate rocks of Paleozoic age

Topographic divide

Approximate geologic contact

3a1 Well and number

1:250,000 Scale

1 0 1 2 3 4 5 6 7 8 9 10 Miles

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

May 1963

Geology by T. E. Eakin, 1963 adapted from Tschanz and Pampeyan 1961 for area in Lincoln County and Kleinhampl (unpublished manuscript) for Nye County

PLATE 1.—MAP OF THE GARDEN AND COAL VALLEYS, LINCOLN AND NYE COUNTIES, NEVADA

SHOWING AREAS OF BEDROCK, VALLEY FILL, AND LOCATION OF WELLS