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DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

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# A Summary of the Hydrology of the Las Vegas Ground-Water Basin, Nevada, With Special Reference to the Available Supply

By

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# FOREWORD

This report is the eighteenth in the series of Nevada Water Resources bulletins covering ground-water resources under a cooperative program between the United States Geological Survey and the State of Nevada. It sets forth in summary form the results of an extensive study starting in 1954. Within a few months a more detailed report will be issued as a U. S. Geological Survey Water-Supply Paper. Due to the nature of the ground-water situation in Las Vegas Valley, it was thought desirable to issue this summary report.

Prior to the present cooperative arrangement, a cooperative study was made of the underground leakage from artesian wells in the vicinity of Las Vegas. The findings of this investigation by Penn Livingston of the Ground-Water Branch, Geological Survey, are set forth in U. S. Geological Survey Water-Supply Paper 849-D. As the result of the present cooperative arrangement the following reports on the ground water of the area have previously been prepared. The first, entitled "Progress report on the ground-water resources of the Las Vegas Artesian Basin, Nevada," was published in 1945. This was followed by "Water levels and artesian pressure in wells in Las Vegas Valley and in other valleys in Nevada, 1913–1945," Water Resources Bulletin No. 3, published in 1947; "Well data in Las Vegas and Indian Spring Valleys, Nevada," Water Resources Bulletin No. 4, published in 1946; "Ground Water in Las Vegas, Pahrump, and Indian Spring Valleys, Nevada" (A summary), Water Resources Bulletin No. 6, published in 1947; and "Geology and Water Resources of Las Vegas, Pahrump, and Indian Spring Valleys," Water Resources Bulletin No. 5, published in 1948.

HUGH A. SHAMBERGER, *Director*
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# A SUMMARY OF THE HYDROLOGY OF THE LAS VEGAS GROUND-WATER BASIN, NEVADA, WITH SPECIAL REFERENCE TO THE AVAILABLE SUPPLY

By GLENN T. MALMBERG

## INTRODUCTION

This report summarizes the results of a study of the ground-water hydrology of the Las Vegas ground-water basin and has been prepared to make the results available to the public, pending publication of a more comprehensive report. The report was prepared by the U. S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources and is one of a series of reports describing the ground-water hydrology of Las Vegas Valley.

The purpose of the study is to re-evaluate the water resources of the Las Vegas basin and to make a quantitative analysis of the water budget.

## HISTORICAL SKETCH

The large springs in Las Vegas Valley were known to the Spaniards as early as 1770 and were used as watering places by the early explorers and travelers to the valley. Mormons under the leadership of William Bringhurst in 1855, attempted to establish a settlement in the valley, but they abandoned the outpost in 1857. After 1857, some use was made of the spring water for agriculture at the Stewart and Kyle Ranches, but the valley remained sparsely settled until the early part of the 20th century.

In 1905, because of the good water supply, the San Pedro, Los Angeles, and Salt Lake Railroad purchased the Stewart Ranch for the development of a townsite, maintenance station, and watering stop. The Las Vegas Land and Water Co., a subsidiary of the railroad company, laid out the townsite and constructed a waterworks system to attract workers and settlers to Las Vegas Valley, thus forming the beginning of the present city of Las Vegas. Most of the water used initially at the townsite came from the Las Vegas and Kyle Springs or from shallow dug wells, and it was not until 1906 that the first successful flowing artesian well was developed.

During the 55 years following the drilling of the first successful flowing well, Las Vegas Valley changed from a dominantly agricultural area of a few hundred inhabitants to a tourist and industrial center of more than 100,000 population.

Until 1942, when a pumping plant and pipeline were constructed to supply water from Lake Mead to the Basic Magnesium plant and the town of Henderson, the only source of water in the Las Vegas basin was from the ground-water reservoir. In 1954 the pumping and transmission facilities bringing water from Lake Mead to Henderson were improved and an additional water main was constructed for the transmission of a limited supply of water from Lake Mead to the cities of Las Vegas, North Las Vegas, and Whitney.

Each year as the demand for water in the valley increased, more wells were drilled, but until about 1942 there was no local concern about the declining water levels and decreasing flow from artesian wells. By the summer of 1942, flow from many artesian wells had diminished or stopped, thus providing evidence that the supply was overdeveloped, at least locally. Because of the possibility of critical water shortages and the possibility that the basin had been overdeveloped, the State Engineer of Nevada, in 1944, entered into a cooperative agreement with the U. S. Geological Survey to make a detailed investigation of the water resources of the Las Vegas ground-water basin. The results of the study by G. B. Maxey and C. H. Jameson were published by the State in 1948 in a comprehensive report entitled, "Geology and Water Resources of Las Vegas, Pahrump, and Indian Spring Valleys, Clark and Nye Counties, Nev." That report shows that precipitation in the mountains within the drainage boundaries of the valleys is the only natural source of recharge to the ground-water basin. The replenishment to the ground-water basin was estimated to average about 30,000 to 35,000 acre-feet per year for Las Vegas Valley and about 4,700 acre-feet per year for Indian Spring Valley, or a total of about 35,000 to 40,000 acre-feet per year for the two valleys.

Since 1940, the rapid expansion of Las Vegas Valley has continued unabated with a corresponding increase in ground-water consumption—an increase from about 22,000 acre-feet per year in 1940 to about 43,000 acre-feet per year in 1955. The resulting accelerated rate of decline of water levels in wells throughout the valley stimulated renewed interest and concern about overdevelopment of the ground-water basin. Therefore in 1954, the State Engineer of Nevada requested the U. S. Geological Survey to make a more detailed appraisal of the ground-water situation

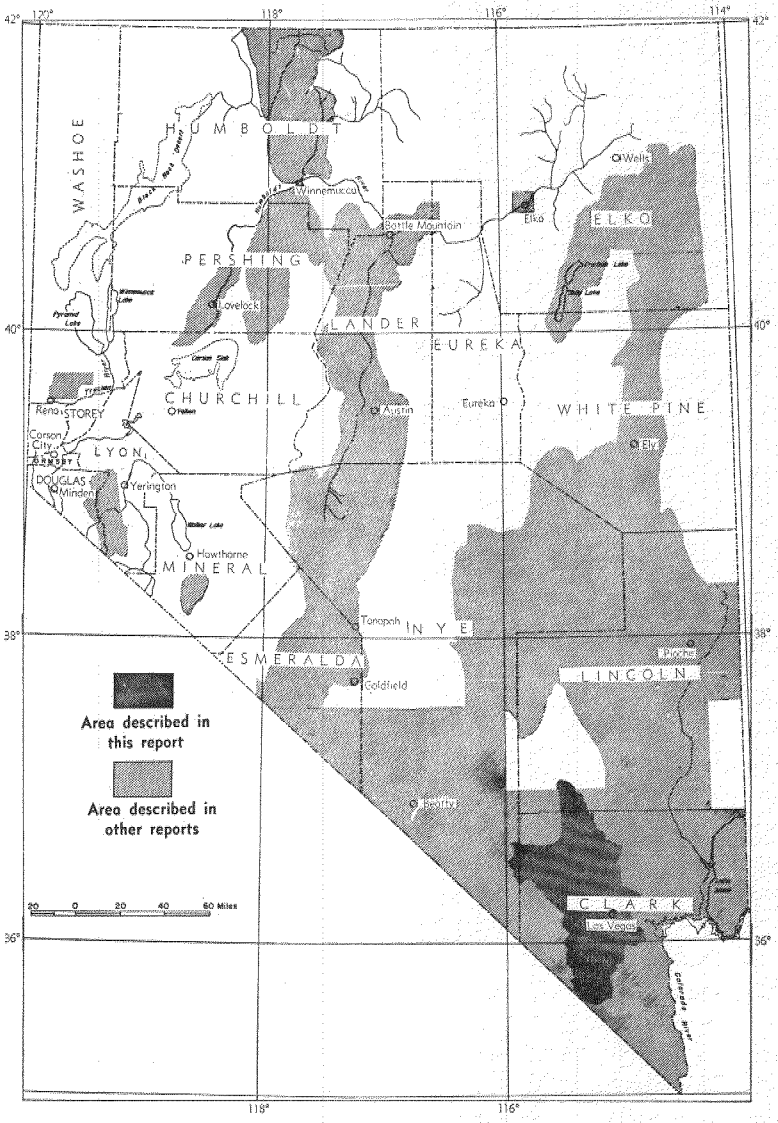


**Figure 1. Map of Nevada showing areas described in other ground-water reports and in the present report.**

in Las Vegas Valley as a part of the statewide cooperative ground-water program between the State and the Survey. The present report summarizes the results of the detailed appraisal.

## GEOGRAPHY

The area described in this report is shown in figure 1. The area lies between 35°30′ and 37°15′ north latitude and 115°00′ and 116°00′ west longitude. As shown in plate 1, it includes the drainage basins tributary to the Las Vegas Valley, the southern part of Indian Spring Valley, Three Lakes Valley, and the northern part of Ivanpah Valley. The alluvial fill in these valleys forms a single hydrologic unit, which in this report is called the "Las Vegas ground-water basin."

The boundary of the area included in this study is formed partly by ground-water divides across Indian Spring and Ivanpah Valleys and partly by the topographic divide along the crest of the Spring Mountains along the western side; the Las Vegas and Sheep Ranges, and Frenchman Mountain along the eastern side; the southern extension of the Desert, Pintwater, and Spotted Ranges along the northern border; and the River Mountains and the McCullough Range along the southern border.

West of Las Vegas Valley, the Spring Mountains rise in a distance of 35 miles to an altitude of nearly 12,000 feet; to the north, the Sheep Range rises to nearly 10,000 feet. The altitude of other mountains bordering the basin generally are less than 8,000 feet.

Drainage is interior in Indian Spring, Three Lakes, and Ivanpah Valleys. Runoff from the adjacent mountains discharges to playas or "dry" lakes that occupy the lower parts of these valleys. Surface runoff from the southern portion of Indian Spring Valley flows to a playa in the central part of the valley, north of the study area. There are no perennial streams of any significance in the basin. Drainage from Las Vegas Valley is through Las Vegas Wash to the Colorado River. The perennial flow in Las Vegas Wash is waste water, principally from the industrial plants at Henderson, and sewage effluent. Occasionally, flood waters discharge through the wash following infrequent cloudbursts in Las Vegas Valley.

## CLIMATE

The climate of the area is characterized by wide variations in precipitation and temperature. In the lower parts of the valleys the climate is arid, the average annual precipitation being less

than 5 inches. The winters are relatively short and mild, and the summers are long and hot. In the mountains the climate is more temperate and the annual precipitation is greater. The average annual precipitation probably exceeds 20 inches on the higher slopes of Charleston Peak.

## GENERAL GEOLOGY AND PRINCIPAL HYDROLOGIC UNITS

The rocks of the area can be divided into two general groups on the basis of their hydrologic properties, (1) consolidated rocks of relatively low permeability that form the mountains bordering the ground-water basin and that underlie the alluvium in the valleys, and (2) unconsolidated and partly consolidated, relatively permeable sedimentary deposits of the valley fill that form the Las Vegas ground-water basin.

The consolidated rocks are composed of sedimentary, igneous, and metamorphic rocks that range from Precambrian to Tertiary in age. These rocks have been extensively faulted and folded into complex geologic structures which have been studied in great detail by several geologists. A structural depression in the bedrock is filled with alluvium and forms a huge reservoir that for all practical purposes is watertight.

Great thicknesses of unconsolidated, relatively porous deposits of alluvium have accumulated in this structural depression. The alluvium is composed principally of boulders, gravel, sand, silt, and clay derived from the adjacent mountain ranges. These sedimentary deposits contain virtually all the ground water of economic importance in the area. Therefore, in this study of the water resources, emphasis was placed on the occurrence and movement of ground water in these deposits. The maximum thickness of the alluvial fill is unknown, but may be as much as 5,000 feet.

The aquifers of the valley fill within the principal area of ground-water development in Las Vegas Valley were divided into four principal hydrologic units by Maxey and Jameson (1948, p. 81, 82, 86) on the basis of their stratigraphic positions. They are: (1) The deep zone of aquifers, (2) the middle zone of aquifers, (3) the shallow zone of aquifers, and (4) the aquifers of the near-surface reservoir. Water in the first three units commonly occurs under artesian (confined) conditions; water in the fourth unit occurs under both water-table (unconfined) and artesian conditions.

The deep zone of aquifers are in the Muddy Creek Formation of Pliocene(?) Age. The Muddy Creek Formation has been extensively faulted and folded. Although it crops out at isolated points

in Las Vegas Valley, it is generally buried about 700 feet below land surface throughout the central part of the valley. Because the Muddy Creek Formation generally consists of a mixture of fine-grained sand, silt, and clay, the formation has a relatively low permeability. However, some wells of moderate yield have obtained water from fine-sand lenses within the formation.

Overlying the Muddy Creek Formation is about 500 feet of unconsolidated alluvial material composed of alternating layers and lenses of gravel, sand, silt, and clay whose age ranges from Pliocene(?) to Recent. This unit extends to within 200 feet of the land surface, and is separated into the middle and shallow zone of artesian aquifers by a bed of blue clay which commonly is about 200 feet above the Muddy Creek Formation. The alluvium in the middle and shallow zones contains the most productive aquifers and yields most of the ground water discharged by wells and springs in the area.

The aquifers are faulted as a result of differential compaction of interbedded and adjacent fine-grained sediments. The compaction faults are important hydrologically in that they significantly affect the movement of water laterally and between aquifers. The depth to which the compaction faults extend is not known.

Hydraulic continuity between the artesian aquifers is poor. However, because of the somewhat limited areal extent of the confining beds there is leakage between aquifers. Leakage also occurs near or along the compaction faults and through improperly constructed wells, with the result that artesian pressures in the various aquifers have tended to become equalized.

Beds and lenses of varying thickness of caliche, fine-grained sand, silt, and clay overlie the shallow zone of aquifers. They comprise the fourth unit, designated the near-surface zone of aquifers. At altitudes of less than about 2,100 feet, these deposits are commonly saturated with ground water to within a few feet of the land surface.

The low permeability of the sediments that make up the near-surface zone of aquifers generally limits the yield of wells developed in it to less than 50 gpm (gallons per minute).

## GROUND WATER

Although it is recognized that in gross aspect the Las Vegas ground-water basin is a leaky artesian system that functions as a single hydrologic unit, for simplicity of treatment the four groups of aquifers have been arbitrarily divided into two interconnected ground-water systems. The deep, middle, and shallow

zones of aquifers and their extensions to the intake areas are designated the artesian system; and the near-surface zone of aquifers, the near-surface system.

## ARTESIAN SYSTEM

### Source, Occurrence, and Movement of Water

The source of all recharge to the artesian system in Las Vegas Valley is precipitation in the mountains within the drainage area tributary to the Las Vegas ground-water basin (pl. 1).

In the lower parts of the area below an altitude of about 6,000 feet, where the precipitation averages less than 5 inches a year, there probably is no direct recharge to the ground-water reservoir by infiltration of precipitation. At altitudes above 6,000 feet precipitation commonly occurs in sufficient quantities to permit some water to infiltrate to the water table and thus recharge the ground-water reservoir. Runoff from precipitation on the higher mountain slopes moves to the floor of the canyons where it percolated directly into the alluvium that mantles the canyon floors or in times of flood, flows onto the alluvial fans at the mouths of the canyons where a large part of it infiltrates to the ground-water reservoir. Infiltration of precipitation and runoff directly into the alluvial material mantling the canyon floors and into the upper parts of the alluvial fans accounts for virtually all the recharge to the ground-water reservoir.

Most of the natural recharge to the Las Vegas ground-water basin enters the alluvial fans and aprons along the front of the Spring Mountain Range. The alluvial-fan deposits along the western side of Las Vegas Valley are the principal means for transmitting this recharge to the ground-water reservoir in the Las Vegas area.

All ground water of economic importance in the Las Vegas ground-water basin is moving through the alluvium of the valley fill from areas of recharge to areas of discharge. As the ground water moves from the recharge areas to the discharge areas, it becomes confined beneath layers of clay or other relatively impermeable material, thus creating the artesian conditions that are common throughout the lower parts of Las Vegas Valley.

Plate 2, which is a highly generalized section extending from Charleston Peak to the base of Frenchman Mountain, shows the inferred shape of the valley fill and the bedrock underlying it and the general pattern of circulation of ground water in Las Vegas Valley.

Figure 2 shows the relative position of the various hydrologic units and the principal geologic and hydrologic features that

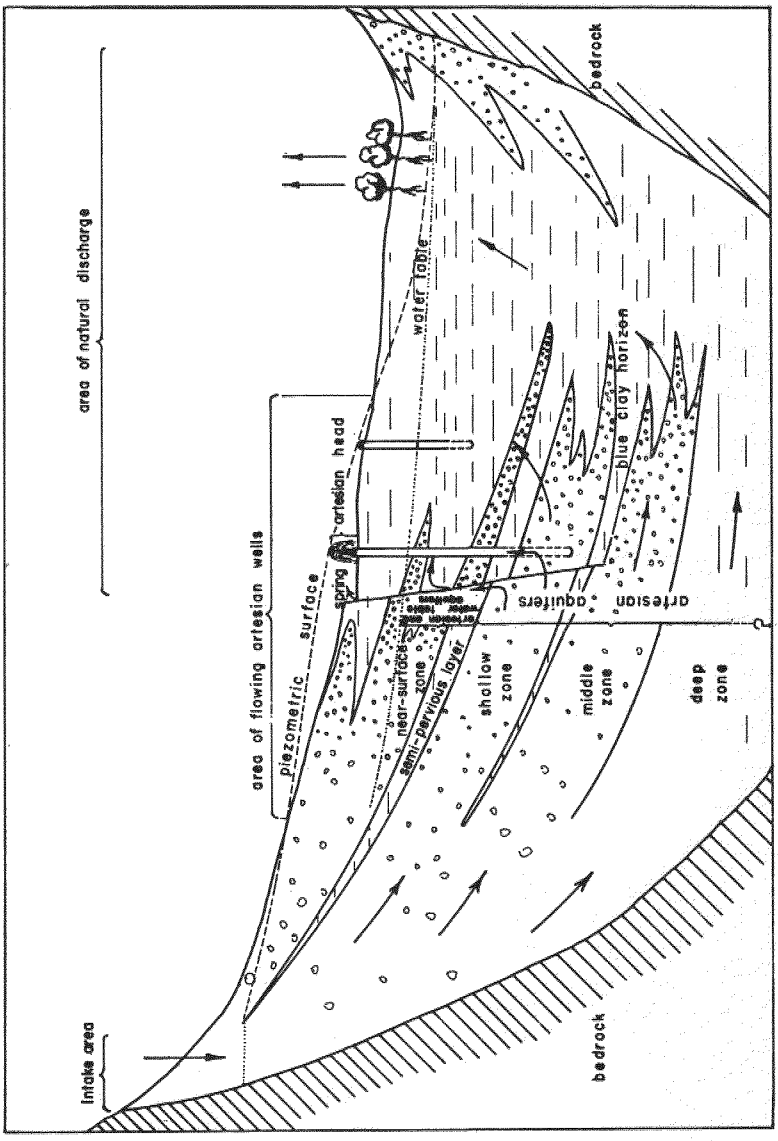


Figure 2. Diagrammatic east-west section across Las Vegas Valley showing the principal zones of aquifers, direction of ground-water movement, and general geology of the valley fill.

control the movement of ground water in the vicinity of Las Vegas. It shows that the general direction of movement of ground water in the artesian aquifers is from west to east, or approximately normal to the compaction faults in the vicinity of Las Vegas. The lateral movement of ground water is impeded by the faults because the vertical displacement of the strata has caused aquifers of relatively high permeability on one side of a fault to be in contact with beds of relatively low permeability on the other side. As a result, ground water under artesian pressure moves upward near or along these compaction faults. Part of the ground water that moves upward eventally reaches the land surface as springs or seeps and part moves laterally into shallower aquifers. The shallow depth to water under much of the city of Las Vegas is largely the result of ground water leaking upward from artesian aquifers.

### Recharge

Virtually all recharge to the artesian system is derived from precipitation in the adjacent mountains. This recharge has been going on throughout the geologic history of the basin. Under natural conditions the hydrologic regimen of the Las Vegas ground-water basin was in dynamic equilibrium; that is, although there was continual movement of ground water within the system, the recharge to the system was balanced by the annual discharge from the system. Therefore, the average annual recharge to the system can be inferred from the average annual discharge from the basin under natural or virgin conditions. On the basis of the estimated average annual discharge from the basin under natural conditions (p. 17), the average annual recharge is inferred to be about 25,000 acre-feet.

The average annual recharge also can be estimated by computing the underflow across sections through which most of the recharge to the basin eventually passes. The shaded area in plate 3 shows the peripheral belt through which underflow was computed in February 1955. Most of the recharge to the Las Vegas ground-water basin flows across this belt in the direction indicated by the arrows (flowlines). Because of the heterogeneous nature of the alluvium of the valley fill, the permeability of the deposits along this belt is not uniform. Therefore, the peripheral belt was arbitrarily divided into 13 segments on the basis of existing data indicating variation in permeability of the sediments. The underflow through each segment was computed on the basis of the width of the segment, the estimated transmissibility of the sediments, and the hydraulic gradient. The

underflow was computed for February 1955 when the hydraulic gradients used for making the estimates of underflow most nearly approached the gradients that existed under natural conditions. Because the section across which the underflow was computed is tens of miles from the principal recharge areas near the mountains, the annual variations in gradients that occur near the recharge areas are dampened to the extent that near the section of computed underflow the hydraulic gradient changes very slowly. Thus, the underflow in February 1955 is considered to be a reasonable measure of the average monthly underflow to the Las Vegas area, had the system been in equilibrium.

Ground-water underflow across the shaded sections shown in plate 3, in February 1955 was computed to be about 61 acre-feet per day. Ground-water discharge upgradient from the 13 segments shown on plate 3 was about 12 acre-feet per day during this same period. Insofar as these ground-water withdrawals represent a portion of the recharge, they must be considered in making an estimate of the total recharge to the system. If the ground-water withdrawals in the remote areas of the reservoir are added to the computed underflow, the inferred total recharge to the artesian system would be about 73 acre-feet per day or about 27,000 acre-feet per year. Although water levels in wells in the vicinity of Las Vegas remained at a relatively uniform altitude during February, water levels in the more remote areas of the reservoir were declining; thus indicating that part of the computed underflow to the Las Vegas area was coming from storage in the areas of the reservoir where declines were occurring outside the segments through which the underflow was computed. The computed underflow of 27,000 acre-feet, therefore, probably is somewhat higher than the average annual recharge to the artesian system.

Another method of estimating recharge to the artesian system is based on the relation between precipitation and the corresponding effects on recharge. If the precipitation and the ground-water discharge are known for one or more periods when the ground-water reservoir is in equilibrium, the relationship between precipitation and recharge can be determined empirically. By applying this relationship to the average annual precipitation, the average annual recharge to the artesian system can be computed. On the basis of the relationship between precipitation and recharge established for 1933, 1934, 1941, and 1942, when the ground-water reservoir was in approximate equilibrium, this

method indicates that the average annual recharge to the artesian system is about 22,000 acre-feet.

Although the estimates of average annual recharge to the artesian system, based on the three methods described, may be subject to considerable error, owing to the broad assumptions and rough estimates that necessarily were made, the relatively narrow range between the computed values suggest that all are reasonable. Thus, it is estimated that the average annual rate of recharge to the artesian system is about 25,000 acre-feet.

#### Discharge

The natural discharge of ground water from the artesian system is by springs and seeps and by upward leakage.

An estimate of discharge from the basin under virgin conditions was made to obtain one of several estimates of the average annual recharge to the artesian system. (See p. 15.) Inasmuch as there is virtually no ground-water underflow from the basin, all ground-water discharge under virgin conditions must have been evapotranspiration within the basin. The areal distribution, types, and density of the phreatophytes were reconstructed from historical documents and areal photographs of the valley. Thus, based on early records of spring discharge and calculations of transpiration by native vegetation, the estimated discharge by evapotranspiration prior to the development of the ground-water reservoir was about 25,000 acre-feet per year.

The estimated discharge from artesian springs during 1955 was about 3,200 acre-feet. During the same year it was estimated that approximately 6,000 acre-feet of ground water leaked upward from the artesian system to the near-surface system. The artificial discharge from artesian wells was approximately 39,000 acre-feet; thus the total draft on the artesian system during 1955 was about 48,000 acre-feet.

### NEAR-SURFACE SYSTEM

#### Source, Occurrence, and Movement of Water

Water in the near-surface system is derived from ground water leaking upward from the artesian system, infiltration of sewage effluent, industrial waste water, excess irrigation water, excess water from watering lawns, and leaky wells. Ground water is within a few feet, or tens of feet, of the land surface east of the fault scarp which passes through the Las Vegas Valley Water District well field. The water table slopes eastward toward the foot of Frenchman Mountain, the lowest part of Las Vegas Valley; thus, the general movement of the unconfined ground water

is in that direction. Because the transmissibility of the sedimentary deposits probably is low, the amount of water moving laterally through the sediments is believed to be small.

### Recharge

The average annual recharge to the near-surface system probably has not changed significantly since the development in Las Vegas Valley first began. However, the sources of recharge have changed considerably. Under natural conditions, virtually all recharge to the near-surface system was from upward leakage and the infiltration of flows from artesian springs. Since the development of the first successful wells, artesian pressures have been declining and, consequently, the amount of upward leakage and discharge from artesian springs has been decreasing. Although the natural recharge to the near-surface system has been decreasing, the net amount of ground water in storage in the near-surface system has not changed significantly because of recharge from infiltration of sewage effluent, water from leaky wells, and water imported from Lake Mead.

The following estimates of recharge to the near-surface system are based on data collected in 1955.

Recharge by upward leakage from the artesian system is estimated to have been about 6,000 acre-feet. Recharge from the infiltration of industrial and municipal waste from Henderson, which is from water originally imported into the basin from Lake Mead, is estimated to have been about 5,000 acre-feet; and recharge from the infiltration of sewage effluent, irrigation water, and spring flow is estimated to have been about 14,500 acre-feet. Thus, the estimated total recharge to the near-surface system in 1955 was about 25,000 acre-feet.

The above analysis shows that almost three-fourths of the recharge to the near-surface system in 1955 was water that has been used at least once. Although this recycling, or reuse, of water increases the amount of ground water annually available in the Las Vegas basin, the use that can be made of the water is limited because recycling commonly causes a significant deterioration in the chemical quality.

### Discharge

Virtually all natural discharge of ground water from the near-surface system is by evapotranspiration. Water-loving plants, such as mesquite, willow, cottonwood, arrowweed, and saltgrass, utilize large quantities of water in their normal growth processes. These plants, known as phreatophytes, obtain their water supply directly from the zone of saturation or the capillary fringe

above it. It is estimated that during 1955, the evapotranspiration in the areas of phreatophytes was about 24,000 acre-feet.

Artificial discharge from wells tapping the near-surface system was about 1,100 acre-feet in 1955. Thus, the total draft on the system was about 25,000 acre-feet.

The average annual discharge from the near-surface reservoir probably remained relatively constant prior to and during the period of ground-water development in Las Vegas Valley. However, as a result of urbanization, the areas of natural discharge have shifted from the vicinity of the springs and faults in and near Las Vegas toward the eastern part of the valley downgradient from the sewage disposal plant east of Las Vegas.

### WATER BUDGET—1955

Because much of the ground water in the near-surface system represents return flow and is in a second cycle of use, the water budget of the Las Vegas ground-water basin can be analyzed more easily if the increments of recharge to and discharge from the artesian system are considered separately from those of the near-surface system. The following water budget is for 1955.

The average annual recharge to the artesian system is estimated to be about 25,000 acre-feet. In 1955, discharge from the artesian system by springs and wells was about 42,000 acre-feet and discharge by upward leakage was about 6,000 acre-feet, making the total draft on the artesian system about 48,000 acre-feet. These estimates indicate that the overdraft on the artesian system in 1955 was about 23,000 acre-feet.

Recharge to the near-surface system by infiltration of water originally derived from the artesian system was about 14,500 acre-feet, infiltration of water imported from Lake Mead was about 5,000 acre-feet, and upward leakage from the artesian aquifers was about 6,000 acre-feet, bringing the total recharge to the near-surface system in 1955 to about 25,000 acre-feet. The total draft on the near-surface system in 1955, principally by phreatophytes and shallow wells, was about 25,000 acre-feet. These estimates indicate that in 1955 there was no overdraft on the near-surface system.

The overdraft on the entire Las Vegas ground-water basin was therefore equal to the overdraft on the artesian system. This overdraft of about 23,000 acre-feet was supplied almost entirely by withdrawal of ground water from storage. The decline of several feet in artesian head for 1955, which was noted in many parts of the developed portions of the Las Vegas artesian basin, resulted from this overdraft.

### Relation Between Reservoir Storage and Water Levels in Wells

The annual discharge has generally exceeded the annual recharge to the Las Vegas artesian system ever since the development of the first successful flowing well in 1906, and as a result water levels in wells tapping the artesian system have declined almost uninterruptedly since that time. The total net declines have ranged widely from a few feet to about 100 feet. The greatest declines have occurred in the areas of the Las Vegas Valley Water District well field, which is immediately east of map segment 6 on plate 3, and "The Strip," which is an area about 4 miles long straddling U. S. Highways 91 and 466 north of McCarran Field. Although the artesian head in these areas has been lowered considerably, artesian conditions still prevail. The large decline in artesian pressure has caused a depletion of ground water in storage within the artesian aquifers owing to the compressibility of the aquifers and the adjacent confining beds and to a slight expansion of the water itself. Because the effects of the large decline in artesian pressure probably have extended to some of the recharge areas, ground water has been removed from storage in these areas also.

In an area of about 40 square miles in and adjacent to Las Vegas, water levels in selected observation wells tapping the artesian system declined on the average about 30 feet between 1941 and 1956. Based on the estimated average annual rate of recharge to the artesian system of about 25,000 acre-feet and the estimated annual discharge from the system, the approximate cumulative overdraft during this period amounted to about 235,000 acre-feet. Thus, the overdraft on the artesian system per foot of lowering of artesian head in the areas of principal development was nearly 8,000 acre-feet during the 15-year period 1941–1956.

When the artesian head is lowered to the bottom of the confining layers and drainage of the deposits begins, the rate of lowering of the ground-water levels probably will decrease to a few tenths of a foot per year, assuming that the rate of recharge to and discharge from the ground-water reservoir remain about the same as in 1955.

## EFFECTS OF GROUND-WATER DEVELOPMENT

Beginning with the development of the first successful well, the additional discharge by wells was superimposed upon the previously stable hydrologic regimen with the result that the ground-water discharge from the basin exceeded the average recharge to the basin. As a result of this overdraft during the past 50 years, a large volume of ground water has been withdrawn from storage,

artesian pressures have been lowered, and the discharge by springs and upward leakage has decreased.

Large withdrawals in the vicinity of the Las Vegas Valley Water District well field, west of the city, lowered water levels in the vicinity of the well field more than 40 feet during the 12-year period 1944–1956. During the same period of time, levels in the area along U. S. Highways 91 and 466, about 2 miles north of McCarran Field, were lowered more than 50 feet. Plate 4 shows the magnitude and distribution of water-level changes in Las Vegas Valley during this 12-year period.

As overdraft on the artesian system continues, the artesian head will continue to decline and the quantity of ground water leaking upward to the near-surface will decrease. Optimum salvage of the natural recharge to the artesian system will be achieved when the artesian head has been lowered to about 50 feet below land surface over most of the area, thereby eliminating nearly all the natural discharge from the artesian system. At the present rate of decline of artesian head, and the present distribution and amount of withdrawals, the artesian head probably will be lowered sufficiently to prevent most upward leakage in the Las Vegas area sometime during the period 1975–1995, and in Paradise Valley area by about the year 2020.

## PERENNIAL YIELD

The perennial yield that can be developed from the Las Vegas ground-water basin after water levels have been lowered to the point where the water is no longer available to the roots of phreatophytes will be limited to the average annual natural recharge plus any additional artificial recharge to the basin. Imported water, flood runoff that is currently discharged through Las Vegas Wash, or water that is recycled, conceivably could be used for artificial recharge, thereby supplementing the natural perennial yield. The present estimated average annual rate of natural recharge, as stated previously, is about 25,000 acre-feet which is the natural perennial yield of the basin.

The natural perennial yield of the basin is supplemented by recharge resulting from the recycling of ground water and the downward percolation of water imported from Lake Mead. In 1955, this supplemental recharge was about 19,500 acre-feet, making the total perennial yield of the basin about 45,000 acre-feet for that year. However, because this supplemental recharge is dependent on the infiltration of used water which may vary as the valley is developed, the total perennial yield of the basin likewise may vary.

## SUMMARY

The Las Vegas ground-water basin is a huge structural depression in bedrock that is partly filled with unconsolidated alluvial deposits which commonly are saturated with water to within a few feet or tens of feet of the land surface. Most of the ground water occurs in a large leaky artesian system. To facilitate quantitative analysis of recharge, discharge, and yield, the ground-water basin arbitrarily was subdivided into an artesian system and a near-surface system.

It is estimated that approximately 25,000 acre-feet of recharge annually replenishes the artesian system. Since the development of the first artesian well in 1906, total discharge from the artesian system has exceeded the recharge by an estimated 550,000 acre-feet. As a result of this overdraft there has been a reduction of artesian pressure, spring discharge, and upward leakage that has continued almost uninterruptedly to the present time. During 1955, the estimated net overdraft on the artesian system was about 23,000 acre-feet.

As overdraft on the artesian system continues, water levels in wells in Las Vegas Valley will continue to decline. At the current rate of decline of water levels, optimum conditions of development of the artesian system in the Las Vegas area are expected to be achieved between about 1975 and 1995, at which time it is estimated that water levels will have dropped to a depth of about 50 feet below the land surface, thereby salvaging most of the natural discharge for beneficial use. In Paradise Valley, however, water levels probably will not decline to the optimum depth of 50 feet until about the year 2020. After virtually all the natural discharge from the artesian system has ceased, it will be necessary to limit net withdrawals from the system to the average annual natural recharge, or approximately 25,000 acre-feet per year, to prevent further decline of water levels, unless the artesian system is recharge artificially.

Ground water in the near-surface system in 1955 was virtually in a state of dynamic equilibrium, the recharge to the system being in approximate balance with the discharge from the system. Recharge to the near-surface system is derived from upward leakage from the artesian system, infiltration of sewage effluent, industrial waste water, excess irrigation water, excess water from lawns, leaky wells, and water imported from Lake Mead.

Approximately 25,000 acre-feet of ground water that replenished the near-surface system in 1955 was discharged by plants of relatively low economic value and by evaporation. Because

the chemical quality of the water in the near-surface system is relatively poor and because of the low yield of most of the shallow wells, there has been little attempt to utilize the ground water in this system, except for domestic purposes.

In 1955 the natural recharge to the basin was supplemented by about 19,500 acre-feet of recharge to the near-surface reservoir. This additional recharge increased the perennial yield of the basin to about 45,000 acre-feet for that year. The total perennial yield of the basin, however, is not constant because it is dependent on the amount by which the natural recharge is supplemented.

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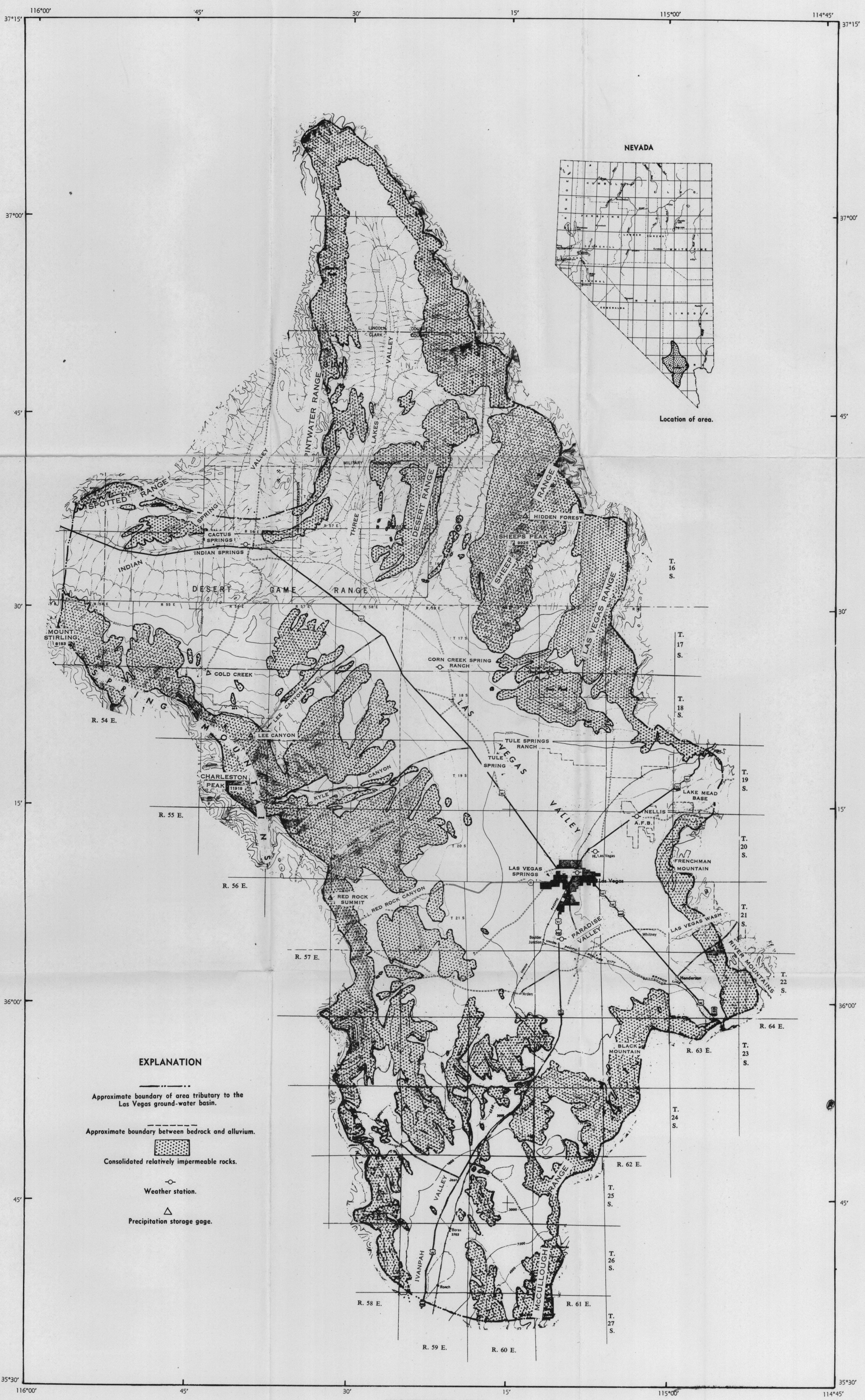
STATE PRINTING OFFICE CARSON CITY, NEVADA
JACK McCARTHY, STATE PRINTER
1961




## EXPLANATION

Approximate boundary of area tributary to the Las Vegas ground-water basin.

Approximate boundary between bedrock and alluvium.

Consolidated relatively impermeable rocks.

Weather station.

Precipitation storage gage.

BASE: ARMY MAP SERVICE TOPOGRAPHIC QUADRANGLES NJ 11–9, NJ 11–12, AND NJ 11–13 (1947)

SCALE APPROXIMATELY 1:375,000

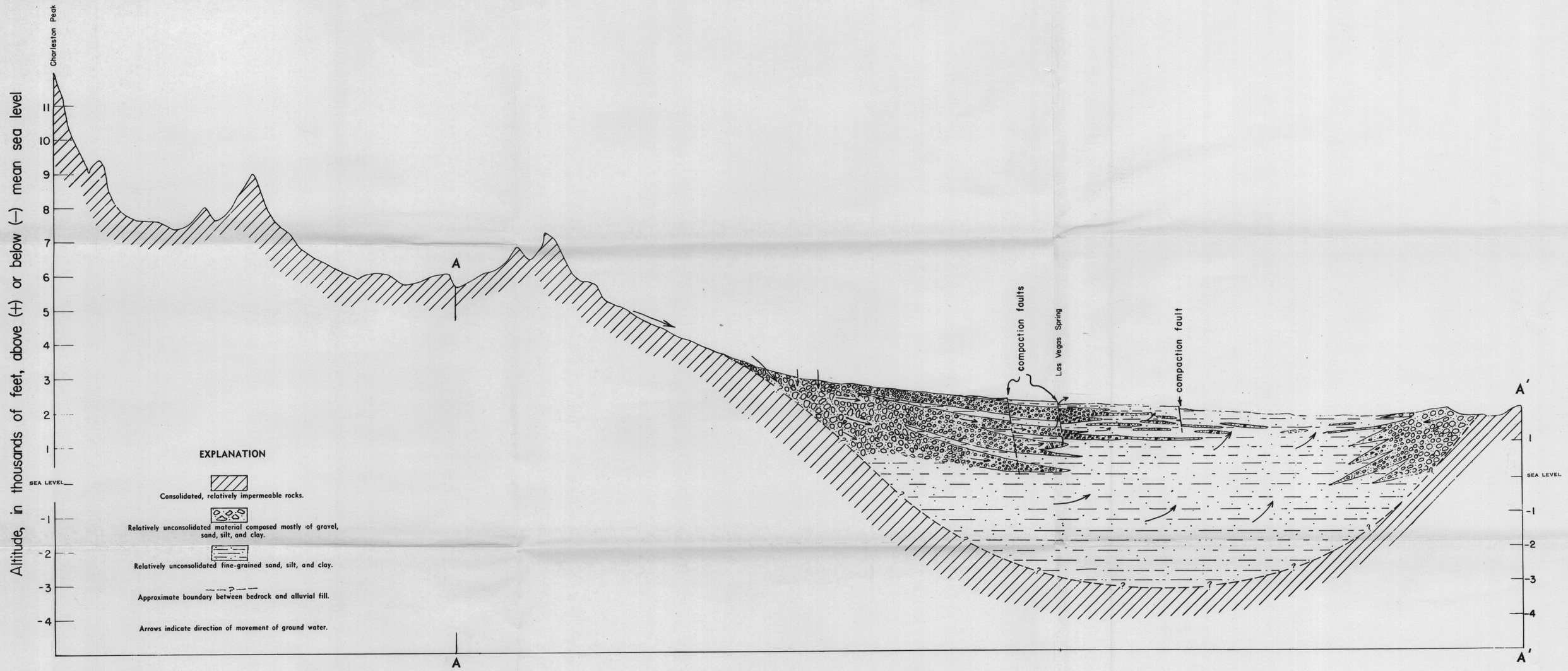
5 0 5 10 15 20 25 Miles

CONTOUR INTERVAL 500 FEET WITH AUXILIARY CONTOURS AT 250 FOOT INTERVALS
DATUM IS MEAN SEA LEVEL

BOUNDARY BETWEEN BEDROCK AND ALLUVIUM IN CLARK COUNTY, NEVADA, COMPILED BY BEN BOYER, E. H. PAMPEYAN, AND C. R. LONGWELL, IN LINCOLN AND NYE COUNTIES, CONTACT DELINEATED FROM AERIAL PHOTOS.

BY G. T. MALMBERG, (1961)

# PLATE 1.—MAP OF THE LAS VEGAS GROUND-WATER BASIN, CLARK, NYE, AND LINCOLN COUNTIES, NEVADA

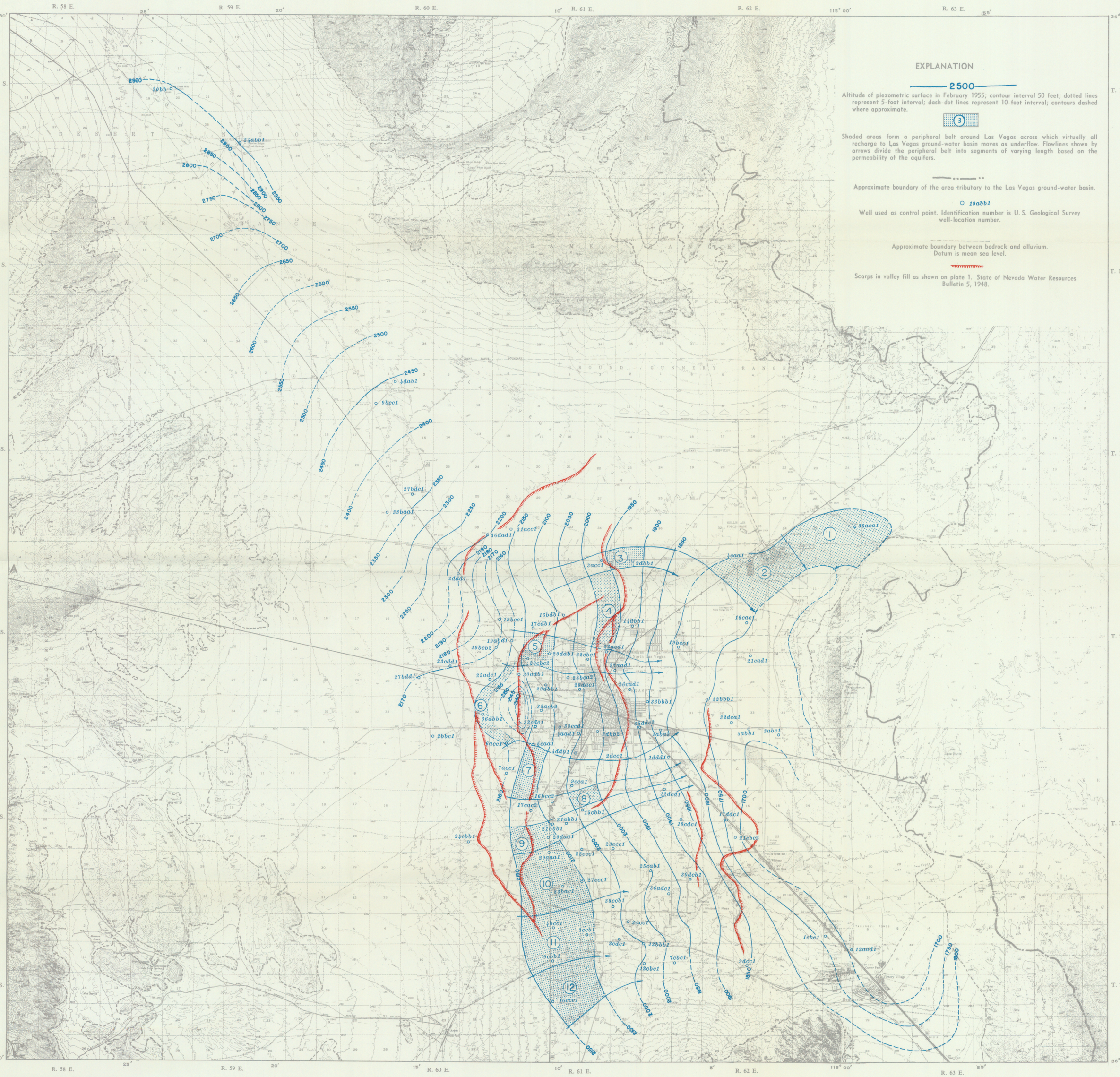



Horizontal scale

0 1 2 3 miles

**PLATE 2.—GENERALIZED EAST–WEST SECTION ACROSS LAS VEGAS VALLEY FROM CHARLESTON PEAK TO THE SOUTHERN END OF FRENCHMAN MOUNTAIN**

SHOWING GENERAL GEOLOGY AND DIRECTION OF MOVEMENT OF WATER FROM THE PRINCIPAL AREA OF RECHARGE TO THE AREA OF DISCHARGE.
(LINE A-A' SHOWN ON PLATE 3. AN EXTENSION OF LINE A-A' SHOWS PROFILE TO CHARLESTON PEAK.)




BASE FROM U. S. GEOLOGICAL SURVEY CORN CREEK SPRINGS (1952), GRASS PEAK (1952), DRY LAKE (1952), HENDERSON (1952), LAS VEGAS (1952), AND BLUE DIAMOND (1952) QUADRANGLES.

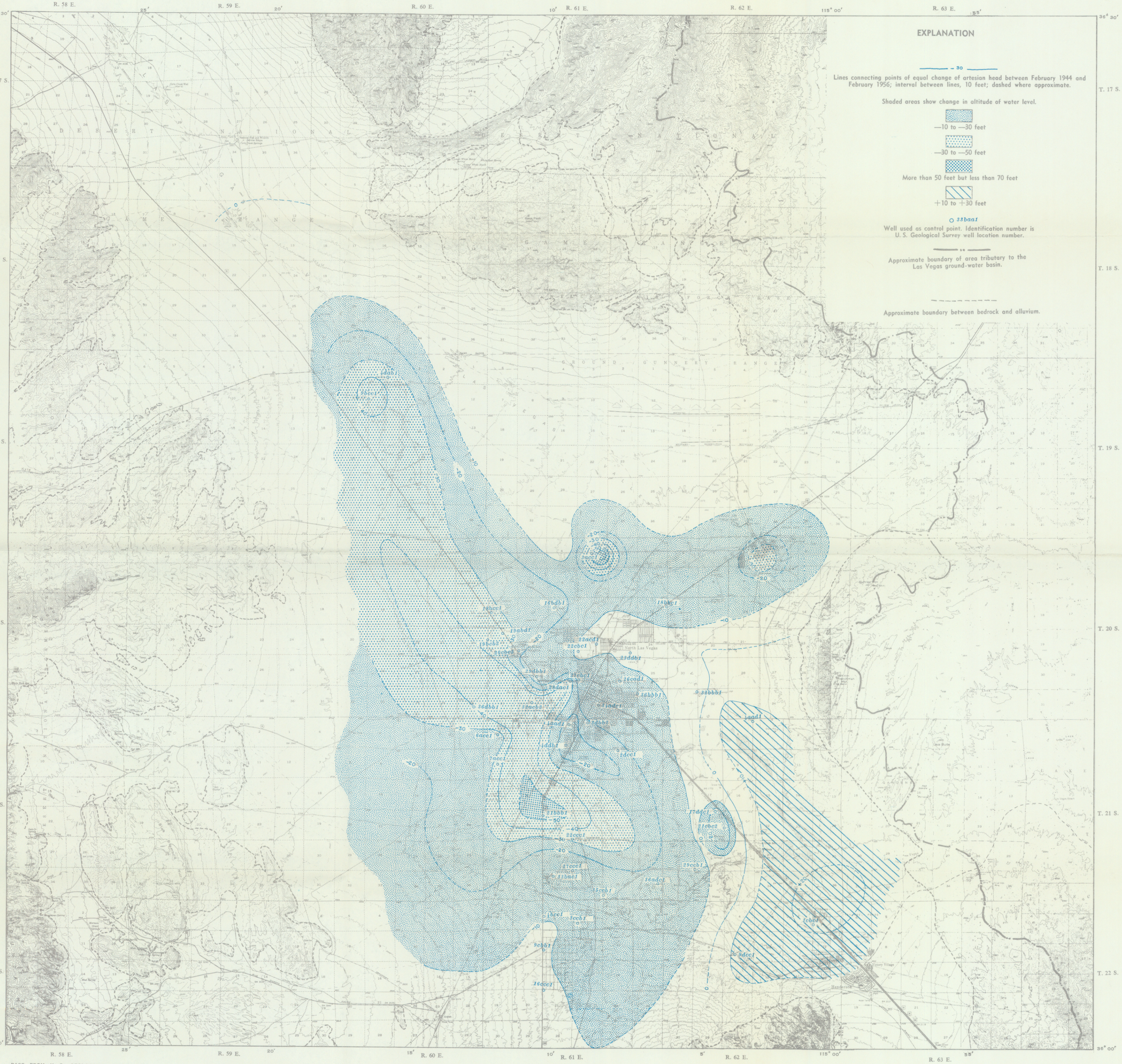
APPROXIMATE MEAN DECLINATION, 1952

SCALE 1:125,000

CONTOUR INTERVAL 20, 40, AND 80 FEET

HYDROLOGY BY G. T. MALMBERG, 1957

PLATE 3.—MAP OF PART OF LAS VEGAS VALLEY SHOWING THE PIEZOMETRIC SURFACE AND DIRECTION OF GROUND-WATER MOVEMENT IN FEBRUARY 1955

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APPROXIMATE MEAN DECLINATION, 1952

SCALE 1:125,000

CONTOUR INTERVAL 20, 40, AND 80 FEET

HYDROLOGY BY G. T. MALMBERG, 1957

PLATE 4.—MAP OF PART OF LAS VEGAS VALLEY SHOWING CHANGES IN THE PIEZOMETRIC SURFACE BETWEEN FEBRUARY 1944 AND FEBRUARY 1956