Ground-Water Potentialities in the Crescent Valley Eureka and Lander Counties Nevada

By C. P. ZONES

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1581

Prepared in cooperation with the State of Nevada, Office of the State Engineer

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1961

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The U.S. Geological Survey Library has cataloged this publication as follows:

Zones, Christie Paul, 1926–

Ground-water potentialities in the Crescent Valley, Eureka and Lander Counties, Nevada. Washington, U.S. iv, 522 p. maps, diagrs., tables. 25 cm. (U.S. Geological Survey. Water-supply paper 1581)

Prepared in cooperation with the State of Nevada, Office of the State Engineer.

Bibliography: p. 48.

1. Water, Underground-Nevada-Crescent Valley. 2. Water-supply-Nevada-Crescent Valley. 3. Borings-Nevada-Crescent Valley. 4. Water-Analysis. I. Nevada. State Engineer. II. Title: Crescent Valley, Eureka and Lander Counties, Nevada. (Series)

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

CONTENTS

ILLUSTRATIONS

TABLES

GROUND-WATER POTENTIALITIES IN THE CRESCENT VALLEY, EUREKA AND LANDER COUNTIES, NEVADA

By C. P. Zones

ABSTRACT

The Crescent Valley is an intermontane basin in Eureka and Lander Counties, just south of the Humboldt River in north-central Nevada. The valley floor, with an area of about 150 square miles, has a shape that more nearly resembles a Y than a crescent, although the valley apparently was named after the arc described by its southern part and northeastern arm. The northwestern arm of the Y extends northward to the small railroad town of Beowawe on the Humboldt River; the northeastern arm lies east of the low Dry Hills. The leg of the Y extends southwestward toward a narrow gap which separates the Crescent Valley from the Carico Lake Valley. The total drainage area of the Crescent Valley—about 700 square miles—includes also the slopes of the bordering mountain ranges: the Shoshone Range to the west, the Cortez Mountains to the east, and the Toiyabe Range to the south.

The early history of the Crescent Valley was dominated by mining of silver and gold, centered at Lander in the Shoshone Range and at Cortez and Mill Canyon in the Cortez Mountains, but in recent years the only major mining activity has been at Gold Acres; there open-pit mining of low-grade gold ore has supported a community of about 200. For many years the only agricultural enterprises in the valley were two cattle ranches, but recently additional lands have been developed for the raising of crops in the west-central part of the valley.

The average annual precipitation upon the floor of the Crescent Valley is probably less than 7 inches, of which only a little more than 1 inch normally falls during the growing season (from June through September). This is far less than the requirement of any plants of economic value, and irrigation is essential to agricultural development. Small perennial streams rising in the mountains have long been utilized for domestic supply, mining and milling activities of the past, and irrigation, and recently some large wells have been developed for irrigation. In 1956 the total pumpage from wells in the valley was 2,300 acre-feet.

The Crescent Valley is a basin in which has accumulated a large volume of sediments that had been eroded and transported by streams from the surrounding mountains. The deepest wells have penetrated only the upper 350 feet of these sediments, which on the basis of the known thickness of sediments in other intermontane basins in central Nevada may be as much as several thousand feet thick. Because this valley fill is saturated practically to the level of the valley floor, the total volume of ground water in storage amounts to millions of acre-feet. In practically all wells drilled to date, the water has been of a quality satisfactory for irrigation and domestic use.

The amount of water that can be developed and used perennially is far smaller than the total in storage and is dependent upon the average annual recharge to the

ground-water reservoir. This recharge comes principally from streams, fed largely by snowmelt, that drain the higher mountains. The average annual recharge to the valley fill is estimated to be about 13,000 acre-feet. This natural supply, which is largely consumed by native vegetation on the valley floor, constitutes a perennial supply for beneficial use only to the extent that the natural discharge can be reduced. In time, much of the natural discharge can probably be salvaged, if it is economically feasible to pump ground water after water levels have been lowered as much as 100 feet in the areas that now appear to be favorable for the development of irrigation supplies.

In 5 wells in the phreatophyte area, where the water table is within 3–8 feet of the land surface, the trends in water level have paralleled those in precipitation—downward during the dry years 1952–55, upward in wetter 1956 and 1957, and as high in 1957 as at any time since 1948. In most wells there is also a seasonal fluctuation of 1–3 feet, from a high in the spring to a low in the fall. There is no evidence to date that pumping has lowered the water table in the area of natural discharge. It is to be noted that all 9 of the large production wells are at the edge of the area of natural discharge.

The most favorable area for the development of ground water appears to be the west-central part of the Crescent Valley, from the Indian Creek fan northward to about the latitude of Corral Canyon. All but one of the large wells already developed are in this area. The favorable areas on the east side of the valley are likely to be at the toes of the fans of the larger flowing streams.

It is believed that any effect of ground-water development in Crescent Valley on the flow of the Humboldt River will be insignificant, because underflow from the valley to the Humboldt River probably is very small and there is rarely any surface flow from the valley.

INTRODUCTION

A cooperative program for the study of the ground-water resources of Nevada was begun in 1944 by agreement between the Director of the U.S. Geological Survey and the State Engineer of Nevada. Since then, under a continuing program, hydrologic investigations have been carried out in selected areas in the State.

PURPOSE AND SCOPE OF THE INVESTIGATION

This report, which is a part of the cooperative program, describes the hydrology of the Crescent Valley. It is concerned primarily with the occurrence and potential development of ground-water supplies in the valley and attempts to answer such questions as: How much ground water can be withdrawn annually? and Which areas are most favorable for development? The section on geology is of limited scope, but the characteristics of the alluvium are discussed as fully as the available data permit, because the alluvium contains the most important aquifers in the valley.

No geologic mapping was attempted in the mountain areas. However, the rocks are described briefly from data contained in both published and unpublished reports, principally because the nature of these rocks determines to a large extent the water-bearing properties of the alluvium that is derived from them.

Most of the fieldwork was done in June and August 1948 by D. A. Phoenix and in November 1953 and August 1954 by the writer. Many of the hydrologic data were collected by Phoenix, who also mapped the phreatophyte areas. The section on the Humboldt(?) formation is based largely on the observations made by Phoenix. The investigation was first under the supervision of T. W. Robinson, district engineer of the Ground Water Branch of the U.S. Geological Survey in Nevada. After December 1953 the project was supervised by O. J. Loeltz, who succeeded Mr. Robinson as district engineer.

GEOGRAPHY

The Crescent Valley is in north-central Nevada in Lander and Eureka Counties. (See fig. 1.) The Valley trends northeast, is about 45 miles long, and includes approximately 700 square miles within its drainage area. The valley floor is shaped roughly like a Y. (See pl. 1.) One arm projects northward to the Humboldt River; the other projects northeastward between the Cortez Mountains and the Dry Hills, a low range of hills that separates the two arms of the Y. The leg of the Y extends southwestward toward Rocky Pass, a narrow gap that separates the Crescent Valley from the Carico Lake Valley.

Mountain ranges enclose the valley almost completely. The Shoshone Range borders the valley on the west and the Cortez Mountains border it on the east. The south end of the valley is closed by the north end of the Toiyabe Range, and the northeastern part of the valley is closed by the northern part of the Cortez Mountains and the Dry Hills. The northwestern part is open to the flood plain of the Humboldt River.

The small railroad town of Beowawe, served by both the Western Pacific and the Southern Pacific Railroads, is just north of the valley on the flood plain of the Humboldt River. A paved section of State Route 21 links Beowawe with U.S. Route 40 at a point 5 miles north of the town. State Route 21 is gravel surfaced south of Beowawe. It traverses the length of the Crescent Valley, leaves the valley through Cortez Canyon, and continues south to Austin. A dry-weather dirt road across the Shoshone Range enters the Crescent Valley through the canyon cut by Indian Creek.

Most of the residents of the Crescent Valley are engaged in mining or agriculture. Mining was started shortly after the middle of the last century,when rich silver-bearing deposits were discovered in 1863 in the Cortez and Mill Canyon districts at the south end of the Cortez Mountains. From the date of this discovery until 1908, ore variously valued at an estimated $10 million for both districts to $15 million for the Cortez district alone was taken from the mines (Lincoln, 1923, p. 86). After 1908, production from the Cortez and Mill Canyon

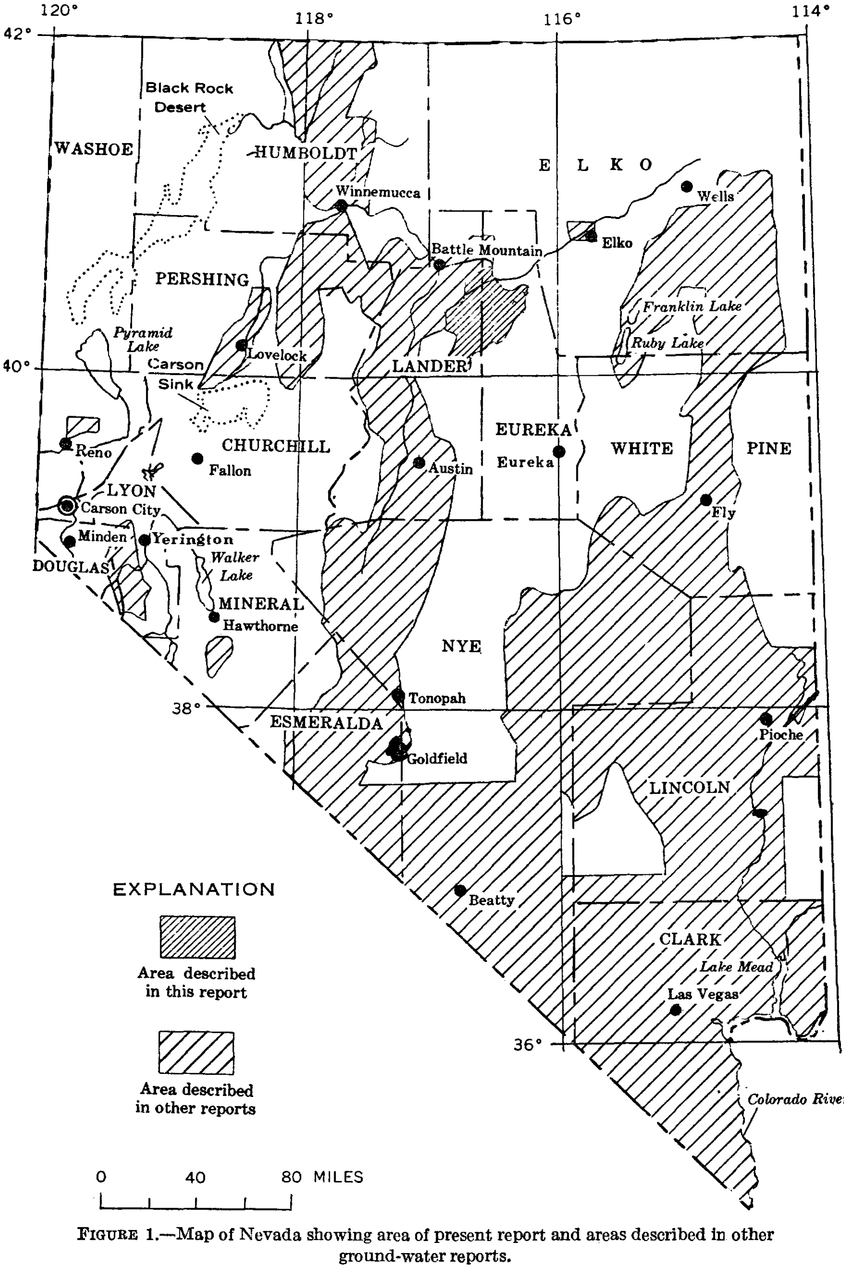

FIGURE 1.—Map of Nevada showing area of present report and areas described in other ground-water reports.

districts was sporadic. Mills were erected at both towns, and when the Mill Canyon mines did not prove very productive, the mill at Mill Canyon treated ore from Cortez. In addition to silver, the two districts produced gold, lead, zinc, copper, and turquoise.

The Bullion district (Lincoln, 1923, p. 110–111), on the east slope of the Shoshone Range, is both north and south of Indian Creek. Lander is the oldest camp in the Bullion district and in the 1880's and 1890's was the milling center of the district. Silver, gold, lead, copper, and arsenic were mined in the district.

The only major mining activity in the valley at the present time is at Gold Acres, a mining community of about 200 inhabitants, 29 road miles south of Beowawe. Extensive open-pit mining at Gold Acres yields 150,000 tons of low-grade gold ore each year.

Two ranches in the Crescent Valley, the Dean Ranch and the Dewey Dann Ranch, raise cattle. The headquarters of the Dean Ranch is about 5 miles east of the old mining town of Tenabo. Two wells on this ranch furnish supplemental water for 240 acres of land ordinarily irrigated by water from Indian Creek. The Dewey Dann Ranch is at the foot of the Cortez Mountains on the east side of the valley. Water for irrigating 120 acres of land at the ranch is obtained from one well and from Duff and Hand-me-down Creeks. Northeast of the Dewey Dann Ranch, water is diverted from Sod House and Frenchie Creeks for irrigating land owned by the Dean Ranch.

Farming is being carried on in the west-central part of the valley, where several wells have been drilled and a few hundred acres of land has been placed under cultivation. Irrigation of crops is essential in this region of little rainfall.

NUMBERING SYSTEM FOR WELLS AND SPRINGS

The number assigned to a well or spring in this report both identifies and locates the well or spring. The number is based on the Bureau of Land Management's system of land division and consists of three units. The first is the township number north of the Mount Diablo base line. The second unit, separated from the first by a virgule, is the range number east of the Mount Diablo meridian. The third unit, separated by a short dash, is the section number. This is followed by an uppercase letter to denote the quarter section in which the well or spring is located. The letters A, B, C, and D designate the northeast, northwest, southwest, and southeast quarter sections. Finally, the consecutive numbers show the order in which the well or spring was recorded in the quarter section. For example, the number 30/48–27C1 designates the first well recorded in the SW¼ sec. 27, T. 30 N., R. 48 E., Mount Diablo base line and meridian.

On plate 1 only that part of the number designating the quarter section, and the specific well in that section, is shown. The section number can be ascertained from the complete location number. Township and range numbers are shown on the edges of the plate.

CLIMATE

The climate is characterized by low precipitation and humidity and extreme daily variations in temperature. Although there is no weather station in the Crescent Valley, climatological records are available for the U.S. Weather Bureau station at Beowawe, which is near the same altitude as the floor of the Crescent Valley. The average annual precipitation at this station is 6.44 inches for the 79-year period of record. Only about 1 inch of this falls during the growing season from June through September. Figure 2 shows

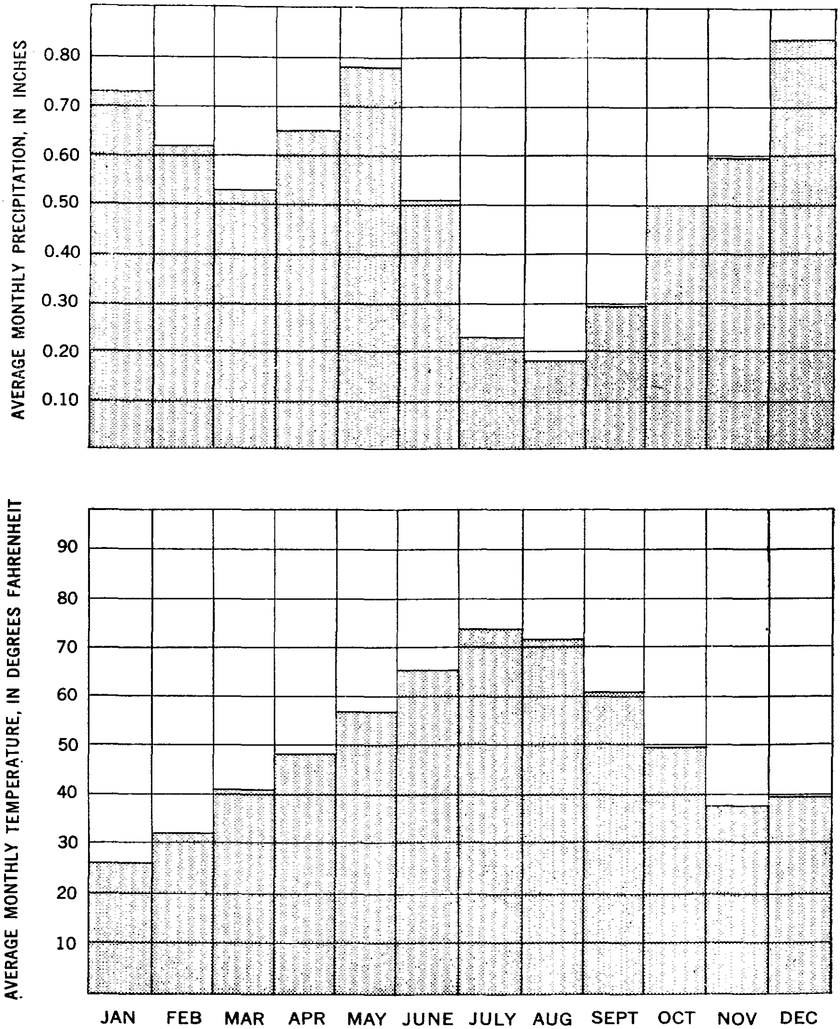

FIGURE 2.—Average monthly precipitation and average monthly temperature at the U.S. Weather Bureau climate station at Beowawe, Nev. (Data from Weather Bureau Summary for 1955.)

graphically the average monthly precipitation at Beowawe as compiled from the U.S. Weather Bureau's annual summary for 1955. Most of the precipitation occurs during the winter and spring, and the least during July, August, and September. In the mountain ranges bordering the Crescent Valley the relation between the amount of precipitation and the season is similar, but the rate of precipitation is greater because of the higher altitudes. According to Hardman (1936), the highest peaks overlooking the Crescent Valley receive more than 20 inches of precipitation annually.

U.S. Weather Bureau records of the temperature at Beowawe are available for 60 years. Figure 2 gives the average temperature, by months. The average yearly temperature is 49.1°F for the period of record.

The July average of 73.6°F is the highest monthly average, and the January average of 26.6°F is the lowest. The highest and lowest temperatures ever recorded at Beowawe were 108°F and −42°F. However, the yearly high and low temperatures normally do not approach such extremes. More representative yearly high and low temperatures covering 9 years, are shown below.

Temperature extremes for 1945 through 1955 at Beowawe, Eureka County, Nev., from records of the U.S. Weather Bureau

Year	Highest temperature (degrees Fahrenheit)	Lowest temperature (degrees Fahrenheit)	Year	Highest temperature (degrees Fahrenheit	Lowest temperature (degrees Fahrenheit)
1945	98		1951	102	−15
1946	99	−7	1952	97	−14
1947	100	−27	1953	99	2
1948			1954		−12
1949			1955	101	−9
1950	98	−22			

Characteristically, daily variations of temperature are large, but they are smaller in winter than in summer. In the winter they are usually about 30°F, whereas in the summer they average between 40° and 50°F. Even during the warmest months, night temperatures often drop into the 40's. Freezing temperatures, however, normally do not occur from late May or early June to about the middle of September. The length of the frost-free season, or approximately the growing season, at Beowawe has ranged from 41 to 193 days during the 40 years for which such estimates were made by the U.S. Weather Bureau. The median length of the frost-free season is between 105 and 108 days.

LANDFORMS AND DRAINAGE

The Crescent Valley is in the Great Basin section of the Basin and Range physiographic province. The Great Basin was named by John C. Fremont, who crossed the region in 1843 and 1845, and includes nearly all of Nevada and the western part of Utah. It is an area of alternating valleys and mountain ranges which generally trend nearly north. The ranges differ in size, but in general they are 50–70 miles long and 6–15 miles wide. Altitudes of the ranges commonly are 3,000–5,000 feet above the valley floors and 7,000–10,000 feet above sea level. The typical range owes its relief to faulting and tilting of the mountain block. Ordinarily, one side of the block is a steep fault scrap, whereas the opposite side is a more gently dipping slope.

The intermontane valleys are characteristically closed basins, although some valleys are connected by drainage channels. Playas, present in most of the valleys, receive the excess runoff from the neighboring mountain ranges.

MOUNTAINS

The northeastward-trending ranges bordering the east and west sides of the Crescent Valley are fault-block mountains that rise more than 4,000 feet above the valley floor. Each range has been faulted on its west side and tilted to the east. The Cortez Mountains, which rise abruptly from the valley floor, have a fairly uniform bulk. The crest is not deeply notched but is generally concordant, although it is progressively lower toward the north. The highest point on the crest is 9,162 feet on Mount Tenabo at the south end of the range.

The west face of the range shows many features that are typical of fault-block mountains. Its base is essentially straight in plan view. The range is cut by deep V-shaped canyons separated by sharp-crested spurs that end abruptly in steep triangular facets. The slope of the facets does not flatten out near the base of the mountains but is fairly uniform. The facets probably represent a fault surface that has been somewhat subdued by erosion.

Dissection of the west side of the range is in a mature stage. Inter-stream divides have been reduced to sharp crests, even between the gullies and the streams that are tributary to the main drainage channels.

The Dry Hills are a spur of the Cortez Mountains that nearly parallels the main mountain block. Its origin is not known. However, a line of hot springs along the southwestern base of the hills indicates the presence of a fault, which suggests that the Dry Hills may have originated as a block that was faulted along the west side and tilted to the east.

The Shoshone Range is about 150 miles long, but only its northern part forms the western boundary of the Crescent Valley. The gently sloping east side of the Shoshone Range is in marked contrast to the steep west face of the Cortez Mountains. At the extreme north end of the Shoshone Range, a steep northeastward-trending scarp—probably a fault scarp—splits that part of the range into two spurs. Only the runoff from the smaller, eastern spur flows into the Crescent Valley. The runoff from the east side of the larger spur to the west enters the narrow valley between the two spurs and thence flows into the Humboldt River. The two spurs merge at about the latitude of Fire Creek. The east side of the spur at the north end of the valley is a dip slope. The spur is composed of lava flows that were extruded on a Tertiary erosion surface. Subsequent faulting and tilting, which formed the Shoshone Range, gave the lava flows an eastward dip of about 10°–15°. The eastern spur is low at its north end but its crest rises gradually to an altitude of more than 7,500 feet near the head of Fire Creek. Deep dissection of the volcanics in the southern part of the spur has resulted in rugged topography, and the area has been appropriately named the Malpais. Streams that descend the Malpais have cut narrow steep-walled canyons, which range in depth from several hundred to a thousand feet. The interstream divides are moderately rounded to flat. Dissection of the rocks near the northern end of the spur has been moderate.

Southwest of the Malpais the Shoshone Range is composed of sedimentary, metamorphic, and intrusive igneous rocks. This part of the range is higher than the Malpais and includes the highest point on the divide, Mount Lewis, altitude 9,680 feet. The area is in a mature stage of dissection. The interstream areas have been rounded, and there are no sharp-crested divides as on the west side of the Cortez Mountains.

PIEDMONT SLOPES

The piedmont slopes of the ranges have gentler gradients than the mountain fronts and generally merge almost imperceptibly into the relatively flat floor of the valley. With one exception, a pediment in the southwestern part of the valley, the slopes are formed by rubble that has been eroded from the uplands and deposited at the base of the ranges to form alluvial fans. Along the east side of the eastern valley the alluvial fans flanking the Cortez Mountains are distinct and well defined. In the interfan areas the valley floor is at places within a few hundred yards of the range front. Most of the fans extend 1–2 miles into the valley and have gradients that range from 200 to 250 feet per mile.

The alluvial fans at the base of the Shoshone Range are considerably larger than those at the base of the Cortez Mountains. The former have coalesced to form an alluvial apron along the base of the range. Their apexes are 600–700 feet above the valley floor, whereas those at the base of the Cortez Mountains are only 300–400 feet above the floor. Indian Creek has deposited the largest alluvial fan in the valley. The fan extends eastward from the base of the Shoshone Range to the Dean Ranch, a distance of about 5 miles; it has a gradient of about 70 feet to the mile. North of the Indian Creek fan the alluvial apron becomes progressively narrower and less distinct. At the base of the Malpais the upper limits of the apron are quite indistinct, because the weathered surface of the volcanic rocks on the dip slope of the Malpais closely resembles the boulder-strewn surface near the upper limits of the apron.

A north-south ridge that probably owes its relief to vertical movement along a fault on the west side of the ridge trends obliquely across the northern part of the Malpais, about 5 miles southwest of Beowawe. Surface runoff that flows down the dip slope of the Malpais is locally diverted by the ridge, where the ridge intersects what would be the normal path of the drainage, so that several intermittent streams are channeled into a single stream that flows along the west side of the ridge. The sediment transported by the combined flow of the merging streams has formed the only large alluvial fan at the foot of the Malpais. The fan extends about a mile onto the floor of the valley.

The only piedmont slope in the Crescent Valley that is definitely not an alluvial fan is in the southwestern part of the valley, in a reentrant in the Toiyabe Range. In this locality beds of Tertiary age have been beveled by lateral planation and covered with a veneer of alluvium to form a pediment that dips to the north. The pediment is now being dissected by ephemeral streams that have eroded valleys into it as deep as 200 feet.

VALLEY FLOOR

The valley floor is the relatively flat area downslope from the alluvial fans. Generally it is about 3 or 4 miles wide; it is about 30 miles long; and it covers an area of about 150 square miles, or less than one-half of the total alluvial area of 330 square miles. The gradient is generally northward and ranges from less than 2 feet per mile in the northern part of the valley to about 40 feet per mile near the south end. Numerous playas that range in area from a few acres to more than 1 square mile occupy the lowest parts of the valley floor. Small dunes border some of the playas and locally form barriers behind which water accumulates seasonally.

Much of the surface of the valley floor is encrusted with a white saline efflorescence which has resulted from the evaporation of water from the capillary zone.

Many areas of well-developed desert pavement are present in the valley, particularly on the lower parts of the fans on the west side of the valley. The presence of desert pavement indicates that wind erosion is active in the Crescent Valley to the degree that, locally, fine material is being removed faster than it is being deposited.

The valley floor for a distance of about 6 miles south of Beowawe is bordered by terraces 10–15 feet high. Farther south, near the center of the valley and on the valley floor, are short segments of other terraces. However, the terraces were not studied in detail and are not described in this report or shown on plate 1. The terraces at the north end of the valley are stream terraces and were probably formed by a Pleistocene stream that drained to the Humboldt River.

Runoff in the Crescent Valley no longer drains into the Humboldt River except during periods of exceptionally high precipitation, when an intermittent stream carries runoff from the north end of the valley.

STREAMS

The streams that drain the mountain ranges are mostly intermittent or ephemeral. Many of the smaller streams carry water only after storms. Others, fed by snowmelt, carry water during the late winter and spring, only to become dry after the snow has disappeared. A few of the larger streams are perennial, but their flow diminishes to only a few tens of gallons a minute by fall or early winter.

Downslope from the bedrock–alluvium contact the volume of streamflow ordinarily diminishes rapidly, owing to percolation of water into the alluvium. Consequently, few of the streams reach the playas except during periods of high runoff.

The streams that drain the west side of the Cortez Mountains are short and have gradients of about 500 feet per mile. From north to south they are Frenchie, Sod House, Duff, Hand-me-down, Little Cottonwood, and Cottonwood Creeks, and the streams in Brock, Mule, Fourmile, and Mill Canyons. Frenchie and Duff Creeks and the stream in Mill Canyon are perennial, but their flows diminish appreciably in the fall. Frenchie Creek is perennial for a distance of several miles above the bedrock-alluvium contact. Duff Creek and the stream in Mill Canyon, however, arise from spring areas that are only a short distance above the mouths of the canyons.

The streams that drain the east side of the Shoshone Range are longer and have gentler gradients than those that drain the west side of the Cortez Mountains. From north to south the more important streams are Fire Creek, the creek in Corral Canyon, Indian Creek, and Cooks Creek. Of these, only Indian Creek is perennial as far downstream as the bedrock-alluvium contact. Cooks Creek is an interrupted stream which originates in the northern part of the Carico Lake Valley and enters the Crescent Valley through the gap at Rocky Pass. At the gap, underflow from the Carico Lake Valley rises to the surface to form a spring area, the discharge of which flows into the Crescent Valley at a rate estimated to average about 50 gpm (gallons per minute) throughout the year.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING CHARACTERISTICS

PREVIOUS GEOLOGIC INVESTIGATIONS

The first geologic investigation of importance was made by Clarence King (1876) in the exploration of the 40th parallel. The exploration resulted in the first geologic map of the area. Since then, Emmons (1910) and Lincoln (1923) have described briefly the mining districts in and near the Crescent Valley. The geology of most of the northern part of the Cortez quadrangle, which covers the northern end of the Toiyabe Range, the southern part of the Cortez Mountains, and a small part of the Shoshone Range, was mapped in the summer of 1949 by a field-geology class from the University of California at Los Angeles. The results have not been published.

TYPES OF ROCKS

For the purposes of this report the rocks in the area are divided into three units: (a) rocks of the mountain ranges, (b) rocks of the pediment at the south end of the valley, and (c) alluvium of the valley fill. The units differ markedly in lithologic and in water-bearing characteristics.

ROCKS OF THE MOUNTAIN RANGES

The rocks of the mountain ranges crop out above the bedrock-alluvium contact (pl. 1). For the most part they are well-indurated rocks of sedimentary and igneous origin. Metamorphic aureoles surround the larger igneous intrusions.

The "Geologic Map of the United States" (1932 ed.) shows the mountains bordering the north half of the valley to be composed largely of igneous extrusive and intrusive rocks. Likewise, the mountains bordering the south half of the valley are largely lava flows and intrusive rocks, but they contain also a thick section of sedimentary rocks. In the Bullion district near Lander, the Shoshone Range consists of quartzite, shale, and limestone of Carboniferous age, which are intruded by granodiorite and locally are capped by Tertiary andesite (Lincoln, 1923, p. 111). Farther south, the rocks exposed in the northern part of the Cortez quadrangle consist largely of a thick Paleozoic sequence of dolomite, limestone, shale, and chert, and subordinate amounts of sandstone, breccia, conglomerate, and quartzite. A quartz monzonite stock of Mesozoic age and associated dikes, sills, and apophyses have intruded the Paleozoic sedimentary rocks and locally have altered them. Conglomerate, gravel, and lava flows of Tertiary age overlie the Paleozoic sedimentary rocks. The lava flows consist of olivine basalt and massive to thin-sheeted flows of quartz latite. The basalt is highly shattered and is very vesicular at the upper and lower horizons.

The rocks of the mountain ranges are not an important source of ground water. Ordinarily, they are well indurated and cemented and therefore do not transmit water readily. Movement of ground water in consolidated rocks is confined largely to joints and other fractures, and to porous zones in lava flows. Of the consolidated rocks just described, the highly shattered and vesicular olivine basalt of the mountain ranges probably transmits water most readily. Other consolidated rocks also may transmit water freely in shattered zones near faults. As a rule, the consolidated rocks are not prospected for water, although wells that yield small supplies of water probably could be developed locally. However, the selection of well sites should be based on a detailed investigation of the stratigraphy and structure of the rocks in a particular area in order to increase the chances for obtaining a successful well.

ROCKS OF THE PEDIMENT

Beds of late Tertiary age are exposed on a dissected gravel-veneered pediment at the south end of the valley. The exposures consist of white, gray, and buff-colored silt and diatomite, overlain by pink and terra cotta silt and fine sand. Locally the beds contain layers of caliche. In general, the outcropping beds are compacted and loosely cemented and dip 4°–13° toward the southeast.

These beds may be correlative with the Humboldt formation, which crops out in the area of the Ruby Mountains (Sharp, 1939). The possible correlation is based on vertebrate fossils that were collected by D. A. Phoenix as float on an outcrop in sec. 28, T. 26 N., R. 46 E. The fossils were examined by R. A. Stirton of Stanford University. Dr. Stirton (written communication to D. A. Phoenix, 1949) says of them:

> The fossils—are not of such nature that we can offer very close identification or correlation of the beds in which they occur. The parts are: parts of a humerus, part of the cannon bone and astragalus, and a median phalanx of a camel, within the size range of those common to our upper Miocene and lower Pliocene faunas.

This, then, does not detract from a correlation of these beds with the Humboldt formation as it was designated by Sharp.

The rocks of the Humboldt formation are of diverse lithology in the type area in the Ruby Mountains and East Humboldt Range. Sharp describes three members. The lower member consists of 800–1,000 feet of shale, oil shale, fresh-water limestone, sandstone, and conglomerate. The middle member is characterized by rhyolitic tuff and ash, and its maximum measured thickness is 1,300 feet. The upper member consists of at least 3,600 feet of fine conglomerate, sandstone, mudstone, siltstone, and shale.

Thus, although the Humboldt formation may underlie the more recent sediments in the Crescent Valley, there is little or no basis for estimating the character of the formation or the depth at which it is buried.

The water-bearing characteristics of different beds in a formation whose lithologic character is as diverse as that of the Humboldt(?) formation are certain to have a wide range. Wells that have moderate to high yields have been drilled in the Humboldt formation near Elko, in Elko County (Fredericks and Loeltz, 1947). Therefore, there is a possibility that successful wells may be drilled in the Humboldt(?) formation in the Crescent Valley. However, no potentially good aquifers were observed in the outcrop. The exposed beds are too fine grained and too indurated to yield large quantities of ground water.

UNCONSOLIDATED SEDIMENTS OF THE VALLEY FILL

Unconsolidated sediments underlie the valley in an area of about 330 square miles downslope from the bedrock-alluvium contact. Except for relatively small eolian and lacustrine deposits along the axis of the valley, the sediments consist of stream-deposited detritus that has been eroded from the mountains. The character of the alluvium depends in part on the nature of the streams that transported and deposited it. Alluvium deposited by perennial streams is sorted better than that deposited by ephemeral streams. The physical characteristics of the alluvium depend also on the type of rocks in the source area. Alluvium derived from the weathering of finer grained rocks, such as lava flows, generally has a large proportion of small grains. Therefore, the alluvium in the northwest branch of the valley, where the adjacent mountains are composed largely of lava flows, probably contains a high percentage of small grains, though undoubtedly it contains also numerous large fragments. Similarly, the alluvium derived from the fine-grained rocks of the Humboldt(?) formation at the south end of the valley probably contains a large proportion of small grains.

Characteristically, the sediments of the basin fill consist of rock fragments that are progressively smaller and somewhat less angular at increasing distances from the mountains. The coarsest and most angular fragments, therefore, are near the apexes of the alluvial fans, where the alluvium ranges from clay to boulders several feet in diameter. The finest grained sediments, consisting mostly of fine sand, silt, clay, and evaporites, are deposited beyond the toes of the fans.

This relation between grain size and distance from the mountain areas is only a general one. The streams responsible for the distribution may be dry one day, move large boulders the next day, and soon afterward be so small that they can carry only silt and clay. This irregularity produces a corresponding irregularity in the valley fill. Thus, in an area where a large proportion of sand and gravel is to be expected there may be only silt and clay; and, conversely, in the center of the valley there may be locally thick gravel beds. But although the transition in fineness of grain size with increasing distance from the source area may not hold true on a small scale, it does hold on a larger scale. This transition is indicated by the lithofacies map (fig. 3), which is based on data obtained from drillers' logs. (See table 5.) Most of the logs are of wells that range from 100 to 300 feet in depth. By use of these data, the valley fill has been arbitrarily divided into three lithologic zones based on the percentage of coarse material (sand size or larger) logged for each well. The limits for the zones have been placed at less than 25 percent, 25–50 percent, and more than 50 percent of coarse material. The zone in which more that 50 percent of the grains are of sand size or larger extends from the mountain fronts to approximately the toes of the fan; the zone in which 25–50 percent of the grains are of sand size or larger occupies a narrow belt below the toes of the fans; and the zone in which less than 25 percent of the grains are of sand size or larger occupies a broader area along the axis of the valley.

The available well logs (table 5) indicate that the sediments at depth are similar to those exposed at the surface except that they are somewhat indurated. Locally, they are well cemented by caliche. The lack of correlation between well logs indicates that the character of the alluvium changes rapidly within short distances. This condition is common for alluvial deposits, especially material that has been deposited by short ephemeral streams, such as those which form the bulk of the Crescent Valley drainage system.

The thickness of the unconsolidated sediments is not known. It cannot be determined from the available logs whether any of the wells have completely penetrated the more recent sediments and entered the Humboldt(?) formation. However, from experience in other intermontane basins in central Nevada, the maximum thickness of the

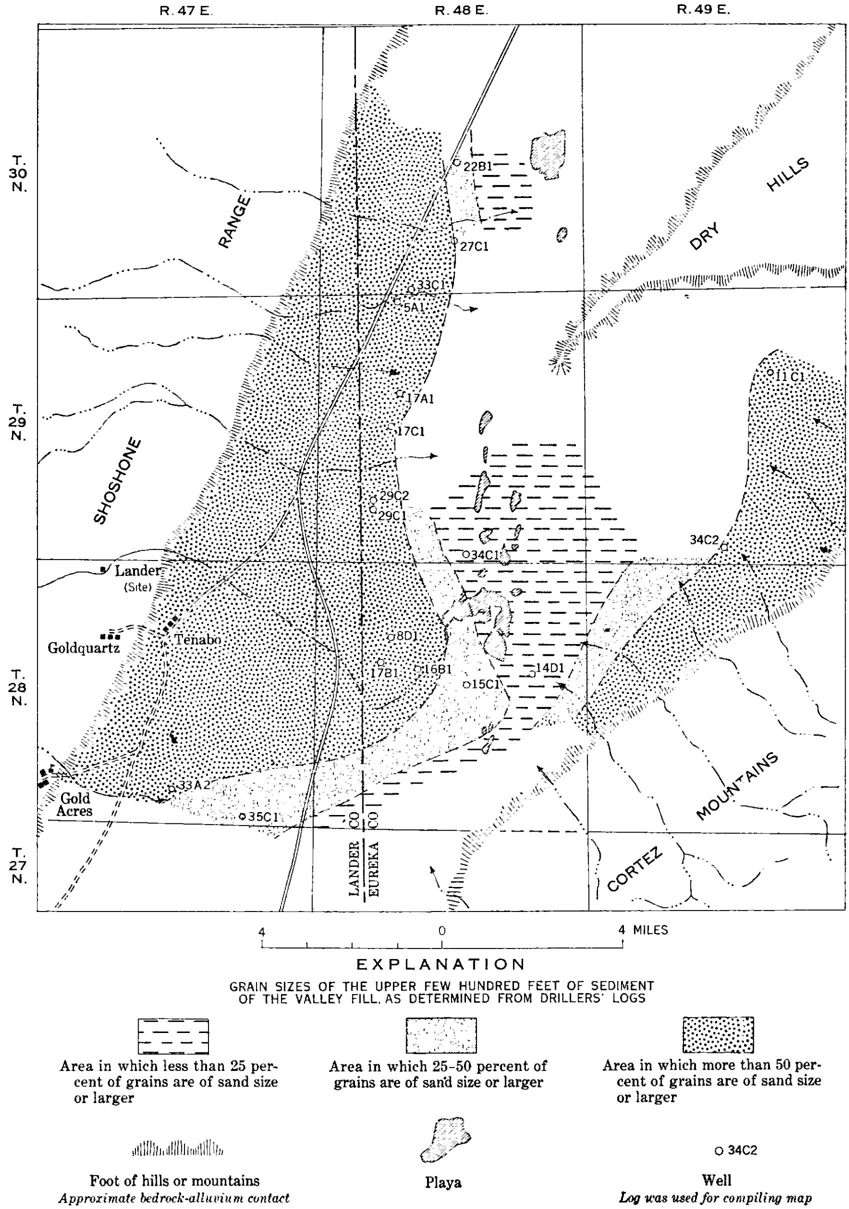

FIGURE 3.—Areal distribution of sediments of the valley fill, classified according to grain size.

fill in the Crescent Valley is likely to be several hundred feet and may even be several thousand feet.

The valley fill is saturated with water almost up to the level of the valley floor and is the most important source of ground water in the valley. As the thickness of the valley fill is probably several hundred or even several thousand feet, the volume of ground water in storage amounts to millions of acre-feet. The hydraulic characteristics of the alluvium may vary greatly even within short distances, so that predictions as to the water-bearing properties of the alluvium at a particular site for which no data are available are hazardous.

Normally the better aquifers underlie the larger alluvial fans, which ordinarily are those deposited by perennial streams. Such fans probably contain many stringers of stream-gravel deposits, which can transmit water more readily than the intervening sediments. On the other hand, the short, steep fans that were formed by small, ephemeral streams consist principally of poorly sorted material that was deposited during floods. Beyond the fans the sediments generally are too fine grained to yield large quantities of water.

Four aquifer tests were made during the investigation in order to determine the coefficients of transmissibility of the aquifers tapped by wells in the central part of the valley. The coefficient of transmissibility, which may be defined as the rate of flow of water, in gallons per day, through a cross section of an aquifer having a width of 1 foot and a height equal to the thickness of the aquifer, under unit hydraulic gradient and at the prevailing water temperature, probably is the best indication of the water-transmitting property of an aquifer. The four irrigation wells that were utilized in making the aquifer tests are (a) well 30/48–27C1, on the valley floor below the toe of an indistinct fan opposite the Malpais; (b) well 30/48–33C1, on the lower part of the fan below Corral Canyon and 1½ miles southwest of well 30/48–27C1; (c) well 28/48–18A1, at the toe of the Indian Creek alluvial fan; and (d) well 29/49–34C2, at the toe of the largest alluvial fan on the east side of the valley. Recovery tests of 1–3 hours' duration were made at these wells. The values obtained for the coefficients of transmissibility are as follows:

Well	*Coefficient of transmissibility (gpd per foot)*
30/48–27C1	6,500
30/48–33C1	37,000
28/48–18A1	61,000
29/49–34C2	30,000

The well in the aquifer of highest transmissibility is at the toe of the largest alluvial fan in the valley, the Indian Creek fan. Well 29/49–34C2, which penetrates aquifers that have an average transmissibility of 30,000 gpd per foot, is at the toe of the largest alluvial fan on the east side of the valley. Well 30/48–33C1, on the indistinct but large fan below Corral Canyon, penetrates aquifers that have a combined transmissibility of 37,000 gpd per foot. On the other hand, the aquifers tapped by well 30/48–27C1, on the valley floor beyond the alluvial fans, have a low average transmissibility. It thus appears that the comparative transmissibilities of the wells correlate with the type of terrain in which they were drilled.

The transmissibilities of the aquifers in the alluvium elsewhere in the valley are not known but may be roughly estimated as low or high, largely on the basis of physiography. Although such estimates are subject to error, they may be useful where no more specific data are available.

GROUND WATER

OCCURRENCE

Ground water in the rocks of the mountain ranges commonly occurs in small quantities in joints, in fractures along fault zones, in porous zones in lava flows, and in other chance openings. Ordinarily, these rocks are not tapped for their water supply.

Ground water occurs also in the consolidated and semiconsolidated rocks of the Humboldt (?) formation exposed in the southern part of the valley. The Humboldt (?) formation probably is present at depth beneath the floor of the valley also. The fineness of the grain and the degree of compaction of the exposed beds indicate that their permeability is low and that they would yield only small quantities of water. However, the water-bearing characteristics of the beds that may be buried under the more recent sediments elsewhere in the valley are not known.

Most of the ground water is in the unconsolidated sediments of the valley fill. These sediments consist largely of clay, silt, sand, and gravel and are saturated below the water table. Although the clay yields only very small quantities of water, the sand and gravel ordinarily transmit water readily.

The depth to water in general is greatest near the bedrock-alluvium contact and least beneath the lowest points in the valley, where the water table normally is less than 10 feet below the land surface. Locally, the piezometric surface (imaginary surface indicating the pressure head of water confined under pressure between beds of low permeability) is above the surface of the land. For example, east of the Indian Creek alluvial fan and near the axis of the valley, ground water in many of the aquifers is under sufficient artesian pressure to rise a few feet above the land surface.

Ground water, in general, moves from the mountain ranges toward the axis of the valley, where it is transpired or evaporated, but in the extreme northwestern part of the valley a small quantity of ground water moves northward into the valley of the Humboldt River.

RECHARGE

Precipitation at the higher elevations within the Crescent Valley drainage area is the main source of water that recharges the ground-water reservoir. Additional, but minor, sources of recharge are precipitation on the valley floor, excess irrigation water, surface flow from the Carico Lake Valley, and seepage from bedrock.

PRECIPITATION AT THE HIGHER ELEVATIONS

A map compiled by Hardman (1936) shows approximately the precipitation zones in Nevada, estimated largely on the basis of elevation and type of vegetation. In general, the valley floors are within the zones that receive the least precipitation; the higher elevations are within the zones that receive the greatest amounts. A comparison of the map with recent topographic maps indicates that in the Crescent Valley drainage area the 8- to 12-inch precipitation zone is between altitudes of 5,500 and 6,500 feet; the 12- to 15-inch zone is between 6,500 and 8,000 feet; and the 15- to 20-inch zone is above 8,000 feet. The total annual precipitation that falls within each zone is equal to the average annual precipitation in that zone multiplied by the area of the zone. On the basis of these computations, the annual precipitation above 5,500 feet is estimated at about 200,000 acre-feet. The limitations of this method for computing the total amount of precipitation should not be overlooked. For instance, it is recognized that precipitation rates are influenced by factors other than altitude. Thus, many local variations are due to the rain-shadow effect of nearby high crests and to the direction of the prevailing winds. Owing to a lack of data, adjustments could not be made for the above factors. Accordingly, 200,000 acre-feet should be considered only an approximate figure.

Only a small part of the total precipitation on the mountain ranges reaches stream courses. Most of the moisture returns directly to the atmosphere through evaporation or enters the zone of soil moisture and is subsequently transpired by vegetation. Studies (Loeltz, Phoenix, and Robinson, 1949, p. 35) in the Martin Creek drainage area in the Paradise Valley, about 100 miles northwest of the Crescent Valley, indicate that in mountains comparable in elevation and vegetative cover to those bordering the Crescent Valley, the yearly evapotranspiration requirement is 9 inches of preciptiation. Thus, only precipitation in excess of 9 inches is available for runoff. In the Crescent Valley the amount of such excess precipitation is estimated at 35,000 acre-feet.

From a study of the relation between runoff and recharge to the ground-water reservoir in the Paradise Valley (Loeltz, Phoenix, and Robinson, 1949) and in the Grass Valley (Robinson, Loeltz, and Phoenix, 1948), approximately 70 miles west of the Crescent Valley, it is estimated that only about 40 percent of the runoff in the Crescent Valley ultimately recharges the ground-water reservoir. The remainder of the runoff is evaporated from the streams and other water surfaces such as ephemeral playa lakes or is transpired by the vegetation along stream courses before it reaches the ground-water reservoir. The average annual recharge in the Crescent Valley from precipitation at altitudes above 5,500 feet is therefore estimated to be about 14,000 acre-feet.

PRECIPITATION ON THE VALLEY FLOOR

Direct precipitation on the floor of the valley is somewhat more than 6 inches a year. Ordinarily this is not enough to satisfy evapotranspiration requirements. Furthermore, downward movement of water beneath the floor of the valley is impeded by the nearly impermeable silt and clay that underlie the valley floor at lower elevations. For these reasons recharge from precipitation on the valley floor is believed to be negligible.

INFILTRATION OF EXCESS IRRIGATION WATER

Owing to the relatively impermeable nature of the sediments for some distance below the floor of the valley, it is improbable that appreciable quantities of excess irrigation water recharge the ground-water reservoir. Most of the excess irrigation water evaporates or is transpired by vegetation outside the irrigated areas.

SURFACE FLOW FROM THE CARICO LAKE VALLEY

Ground water from the Carico Lake Valley surfaces at the gap at Rocky Pass and flows into the Crescent Valley. In addition, excess irrigation water from the Henry Filippini ranch at Rocky Pass enters the Crescent Valley through the gap. On the basis of a few measurements of streamflow at Rocky Pass, it is estimated that during an average year 200–300 acre-feet of water enters the Crescent Valley as surface flow from the Carico Lake Valley. Of this amount, perhaps 100 acre-feet a year ultimately enters the ground-water reservoir in the Crescent Valley. The remainder is lost through evapotranspiration.

SEEPAGE FROM BEDROCK

The contribution of ground water to the valley fill from the bedrock of the surrounding mountain blocks and from the bedrock that underlies the alluvium is unknown. However, it is probably negligible.

DISCHARGE

Discharge from the ground-water reservoir of the Crescent Valley is effected in several ways. Evaporation and transpiration, or evapotranspiration, account for the largest losses. Discharge by evaporation takes place in areas where the capillary fringe (a belt of moisture held above the water table by capillarity) reaches the land surface. Discharge by transpiration occurs in areas where the vegetation consists of phreatophytes (plants that normally send their roots to the water table or to the capillary fringe). Smaller quantities of ground water are discharged by springs and seeps, by underflow out of the valley, and by pumping and subsequent evaporation and transpiration of water from the ground-water reservoir.

EVAPOTRANSPIRATION

The quantity of ground water that is discharged by evapotranspiration is dependent on many factors, including the depth to water, the species of plants and their density of growth, and the type of soil. Evapotranspiration does not proceed at a constant rate but varies with the season, the time of day, the temperature, humidity, and wind velocity, and other climatic factors.

The two areas of evapotranspiration shown on plate 1 have been designated the greasewood area and the saltgrass area, after the species of phreatophytes that are dominant in those areas. Rabbitbrush, saltgrass, shadscale, and sagebrush are associated with the greasewood and are abundant locally. However, shadscale and sagebrush are not phreatophytes. The density of growth of the greasewood and associated phreatophytes varies locally but averages about 15 percent of the maximum possible density for the 33,300 acres of the greasewood area. The depth to water in the greasewood area ranges from about 8 to 20 feet below the land surface.

The saltgrass area of about 14,000 acres also includes other associated phreatophytes such as rabbitbrush, greasewood, and scattered saltbush. It contains several small playas whose areas range from less than an acre to nearly a square mile. The depth to water in the saltgrass area is generally 3–10 feet below the land surface.

The surface of much of the saltgrass area is encrusted with a white saline efflorescence. Most of the saline material probably has been deposited from ground water that evaporated from the capillary fringe. Because the sediments that underlie the saltgrass area are fine grained, the capillary fringe may extend to the land surface even though the water table is 5 feet or more below the land surface.

On the basis of data derived from evapotranspiration experiments conducted by White (1932) in the Escalante Valley, Utah, it is estimated that in the Crescent Valley the annual evapotranspiration rate in the greasewood area is about 0.15 acre-foot per acre, and in the saltgrass area about 0.5 acre-foot per acre. At these rates, about 5,000 acre-feet a year of ground water is discharged in the greasewood area and about 7,000 acre-feet in the saltgrass area.

SPRINGS AND SEEPS

There are both thermal and nonthermal springs and seeps in the area. None discharge large quantities of water. The thermal springs include the Crescent Valley Hot Springs at the southwest end of the Dry Hills in secs. 1, 2, and 11, T. 29 N., R. 48 E., and the hot spring locally called the Chillis Hot Spring near the southwest end of the Crescent Valley in sec. 27, T. 27 N., R. 46 E. The nonthermal springs and seeps include small springs in the mountains and seepage areas on the lower fields of the Dean Ranch in sec. 5, 28, 32, and 33, T. 28 N., R. 48 E.; 2 small seeps near the center of the valley floor in secs. 25 and 36, T. 29 N., R. 48 E.; and 3 springs near the north end of the valley in sec. 36, T. 31 N., R. 48 E.

The Crescent Valley Hot Springs consist of 5 major springs which are along, or adjacent to, a probable fault zone at the base of the Dry Hills. The springs arise from alluvium and bedrock in a line 1½ miles long and have a combined flow estimated at a little less than 100 gpm. Calcareous sinter is being deposited by the springs. The temperatures of the water from all but 1 of the springs are between 124° and 138°F; 1 spring, on the valley floor, has a temperature of 79°F. An analysis of water from one of the largest springs is shown in table 1.

The Chillis Hot Spring, at the bedrock-alluvium contact at Rocky Pass, discharges 10 gpm. The temperature of the water is 102°F.

The two springs in sec. 36, T. 31 N., R. 48 E., discharge a few gallons a minute. An analysis of water from the springs is shown in table 1. The temperature of the water, 66°F, was measured in the summer and may therefore be higher than the actual temperature of the water that seeps into the pools.

It is estimated that the combined flow of all the springs and seeps in the Crescent Valley is not much more than 100 gpm, or about 150 acre-feet a year.

UNDERFLOW

Underflow from the Crescent Valley is believed to be confined to the extreme north end of the valley where an unknown, but probably small, quantity of ground water flows into the valley of the Humboldt River. That the underflow is small is suggested by the combination of a low hydraulic gradient of only 1.5 feet per mile at the northeast end of the valley and the probably low permeability of the valley fill, which was derived from the low-lying mountains that flank the valley near its mouth.

A further indication that the underflow is small is the fact that the low flow of the Humboldt River and the canals through the gap at Beowawe is only 1½ cfs (cubic feet per second) during dry years (Mr. George Hennan, supervising commissioner, Humboldt Water

Distribution District, oral communication, 1958). Because any substantial underflow from the Crescent Valley into the Humboldt River would be evidenced by a pickup in the flow of the river, the underflow is included in the 1½ cfs and is probably only a small fraction of that amount, or only a few hundred acre-feet per year. The actual pickup is not known, as no data are available on the flow of the Humboldt River above the mouth of the Crescent Valley.

PUMPAGE

During 1956, several stock and domestic wells, 2 industrial wells, and 6 irrigation wells were in use in the Crescent Valley. It is estimated that the stock wells and domestic wells discharged about 50 acre-feet of water. Wells 28/47–33A1 and –33A2 supplied water to the homes and to the cyanide plant at Gold Acres at an average rate of 275 gpm, or about 500 acre-feet a year. The two irrigation wells on the Dean Ranch were pumped about 169 days at a combined average rate of 1,000 gpm; thus, about 750 acre-feet of water was pumped from both wells. No pumpage data are available for irrigation wells 29/48–29C1 and 30/48–33C1, but it is estimated on the basis of the number of acres irrigated that about 350 acre-feet of water was pumped from them during the year. Well 30/48–27C1 discharged 400 acre-feet of water during the irrigation season. Well 29/49–34C2 reportedly discharged 250 acre-feet. The total discharge of ground water from all the wells in the valley was thus about 2,300 acre-feet in 1956.

INVENTORY

In a ground-water basin such as the Crescent Valley, the average annual recharge is equal to the average annual discharge plus or minus changes in ground-water storage. Unfortunately, the changes in ground-water storage resulting from the increased rate of pumping in recent years cannot be satisfactorily evaluated from the limited data available. Therefore, it is desirable to use a more favorable period, during which changes in ground-water storage were less significant, for checking estimates of recharge against estimates of discharge. The most favorable period appears to be about 1948, the year in which the phreatophytes were mapped.

It is believed that the average annual discharge from the ground-water reservoir by evapotranspiration was greater then than it is now, or about 12,000 acre-feet. Underflow from the valley was probably about the same in amount as today—that is, probably only a few hundred acre-feet, and springs annually discharged about the same quantity of water as today—about 150 acre-feet. Thus the average annual natural discharge was a little more than 12,000 acre-feet.

To this should be added the estimated annual pumpage of about 600 acre-feet at the time the phreatophytes were mapped. The average annual discharge under equilibrium conditions thus is estimated to be about 13,000 acre-feet. In preceding sections of the report the average annual recharge was estimated at about 14,000 acre-feet. The estimates of recharge and discharge agree as closely as could be expected from the nature of the data and estimates used.

FLUCTUATIONS OF WATER LEVELS

The volume of ground water in storage does not remain constant but varies with changes in the amounts of recharge and discharge. During periods when recharge exceeds discharge there is an increase in the quantity of water in storage. Conversely, when discharge exceeds recharge the amount of ground water in storage decreases. These changes in storage cause fluctuations of the water table and the piezometric surface, which can be determined by measurements of the water levels in wells.

In order to obtain an indication of the changes in ground-water storage, periodic measurements were made in 5 observation wells. In addition, 2 or 3 measurements were made in each of 8 other wells. Hydrographs of the fluctuations of water level in the 5 observation wells are shown in figure 4. Measurements made in the other wells are given in table 4.

The hydrographs indicate that the maximum fluctuation in ground-water levels during the year ranges from about 1 to 3 feet in the areas of natural discharge. Generally, the levels reach their highest stage in the spring or early summer, and then decline until fall. The period during which ground-water levels rise in the spring corresponds with or lags slightly behind the period of maximum runoff. After the runoff period the ground-water levels decline steadily owing to discharge of water by evapotranspiration.

In addition to the seasonal fluctuations in ground-water levels, long-term trends due to climatic variations also are evident. The long-term fluctuations result largely from annual changes in the amount of precipitation but are caused also, to a small extent, by other factors such as changes in temperature.

The hydrographs in figure 4 indicate a general decline of a few tenths of a foot from 1952 to 1955. During that period precipitation, and consequently recharge to the aquifers, was deficient. Natural discharge, however, continued at approximately the same rate. Therefore, a part of the total discharge was necessarily derived from storage. In 1956 the levels rose sharply, and they have continued to rise. This rise is believed to have resulted from increased precipitation. Over a period of many years, the fluctuations due to climatic

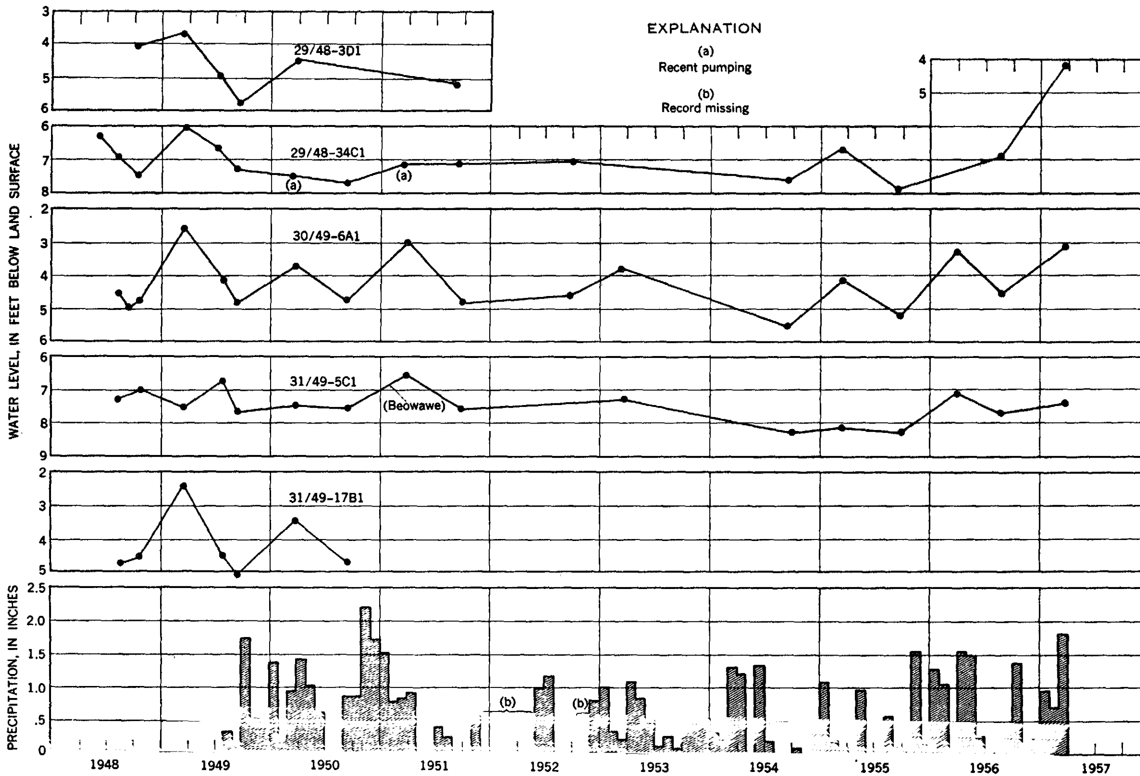

Figure 4.—Hydrographs of observation wells and monthly precipitation data, where available, for the period of record, 1948–57.

variations average out, so that the long-term effect of these variations on ground-water levels is insignificant.

Of more immediate concern to the economy of the valley is the effect of artificial withdrawals on the ground-water levels. Although insufficient data are available for evaluation of these effects, it is certain that water levels have been lowered somewhat as a result of ground-water withdrawals. However, because the withdrawals until recently have been small, their effect has been negligible.

CHEMICAL QUALITY OF THE GROUND WATER

WATER FOR IRRIGATION

In evaluating water to be used for irrigation, the salinity hazard, the sodium (alkali) hazard, and the concentration of bicarbonate, boron, and other ions must be considered. The above properties of water were discussed by Wilcox (1955) and the following discussion is based almost entirely on his report.

SALINITY HAZARD

The salinity hazard depends on the concentration of dissolved solids. It is commonly measured in terms of the electrical conductivity of the water, expressed as micromhos per centimeter, or $EC \times 10^6$, at 25° C. The electrical conductivity is an approximate measure of the concentration of the ionized constituents of the water. Wilcox (1955) divides water into four classes with respect to its conductivity. The dividing points between the classes are at 250, 750, and 2,250 micromhos per centimeter. (See fig. 5.) Water of low conductivity is more suitable for irrigation than water of high conductivity, all other factors being equal. Wilcox provides the following classification of irrigation water with respect to salinity hazard:

1. Low-salinity water (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.
2. Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.
3. High-salinity water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.
4. Very high salinity water (C4) is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances.

SODIUM HAZARD

The sodium, or alkali, hazard is indicated by the sodium-adsorption ratio (SAR), which may be defined as $SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$, in

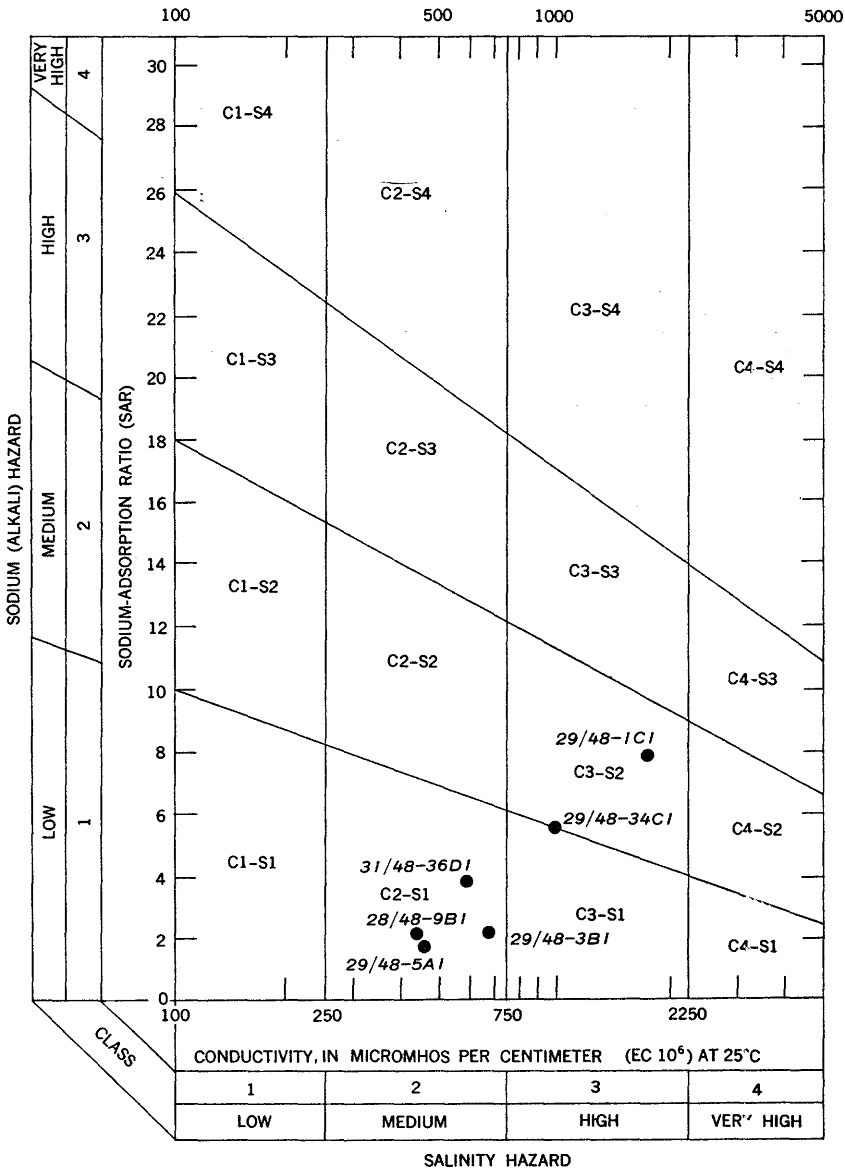

FIGURE 5.—Classification of irrigation water on the basis of conductivity and sodium-adsorption ratio

TABLE 1.—*Chemical analyses and classification of waters*

[Analysis by U.S. Geological Survey, Quality of Water Laboratory, Salt Lake City,

Well or Spring No. and location	Classification									Constituents (ppm)		
	Source of sample	Depth of well (feet)	Temperature (° F)	Date collected	Specific conductance (micromhos at 25° C)	Dissolved solids (ppm)	Sodium-adsorption ratio (SAR)	Residual sodium carbonate (RSC) (epm)	Classification for irrigation	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)
28/48-9B1	W	129	54	9-15-48	441	298	2.1	0.38	C2-S1	39	0.08	34
29/48-1C1	S	------	138	6-10-48	1,750	1,140	7.9	9.9	C3-S2	73	.03	53
3B1	W	216	56	6-11-48	675	448	2.3	0	C2-S1	34	.18	53
5A1	W	106	-----	11-3-54	456	276	1.8	.05	C2-S1	13	.11	34
34C1	W	------	50	9-15-48	994	638	5.6	1.50	C3-S2	68	.08	36
31/48-36B1	S	------	66	6-14-48	584	424	3.9	1.12	C2-S1	90	.03	30

in the Crescent Valley, Eureka and Lander Counties, Nev.

Utah. Source of sample: S, spring; W, well. Classification for irrigation: See fig. 5]

Constituents (ppm)—Continued											
Magnesium (Mg)	Sodium (Na) and potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness as $CaCO_3$, total	Noncarbonate	pH	Remarks
9.0	52	172	48	29	1.0	1.2	0.02	122	0	8.7	CO_3 not reported.
43	319	980	117	44	5.9	.0	.4	309	0	------	Not suitable for irrigation or domestic use.
17	75	246	121	26	.3	.1	.06	202	0	------	Hard water. Some softening desirable for certain domestic uses. 7.9 ppm Fe precipitated from sample.
10	46	157	53	32	.2	3.0	------	126	0	7.4	Zinc, 1.6 ppm; manganese, 0 ppm.
14	157	270	155	73	.9	.8	.04	148	0	8.2	Quality for irrigation is marginal.
5.7	89	188	71	42	1.4	2.4	.02	98	0	------	

which concentrations are expressed in equivalents per million (epm). If the proportion of sodium among the cations is high, the sodium hazard is high; but if calcium and magnesium predominate, the sodium hazard is low. Wilcox classifies irrigation waters, with respect to sodium hazard, as follows:

1. Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stonefruit trees and avocados may accumulate injurious concentrations of sodium.
2. Medium-sodium water (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.
3. High-sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management—good drainage, high leaching, and organic matter additions.
4. Very high sodium water (S4) is generally unsatisfactorily for irrigation purposes except under special circumstances.

BICARBONATE ION

Residual sodium carbonate (RSC) is a measure of the hazard involved in the use of high-bicarbonate water and is defined by the formula $RSC=(CO_3^{--}+HCO_3^{-})-(Ca^{++}+Mg^{++})$, in which concentrations are expressed in equivalents per million. Water in which the value for residual sodium carbonate is greater than 2.5 epm is not suitable for irrigation. Water that contains 1.25–2.5 epm is considered marginal, and water containing less than 1.25 epm is probably safe.

BORON

Boron is present in nearly all natural water in amounts that range from less than 1 to several parts per million. In small amounts it is essential to plant growth, but it is toxic at concentrations slightly higher than the optimum. Scofield (1935) has proposed limits for boron depending on the sensitivity of the crops to be irrigated.

WATER FOR DOMESTIC USE

The concentration limits of some chemical substances in drinking water used on interstate carriers and for public supplies in general, as specified by the U.S. Public Health Service, follow:

Constituent	*Maximum concentration (ppm)*
Iron and manganese (sum)	0.3
Magnesium	125
Sulfate	250
Chloride	250
Fluoride	1.5
Dissolved solids	500 (1,000 permitted)

It should not be assumed, however, that all water containing dissolved mineral matter in concentrations exceeding these limits is necessarily harmful. Rather, the limits should be used only as a guide in determining the suitability of water for human consumption.

Another factor for consideration is the hardness. Hard water requires a large quantity of soap to produce suds, although this problem has been largely eliminated through the use of synthetic detergents; further, hard water contributes to the formation of scale in water heaters, radiators, and pipes.

Hardness is caused almost entirely by the presence of calcium and magnesium. Iron, manganese, aluminum, some other metallic cations, and free acid also cause hardness, but generally they are not present in sufficient quantities to be objectionable. Although no rigid limits have been set as to what constitutes hard water, any water that has a hardness of 60 ppm or less is generally considered soft. Water that has a hardness ranging from 61 to 200 ppm can be considered moderately hard to hard, and water having a hardness greater than 200 ppm is considered very hard. Water having a hardness of more than 200 ppm is generally too hard for many purposes and therefore normally is softened.

CLASSIFICATION AND INTERPRETATION OF ANALYSES

The chemical analyses and other significant characteristics of water from 4 wells and 2 springs are given in table 1.

WATER FOR IRRIGATION

As stated previously, consideration should be given first to the salinity and sodium (alkali) hazards in appraising water for irrigation. Accordingly, in figure 5 the salinity and alkali hazards of all the waters that were analyzed are plotted on a diagram proposed by Wilcox for the classification of irrigation water. As shown, most of the water is in class C2–S1; that from the Crescent Valley Hot Springs, 29/48–1C1, and from well 29/48–34C1 are in class C3–S2. On the basis of salinity and sodium hazards alone, then, all the water, except the water from these two sources, can be safely used to irrigate most crops.

Water from well 29/48–34C1 also contains 1.5 epm of residual sodium carbonate and must therefore be considered marginal on that basis. The high residual sodium carbonate (9.9 epm) of the sample from the Crescent Valley Hot Springs, 29/48–1C1, is beyond the limit considered safe for irrigation. All the other samples analyzed are within safe limits with respect to residual sodium carbonate. The low boron content of all the samples is within the limits proposed by Scofield (1935) for sensitive corps.

WATER FOR DOMESTIC USE

With the exception of the water from the Crescent Valley Hot Springs, all the waters that were analyzed are suitable for domestic use. However, all are moderately hard to hard, and it may therefore be desirable to soften some of the harder waters for certain domestic uses.

The concentration of fluoride in the water from the Crescent Valley Hot Springs is much in excess of the mandatory limit of 1.5 ppm set by the U.S. Public Health Service for interstate carriers. The continual use of this water by young children during the formation of their permanent teeth undoubtedly would result in mottling of the enamel (Dean, 1936). Mottling becomes more noticeable as the fluoride content exceeds 1.5 ppm.

LOCAL VARIATIONS IN THE CHEMICAL QUALITY OF GROUND WATER

All ground water carries minerals in solution. A small part of the dissolved minerals is present originally in the rain and snow from which the ground water is derived, but most of the mineral matter is dissolved from the rocks with which the water comes into contact. The longer water is in contact with the rocks the more highly mineralized it becomes, so that ordinarily the concentration of dissolved solids increases with increasing distance from the recharge area. In addition, the opportunity for solvent action is increased in fine-grained rocks having a high porosity, because the surface area of the rock that is exposed to the water is very large.

From these general principles and from the results of the chemical analyses, it is possible to make some statements concerning the quality of ground water in the valley. A study of the analyses indicates a marked increase in the concentration of dissolved solids near the axis of the valley. For example, wells 29/48–3B1 and 29/48–34C1 yield waters that contain respectively 448 and 638 ppm of dissolved solids. Water from wells 29/48–5A1 and 28/48–9B1, which are closer to the recharge area, contain only 276 and 298 ppm of dissolved solids. It is inferred that the increase in dissolved solids with increased distance from the recharge area is due to the solution of the clastic rock particles and evaporites of the valley fill by ground water percolating through them. It is probably safe to generalize that the ground water in and near the axis of the valley, or in the area shown on plate 1 as the saltgrass area, is more highly mineralized than ground water nearer the areas of recharge. It is more difficult, however, to predict the chemical composition of the dissolved solids.

On the basis of one analysis, that of the sample from spring 31/48–36B1, it is thought that the hardness of the water in the northern part of the valley probably is less than that in the central part of the valley. In the discussion of the geology of the mountain ranges, it was stated that the mountains flanking the northwestern part of the valley are composed largely of volcanic rocks, whereas the mountains bordering the central part of the valley contain much limestone. Inasmuch as the chemical composition of the ground water is related to the chemical composition of the rocks from which the valley fill was derived, it may tentatively be assumed that ground water from the valley fill north of T. 29 N. contains proportionally less calcium and magnesium and more sodium than does the ground water farther south.

The amount of boron is low in all the samples that were analyzed, and it seems reasonable to assume that, as the samples were obtained from the central and northwestern parts of the valley, high concentrations of boron will not pose a problem in those areas.

DEVELOPMENT OF GROUND WATER

Small perennial streams rising in the mountains have been utilized for domestic supply, for mining and milling activities of the past, and for irrigation, but the ultimate development of the valley will be based largely on its supply of ground water.

PRESENT DEVELOPMENT

About 2,300 acre-feet of ground water is presently being pumped from 6 irrigation wells and 2 industrial wells. Of the 8 wells, 7 are in the west-central part of the valley; the 8th is in the eastern part. All the wells obtain water from the unconsolidated sediments of the valley fill. A few other wells have been drilled for irrigation but to date they have not been used for that purpose. In addition, several stock wells and a few domestic wells have been drilled or dug in the valley. All the known wells are shown on plate 1.

The two industrial wells, 28/47–33A1 and –33A2, supply water for milling and domestic purposes at the Gold Acres mining community. Each well is 12 inches in diameter and 250 feet deep. They are pumped throughout the year, either singly or together, and in 1956 yielded 500 acre-feet of water, according to data in the files of the Office of the State Engineer. The water is pumped more than 3 miles through a pipeline to Gold Acres.

The two irrigation wells at the Dean Ranch are at or near the toe of the Indian Creek fan. Well 28/48–18A1, which is between 300 and 350 feet deep, penetrates aquifers that have a transmissibility of about 60,000 gpd per foot. The specific capacity of the well is not known but is estimated, on the basis of the transmissibility, the type of well construction, and an assumed coefficient of storage of a few hundredths, to be between 20 and 30 gpm per foot of drawdown. No data relative to the transmissibility or specific capacity are available for the other well, 28/48–17B1, which is only 190 feet deep. Each well is pumped at a rate of 1,000 gpm or more for a few weeks to 2 months or longer each year and is used to supplement surface water diverted from Indian Creek. Water from both surface and underground sources is used to irrigate 240 acres. Feed for cattle is the only crop raised at the ranch.

In 1956 an irrigation well, 29/49–34C2, was drilled at the Dewey Dann Ranch in the northeastern part of the valley. The well is 228 feet deep and taps aquifers that have an average transmissibility of about 30,000 gpd per foot. Its specific capacity is about 13 gpm per foot of drawdown. At the beginning of the 1957 irrigation season, the well was pumped at the rate of about 1 cfs (cubic foot per second; about 450 gpm), but in 1956 it reportedly was pumped at the rate of 1,000 gpm for a period of 2 months.

Farming is presently carried on in the west-central part of the valley, where several irrigation wells are in use. Aquifer tests made at wells 30/48–27C1 and –33C1 indicate transmissibilities of 6,500 and 37,000 gpd per foot, respectively, for the aquifers penetrated by these wells. In August 1953, after 6 hours of pumping, the measured discharge from the latter well was 665 gpm and the pumping lift 122 feet, indicating a specific capacity of about 10 gpm per foot of drawdown. Well 30/48–27C1 has a specific capacity of only 5 gpm per foot of drawdown. Both wells were drilled in 1952—well 30/48–33C1 to a depth of 300 feet, and well 30/48–27C1 to a depth of 352 feet. The number of acres irrigated by the two wells is not known but is estimated to be between 200 and 300.

Well 29/48–29C1 was drilled to a depth of 276 feet in 1953. Data furnished by Mr. Arnold of Beowawe indicate that the specific capacity of the well is less than 10gpm per foot of drawdown. Water is pumped from the well at a rate of about 500 gpm into a reservoir, from which it is pumped into a sprinkler system, and irrigates 170 acres. In 1956 well 29/48–29C2 was drilled to a depth of 300 feet, a quarter of a mile north of well 29/48–29C1. Reports by the driller indicate that the specific capacity of the well may be as high as 40 gpm per foot of drawdown.

Relatively insignificant quantities of water are withdrawn from stock and domestic wells in the valley. In at least 6 wells, the water is under sufficient pressure to flow at the land surface. All the flowing wells are on the valley floor beyond the toes of the alluvial fans, and all but one are on the Dean Ranch in the central part of the valley. None has a large yield, their specific capacities ranging from 5 to less than 1 gpm per foot of drawdown.

POTENTIAL DEVELOPMENT

Water can be pumped from the ground-water reservoir without causing a persistent decline in water levels only to the extent that an equal amount of water can be salvaged from natural discharge. Inasmuch as nearly all the natural discharge takes place by evapotranspiration from the phreatophyte areas, salvaging all the ground water for beneficial use would entail lowering the water table to a level below the root zone of the phreatophytes—possibly more than 50 feet below the land surface.

At present, all the large producing wells are located at the periphery of the phreatophyte area, and any future large producers probably will be located there also. Pumping from wells in these areas might appear to intercept the water moving toward the areas of natural discharge on the floor of the valley, but pumping will not reduce that discharge until it has caused a significant lowering of the water table under the floor of the valley. This would require a far greater lowering of the water table—that is, a reduction in storage—in the area of pumping. In other words, before there can be salvage for beneficial use of the water now discharged by phreatophytes, there must be some depletion of the water that is stored in the ground-water reservoir.

Ultimately, the lowering of water levels by pumping from storage should result in a reduction of natural discharge; and theoretically, by continued pumping for a period of years it should be possible to stop all natural discharge. Annual withdrawals of ground water equal in amount to the annual recharge could then be made without a further continuing decline of ground-water levels. However, the degree to which such "mining" can be carried out is limited by both economic and hydrologic considerations. To withdraw water from wells in the more favorable areas of the valley (see fig. 6) until all natural discharge is stopped may necessitate lowering ground-water levels in those areas a hundred feet or more. Pumping costs may become prohibitive before such a lowering can be effected, in view of the fact that crops normally grown in this part of the State have a relatively low market value. Also, some water must be allowed to discharge naturally in order to maintain "salt balance"—that is, to carry off the salt deposited as a result of evaporation of the water, and thus prevent the salt content of the water from rising too high.

If future exploration for ground water indicates that large quantities can be withdrawn also from the axial part of the valley and from other areas now believed to be unfavorable for development, the quantity of water that can feasibly be developed may be consid-

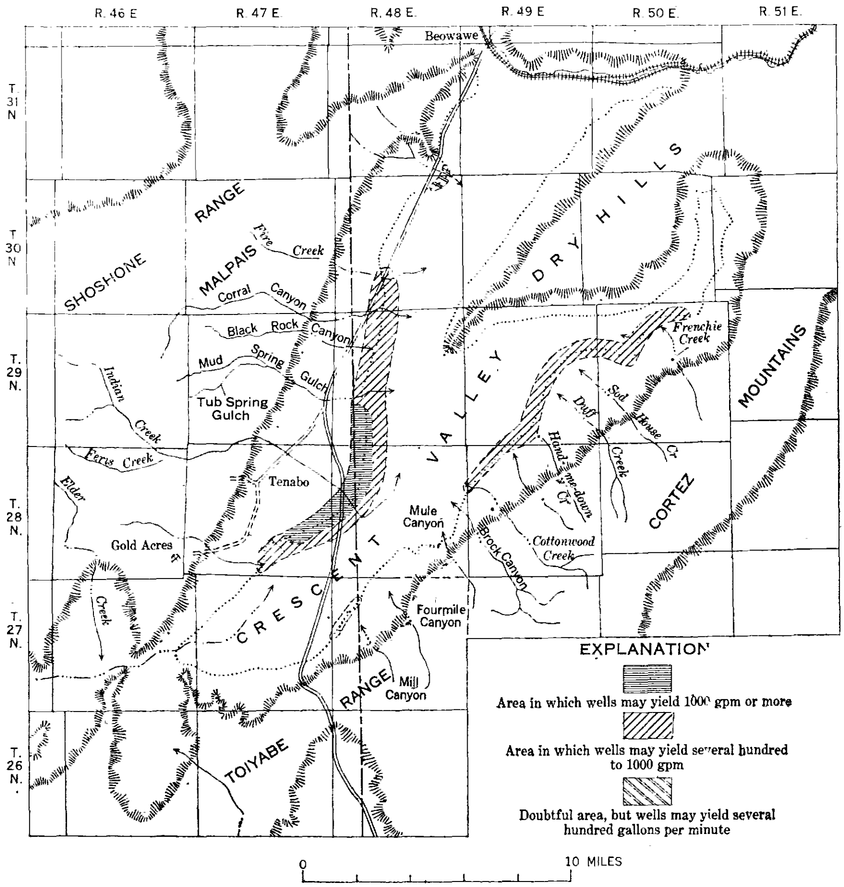

FIGURE 6.—Map showing areas of prospective development of ground water for irrigation or other large-scale uses.

erably greater than if large producing wells are confined to the favorable areas shown in figure 6.

It should be noted that, as the underflow from the Crescent Valley to the Humboldt River is probably very small and as some outflow must continue if salt balance is to be maintained, development of the ground-water resources of the Crescent Valley will have no significant effect on the flow of the river.

AREAS SUITABLE FOR DEVELOPMENT

The suitability of an area for the development of ground water can be evaluated on the basis of (a) the quantity of ground water locally available; (b) the physical characteristics of the aquifer, in this area; (c) the chemical quality of the water, and the possibility that the quality may deteriorate after prolonged pumping; and (d) miscellaneous factors such as topography, depth to water, and type of soil.

QUANTITY OF GROUND WATER AVAILABLE LOCALLY

The total recharge to the valley is derived in varying amounts from different parts of the adjoining mountain areas. Generally, the larger and topographically higher watersheds in the mountains contribute the most runoff and consequently the most recharge. Thus the large watershed drained by Indian Creek may contribute as much as one-fourth of the total recharge to the Crescent Valley, whereas the low hills of the Malpais contribute only a very small part.

Probably about one-third of the total recharge originates in the Cortez Mountains. Some watersheds in the Cortez Mountains contribute considerably more recharge than others. The relative amount contributed by each is indicated by the streamflow data in table 2, if the assumption is made that the recharge contributed by each stream is directly proportional to the volume of the streamflow. Although it is known that this assumption is not exactly true, owing to many variables, still it is useful as a guide in estimating the amount of recharge that is effected locally. The data in table 2 indicate that the major part of the recharge from the Cortez Mountains is derived from Duff and Frenchie Creeks and the stream in Mill Canyon.

TABLE 2.—*Flow measurements of streams on the west side of the Cortez Mountains*

Name of stream	Date of measurement	Flow (cfs)	Remarks
Mill Canyon	6- 9-48	2.2	
Fourmile Creek	6- 9-48	.2	Measured at mouth of canyon.
Brock Canyon	6- 9-48	.7	
Cottonwood Creek	6- 9-48	.6	Measured near toe of alluvial fan.
Little Cottonwood Creek	6- 9-48	.3	Measured on alluvial fan.
Hand-me-down Creek	6-10-48	.8	
Duff Creek	6-10-48	6.9	Measured at mouth of canyon.
Sod House Creek	6-10-48	.8	
Frenchie Creek	6-10-48	3.4	

PHYSICAL CHARACTERISTICS OF THE ALLUVIUM

Insofar as the water-yielding properties of the saturated alluvium are concerned, its most important characteristics are the degree of sorting, the porosity, and the average grain size. A high degree of sorting increases the porosity of the alluvium, but a high porosity does not of itself determine the quantity of water that a saturated

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deposit will yield to wells. A material may be highly porous, but if the average size of the mineral grains is small it will yield little water to wells. The yield of a sediment is reduced to the extent that water adheres to the walls of the mineral grains by molecular attraction. Because the total surface area of the component fragments of a fine-grained sediment is greater than that of an equal volume of coarse material, the quantity of water that is retained by molecular attraction in the finer grained sediment is also greater.

The physical characteristics of the alluvium were discussed in the section on geologic formations. It was stated there that the alluvium becomes progressively finer grained toward the axis of the valley. Few data are available concerning the sorting of the alluvium in the Crescent Valley, but it is probable that the degree of sorting and the porosity of the alluvium that was deposited by perennial streams are greater than those of the deposits of intermittent streams. Therefore, the most favorable well sites probably are on the larger alluvial fans, which normally are those traversed by perennial streams or by the larger intermittent streams. Ordinarily, the site should be selected on the lower part of the alluvial fan, as the alluvium near the apex may contain boulders several feet or more in diameter. Also, the depth to the permanent water body near the apex of the fan will usually be great and often may be excessive.

CHEMICAL QUALITY OF THE WATER

As previously stated, ground water becomes more highly mineralized with distance from the recharge area. This general relation between the amount of mineralization and distance from the recharge area should be considered in selecting a site for a well. Ordinarily ground water in the aquifers that underlie the alluvial fans is suitable for irrigation and industrial use, whereas water in the aquifers near the axis of the valley may contain dissolved minerals in objectionable quantities.

The chemical quality of water pumped from a well will deteriorate if the withdrawals are sufficient to divert water of poor chemical quality to the well. Therefore, water pumped from wells near the axis of the valley may deteriorate somewhat in chemical quality if the pumping is sufficient to reverse the normal gradient and thus divert water from the axis of the valley, and especially from the playa areas, to the wells.

OTHER FACTORS

Other factors, such as the depth to water, also govern the choice of a well site. Although the piezometric surface slopes downward toward the axis of the valley, its gradient usually is considerably less than that of the land surface. Consequently, the depth to water is usually greater at the higher elevations and may be several hundred feet near the bedrock-alluvium contact. Locally, however, the ground water may occur under perched water-table conditions, and there the depth to water may be considerably less than expected, though the quantity of ground water would probably be small.

The choice of a site for an irrigation well is affected also by the type of soil. No data on soil types in the Crescent Valley are available, but it is apparent that much of the area that corresponds to the saltgrass area is now unsuitable for agriculture because of the presence in the soil of large quantities of soluble salts.

SUMMARY

The selection of favorable areas for the development of ground water for irrigation in the Crescent Valley is based on the factors just discussed and on the known characteristics of existing wells in the valley. The most promising area for the development of ground water on the west side of the valley extends from the southern limit of the Indian Creek fan northward to Corral Canyon. (See fig. 6.) With proper construction, most wells drilled in the lower parts of the alluvial fans in this area to depths of several hundred feet will be capable of yielding several hundred to more than 1,000 gpm with a reasonable lift. This area, and particularly the lower section of the Indian Creek fan, appears to be the most favorable in the valley.

It is more difficult to evaluate the aquifers on the east side of the valley. Perhaps quantities of ground water on the order of several hundred acre-feet can be pumped annually from each of the alluvial fans traversed by the larger streams, such as Duff and Frenchie Creeks and the stream in Mill Canyon. The yields of wells on the east side of the valley probably will be less than those in the more favorable areas on the west side of the valley.

A small area on a fan at the foot of the Malpais has been designated as doubtful, but wells there may yield a few hundred gallons per minute. The fan is the only large one below the Malpais and may contain alluvium of sufficient permeability to carry a moderately large quantity of water.

TABLE 3.—*Record of wells in the Crescent Valley, Eureka and Lander Counties, Nev.*

[Type of well: B, bored; Dg, dug; Dr, drilled; J, jetted. Use of water: D, domestic; Ind, industrial; Irr, irrigation; N, none; O, observation; S, stock. Asterisk (*) indicates reported]

Well No. and location (pl. 1)	Owner	Type of well and year completed	Diameter (inches at land surface)	Depth (feet)	Measuring point			Pressure head or water level		Use	Temperature (°F)	Remarks
					Altitude (feet)	Above (+) or below (−) land surface (feet)	Description	Above (+) or below (−) measuring point (feet)	Date			
27/47-8C1	Unknown	Dg	144	45				Dry		N		
17B1	Ed Filippini	Dr	8	103	4,846	+0.5	Top of casing	−70.17	9-21-54	N		
28/47-22D1	Mill Gulch Placer Mining Co.	Dr, 1934?	12	*300	4,838	0	Hole in pump base.	−71.13	6-9-48	N		
27A1	Scott Placer Co.	Dr	8	87				Dry		N		
33A1	London Extension Mining Co.	Dr, 1941	12	250		0	Land surface	−90 to −95*		Ind, D		Gravel-packed; water reported "very hard;" log.
33A2	do	Dr, 1950	12	250		+2.1	Top of casing	−95.48 (see remarks).	8-6-53	Ind, D		Well −33A1, 100 ft away, being pumped at 240 gpm when water level measured; log.
35C1	Frances McCoy	Dr, 1956	14	200						N		To be used for irrigation; log.
36D1	Dan Filippini	Dr	6	134	4,768	+.8	Top of casing	−7.02	8-18-54	N		
28/48-8D1	do	Dr, 1949	4	151						N		Reported flowing 15 gpm. Destroyed; log.
9B1	do	Dr	4	*129	4,737	+.8	Top of bushing	+5.66	9-22-54	S	54	Flow 15 gpm. Analysis.
11D1	do	Dr	6			+1.0	Top of 1-in. pipe	+1.3	9-22-54	S	56	Flow 1-2 gpm.
14B1	do	Dr	6		4,740	+2.0	Top of concrete block.			S		Flow 3 gpm from outlet 2.5 ft above land surface.
14D1	do	Dr, 1949	16	180	4,750	0	Land surface, south side.	−12.6	8-19-54	N		Log.
15C1	do	Dr, 1956	4	89		0	Land surface	+7*	12-21-56	S		Flows 15 gpm; log.
16B1	do	Dr, 1949	4	108						N		Reported flowing 20 gpm. Destroyed; log.
17B1	do	Dr, 1949	16	190	4,764	+.3	Base of pump at airline opening.	−18.12	7-29-54	Irr	63	Pumped at 1,000 gpm; log.
18A1	do	Dr	12	*300-350	4,783	+2.0	Plug hole in top of discharge pipe.	−38.52	11-3-54	Irr	56½	Pumped at 1,000 gpm.
19D1	do	Dr	4	158	4,754	+.8	Top of casing collar.	+0.50	11-3-54	S	54	Flow less than 1 gpm.
27D1	do	Dr	4	144	4,739	+.6	Top of 4-in. casing	+3.04	8-11-48	S	54	Do.

29/48-3B1	do	Dr	6	216	4,732	+1.4	Top of casing collar.	−4.60	8-21-54	S	56	Flow 1 gpm in June 1948; analysis.
3D1	U.S. Geological Survey.	B, 1948	4	8	4,721	+.2	Top of casing	−5.40	9-14-51	O		Caved in.
5A1	H. J. Buchaneau	Dr, 1953	10	106	4,812	0	Land surface	−74*	5-53	D		Log; analysis.
17A1	do	Dr, 1953	14	212	4,810	+1.0	Top of casing	−71.03	8-20-54	N		Log.
17C1	do	Dr, 1953	14	200	4,798	+.5	do	−55.72	8-20-54	N		Do.
29C1	do	Dr, 1953	14	276	4,802	+1.1	Airline opening	−57.63	9-21-54	Irr		Do.
29C2	Beowawe Farms	Dr, 1956	14	300		0	Land surface	−66*	12-56	Irr		Do.
34C1	Dan Filippini	Dr, 1952	4	296	4,729	+.4	Base of pump, north side.	−7.33	8-25-56	S	50	Log; analysis.
29/49-11C1	do	Dr, 1952	6	298		0	Land surface	−13*	12-52	S		Log.
34C1	Dewey Dann	Dr, 1945	8	135		+.3	Top of casing	−71.91	8-11-48	D		
34C2	do	Dr, 1956	14	228		+.5	Hole in pump base.	−53.27	6- 4-57	Irr		Do.
30/48-22B1	Pat Arnold	Dr, 1954	14	200	4,760	+.2	Top of casing	−31.67	7-29-54	N		Do.
27C1	H. J. Buchaneau	Dr, 1952	14	352	4,748	+.1	do	−13.96	3- 6-53	Irr	65	Do.
33C1	do	Dr, 1952	14	300	4,804	+.2	Hole in pump base.	−69.04	10-21-53	Irr	54½	Do.
30/49-6A1	U.S. Geological Survey.	B, 1948	4	9	4,712	+.4	Top of casing	−4.98	8-25-56	O		
31/49-5C1	Wm. Connelly	Dg	48	10	4,698	0	do	−7.57	8-25-56	D		
17B1	U.S. Geological Survey.	B, 1948	4	12	4,708	+3.2	do	−7.93	9-13-50	O		Well destroyed.

TABLE 4.—*Water-level measurements in wells in the Crescent Valley, Eureka and Lander Counties, Nev.*

27/47–17B1

Ed Filippini. Drilled, unused well, diam 8 in, depth 103 ft. Measuring point, top of casing, 0.5 ft above land surface. Water levels, in feet below measuring point: Aug. 12, 1948, 70.09; Sept. 21, 1954, 70.17.

28/47–36C1

Dan Filippini. Drilled, unused well, diam 6 in, depth 134 ft. Measuring point, top of casing, 0.8 ft above land surface. Water levels, in feet below measuring point: July 8, 1948, 5.76; Aug. 11, 1948, 5.89; Aug. 18, 1954, 7.02.

28/48–9B1

Dan Filippini. Drilled stock well, diam 4 in, reported depth 129 ft. Measuring point, top of bushing, 0.8 ft above land surface. Water levels, in feet above measuring point: Aug. 11, 1948, 7.02; Sept. 22, 1954, 5.66.

28/48–19D1

Dan Filippini. Drilled stock well, diam 4 in, depth 158 ft. Measuring point, top of casing collar, 0.8 ft above land surface. Water levels, in feet above measuring point: Aug. 11, 1948, 0.95; Nov. 3, 1954, 0.50.

29/48–3D1

U.S. Geological Survey. Bored observation well, diam 4 in, depth 8 ft. Measuring point, top of casing 0.2 ft above land surface. Water levels, in feet below measuring point, 1948–51.

Date	Water level	Date	Water level	Date	Water level
Aug. 12, 1948	5.85	July 21	5.15	Mar. 20, 1950	4.64
Oct. 26	4.44	Sept. 7	6.00	Sept. 14, 1951	5.40
Mar. 15, 1949	3.84				

29/48–29C1

H. J. Buchaneau. Drilled irrigation well, diam 14 in to 207 ft, 12 in to 276 ft. Measuring point, airline opening, 1.1 ft above land surface. Water levels, in feet below measuring point: Aug. 6, 1953, 56.45; Oct. 21, 1953, 57.14; Sept. 21, 1954, 57.63.

29/48–34C1

Dan Filippini. Drilled stock well, diam 6 in, depth 296 ft. Measuring point, base of pump, north side, 0.4 ft above land surface. Water levels, in feet below measuring point, 1948–56.

Date	Water level	Date	Water level	Date	Water level
July 9, 1948	6.74	Sept. 7	7.68	Sept. 29, 1952	7.48
Aug. 11	7.37	Mar. 20, 1950	7.79	Sept. 21, 1954	8.01
Oct. 26	7.87	Sept. 13	8.10	Mar. 10, 1955	7.07
Mar. 15, 1949	6.48	Mar. 29, 1951	7.58	Sept. 20	8.33
July 21	7.07	Sept. 14	7.55	Aug. 25, 1956	7.33

29/49–34C1

Dewey Dann. Drilled domestic well, diam 8 in, depth 135 ft. Measuring point, top of casing, 0.3 ft above land surface. Water levels, in feet below measuring point: June 8, 1948, 72.40; Aug. 11, 1948, 71.91.

30/48–33C1

H. J. Buchaneau. Drilled irrigation well, diam 14 in, reported depth 300 ft. Measuring point, hole in pump base, 0.2 ft above land surface. Water levels, in feet below measuring point: Mar. 6, 1953, 58.60; Oct. 21, 1953, 69.04.

TABLE 4.—*Water-level measurements in wells in the Crescent Valley, Eureka and Lander Counties, Nev.*—Continued

30/49–6A1

U.S. Geological Survey. Bored observation well, diam 4 in, depth 9 ft. Measuring point, top of casing, 0.4 ft above land surface. Water levels, in feet below measuring point, 1948–56.

Date	Water level	Date	Water level	Date	Water level
Aug. 12, 1948	4.90	Mar. 20, 1950	4.18	Sept. 22, 1954	5.95
Sept. 15	5.35	Sept. 13	5.22	Mar. 10, 1955	4.58
Oct. 25	5.16	Mar. 29, 1951	3.40	Sept. 20	5.63
Mar. 15, 1949	3.01	Sept. 14	5.21	Mar. 27, 1956	3.66
July 21	4.57	Sept. 29, 1952	5.01	Aug. 25	4.98
Sept. 7	5.25	Mar. 6, 1953	4.30		

31/49–5C1

Wm. Connelly. Dug domestic well, diam 4 ft, depth 10 ft. Measuring point, top of casing, at land surface. Water levels, in feet below measuring point, 1948–56.

Date	Water level	Date	Water level	Date	Water level
Aug. 10, 1948	7.31	Sept. 13	7.55	Sept. 22, 1954	8.33
Oct. 26	7.01	Mar. 29, 1951	6.58	Mar. 10, 1955	8.17
Mar. 15, 1949	7.54	Sept. 14	7.60	Sept. 20	8.32
July 21	6.77	Sept. 29, 1952	7.41	Mar. 27, 1956	7.09
Sept. 9	7.69	Mar. 6, 1953	7.33	Aug. 25	7.57
Mar. 20, 1950	7.43				

31/49–17B1

U.S. Geological Survey. Bored observation well, diam 4 in, depth 12 ft. Measuring point, top of casing, 3.2 ft above land surface. Water levels, in feet below measuring point, 1948–50.

Date	Water level	Date	Water level	Date	Water level
Aug. 12, 1948	7.99	July 21	7.72	Mar. 20, 1950	6.64
Oct. 25	7.74	Sept. 9	8.29	Sept. 13	7.93
Mar. 15, 1949	5.60				

TABLE 5.—*Drillers' logs of wells in the Crescent Valley, Eureka and Lander Counties, Nev.*

28/47–33A2

London Extension Mining Co. Drilled industrial and domestic well; 12-in casing to 250 ft; perforated 150 to 240 ft, with ¼- by 2-in slots. First water at 93 ft; static level reported at 94 ft. Drilled by John Champion, Reno, Nev. Completed Oct. 19, 1950.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Topsoil and gravel	3	3	Gravel, coarse	6	157
"Hardpan"	4	7	Clay and gravel, fine	4	161
Gravel, coarse, and clay	18	25	Gravel, coarse	10	171
Clay and gravel, fine	68	93	Clay and gravel	19	190
Gravel, fine; water	2	95	Gravel, fine	4	194
Clay and gravel	14	109	Clay and gravel	4	198
Clay	3	112	Gravel, ¼–3 in. in diameter	23	221
Gravel, fine; water	17	129	Clay and gravel	13	234
Clay	3	132	Gravel	9	243
Gravel, coarse; water	6	138	Clay and gravel	7	250
Clay	2	140			
Clay and gravel	11	151	Total depth		250

TABLE 5.—*Drillers' logs of wells in the Crescent Valley, Eureka and Lander Counties, Nev.*—Continued

28/47–35C1

Frances McCoy. Drilled irrigation well; 14-in casing to 200 ft; perforated 55 to 182 ft with ½- by 3-in slots. First water reported at 55 ft. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed June 26, 1956.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	2	2	Streaks of clay and sand	10	125
Gravel	10	12	Sand, hard	9	134
Clay, brown	13	25	Clay and sand streaks	9	143
Clay, gray	30	55	Clay, silty	24	167
Sand; water	3	58	Sand	3	170
Streaks of clay and sand	12	70	Clay	7	177
Sand	7	77	Sand	5	182
Clay	4	81	Clay, sandy	13	195
Sand, coarse	6	87	Clay	5	200
Clay	14	101			
Sand	8	109	Total depth		200
Clay	6	115			

28/48–8D1

Dan Filippini. Drilled, unused well; 4-in casing to 151 ft; perforated 100 to 140 ft with ⅛- by 6-in slots. First water reported at 11 ft. Flows 15 gpm. Drilled by Louis Clarkson, Elko, Nev. Completed Mar. 5, 1949.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Clay, yellow	11	11	Clay, yellow	29	108
Gravel; water	5	16	Sand	12	120
Clay, blue	9	25	Clay, yellow	9	129
Clay, yellow	11	36	Sand	7	136
Sand	4	40	Clay, yellow	15	151
Clay, yellow	28	68			
Sand	11	79	Total depth		151

28/48–14D1

Dan Filippini. Drilled, unused well; 16-in casing to 180 ft; perforated 35 to 178 ft with ⅜- by 3½-in slots. First water at 32 ft; static level reported at 15 ft; depth to water 12.6 ft, Aug. 19, 1954. Drilled by Mel Meyer. Completed Sept. 21, 1949.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Topsoil	2	2	Gravel and clay	4	124
Gravel and sand	3	5	Clay, red, and gravel	9	133
Clay, gray	27	32	Sand; water	2	135
Gravel; water	4	36	Clay	20	155
Clay, gray	8	44	Gravel; water	1	156
Clay, white	4	48	Clay, red, and gravel	14	170
Clay, brown	12	60	Gravel; water	1	171
Clay, brown, and gravel	32	92	Clay, red	4	175
Clay, red	13	105	Clay and gravel	5	180
Clay, white	5	110			
Clay, red	5	115	Total depth		180
Clay, brown	5	120			

28/48–15C1

Dan Filippini. Drilled stock well; 4-in. casing to 89 ft; perforated 59 to 84 ft with ⅛- by 4-in. slots. First water at 14 ft; static level reported at +7 ft. Flows 15 gpm. Drilled by Louis Clarkson, Elko, Nev. Completed Dec. 21, 1956.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Clay, yellow	14	14	Sand	15	89
Sand; water	26	40			
Clay, yellow	34	74	Total depth		89

28/48–16B1

Dan Filippini. Drilled, unused well; 4-in. casing to 108 ft; perforated 70 to 108 ft with ⅛- by 6-in. slots. First water at 11 ft. Flows 20 gpm. Drilled by Louis Clarkson, Elko, Nev. Completed Feb. 22, 1949.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Clay, yellow	11	11	Sand	36	108
Sand	9	20			
Clay, blue	8	28	Total depth		108
Clay, yellow, sandy	44	72			

TABLE 5.—*Drillers' logs of wells in the Crescent Valley, Eureka and Lander Counties, Nev.*—Continued

28/48–17B1

Dan Filippini. Drilled irrigation well; 16-in. casing to 168 ft; uncased 168 to 190 ft; perforated 75 to 166 ft with ⅜- by 3½-in. slots. First water at 75 ft; static level reported at 15 ft. Drilled by Mel Meyer, Reno, Nev. Completed Oct. 27, 1949.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Topsoil	5	5	Gravel	21	156
"Hardpan"	7	12	Sand and gravel	12	168
Sand and gravel	23	35	Gravel	2	170
Clay	12	47	Clay, red	4	174
Clay, sandy	16	63	Sand, gray, fine	2	176
Clay	12	75	Clay	14	190
Gravel; water	35	110			
Clay	10	120	Total depth		190
Sand and clay	15	135			

29/48–5A1

H. J. Buchaneau. Drilled domestic well; 10-in. casing to 106 ft; perforated 75 to 106 ft with ¼- by 12-in. slots. First water at 97 ft; static level reported at 74 ft. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed May 25, 1953.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	2	2	Sand	5	80
Gravel	21	23	Clay, sticky	8	88
Sand, hard	5	28	Sand	4	92
Clay, sandy	16	44	Clay, sandy	5	97
Clay	6	50	Gravel and sand; water	6	103
Clay, sticky	4	54	Clay, sandy	3	106
Sand, hard	6	60			
Clay	4	64	Total depth		106
Clay, sandy	11	75			

29/48–17A1

H. J. Buchaneau. Drilled, unused well; 14-in. casing to 212 ft; perforated 72 to 212 ft with $^3/_{16}$- by 1½-in. slots. First water at 77 ft; static level reported at 70 ft; depth to water 71.03 ft, Aug. 20, 1954. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed Oct. 14, 1953.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	2	2	Clay, sandy	16	120
Clay and gravel	13	15	Gravel; water	2	122
Cobbles	5	20	Clay, hard	10	132
Sand, hard, and gravel	7	27	Sand; water	1	133
Clay, sandy	12	39	Clay, sandy	7	140
Gravel and clay	5	44	Sand, silty	8	148
Clay, soft	4	48	Clay, sticky, gravel	29	177
"Conglomerate"	4	52	Sand, fine, hard; water	7	184
Clay, sandy	17	69	Sand, coarse; water	7	191
"Conglomerate"	3	72	Clay, sandy	6	197
Clay, sandy	2	74	Sand; water	3	200
"Hard shell"	3	77	Clay, sticky	6	206
Sand, hard; water	9	86	Sand and clay; water	6	212
Clay, sticky	4	90			
Sand and gravel; water	14	104	Total depth		212

29/48–17C1

H. J. Buchaneau. Drilled, unused well; 14-in casing to 200 ft; perforated 54 to 192 ft with ½- by 3½-in slots. First water reported at 54 ft; depth to water 55.72 ft; Aug. 20, 1954. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed Nov. 24, 1953.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	2	2	Clay, sticky	5	124
Clay and gravel	16	18	Clay, sandy	8	132
Clay, soft	10	28	Gravel	2	134
Clay, sandy	8	36	Clay, sandy	7	141
"Conglomerate"	3	39	Sand, fine, hard	7	148
Clay, sandy	15	54	Sand and gravel	6	154
Sand; water	6	60	Clay, sandy	15	169
Clay, sandy	7	67	Sand	3	172
Sand	2	69	Clay, sandy	5	177
Clay, sandy	14	83	Sand	3	180
Sand	4	87	Clay, sticky	7	187
Clay, soft	4	91	Sand and gravel	3	190
Sand and gravel	4	95	Clay, sticky	10	200
Clay, sandy	13	108			
Sand and gravel	11	119	Total depth		200

TABLE 5.—*Drillers' logs of wells in the Crescent Valley, Eureka and Lander Counties, Nev.*—Continued

29/48–29C1

H. J. Buchaneau. Drilled irrigation well; 14-in casing 0 to 207 ft; 12-in, 200 to 276 ft; 14-in casing perforated 55 to 207 ft with ⅛- by 3½-in slots; 12-in casing perforated 200 to 276 ft with ⅛- by 1½-in slots. First water at 60 ft; static level reported at 55 ft; depth to water 57.63 ft, Sept. 21, 1954. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed Mar. 4, 1953.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Clay	5	5	Gravel	3	160
Sand, fine, hard	20	25	Clay and cobbles	4	164
Clay and cobbles	15	40	Clay, sandy	20	184
Clay, sandy, and gravel	17	57	Clay, red, sticky	16	200
"Conglomerate"	3	60	Sand, coarse	6	206
Gravel; water	12	72	Clay, sandy, hard	12	218
Sand, fine, hard, and clay	12	84	Sand, hard	5	223
Gravel	8	92	Silt	4	227
Clay	4	96	Sand, coarse	7	234
Sand, coarse	4	100	Clay, sandy	15	249
Clay and sand	13	113	Sand, coarse	3	252
Clay and gravel	12	125	Clay	3	255
Gravel	7	132	Sand, hard	9	264
Clay	2	134	Sand and clay	12	276
Clay, sandy	13	147			
Sand	8	155	Total depth		276
Clay	2	157			

29/48–29C2

Beowawe Farms. Drilled irrigation well; 14-in casing 0 to 242 ft and 12-in, 232 to 300 ft; perforated 66 to 300 ft with ½- by 3½-in slots. First water at 67 ft; static level reported at 66 ft. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed Dec. 20, 1956.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	2	2	"Decomposed granite"	8	143
Gravel	4	6	Clay and gravel	24	167
Sand, hard	4	10	Sand	8	175
Sand, fine, hard	7	17	Clay, sticky, and sand	8	183
Gravel	4	21	Sand, hard	4	187
Sand, coarse	9	30	Clay, sticky, and gravel	16	203
Clay	6	36	Clay, sandy	5	208
Clay, sandy	9	45	Clay, sticky, and gravel	9	217
Gravel	3	48	Sand	4	221
Clay, sandy	6	54	Clay, sticky, and gravel	7	228
Sand, hard	11	65	Sand	4	232
Sand, silty	2	67	Clay	3	235
Sand, hard; water	8	75	Sand, hard	6	241
Clay, sandy	5	80	Clay	6	247
Sand, coarse	8	88	Clay, sandy	13	260
Sand, hard	9	97	"Decomposed granite"	15	275
Clay	8	105	Sand, hard, and clay	12	287
Sand	4	109	Clay, sticky	4	291
Clay and gravel	5	114	Clay, sandy	9	300
"Decomposed granite"	7	121			
Clay, sandy	14	135	Total depth		300

29/48–34C1

Dan Filippini. Drilled stock well; 4-in casing to 296 ft; perforated 100 to 105 ft with ⅛- by 5-in slots. First water at 12 ft; static level reported at 3 ft; depth to water 7.33 ft, Aug. 25, 1956. Drilled by Louis Clarkson, Elko, Nev. Completed Dec. 8, 1952.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Clay, yellow	100	100	Sand	3	271
Sand and gravel	5	105	Clay, gray	25	296
Clay, light-gray	100	205			
Clay, blue	63	268	Total depth		296

29/49–11C1

Dan Filippini. Drilled stock well; 6-in casing to 109 ft; uncased 109 to 298 ft; perforated 68 to 107 ft with ⅛- by 5-in slots. First water at 15 ft; static level reported at 13 ft. Drilled by Louis Clarkson, Elko, Nev. Completed Dec. 13, 1952.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Clay, yellow	15	15	Sand and gravel	8	298
Gravel and clay; water	27	42			
Sand, yellow, coarse	68	110	Total depth		298
Clay, sandy, yellow	180	290			

TABLE 5.—*Drillers' logs of wells in the Crescent Valley, Eureka and Lander Counties, Nev.*—Continued

29/49-34C2

Dewey Dann. Drilled irrigation well; 14-in casing to 228 ft; perforated 55 to 218 ft with ½- by 3-in slots. First water at 55 ft; depth to water 53.27 ft, June 4, 1957. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed May 30, 1956.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	6	6	Clay, silty	5	147
Gravel	6	12	"Decomposed granite"	3	150
Clay	33	45	Clay, sandy	12	162
Clay, sandy	13	58	Sand, fine, hard	5	167
Sand, coarse; water	12	70	Sand, coarse	4	171
Clay, sticky	8	78	Clay, sandy	4	175
Clay	8	86	"Decomposed granite"	2	177
Sand	3	89	Sand, silty	3	180
Clay, sandy	6	95	"Decomposed granite"	8	188
Sand	3	98	Clay	14	202
Clay, sandy	16	114	Clay, sandy	12	214
"Hard fine material"	11	125	"Decomposed granite"	4	218
Clay, sandy	7	132	Clay, sandy	10	228
Clay, sticky	4	136			
Sand, hard	6	142	Total depth		228

30/48-22B1

Pat Arnold. Drilled unused well; 14-in casing to 200 ft; perforated 15 to 200 ft with 3/16- by 1½-in slots. First water at 59 ft; depth to water 31.67 ft, July 29, 1954. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed May 27, 1954.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	2	2	Clay	17	130
Clay and gravel	8	10	Clay and gravel	12	142
Clay	49	59	Clay, sandy, soft	8	150
Sand; water	2	61	Clay	14	164
Clay	3	64	Sand, hard	6	170
Sand; water	8	72	Clay, sandy, and gravel	7	177
Gravel; water	8	80	Clay, sandy	10	187
Clay, sandy	15	95	Sand, hard	3	190
Clay, sticky	3	98	Clay and gravel	10	200
Sand	2	100			
Clay, sandy	8	108	Total depth		200
Sand, fine, hard	5	113			

30/48-27C1

H. J. Buchaneau. Drilled irrigation well; 14-in casing to 352 ft; perforated 30 to 340 ft with ½- by 3½-in slots. First water at 30 ft; static level reported at 13 ft; depth to water 13.96 ft, Mar. 6, 1953. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed Oct. 7, 1952.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	3	3	Clay and streaks of sand	17	257
Clay, sandy, and gravel	15	18	Sand, fine, hard	5	262
Clay	12	30	Gravel	5	267
Sand and gravel, coarse; water	3	33	Sand	23	290
Clay, sandy	25	58	Gravel	2	292
Clay, gray	20	78	Clay, sandy	15	307
Clay, red, and gravel	13	91	Sand	5	312
"Conglomerate"	2	93	Clay, sandy	17	329
Gravel; water	5	98	Sand	4	333
Clay, sandy	2	100	Clay	3	336
Clay and gravel	103	203	Sand	3	339
Sand and gravel	5	208	Clay, sticky	13	352
Clay and gravel	20	228			
Clay, sandy	12	240	Total depth		352

TABLE 5.—*Drillers' logs of wells in the Crescent Valley, Eureka and Lander Counties, Nev.*—Continued

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)

30/48-33C1

H. J. Buchaneau. Drilled irrigation well; 14-in casing to 300 ft; perforated 70 to 295 ft with ⅜- by 2⅛-in slots. First water at 67 ft; depth to water 69.04 ft, Oct. 21, 1953. Drilled by Carruthers Drilling Service, Beowawe, Nev. Completed Apr. 25, 1952.

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
Soil	1	1	Gravel	4	164
Gravel	1	2	Cobbles and clay, sandy	24	188
Clay	2	4	Sand, hard; water	16	204
Clay and cobbles	26	30	Sand and clay	28	232
Sand, hard	2	32	Gravel; water	3	235
Clay and cobbles	16	48	Clay, sticky	2	237
Clay, sandy, and gravel	12	60	Sand, hard, and gravel; water	16	253
Clay	7	67	Clay, sandy	7	260
Gravel and sand; water	11	78	Gravel	3	263
Clay	6	84	Clay, sticky	11	274
Clay, sandy	12	96	Sand and gravel; water	6	280
Clay, sticky	8	104	Clay, sandy	7	287
Sand and gravel; water	8	112	Sand, hard	8	295
Sand and streaks of clay	34	146	Clay, sticky	5	300
Gravel; water	4	150			
Clay, sandy	10	160	Total depth	----------	300

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INDEX

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