STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Carson City

View north from above Vya showing cultivated fields. Alkali Lake in middle distance.

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES
REPORT 15

GROUND-WATER APPRAISAL OF THE LONG VALLEY MASSACRE LAKE REGION, WASHOE COUNTY, NEVADA

By

WILLIAM C. SINCLAIR

Geologist

With a section on

THE SOILS OF LONG VALLEY

By

RICHARD L. MALCHOW

Soil Scientist

PRICE $1.00

Prepared cooperatively by the

Geological Survey, U. S. Department of the Interior

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FOREWORD

This is the 15th report in the series of reconnaissance ground-water studies which were initiated by action of the Legislature in 1960. In these fifteen reports, the ground-water resources of some seventeen valleys have been appraised and described.

The present appraisal of the ground-water resources of Long Valley and adjacent basins in Washoe County, Nevada, and of several small valleys partly in Nevada and California and Nevada and Oregon, was made by William C. Sinclair, geologist, U. S. Geological Survey.

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

Hugh A. Shamberger
Director
Department of Conservation
and Natural Resources

May 1963.

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GROUND-WATER APPRAISAL OF THE LONG VALLEY-MASSACRE LAKE REGION, WASHOE COUNTY, NEVADA

by
William C. Sinclair

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SUMMARY

The Long Valley-Massacre Lake region is an area of about 1,500 square miles in the northwestern corner of Nevada. It includes all or parts of seven intermontane valleys. The climate is semiarid; annual precipitation averages about 8 to 12 inches throughout the area.

Long Valley, the largest of the closed basins in the region, covers an area of about 450 square miles. Block-faulting, which began in late Tertiary time, resulted in the present gross topographic features of the region. The ranges surrounding and separating the valleys are composed of volcanic rocks which were uplifted with respect to the valleys. Material eroded from the uplands has filled the intermontane basins with alluvium, which includes lake and stream deposits. The alluvium may be 1,000 feet thick in parts of Long Valley, but probably is less in the smaller basins.

Layers of sand and gravel within the alluvium constitute the most important aquifers in the region and in most valleys probably will yield moderate to large amounts of water to properly constructed and developed wells.

Chemical analyses of several samples of ground water from the region indicate that, except in the playa areas, the water generally is low in dissolved-solids content and suitable for irrigation and domestic use.

This study indicates that the total annual recharge to the ground-water in the Long Valley-Massacre Lake region is on the order of 27,000 acre-feet. Preliminary estimates of perennial yield, or the amount of ground water that can be salvaged from the natural discharge, for four valleys wholly within Nevada are: Long Valley, 10,000 acre-feet; Massacre Lake Valley, 3,000 acre-feet; Mosquito Valley, 1,500 acre-feet; and Boulder Valley, possibly as much as 2,000 acre-feet. For three valleys lying astride the Nevada-California and Nevada-Oregon borders, preliminary estimates of the partial yield that could be developed in Nevada are: Surprise Valley, probably no more than 2,000 acre-feet; Coleman Valley, possibly 1,000 acre-feet; and Guano Valley, possibly 2,000 acre-feet. The extent to which ground-water development can approach these amounts will depend largely upon the amount of natural discharge that can be salvaged by pumping.

This reconnaissance suggests that the water resources of the region are adequate to sustain any agricultural development which the climatic factors and soil conditions will permit.

INTRODUCTION

Purpose and Scope of the Investigation:

This report is the 15th in a series of reconnaissance studies of the valleys of Nevada. These studies are made by the U. S. Geological Survey in cooperation with the Department of Conservation and Natural Resources, State of Nevada, and are part of a statewide study to evaluate the ground-water resources of Nevada.

The purpose of this study is: (1) to determine the nature and extent of the aquifers; (2) to determine the occurrence and movement of ground water, including the areas of recharge and areas of discharge; (3) to determine the sources of recharge and to estimate the average annual recharge to the aquifers; (4) to estimate the quantity of ground water that can be developed perennially; and (5) to determine the chemical quality of the ground water and its suitability for irrigation and domestic use.

Most of the field work for this report was done during the late summer and early fall of 1962. It consisted of a brief study of the physiographic features of the area and of the water-bearing character of the geologic units, an inventory of the wells and springs, and collection of samples of water for chemical analysis.

The assistance provided by residents of the area in supplying information about wells and springs is gratefully acknowledged. Most of the information concerning wells drilled for the Bureau of Land Management was obtained through the courtesy of Mr. Stuart Porter of that agency's office at Susanville, California. The area of phreatophytic vegetation delineated on plate 1 is adapted from a forage-type survey being conducted by Mr. Howard Gebel and his associates, also of the Bureau of Land Management.

Location and Extent of the Area:

The Long Valley-Massacre Lake region covers an area of about 1,500 square miles in the extreme northwest corner of Nevada (figure 1). The area is almost entirely in Washoe County, although the extreme eastern edge extends into Humboldt County (pl. 1). The region considered in this report includes Long, Massacre Lake, Mosquito Lake, Boulder, Surprise, Coleman, and Guano Valleys. Long Valley is a north-trending structural trough averaging about 5 miles wide and 25 miles long. Massacre Lake Valley trends roughly northeastward; the valley floor is about 3 miles wide and 8 miles long. Streamflow in both valleys drains to playa lakes along their axis. The combined drainage area of both valleys is about 600 square miles.

The Hays Canyon Range separates Long Valley, to the east, from Surprise Valley, another structural depression which lies principally in California. The country surrounding the Long Valley-Massacre Lake drainage area on the north and east, and also considered in this report, is chiefly

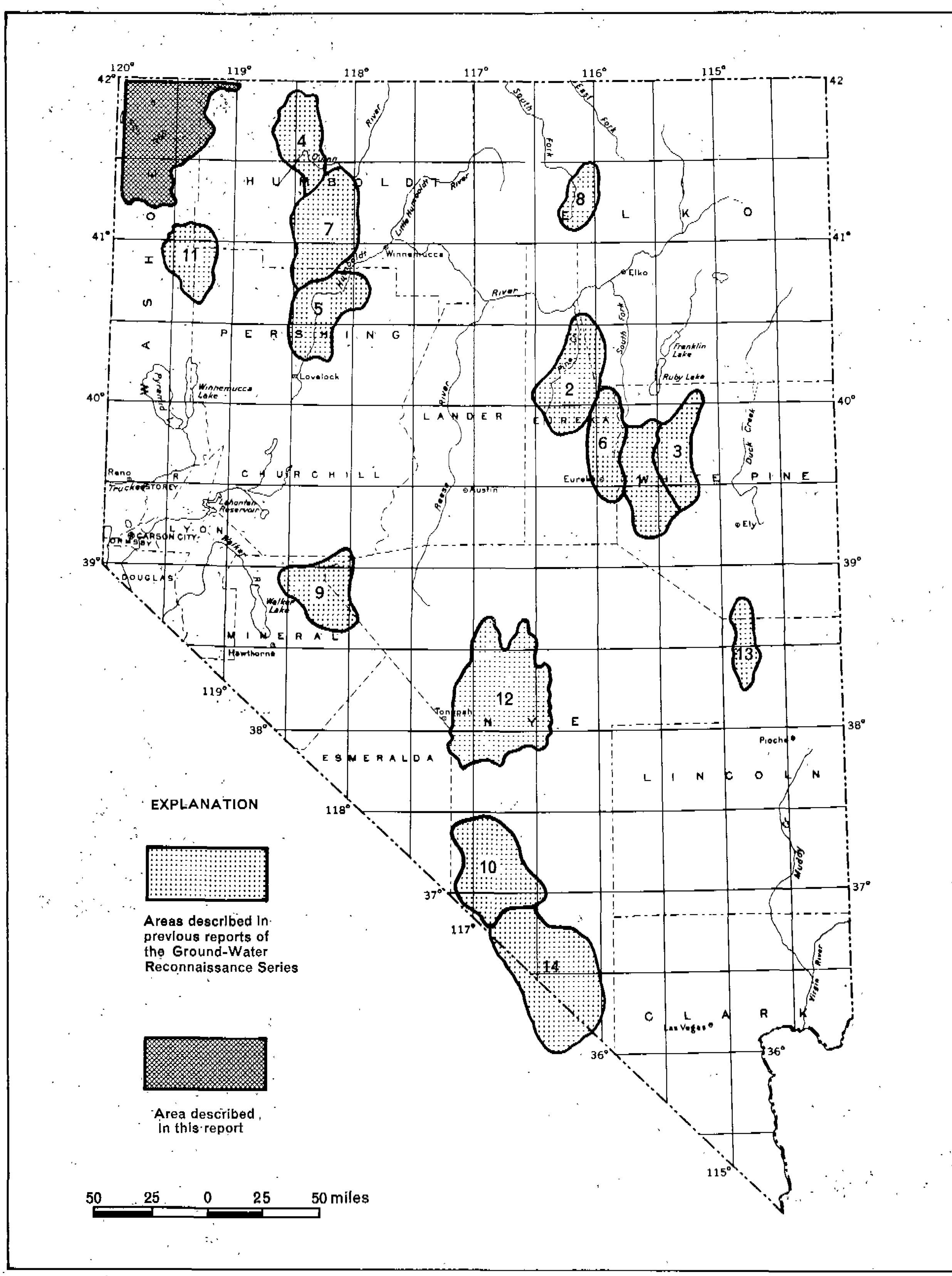


FIGURE 1. MAP OF NEVADA SHOWING AREAS DESCRIBED IN PREVIOUS REPORTS OF THE RECONNAISSANCE SERIES AND IN THIS REPORT.

dissected rimrock terrain draining northward into Oregon through Coleman Valley, Guano Valley, and several other minor drainage ways.

Two well-maintained gravel roads traverse the area. State Route 34 trends northward through Long Valley connecting Gerlach, on the Western Pacific Railroad, which is about 85 miles south of Vya, with Adel, Oregon, which is about 20 miles north of the Nevada-Oregon State boundary. State Route 8A crosses the region from Cedarville, California, about 25 miles west of Vya, eastward about 90 miles to Denio, thence to Winnemucca, the county seat of Humboldt County, Nevada.

The Sheldon National Antelope Refuge and Antelope Range, administered by the U. S. Fish and Wildlife Service, covers most of the northeastern part of the area studied. Throughout the rest of the area, the grazing of cattle is the principal occupation. Some hay and meadowlands are irrigated by streamflow and spring discharge. No successful irrigation wells have been developed in the region to date.

Numbering System for Wells and Springs:

The well-numbering system used in this report indicates the location of the wells within the rectangular subdivisions of the public lands referenced to the Mount Diablo meridian and base line. The first two segments of a well number designate the township and range; the third segment is the section number followed by a letter which designates the quarter section in which the well or spring is located. Following the letter, a number indicates the order in which the well or spring was recorded within the subdivision. The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarters of the section. For example, well number 47/20-30b1 designates the first well recorded in the NW 1/4 sec. 30, T. 47 N., R. 20 E., Mount Diablo base and meridian.

Plate 1 shows the locations of wells and springs in the valley. The available data on the wells are listed in tables 4 and 6 and on the springs in table 5. The chemical analyses of water from selected springs and wells are shown in table 3.

PHYSIOGRAPHIC FEATURES

Mountains:

Much of the relief in the area is due to the vertical displacement of large mountain blocks by faulting. The Hays Canyon Range is the most prominent example of this type of relief. The crest of the range averages about 7,000 feet above sea level, or 2,500 feet above the floor of Long Valley and 3,500 feet above Surprise Valley to the west. North of Vya, in the vicinity of New Year Lake, the relief of the Hays Canyon Range is more subdued. A resistant layer of basalt covers the surface throughout much of the region and overlies tuffs and agglomerates which are more susceptible to erosion. The resultant topography is characterized by relatively flat, or gently rolling, upland surfaces which are cut by nearly vertical canyon walls. Block faulting serves to heighten this feature along the sides of Long Valley where nearly vertical escarpments rise several hundred feet.

Eastward, from the top of the escarpment bordering the east side of Long Valley, the terrain is a dissected plateau rising gradually to several peaks having altitudes of about 7,000 feet.

Valleys:

Time and erosion have only begun to modify the fault-block topography in the Long Valley-Massacre Lake region. Most stream channels and valleys are in early stages of development and have characteristically steep-sided canyons and steep irregular stream gradients. The major valleys are structural troughs or depressions which were displaced downward by faulting relative to the mountain ranges and have become the catchment areas for streamflow from the surrounding mountains and the sediment load which the streams carry.

The valley floors are characteristically flat and their elevations depend on the vertical displacement of the fault blocks and the amount of subsequent filling. The flatness of the valley floors is due in large part to sedimentation in and the planning action by the ephermeral lakes which occupy the valleys during and after periods of excessive runoff. The presence of the water table at shallow depth beneath the valley floors is another controlling factor and provides a base level which limits the effect of wind action as an erosional agent.

Intermediate slopes between the valley floors and the surrounding mountains are formed by the accumulation of mudflows and stream deposits, laid down as the gradients and carrying power of the streams are abruptly reduced as they debouch upon the valley floor.

Long Valley is about 25 miles long, trends northward, and has an average width of about 5 miles. At the north end the valley is divided by a low range of hills. East of the hills the valley extends northeastward to within a few miles of the Oregon border. The western arm of the valley terminates at a low bedrock ridge which separates it from Mosquito Valley, another fault-block valley whose floor stands at an altitude of about 5,700 feet and about 200 feet above that of Long Valley.

Massacre Lake Valley trends northeastward. It is about 8 miles long and 3 miles wide. Most of the valley floor is covered by the ephermeral Massacre, Middle, and West Lakes. Ridges and dunes of windblown silt and sand cover much of the valley floor surrounding these playas. Massacre Lake Valley is connected to Long Valley by a narrow canyon which trends westward from West Lake and passes north of Painted Point. This gap was apparently developed early in the erosional history of the area and no longer drains

Massacre Lake Valley. The present drainage divide between the two valleys crosses the gap just west of West Lake, and water in Massacre Lake Valley would have to rise about 20 feet above the playa before it could spill into Long Valley.

Several other small structural basins or parts of larger basins lie within the study area. Of these, Mosquito, Boulder Lake, Surprise, Coleman, and Guano Valleys, the latter three of which lie only partly within Nevada, probably are underlain by sufficient thicknesses of alluvium to constitute ground-water reservoirs.

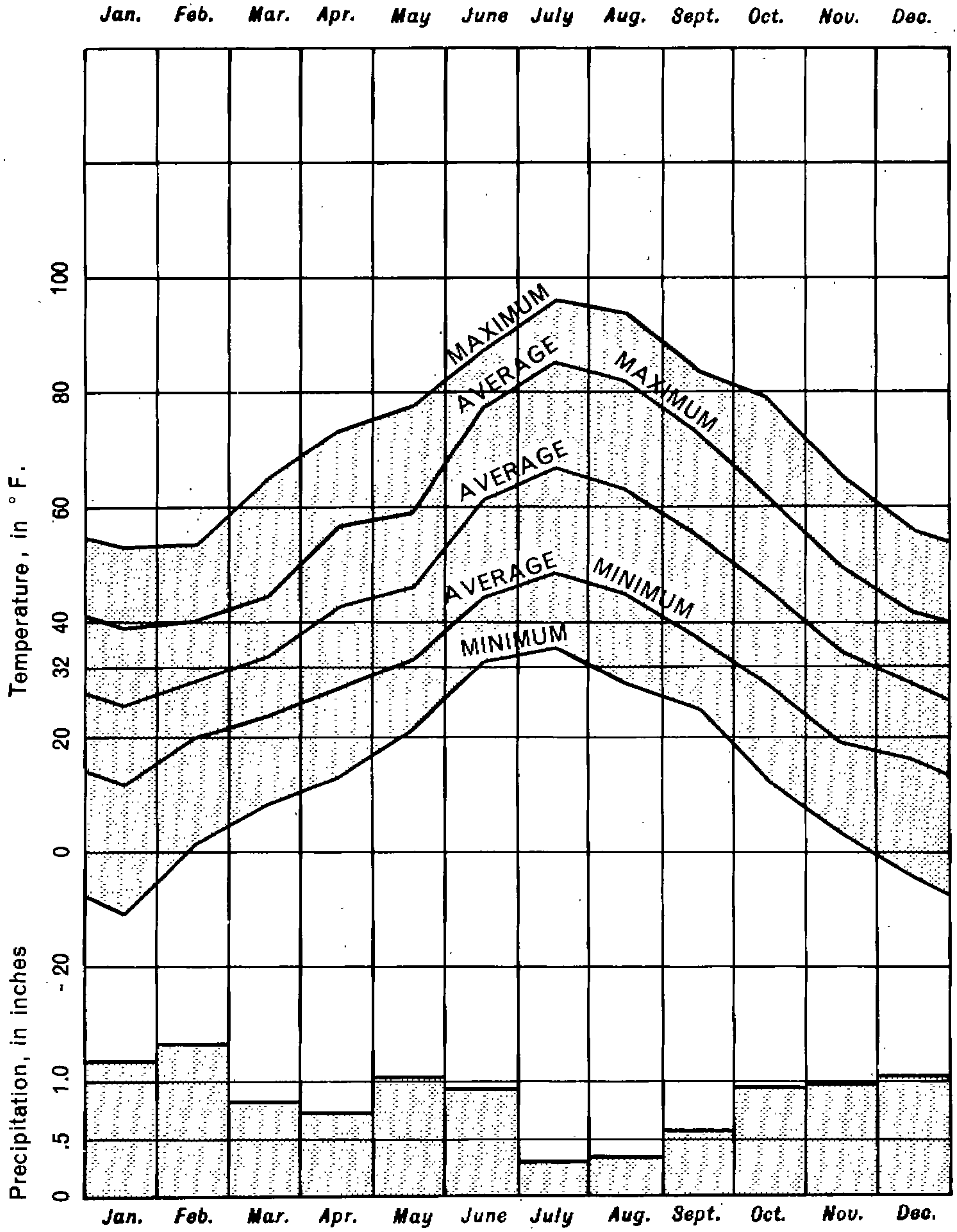
Streams:

Most of the streams in the Long Valley-Massacre Lake region are relatively short, their profiles are quite irregular, and their canyons generally narrow and steep-sided. The streams are fed principally by snowmelt and storm runoff. Their flow, therefore, is ephemeral, and occurs mostly during the spring and early summer. The streams flow to the playas on the valley floors during periods of peak flow. However, much of the streamflow seeps into the streambeds and probably is the largest source of recharge to the ground-water reservoirs.

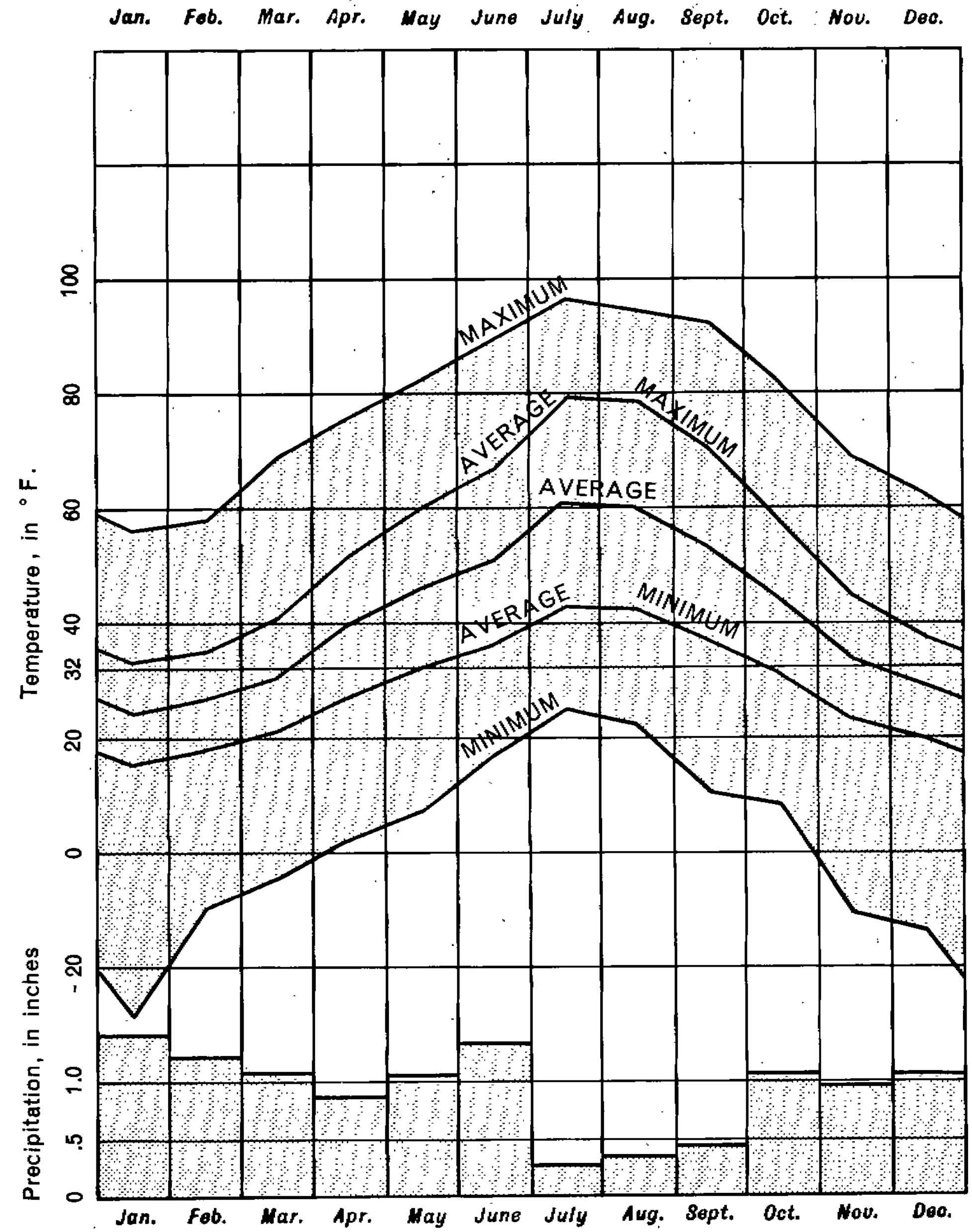
Climate:

Precipitation in northwestern Nevada is controlled largely by the storm centers which move eastward or southeastward across the area from the Pacific Ocean in late autumn, winter, and early spring. The summer months of July, August, and September account for less than one-tenth the total annual precipitation, as illustrated by the precipitation graphs in figure 2. Topography exerts considerable control on precipitation, in addition to the seasonal variations, and the high mountains of California and Oregon intercept much of the moist Pacific air that moves inland with the storm centers. The Long Valley-Massacre Lake region lies to leeward of these mountains along the major storm tracks and therefore has a semi-arid climate. Although the average annual precipitation for the entire area may range from 8 to 12 inches, it is considerably less on the valley floors. On the other hand, some of the higher peaks in the Hays Canyon Range may receive as much as 15 inches of precipitation a year. Thus, most of the precipitation, generally in the form of snow, falls on the highlands surrounding the valleys during the winter months.

The average annual temperature in the area is 40 to 50°F., and varies inversely with the elevation. The range at the two stations shown in figure 2 is large, and at Sheldon, below freezing temperatures may be expected any month of the year. The temperature at Vya, on the floor of Long Valley, is somewhat more moderate, and the graph of minimum monthly temperatures indicates an average growing season of at least 6 weeks. For the crops grown in the area, the time between killing frosts, however, probably is somewhat greater than 6 weeks.



VYA - average monthly precipitation for the period 1915-1925, and average monthly temperature data for the 2-year period ending August 1962.



SHELDON - average monthly precipitation and temperature data for the period 1933-1952.

FIGURE 2. GRAPHS ILLUSTRATING THE CLIMATIC CONDITIONS AT THE U. S. WEATHER BUREAU STATIONS AT VYA AND SHELDON.

The rate of evaporation from a free water surface in the Long Valley-Massacre Lake region is about 44 to 48 inches a year, according to the U. S. Weather Bureau's Technical Paper No. 37, "Evaporation maps for the United States". This rate of evaporation is roughly four times the annual precipitation in the area.

THE SOILS OF LONG VALLEY

by
Richard L. Malchow [1/]

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For simplicity of discussion, Long Valley may be divided into four general areas as shown in figure 3.

1. Low-lying lake terraces surround the playas and occupy much of the central part of the valley. These terraces have a native plant cover consisting primarily of greasewood, rabbitbrush, and saltgrass. The soils are deep, silty or clayey, and slowly permeable. They are high in water soluble salts and alkali. Under irrigation most of these soils would be limited to the production of saline-alkali tolerant grasses, unless reclaimed. And, because of their low topographic position, generally poor drainage and low permeability, reclamation would be difficult to achieve. Most of these soils are in the Solonetz or Solonchak Great Soil Groups.

2. Recent, moderately sloping alluvial fans occupy the western edge of the valley south of a point that is approximately 2 miles north of Vya. The deep, sandy soils of these fans support vigorous native stands of big sagebrush. These soils are fertile, but have little capacity for moisture storage. They, therefore, would require frequent, light irrigations. In most cases, sprinkler irrigation would best solve the combined problem of slope and rapid water intake rates. Wind erosion is a serious problem with these soils if they are left barren. Accordingly, they are best suited to the production of perennial hay crops, if irrigated. Most of these soils are in the Alluvial Great Soil Group.

3. The northern part of the western edge of Long Valley and its northern end are composed of a complex mixture of three different kinds of land. First, are low, moderately sloping ridges with deep, loamy soils. Proper irrigation of most of these ridges would require sprinklers. The soils are suited to alfalfa, small grain, or pasture. Second are soils having heavy and restrictive clay subsoils. These soils produce low sagebrush under native conditions, and are best suited to permanent pasture if irrigated. Third are small scattered bodies of deep, loamy, nearly level soils well suited to the production of all climatically adapted crops if irrigated. Most of these soils are in the Brown or Sierozem Great Soil Group.

4. The eastern edge of the valley consists of a series of gently sloping terraces having deep, somewhat gravelly, loamy soils that support good stands of big

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1/ Soil Scientist, Soil Conservation Service, U. S. Department of Agriculture.

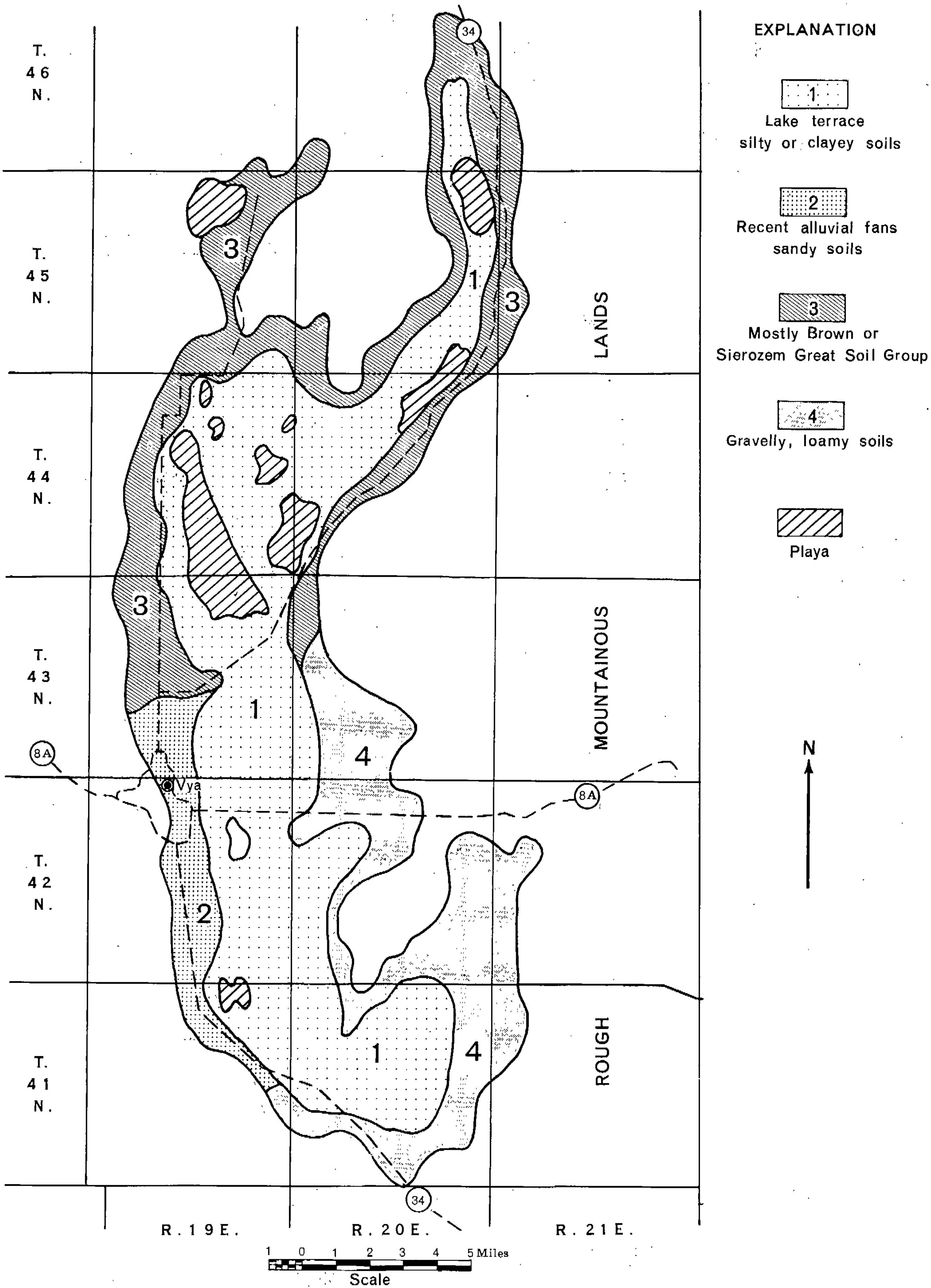

FIGURE 3. GENERALIZED SOIL MAP OF LONG VALLEY, WASHOE COUNTY, NEVADA, BY RICHARD L. MALCHOW.

sagebrush. Most of these soils are well suited to all climatically adapted crops if irrigated. However, some of these soils have subsoils that are weakly cemented by lime and silica. In these areas the native sagebrush has a somewhat stunted appearance. Ripping, or irrigation itself, might cause this pan to disintegrate. Most of these soils are in the Brown or Sierozem Great Soil Group.

This resume' of Long Valley soils is based upon a limited amount of soil investigation and mapping. The development of irrigation programs in these areas should not be undertaken without further, more detailed study.

PREVIOUS INVESTIGATIONS

I. C. Russell of the U. S. Geological Survey was the first geologist to describe the geology and hydrography of the Long Valley-Massacre Lake region. His comments, based on a brief study of the area in 1882, are included in, "A Geological Reconnaissance in Southern Oregon", published in the Fourth Annual Report of the U. S. Geological Survey in 1884.

In a study of the Tertiary mammal beds of Virgin Valley, J. C. Merriam (1910) included a tentative description of the stratigraphy of that area, which is about 45 miles east of Vya. A description of the structure and stratigraphy of the Warner Range by R. J. Russell (1928), which borders the west side of Surprise Valley in California, about 20 miles west of Vya, includes some discussion of the geology of the Hays Canyon Range and is thus applicable to the area considered in this report.

A study of the paleobotany of sections of the Hays Canyon Range, just west of Vya, was made by R. S. LaMotte (1936).

A discussion of the Quaternary history of the area is included in a paper on the hydrographic history of the Great Basin by Hubbs and Miller (1948).

Several unpublished reports and basic data compilations on the hydrology of stockwater sites in the Massacre Lake Grazing District were prepared by C. T. Snyder of the U. S. Geological Survey for the Bureau of Land Management. Information contained in those reports was useful in the preparation of this report.

SUMMARY OF GEOLOGIC HISTORY

The rocks exposed at the surface and in wells in the Long Valley-Massacre Lake region are principally of volcanic origin. The geologic section shown in table 1 is a generalized summary of the stratigraphy of the area, based largely on conversations with Dr. V. P. Gianella and Harold F. Bonham, who are presently engaged in mapping the geology of northern Washoe County under the auspices of the Nevada Bureau of Mines. Their description of the geology of the area is somewhat at variance with that of R. J. Russell (1928) but is consistent with the work of Merriam (1910) in Virgin Valley to the east, and of several studies of the geology of southeastern Oregon to the north of Long Valley.

The present topography of the area and the present hydrologic setting began to take form during and shortly after the extrusion of the basalt (table 1). During late Pliocene and early Pleistocene time, the country rock was disrupted by vertical movement along an extensive system of faults by which the present valleys were downfaulted and mountain ranges uplifted with respect to one another. The vertical displacement along the major rangefront faults was even greater than the present relief would indicate. Erosional debris from the uplifted areas has filled the basins with an unknown thickness of alluvium, which includes stream and lake deposits. The thickness of the alluvium in the center of Long Valley may be on the order of 1,000 feet and probably is thinner in the smaller basins.

The Pleistocene Epoch was characterized by worldwide climatic changes which resulted in the formation of lakes in many of the undrained valleys of the Great Basin. In Long Valley the highest shoreline of pluvial Lake Meinzer, as it was named by Hubbs and Miller (1948), stands about 250 feet above the present valley floor. Much of the valley fill is composed of lake deposits. Silt and clay were deposited in the still water of the high lake stages, while lenses of sand and gravel represent beaches and bars of a near shore or shallow-water environment. Layers of alluvium were deposited on the valley floor during periods of desiccation.

PHYSICAL CHARACTER AND WATER-BEARING PROPERTIES OF THE ROCKS

Bedrock:

The primary permeability of the volcanic rocks in the region generally is low, although locally zones between flow units or in agglomerate or tuff may be moderately permeable. Secondary permeability has developed in the more massive flow rocks along joint systems or as a result of fracturing. Interflow zones, joint systems, and fractures collectively provide the principal avenues for ground-water movement through the volcanic rocks. Although the amount of water moving in any one locality may be small, the amount moving over a large area may involve a considerable volume of water and may constitute a significant factor in the hydrologic regimen of the area.

The success or failure of wells drilled in the bedrock is determined largely by the number of fractures, joints, and interflow zones encountered below the water table.

Alluvium:

The character and permeability of the alluvium vary locally as a result of the mode of deposition. Along the alluvial slopes flanking the mountains, the alluvium is composed of poorly sorted material ranging in size from clay to boulders. The permeability of this alluvium is generally low. Wells penetrating a sufficient saturated thickness of alluvium may yield moderate to large volumes of water, but near the mountains the depth to water may be on the order of 100 feet or more, and pumping lifts would be even greater.

In the central parts of the valleys the alluvium is generally composed of lake deposits, principally silt and clay. The permeability of these fine-grain deposits is low. Layers and lenses of sand and gravel are found within the section of clay. These represent near-shore and shallow-water features of deposition, such as beaches and bars, and alluvium deposited on the valley floors during periods of desiccation and later reworked by the advancing waves of a subsequent inundation.

The layers of sand and gravel contain the principal reservoir of available ground water in the valleys. Near the center of the valleys they represent only about 10 percent of the total section of lake deposits, as shown by some of the well logs in table 5. Around the margins of the valleys the thickness of these permeable zones increases considerably.

GROUND WATER

Occurrence and Movement

Most of the ground water available to wells in the region occurs in the unconsolidated alluvium. Ground water moves from recharge areas in the mountains and on alluvial slopes downgradient through the alluvium toward the axes of the valleys where, under natural conditions, it is discharged by evaporation from playas and springs and transpiration by plants.

The lake deposits in the larger valleys form an excellent environment for artesian conditions, because they are composed of alternating layers of permeable and impermeable materials and because the recharge to them is from the margins of the valley, which are at higher elevations than the valley floor. This condition, greatly simplified, has been compared to two bowls with a layer of sand between; the bowls represent the impermeable clay of the valley fill and the sand the more permeable layers which comprise the aquifers in the system. Water poured into the sand, where it is exposed between the rims of the two bowls, is analogous to recharge of the aquifers where they crop out around the margin of the valley. If the upper bowl were cracked or penetrated by a drill, the water would then rise through the opening to a level determined by the water level in the sand.

The many springs on the floor of Long Valley and Massacre Lake Valley probably are the result of conditions similar to those described above, and it seems likely that artesian wells might also be developed in the confined aquifers of the alluvium. Artesian conditions do not always produce a flow of water at the surface. The relatively low elevation of the hills surrounding Long and Massacre Lake Valleys combine with the small discharge of most of the springs on the valley floor to suggest that heads will not be great in wells tapping the artesian aquifers, even in the lowest part of the valley.

The drainage boundaries on Plate 1 are determined by the topography and may not correspond to the ground-water divides. This is particularly true in the cuesta, or rimrock, type of topography such as that bordering the northern part of Long Valley on the west. It seems likely that some of the water which has infiltrated into the rock on the west side of the topographic divide is moving eastward into the alluvium of Long and Mosquito Valleys. This condition is strongly suggested by the springs which issue both from the bedrock and the alluvium at the base of the escarpment. The volume of spring discharge is more than might be expected from the drainage area above them. Even so the discharge of these springs probably represents only a fraction of the ground water which may be moving through the bedrock into the alluvium.

Recharge:

Precipitation is the ultimate source of recharge to the ground-water reservoirs of the region. Of the precipitation that reaches the ground part infiltrates, part runs off, and the remainder returns to the atmosphere by evaporation and transpiration.

An important source of recharge to the ground-water reservoir is seepage from streams crossing the alluvial slopes. The streambeds are composed of permeable gravel and sand and generally are above the regional water table. Rapid infiltration is possible under these circumstances. However, no seepage-loss data are available in this area to estimate recharge from streams.

The amount of the precipitation that infiltrates to the ground-water reservoir is determined largely by the total quantity and intensity of the precipitation-type and density of vegetation, the permeability of the surface and sub-soil, and the geology of the area. In areas of very little precipitation, such as the valley floor, all, or nearly all, the precipitation may be lost by evaporation and transpiration. On the other hand, precipitation is heaviest in the mountains where bedrock is at or near the surface. Because of the manner in which volcanic rocks such as basalt and rhyolite are formed, they commonly develop an extensive system of joints and fractures. At the surface these rocks generally weather into cobbles and boulders, and large areas of the volcanic terrane are covered with this scree. Infiltration of precipitation through the scree into the fractured rock below is so readily accomplished that surface runoff in this type of terrane usually is negligible.

Where soils have developed over the bedrock, however, the infiltration is impeded by a claypan, or impermeable layer, that commonly occurs within a foot or two of the surface. The lacustrine deposits and tuff which underlie some of the region weather into dense clay which also retards infiltration.

The average annual precipitation within the region was obtained from a generalized isohyetal map of Nevada, prepared by Hardman and Mason (1949, p. 10). A comparison of more recent topographic maps with the isohyetal map, suggests that in the area, or zone, lying below an altitude of 5,700 feet, the average annual precipitation is less than 8 inches. At altitudes between 5,700 and 6,500 feet the average annual precipitation ranges from 8 to 12 inches, and above 6,500 ranges from 12 to 15 inches. In the southern part of Hays Canyon Range the average annual precipitation locally may exceed

15 inches, but the areas are so small that they are omitted from the computations of recharge.

Even under favorable conditions the percentage of precipitation that recharges the ground-water reservoir is small, and the percentage for a given amount of precipitation varies considerably with the terrane. For the purposes of this report, rough estimates, based on empirical methods devised by Eakin and others (1951), are made of the amount of water which annually recharges the ground-water aquifers of the region.

In this method, 7 percent of the precipitation in the 12- to 15-inch zone and 3 percent in the 8- to 12-inch zone is presumed to reach the water table. Where precipitation is less than 8 inches, the recharge is assumed to be negligible. These assumptions in the Long Valley-Massacre Lake region provide the basis for the estimates of recharge shown in table 2.

Discharge:

Ground water is returned to the atmosphere by evaporation from the land surface and by transpiration through plants. It may be discharged to the surface by springs, seeps, and pumping, or it may move from one area to another by underflow through the aquifers.

Evaporation: Evaporation from the ground-water reservoirs occurs where the capillary fringe reaches or is near the land surface. In Long Valley an area of about 8,000 acres is covered by playas, or ephemeral lakes. Much of the water which reaches the playas is the result of storm runoff, but ground water is also discharged to the playas by artesian springs and seeps in the valley floor and in some low areas where the land surface intersects the capillary fringe.

In a normal year the full 8,000 acres of playa probably is inundated by the spring runoff, but the depth of water over the entire playa area may average no more than half a foot. The rate of evaporation from a free-water surface of 44 to 48 inches (p. 6) is more than enough to dry up the playa lakes by the end of the summer. The lowest playa lakes rarely become completely dry, however, but are reduced to a sump area where a residual body of water generally persists. These perennially wet areas are maintained by discharge from the ground-water reservoir. In Long Valley the area of standing water or wetted surface due to ground-water discharge may be on the order of 1,000 acres. Evaporation from this area represents nearly 4,000 acre-feet of ground-water discharge annually.

Applying this reasoning to Massacre Lake and Mosquito Valleys, where the areas of perennially wet surface are about 500 and 200 acres, respectively, the estimates of ground-water discharge by evaporation are on the order of 2,000 and 800 acre-feet per year.

In areas of shallow water levels, evaporation from the surface of the dry playas may also occur, but the loss of water by evaporation decreases rapidly with increasing depth to water. Although the water level is presumed to be relatively shallow beneath the playas of the region, this critical factor is

Table 2.--Estimated precipitation and recharge to the ground-water reservoirs of the Long Valley-Massacre Lake region, Washoe County, Nev.

Altitude of precipitation zone (feet)	Area of precipitation zone (acres)	Range of average annual precipitation (inches)	Precipitation (acre-feet per year) (rounded)	Percent recharge[1]	Estimated recharge (acre-feet per year) (rounded)
Long Valley					
above 6,500	19,600	12-15	22,000	7	1,500
5,700-6,500	176,500	8-12	146,000	3	4,400
below 5,700	144,500	less than 8	72,200	0	
Total			241,000		6,000
Massacre Lake Valley					
above 6,500	17,500	12-15	19,700	7	1,400
5,700-6,500	82,200	8-12	68,500	3	2,100
below 5,700	16,700	less than 8	3,400	0	
Total			97,000		3,500
Mosquito Valley					
above 6,500	1,600	12-15	1,800	7	300
5,700-6,500	15,000	8-12	12,500	3	400
below 5,700	3,000	less than 8	1,500	0	
Total			16,000		700
Boulder Valley					
above 6,500	12,600	12-15	14,200	7	1,000
5,700-6,500	43,500	8-12	36,200	3	1,100
below 5,700	7,500	less than 8	3,700	0	
Total			54,000		2,000
Surprise Valley (Nevada part only)					
above 6,500	8,900	12-15	10,000	7	700
5,000-6,500[2]	33,000	8-12	27,500	3	800
Total			37,500		1,500
Coleman Valley (Nevada part only)					
above 6,500	3,100	12-15	3,500	7	300
below 6,500	29,300	8-12	24,400	3	700
Total			28,000		1,000
Guano Valley (Nevada part only)					
above 6,500	27,200	12-15	30,800	7	2,200
below 6,500	210,000	8-12	175,000	3	5,300
Total			206,000		7,500

1. After Eakin and others (1951).

2. Lower limit of zone reduced to 5,000 feet because western exposure probably receives 8 inches of rain at that level.

not known in sufficient detail to warrant an estimate of the amount of ground water discharged in this manner.

Transpiration: Large quantities of ground water are transpired by plants, known as phreatophytes, whose roots descend to the water table or to the capillary fringe above it. Greasewood is the most common phreatophyte in the region, and its presence is an indication that the water table is within about 30 feet or less of the surface. Other, less common phreatophytes are salt-grass and rabbitbrush. Saltgrass is generally an indication that the depth to water is 10 feet or less. The areas of phreatophyte growth in Long and Massacre Lake Valleys are shown in Plate 1.

The estimated annual rate of ground-water use by phreatophytes used in this study is based largely on work done by White (1932, p. 28-93) in Escalante Valley, Utah, and investigations by Young and Blaney in California (1942, p. 41-246). The results of these investigations suggest that the rate of ground-water use by greasewood in an environment such as the Long Valley-Massacre Lake region probably is on the order of 0.2 feet per year. Based on this rate the estimated volume of ground-water discharged by about 35,000 acres of phreatophytes in Long Valley amounts to about 7,000 acre-feet per year, and by about 2,500 acres in Massacre Lake Valley is about 500 acre-feet per year.

Grass is the principal phreatophyte in Mosquito Valley. About 700 acres of alfalfa in several fields throughout the basin and 100 acres of native grass, associated with the springs which discharge along the base of the bluff bordering the west side of the basin are estimated to discharge about 800 acre-feet of ground water per year.

No attempt has been made to estimate the ground-water discharge by transpiration from the smaller basins in the region. Small areas of phreatophytes are generally found along incised stream channels and downgradient from the numerous springs. Transpiration from small areas of phreatophytes, taken in aggregate, probably represents the major portion of ground-water discharge from the basins.

Springs: The springs and seeps on the floors of Long and Massacre Lake Valleys probably are fed by upward leakage from underlying artesian aquifers. Spring discharge is included in the estimates of evapotranspiration of ground water previously described.

Around the margins of the valleys and in the upland regions, springs and seeps of the gravity type are common. These occur in places where the water table intersects the land surface, commonly at the foot of an escarpment, at canyon mouths, and along stream channels. Most of the water discharged by springs is lost by evaporation and transpiration either near the spring sites or along the stream channel; only a small part persists as streamflow, a fraction of which may invlltrate to the ground-water reservoir.

Pumpage: The ground-water regimen in the Long Valley-Massacre Lake region had not been affected to any appreciable extent by pumping through 1962. Most of the wells listed in table 4 and shown on Plate 1 are pumped by windmill and used to water stock. The total discharge of all the wells in the region probably does not exceed 200 acre-feet per year.

Perennial Yield:

Under natural conditions the average annual recharge to the ground water reservoir in a closed basin equals the average annual discharge from the basin. Temporary extremes of drought or flood are compensated for by changes of ground water in storage.

Just as discharge is balanced by recharge under natural conditions, so must pumpage of ground water from a closed basin be limited if declining water levels and eventual depletion are to be prevented. Perennial yield is the maximum rate at which water can be withdrawn from a ground-water system for an indefinite period of time. It is ultimately limited by the amount of recharge available to the system. In practical terms the net amount of ground water that can be pumped perennially in a closed basin without causing a continuing decline in ground-water levels is limited to the amount of natural discharge that can be salvaged. The allowable gross pumpage may exceed the net pumpage to the extent that some of the ground water returns to the ground-water reservoir and is available and suitable for reuse.

The perennial yield of a ground-water basin can be determined more readily after several years of extensive development when more quantitative data become available for analysis of the reservoir systems. Present knowledge of the hydrology of the Long Valley-Massacre Lake region is meager; therefore the quantities estimated in the following sections can be used only as tentative guides for the controlled development of the ground-water resources of the region.

The estimates of recharge to the basins in the region should be about equal to the estimated natural discharge. Exact agreement of the estimates is not to be expected, however, because of the many variables involved and because of the crude methods that were used in estimating the various elements of recharge and discharge.

Long Valley: The estimated average recharge to the ground-water reservoir of Long Valley of 6,000 acre-feet per year (table 2) is only about half the estimated total average discharge of 11,000 acre-feet per year. One important factor in this apparent imbalance, aside from the errors inherent in the methods of estimation, is the possibility of ground-water underflow from areas outside the drainage boundaries of the valley. It is likely that a considerable volume of ground water may be moving into Long Valley from the New Year Lake area, from the northern part of the Massacre Lake drainage, and possibly from Boulder Valley as well. Thus, if the estimated discharge is a reasonable measure of the annual supply to Long Valley, the perennial yield is on the order of 10,000 acre-feet.

Massacre Lake Valley: The estimated average discharge from Massacre Lake Valley by evaporation and transpiration totals about 2,500 acre-feet per year. The estimated average recharge is about 3,500 acre-feet per year (table 2). Underflow to Long Valley may account for part of the apparent imbalance. Although the estimates suggest that the perennial yield of the valley probably is on the order of 3,000 acre-feet, it seems unlikely that this amount of ground water could be developed economically because of the low permeability of the extremely fine-grained deposits which underlie most of the valley.

Mosquito Valley: The estimated average recharge to Mosquito Valley of 700 acre-feet per year (table 2) may be no more than half the actual recharge, considering the possibility of ground-water underflow into the western part of the basin from the plateau to the west. The estimated average discharge by evaporation and transpiration total about 1,600 acre-feet per year, which probably more closely approximates the annual supply to the valley. A reasonable estimate of the perennial yield probably is on the order of 1,500 acre-feet.

Boulder Valley: The estimated average recharge to the ground-water reservoir of Boulder Valley is about 2,000 acre-feet per year (table 2). Natural discharge, although not estimated, does not appear to equal this amount. Some ground water may be moving from Boulder Valley into the southern end of Long Valley through the low range of hills which separate the two basins. The perennial yield could be as much as 2,000 acre-feet, provided that the underflow to Long Valley could be diverted to any wells that might be drilled.

Surprise Valley: The estimated recharge to the ground-water reservoir of Surprise Valley in the portion lying only within Nevada and between Forty-nine Creek and Hays Canyon is about 1,500 acre-feet annually (table 2). The natural discharge of ground water from Surprise Valley takes place almost entirely in California and was not estimated. The estimated partial perennial yield of Surprise Valley (Nevada segment only) probably is no more than 2,000 acre-feet; even this supply may be limited by the saline water in the central part of the valley which could move into areas of future development if water levels were lowered enough to reverse the natural gradient.

Coleman Valley: Coleman Valley lies almost entirely in Oregon. The estimated recharge to that part of the ground-water reservoir lying in Nevada is about 1,000 acre-feet annually (table 2) and the partial perennial yield probably is of the same magnitude.

Guano Valley: Guano Valley also lies almost wholly in Oregon. The estimated ground-water recharge within that part of the drainage basin of Guano Valley lying within Nevada is about 7,500 acre-feet per year (table 2). Although no estimates of natural discharge were made for this valley, it seems likely that most of this water is discharged by springs and phreatophytes from the rolling plateau country which comprises most of the drainage area in Nevada. Because of the practical problems involved in salvaging the discharge, the amount of ground water which could be recovered in the Nevada segment of the valley probably would not exceed 2000 acre-feet per year.

Ground Water in Storage:

The amount of recoverable ground water in storage in the alluvium of the basins in the region is many times their average annual recharge. An estimate of the magnitude of the recoverable water in storage can be obtained by computing the amount of ground water that will drain from the deposits for each foot of lowering of water level. An average specific yield of 10 percent is considered to be a conservative estimate of the amount of water by volume that will drain from the deposits in the region. For example, in Long Valley the alluvium covers an area of about 200,000 acres. Thus, the amount of ground water that could be recovered from a lowering of water levels would be on the order of about 20,000 acre-feet per foot of lowering, or about twice the average annual recharge.

Much of the water in storage within the alluvium, however, may be of poor chemical quality, particularly in and near the centers of the basins. In addition, in some areas the permeability is so low that it would not be feasible to develop ground-water supplies. Thus, the amount of usable ground water in storage that is economically available probably is less than the gross amount calculated for Long Valley.

CHEMICAL QUALITY OF THE GROUND WATER

The chemical constituents in ground water are acquired by the solution of minerals in the material through which the water percolates. In general, the dissolved-solids content of the water is determined by the solubility of the rock or soil, the area and duration of contact, and other factors, such as pressure and temperature.

Table 3 lists the chemical analyses of water from five wells and one spring in the region. All of the analyses show that the water is of good chemical quality and is suitable for irrigation and domestic use. The water probably becomes more saline as it moves toward the centers of the basins, however, and excessive pumping could reverse the hydraulic gradient and induce mineralized water to flow toward the area of pumping.

Temperature:

The temperature of ground water is an indication of the length of time the water has been in the ground and the depth to which it may have circulated.

The temperatures of 15 of the springs listed in table 4 range from 48° to 62° F., and three others have temperatures of 71, 73, and 80° F. The coolest of these is Vya Spring, which is discharging from the alluvial slope at the base of a several hundred foot escarpment of tuff and agglomerate. Discharge from the other two, 44/19-12b1 and 44/20-18c1, rises through the lake deposits of the valley floor. The temperature of water from the few wells sampled in the area ranges from 48 to 69° F.

Table 3.--Chemical analyses of ground water in the Long Valley-Massacre Lake region, Washoe County, Nev.

(Analyses by U.S. Geological Survey. Constituents in parts per million.)

Well or Spring number	Date collected	Temperature °F	Silica (Si)	Calcium(Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	Dissolved solids residue at 180°C	Sodium adsorption ration (SAR) (epm)	Residual sodium carbonate (RSC) (epm)	pH
															non-Carbnnate	Calcium Magnesium					
Well 45/19-2a1	5-2-61	48	60	75	26	97	8.5	0	243	49	70	0.8	215	0.35	97	296	1030	721	2.47	0	7.6
Spring 45/21-18b	5-2-61		55	12	3.2	14	7.3	0	62	11	13	.2	1.6	.10	0	42	173	160	.09	.14	7.4
Well 43/19-33b1	5-2-61	53	59	22	7.5	69	9.8	0	198	45	32	.4	.3	.26	0	87	499	356	3.15	1.4	7.5
Well 42/20-8d1	5-2-61	48	61	57	25	151	11	5	289	134	94	.5	70	.76	0	244	1130	749	4.25	0	8.3
Well 43/21-34d1	5-2-61	55	69	13	3.4	17	4.0	0	89	5.6	7.0	.2	.8	.17	0	46	174	157	.78	.6	7.4
Well 40/20-3d1	5-3-61	58	61	25	9.0	32	4.7	0	148	16	23	.2	.5	.13	0	100	339	243	1.4	.46	7.8

CONCLUSIONS

On the whole it appears that the water resources of the Long Valley-Massacre Lake region are more than adequate to support the development which the climatic factors and soil conditions will permit.

The most important sources of ground water in the region are the sand and gravel aquifers buried within the less permeable deposits of the alluvium. These aquifers probably are most productive along the margins of the valley floor, and particularly opposite the mouths of canyons where streams have created channels filled with coarse, well-sorted material at various depths within the lake deposits underlying the valley floor.

The best estimate of the average annual recharge to the ground-water reservoir of Long Valley is considered to be about 11,000 acre-feet, and Massacre Lake Valley about 3,500 acre-feet. The perennial yield, if based on the amount of water that can be salvaged from natural discharge, may approach these figures and would depend on the pattern of development and the conservation measures that are used.

Although some ground water must be withdrawn from storage in order to induce movement of water toward a pumping well, the long-term net draft on the ground-water reservoir should not be allowed to exceed the perennial yield, if a long-term decline in water levels and an extensive depletion of the water in storage is to be avoided.

Chemical analyses indicate that most of the ground water in the region is suitable for irrigation and domestic use. The water probably becomes more saline as it moves toward the center of the basins, however, and excessive pumping could reverse the hydraulic gradient and induce mineralized water to flow toward the area of pumping.

Table 4.--Record of wells in the Long Valley - Massacre Lake Region, Washoe County, Nev.

Use of water: D, domestic; I, irrigation; O, observation; S, stock.
Water level: M, measured; R, reported.
Altitude: Determined from altimeter readings.
Remarks: Number is log number in files of State Engineer.
Owner: BLM, Bureau of Land Management.

Well No. and location	Owner	Date drilled	Diameter (inches)	Depth (feet)	Depth of principal aquifers (feet)	Water level: Below measuring point (feet)	Water level: M or R	Water level: Date	Measuring point: Altitude (feet)	Measuring point: Above land surface (feet)	Measuring point: Description	Use	Remarks
47/20-30b1	Oscar Kittridge	- -	4	- -	- -	16+	R	- -	4,860	- -	- -	-	- -
46/20-1b1	Cahill	- -	-	- -	- -	2	R	- -	5,780	- -	- -	S	- -
46/20-24b1	E.W. Toney	- -	6	20	- -	6.7	R	4-24-50	5,610	- -	- -	S	- -
45/19-2a1	Drawn Ranch	- -	5 ft.	45	- -	26.4	M	7-10-62	- -	- -	wood pump base	D	Chem Anal.
45/19-2a2	Homer Drawn	1947	12	147	- -	35.4	R	- -	- -	- -	- -	D	Log 1361
45/19-14c1	BLM	- -	8	55	33to39	22.4	M	7-10-62	5,700	- -	top of flange on top of casing	S	- -
45/19-26c1	Stan Morris	- -	16	40	- -	26.8	R	- -	5,560	- -	- -	-	- -
45/19-26d1	Glen Knoll	- -	-	30	- -	21.5	R	- -	5,490	- -	- -	-	- -
45/19-26d2	Glen Knoll	- -	6	- -	- -	43	R	- -	5,520	- -	- -	D	- -
45/20-24b1	BLM	- -	-	40	- -	8	M	- -	5,550	- -	- -	S	- -
45/20-27b1	Hill	- -	-	- -	- -	34	R	5-12-50	5,600	0.2	base of pump	D	- -
45/20-27b2	BLM-E. Hill	1955	-	108	- -	86	R	9- -55	- -	- -	- -	S	- -
45/20-33d1	BLM	7-1955	8	200	- -	- -	-	- -	- -	- -	- -	S	- -
44/19-4c1	BLM	- -	-	60	- -	2	R	- -	- -	- -	- -	S	Log
44/19-8a2	J.F. Schutz	- -	-	50	- -	35.4	R	- -	5,640	- -	- -	D	- -
44/19-33a1	BLM	4-1954	6	- -	43to60	2	R	4-1954	- -	- -	- -	S	Log
44/22-5a1	BLM	7-1954	4	273	260to273	251	R	7-9-54	5,950	- -	- -	S	Log
43/19-20d1	C.T. Bandy	- -	-	90	- -	- -	-	- -	- -	- -	- -	D,S	- -
43/19-21c1	abandoned	- -	-	- -	- -	16.7	M	4-20-50	- -	- -	planking over well	unused	- -
43/19-33b1	- -	- -	6	70	- -	14.5	M	5-2-61	- -	1	top of casing	S	- -
43/19-34d1	BLM	11 -1952	8	25	24to25	5	R	11-'52	- -	-	- -	S	Log
43/20-6b1	BLM	5-1954	6	57	60to91	15.2	M	4-12-60	5,600	.5	top of casing	S	Log
43/20-20b1	BLM	11- 1952	6	136	119to124	35	R	11-18-62	- -	1	- -	S	Log 2107
43/20-22a1	BLM	12-1950	8	100	85to100	60	R	12-4-50	- -	-	- -	S	Log 1500
43/20-34b1	BLM	9-1954	6 5/8	114	82to133	58.5	M	10-23-62	5,520	1	plate on top csg.	S	Log 2747
43/21-3a1	K. Heard	- -	-	16	- -	6	R	- -	- -	-	- -	S	- -
43/21-4b1	BLM	9-1952	6	120	92to96	75	R	9-6-'52	- -	-	- -	S	Log 2041
43/21-14a1	BLM	- -	24	- -	- -	5.5	R	5-16-50	5,635	1.5	- -	S	- -
43/21-17b1	BLM	8-1952	6	65	50to55	79.5	M	9-12-62	- -	.5	top of casing	S	Log 2040
43/21-30a1	BLM	11-1950	6	46	8to10	8	R	11-28-50	5,520	-	- -	S	Log 1501
43/21-34d1	BLM	11-1950	8	160	100to110	87	R	11-30-50	5,710	-	- -	S	Log 1502
43/22-14c1	BLM	10-1954	6 5/8	325	234to305	284	R	10-5-54	5,910	-	- -	S	Log 2744
43/22-18d1	BLM	12-1954	6	164	140to164	125	R	12-1954	- -	-	- -	S	Log
43/22-32a1	BLM	10-1954	6 5/8	212	204to212	188	R	10-2-54	5,815	-	- -	S	Log 2745
43/24-5a1	BLM	6-1955	8	74	- -	5	R	6-1955	- -	-	- -	S	- -
42/19-16d1	BLM	- -	6	80	- -	61	M	- -	5,620	0.2	pump base	S	- -
42/19-22c1	- -	- -	6	77	- -	14.1	M	4-12-60	- -	.08	top of casing	S	- -
42/19-22c2	- -	- -	-	438	- -	-	-	- -	- -	-	- -	-	Log
42/20-3c1	Cap't Johnson headqtrs.	- -	6	200	- -	31.5	R	- -	5,595	-	- -	-	- -
42/20-8d1	BLM	- -	48	27	- -	18.0	M	9-12-62	5,460	1	top of casing	S	Chem anal
42/20-9d1	BLM	- -	48	30.6	- -	27.5	R	- -	5,560	1.4	top of casing	-	- -
42/20-17b1	BLM	- -	30	- -	- -	16.2	R	- -	5,560	2.4	top of curb	-	- -
42/20-21b1	BLM	- -	6	123	- -	88.4	M	9-12-62	- -	.5	top of casing	S	- -
42/20-26a1	BLM	- -	6	200	- -	98.9	R	- -	5,660	-	- -	-	- -
42/20-27b1	BLM	- -	-	79.5	- -	66.5	M	- -	5,600	-	top of casing	-	- -
42/21-5a1	BLM	9-1952	8to6	150	106to109	59.5	R	9-12-62	5,560	1.0	- -	S	Log 2039
41/19-12a1	BLM	- -	8	363	- -	-	-	- -	- -	-	- -	S	Log
41/20-3d1	BLM	- -	6	150	- -	36.9	M	9-12-62	5,570	10.0	top of casing	-	- -
41/20-24b1	BLM	1950	8	100	- -	45.2	M	9-11-62	- -	.2	hole in casing cap	S	Log
40/18-30d1	BLM	12-1950	8	86	50-86	27	R	12-9-50	- -	-	- -	-	Log 1498
40/20-3d1	- -	- -	4	185	- -	154	R	- -	- -	-	- -	S	- -
40/20-18c1	BLM	10-1954	6 5/8	234	195to234	149	R	10-8-54	- -	-	- -	S	Log 2743
40/21-6c1	BLM	12-1950	8	307	160to307	96.3	M	9-11-62	- -	.5	to casing	S	Log 1499

Table 5.--Record of Springs in the Long Valley-Massacre Lake Region
Washoe County, Nevada.
Use: D, Domestic; S, Stock; I, Irrigation.
Discharge is estimated.

Spring Number	Name	Probable Source	Discharge (gpm)	Use	Temperature
46/18-15c1		basalt	5	S	--
45/19-4d1	---	basalt	5	S	61
45/19-33b1	Parry			S	56
45/20-11a1	Hapgood Ranch			-	50
45/20-10d1	Antelope	---	10	S	48
45/20-12c1	Mud Lake	lake deposits	-	S	--
45/21-31b1	Board Corral	--	25	S,I	56
45/21-18b1	---	--	5	S	61
44/20-18c1	---	lake deposits	10	S	80
44/19-8a1	---	--	-	S	55
44/19-12b1	---	lake deposits	5	S	73
43/19-10a1	Harris	lake deposits	30	S	--
43/19-12c1	---	lake deposits	3	S	52
43/19-29b1	---	--	50	S	62
43/21-21b1	---	lake deposits	2	S	56
43/21-29a1	---	lake deposits	2	S	--
42/21-31c1	Lone	basalt	10	S	55
42/19-4b1	Vya	tuff and agglomerate	50	S,D	71
40/20-33b1	Boulder	Basalt	30	S	55
40/21-22d1	Little Indian	alluvium	3	S	57
40/21-26a1	Nellie	alluvium	5	S	54
39½/21-34a1	Hart Ranch	rhyolite	10	S,D	51

Table 6.--Driller's logs of wells in the Long Valley-Massacre Lake Region, Washoe County, Nevada.

	Thickness (feet)	Depth (feet)
45/19-2a2		
No record	7.5	7.5
Gravel, small strata, sand	25.5	33
Gravel, water	3	36
Gravel, medium	4	40
Gravel, heavy	4	44
Gravel	6	50
Gravel, water	4	54
Gravel, water	3	57
Clay and gravel	9	66
Gravel, water	3	69
Clay	3	72
Clay, heavy	3	75
Gravel, good	3	78
Clay, hard	4	82
Clay	2	84
Clay, light colored	2	86
Sand, water	2	88
Rock, red	2	90
Clay, red	4	94
Clay, red, soft, and gravel	3	97
Clay, dark, some gravel	3	100
Clay, dark	2	102
Sand	24	126
Sand and gravel	10	136
Sand, red	6	142
Rock, red	5	147
45/19-14c1		
Soil	3	3
Silt, brown	9	12
Hardpan	2	14
Clay, yellow	19	33
Shale, brown	6	39
Basalt	17	56
45/20-27b2		
Sand	31	31
Sandy clay	9	42
Cemented gravel	35	77
Clay	8	85
Sandy clay	8	93
Sand - water	15	108
45/20-33d1		
Rock and clay	43	43
Clay and Gravel	59	102
Rock, brown	46	148
Pink rock	17	165
Basalt	35	200
44/10-4c1		
Silt, brown	12	12
Silt, blue and gray	48	60
44/19-33a1		
Soil	3	3
Silt, brown	9	12
Clay, blue, silt	10	22
Clay, green, silt	21	43
Clay, blue, in small granules	17	60
44/22-5a1		
Top soil	4	4
Hardpan	8	12
Sand	18	30
Sandstone, hard	25	55
Rock, gray	63	118
Rock, red	18	136
Sandstone	23	159
Rock	101	260
Gravel	13	273
43/19-34d1		
Clay, yellow	12	12
Clay, white	12	24
Sand, water	1	25
Clay, yellow	3	28
43/20-6b1		
Soil	4	4
Sandy soil, brown	10	14
Clay, soft, blue	12	26
Silt, blue	10	36
Sand, fine, blue	55	91

Table 6.--Continued.

	Thickness (feet)	Depth (feet)
<u>43/20-20b1</u>		
Sand	7	7
Clay, red	82	89
Clay, white	30	119
Sand - water	5	124
Clay, white	12	136
Sand - water	4	140
<u>43/20-22a1</u>		
Clay, red, sand	60	60
Clay, yellow, gravel	40	100
<u>43/20-34b1</u>		
Sand and clay	30	30
Sandy clay	52	82
Sand, very fine	24	106
Sand, fine, and silt	27	133
<u>43/21-4b1</u>		
Clay and gravel	2.6	2.6
Boulders	17.6	20
Gravel	2	22
Hard rock	20	42
Clay, red	5	47
Clay, yellow	15	62
Clay, red	16	78
Sandstone	14	92
Sand - water	4	96
Clay, yellow	20	116
Clay, red	4	120
<u>43/21-17b1</u>		
Clay	4	4
Gravel and boulders	13	17
Clay	1	18
Sand, fine	2	20
Sandy clay, hard	17	37
Clay	13	50
Sand - water	5	55
Sandstone, brown	10	65
<u>43/21-30a1</u>		
Clay, talc	8	8
Brocken rock, coarse sand & gray-black clay	2	10
Coarse sand & clay, gray-black	36	46
<u>43/21-34d1</u>		
Top soil, small rocks	5	5
Clay, red	55	60
Sandstone	4	64
Clay, sand	36	100
Sandy clay	10	110
Sandy red clay	50	160
<u>43/22-14c1</u>		
Clay and rock, brown	120	120
Clay, red	15	135
Clay, red	6	141
Clay, some white sand	26	167
Broken rock, gray	60	227
Broken rock, gray	7	234
Sand, cemented, and gravel - water	71	305
Sand, coarse, hard	16	321
Hard rock	4	325
<u>43/22-18d1</u>		
Soil	3	3
Tuff	136	139
Sand and gravel	25	164
<u>43/22-32a1</u>		
Old well	149	149
Black lava rock	23	172
Black lava rock	20	192
Black lava rock	12	204
Black sand	8	212
Black lava rock		212

Table 6.--Continued.

	Thickness (feet)	Depth (feet)
43/24-5a1		
Clay, sticky	14	14
Clay and gravel	18	32
Sandstone, pink	41	73
42/19-22c2		
Top soil, light gravel	9	9
Gravel, fine and coarse Sand - water	17	26
Clay, soft, blue	2	28
Gravel, fine, and coarse sand	13	41
Clay, firm, blue	7	48
Gravel, rough, coarse	6	54
Clay, soft, blue	12	68
Gravel, rough, boulders	8	76
Clay and gravel	22	98
Sand, gravel, hard clay, mixed	20	118
Clay, soft, and gravel	10	128
Clay, blue, soft	12	140
Clay, brown, with gravel, firm	34	174
Clay and gravel, very hard	2	176
Clay, soft, brown	108	284
Clay, brown, with coarse sand and fine gravel	46	330
Clay, brown, coarse sand, some pea gravel, very hard	108	438
42/20-21b1		
Clay, sandy, gray	32	32
Clay, sandy, red	25	57
Clay, sandy, brown	46	103
Rock, broken, brown-water	18	121
Rock, black	4	125
42/21-5a1		
Clay, sandy	4	4
Clay, hard, red, sticky to drill	93	97
Hardpan	2	99
Clay, yellow	7	106
Sand - water	3	109
Clay, yellow	12	121
Sandstone, soft	29	150
41/19-12a1		
Clay, hard	28	28
Sandstone	33	61
Bentonite	23	84
Sandstone, soft	19	103
Sandstone, hard, grey	20	123
Sandstone, hard, brown	62	185
Rock, gray, hard	6	191
Sandstone, soft	59	250
Sandstone, brown	40	290
Sandstone, gray	55	345
Gravel, loose, very little water	4	349
Rock, gray, solid	14	363
41/19-23c1		
Soil	3	3
Tuff, brown	16	19
Tuff, pink	104	123
Sand, coarse, black	12	135
Basalt		135
41/20-24b1		
Clay, red & sand	60	60
Clay, yellow, & sand	20	80
Sand, coarse, & gravel	15	95
Sand, and yellow clay	5	100

Table 6.--Concluded.

	Thick-ness (feet)	Depth (feet)		Thick-ness (feet)	Depth (feet)
<u>40/18-30d1</u>					
Top soil	3	3			
Rock, broken	35	38			
Rock, broken, hard clay	12	50			
Sand and gravel	36	86			
<u>40/20-18c1</u>					
Boulders and clay, red	15	15			
Clay, sandy, brown	30	45			
Clay, sandy, white	28	73			
Sand, coarse and clay, brown	27	100			
Sand, coarse and clay, brown	95	195			
Gravel, cemented-water	28	223			
Rock, broken	11	234			
<u>40/21-6c1</u>					
Clay, red	2	2			
Gravel and rocks	2	4			
Clay, gray, sand, volcanic glass	16	20			
Clay, red, sand and gravel	50	70			
Clay, yellow, sand and gravel	20	90			
Clay, brown, sand and gravel	20	110			
Clay, red, sand and gravel	90	200			
Clay, red, sand and gravel	35	235			
Clay, white, sand and gravel	35	270			
Sand	13	283			
Sandy clay	24	307			

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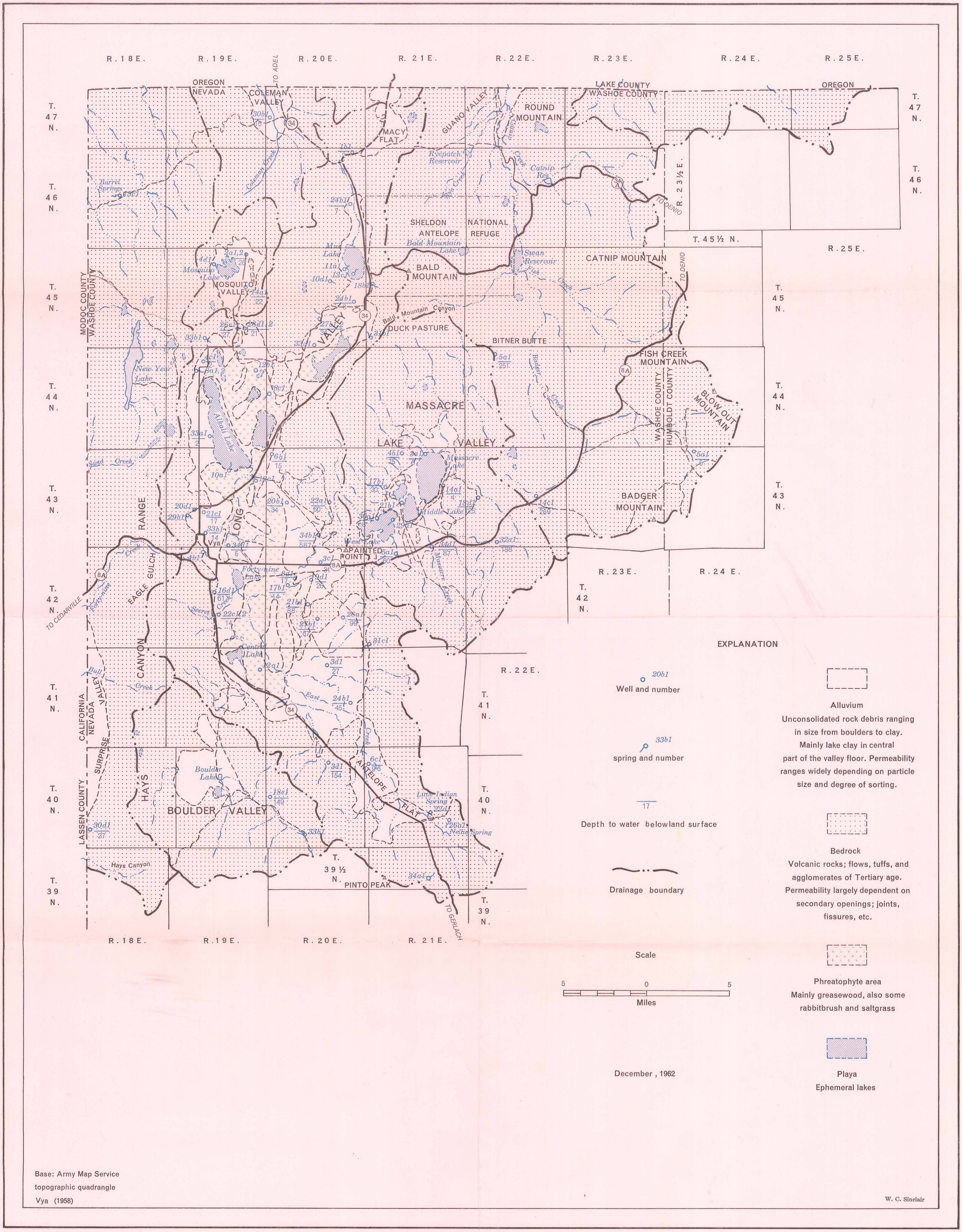

PLATE 1. GENERALIZED GEOLOGIC AND HYDROLOGIC MAP OF THE LONG VALLEY–MASSACRE LAKE REGION, WASHOE COUNTY, NEVADA.