View of barley field

#232

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 24

GROUND-WATER APPRAISAL OF LAKE VALLEY IN LINCOLN AND WHITE PINE COUNTIES, NEVADA

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The Tertiary volcanic rock and older Tertiary sedimentary deposits exposed in the mountains are moderately consolidated. Although there may be some interstitial permeability, much of the limited amount of water transmitted probably is through fractures. In general, the capability of Tertiary rocks to transmit water is relatively low.

The unconsolidated sand and gravel deposits of Quaternary age are capable of transmitting ground water freely. However, the finer sand, silt, and clay have low permeability and transmit water slowly. These deposits occupy a large volume and have a relatively high porosity. Thus, where saturated, the Quaternary deposits contain a large volume of water in storage.

GROUND-WATER APPRAISAL

General Conditions:

Ground water in Lake Valley is derived from precipitation within the drainage area of the valley. Some of the precipitation in the mountains infiltrates into the bedrock and much of it moves laterally into the valley fill. In addition, some precipitation in the mountains collects and runs off onto the alluvial apron; part of the runoff infiltrates into the ground-water reservoir in the valley fill. Also some precipitation that falls on the alluvial apron may infiltrate directly to the ground-water reservoir or in part may infiltrate to the ground-water reservoir after it has collected as runoff. Most of the recharge to ground water occurs in or adjacent to the principal areas of precipitation. The principal areas of precipitation are the Schell Creek and Wilson Creek Ranges. Thus, the principal areas of recharge are in or adjacent to these ranges.

From the areas of recharge, ground water moves toward the ground-water reservoir in the valley fill. The total amount of ground water stored within Lake Valley may be hundreds of times the average annual natural recharge and discharge.

Natural ground-water movement in the reservoir is slow, ranging from a few feet to perhaps a few tens of feet a year. However slow, the movement generally is toward the area or areas of natural discharge.

Most of the natural discharge from Lake Valley is accomplished by evaporation from soil or free-water surfaces or by transpiration of phreatophytes, such as meadow grasses, salt grass, rabbitbrush, and greasewood. The discharge of the springs supplying the area of the Geyser Ranch also is consumed largely by evapotranspiration processes. Plate 1 shows the area of evapotranspiration. The rate of evapotranspiration is greatest where the water table is at or near land surface and the rate decreases as the depth to water increases. In Lake Valley the rate of evapotranspiration is greatest adjacent to the springs which bring ground water to the land surface. Elsewhere evapotranspiration is minimal because the depth to ground water is moderate to substantial. For example, the depth to water ranges from about

25 to 50 feet in the eastern one-third of Tps. 7 and 8 N., R. 65 E., and the western one-half of Tps. 7, 8, and 9 N., R. 66 E. The shallowest measured depth to water was 24 feet in well 8/65-12dl. Away from the phreatophyte area the depth to water increases. The maximum measured depth to water was 292 feet in well 8/65-33dl.

In hydrologically closed valleys all of the natural discharge occurs by evapotranspiration. This is not the case for Lake Valley. Inspection of the water-level contours on plate 1 shows a southward gradient about along the topographic trough of the valley. That is, some ground water discharges by underflow from Lake Valley southward into Patterson Wash. Figure 2 illustrates the gradient of the water surface along line A-A' shown on plate 1. Figure 2 also shows a hydraulic divide between Lake Valley and Spring Valley to the north in the vicinity of the topographic divide at Lake View Summit. Similar hydraulic divides are believed to occur more or less alined with the topographic divides in the mountains along the east and west sides of the valley. Thus, ground water is discharged naturally from Lake Valley by evapotranspiration within the valley and by underflow southward in the direction of lower hydraulic head.

Estimated Average Annual Recharge:

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

The precipitation map of Nevada (Hardman and Mason, 1949, p. 10) has been modified by Hardman (oral communication, 1962) in part to adjust to recent topographic base maps for the region. This is the same base used for plate 1 of this report. Five precipitation zones were selected: the boundary between the zones of less than 8 inches and 8 to 12 inches was delineated at the 6,000-foot contour; between 8 to 12 inches and 12 to 15 inches at the 7,000-foot contour; between 12 to 15 inches and 15 to 20 inches at the 8,000-foot contour; between 15 to 20 inches and more than 20 inches at the 9,000-foot contour.

The average precipitation used for the respective zones, beginning with the zone of 8 to 12 inches of precipitation, is 10 inches (0.83 feet), 13.5 inches (1.12 feet), 17.5 inches (1.46 feet), and 21 inches (1.75 feet).

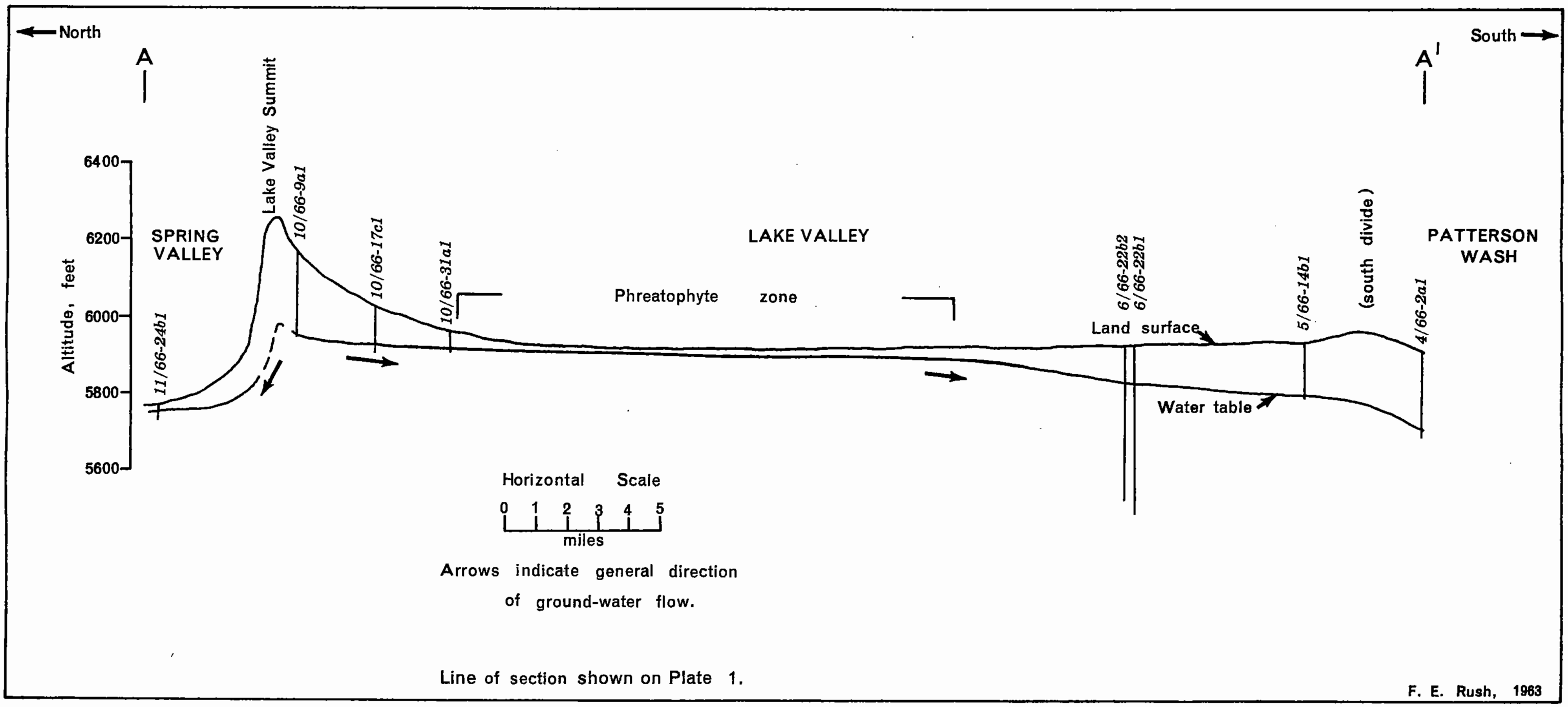

Figure 2.— Cross-section of Lake Valley, as seen looking east from U. S. Highway 93, showing the general topography and water table.

The recharge estimates as a percentage of the average precipitation for each zone are: less than 8 inches, 0; 8 to 12 inches, 3 percent; 12 to 15 inches, 7 percent; 15 to 20 inches, 15 percent; and more than 20 inches, 25 percent.

Table 3 summarizes the computation of recharge. The approximate recharge (column 5) for each zone is obtained by multiplying the figures in columns 2, 3, and 4. Thus, for the zone receiving more than 20 inches of precipitation, the computed recharge is 4,000 acres x 1.75 feet x 0.25 (25 percent) = about 1,800 acre-feet. The estimated average annual recharge to the ground-water reservoir in Lake Valley is about 13,000 acre-feet.

Table 3.--Estimated average annual ground-water recharge from precipitation in Lake Valley

(1) Precipitation zone (inches)	(2) Approximate area of zone (acres)	(3) Average annual precipitation (feet)	(4) Percent Recharged	(5) Estimated recharge (acre-feet) (2 x 3 x 4 ÷ 100)
20+	4,000	1.75	25	1,800
15 to 20	13,000	1.46	15	2,800
12 to 15	53,000	1.12	7	4,300
8 to 12	173,000	.83	3	4,300
8-	111,000	.58	--	--
	354,000	Estimated average annual recharge (rounded)		13,000

Estimated Average Annual Discharge:

Natural Discharge by Evapotranspiration and Underflow: Ground water is discharged from Lake Valley by the natural processes of transpiration of vegetation, evaporation from the soil surface, and to a lesser extent by subsurface outflow from the valley at the low, alluvial divide which separates Lake Valley from Patterson Wash to the south. In the absence of precise data, annual discharge rates can only be approximated. For this report, rates of use are adapted from studies of evapotranspiration of certain phreatophytes made by Lee (1912) and White (1932) in the Great Basin in the western United States, and by Young and Blaney (1942) in southern California. Rates of use were assigned on the basis of vegetative types, density, and depth to water table. The estimates of discharge by transpiration, evaporation, and outflow are summarized in table 4.

The principal area of phreatophytes is in Tps 7, 8, and 9 N., Rs. 65 and 66 E. as shown on plate 1. In addition, a minor amount of evapotranspiration occurs in small areas along spring-fed streams in the upper part of the alluvial fans. The average discharge of ground water attributed to phreatophytes is about 8, 500 acre-feet per year.

A rough estimate of the subsurface outflow from Lake Valley to Patterson Wash can be made, based on the limited available data, by use of the following equation:

$$Q = 0.00112TIW \qquad (1)$$

in which T is the coefficient of transmissibility, in gallons per day per foot, I is the hydraulic gradient in feet per mile, W is the width of the underflow section in miles, and 0. 00112 is a factor for converting gallons per day to acre-feet per year.

Table 4.--Estimated average annual ground-water discharge by natural processes from Lake Valley

Process of ground-water discharge	Depth to water (feet)	Area (acres)	Approximate discharge (acre-feet per year)
Native vegetation:			
Saltgrass and very wet meadow area, average rate of use about 1.5 feet a year	less than 5	640	1,000
Saltgrass and moderately wet meadow area, average rate of use about 1.25 feet a year	less than 5	280	400
Saltgrass and dry meadow area, average rate of use about 0.5 foot a year	5-20	4,200	2,100
Principally by greasewood, average rate of use about 0.25 foot a year	20-25	5,800	1,400
Principally by greasewood and rabbitbrush mixed with big sage, average rate of use, about 0.1 foot a year	25-50	35,600	3,600
Estimated average annual discharge by phreatophytes			8,500
Subsurface outflow:			
Ground-water outflow to Patterson Wash			3,000
Estimated average annual natural discharge, (rounded)			12,000

The coefficient of transmissibility can be approximated by multiplying the specific capacity (gallons per minute per foot of drawdown) by an empirical factor. The specific capacity of wells 6/66-22b1 and 22b2 is about 80 gallons per minute per foot of drawdown. The empirical factor may be 1,500 to 2,000. Thus the transmissibility may be on the order of 120,000 to 160,000 gallons per day per foot.

The hydraulic gradient at the south end of the valley is about 20 feet per mile (pl. 1). The effective width of ground-water flow is about 1 mile (pl. 1). Substituting these values in equation 1, the estimated subsurface outflow is computed to be 3,000 acre-feet per year.

Discharge of Springs: Several small springs occur in the mountains surrounding Lake Valley. Most of these probably are supplied from perched or semi-perched ground-water bodies. As such, though important for stock supplies, they are of only local significance in the overall hydrologic system of the valley.

The largest springs are those which provide the supply for the Geyser Ranch area. Measurements were made at several localities and show the magnitude of the discharge of the several springs or spring areas. However, they do not indicate the total discharge of the springs because some discharge occurs by seepage which is not collected into channels when a direct measurement could be made.

The flow of spring-fed North Creek was 1.71 cfs (cubic feet per second) on August 4, 1963, at a point about 9,000 feet upstream from the intake of the pipe line. On the same day the flow at the pipe line intake was only 0.70 cfs. The discharge of Geyser Spring (9/65-4c1) is carried in an unlined ditch to the reservoir half a mile west of Geyser Ranch headquarters. Geyser Spring is characterized by a cyclic variation in discharge. The cycling pattern is shown by the sequence of measurements made in 1950 and graphed in figure 3. The 1950 measurements were made just west of U. S. Highway 93. Inspection of the graph suggests that the flow here may average about 200 to 225 gpm, or about 0.5 cfs.

During the present investigations a series of measurements were made on August 4, 1963, about 50 yards downstream from the outlet of Geyser Spring. As shown also on figure 3, the discharge ranged from about 0.13 to 2.57 cfs, and the apparent average discharge was about 1.2 cfs.

In the spring complex (9/65-1 to 9/65-12) along the lower part of the alluvial apron at Geyser Ranch, water is collected in two ditches to conduct the water northward and southward for irrigation. The flow in these ditches was measured at 0.96 and 2.17 cfs, respectively, on August 4, 1963. These measurements, of course, are indicative of spring flow at that time. During the spring, the combined flow probably is greater; during the fall, probably less. The total flow of these several springs at the time of measurement was

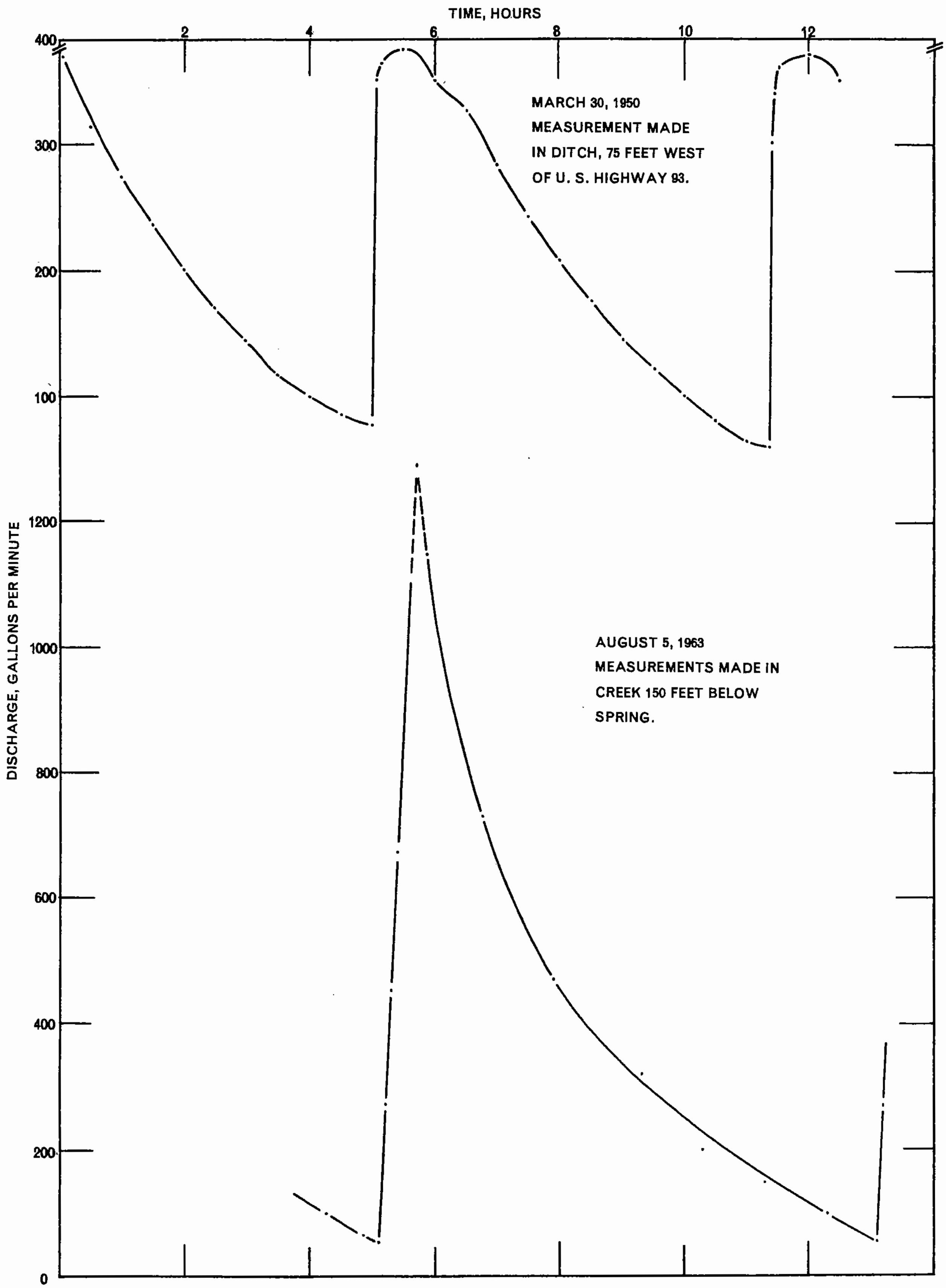

FIGURE 3.—GRAPH SHOWING CYCLIC VARIATION IN THE RATE OF DISCHARGE OF GEYSER SPRING.

roughly 6 cfs, or a rate of about 4,500 acre-feet a year. In considering the annual flow of the springs the average flow probably will be about equal to or somewhat greater than the measurements made on August 4, 1963.

The discharge of these springs to a large extent is finally discharged from the valley by evapotranspiration. Some, however, may return to the ground-water reservoir and be discharged by underflow at the south end of the valley. In either case, the estimates of ground-water discharge from the valley listed in table 4 and by subsurface outflow includes the spring discharge. It may be noted, however, that to the extent to which spring flow is returned to the ground-water reservoir it may be re-used in the valley, if intercepted prior to discharge by evapotranspiration or underflow from the valley.

Discharge from Wells: Pumpage from stock wells probably does not exceed 100 acre-feet a year. However, about 1,900 acre-feet of ground water was pumped to irrigate about 600 acres of barley during the 1963 crop season. This water was obtained from wells 6/66-22b1 and 22b2, drilled to depths of 410 and 450 feet and each yielding approximately 2,400 gpm with a drawdown of 30 feet. (see table 5.) During the 90-day period of irrigation, a total of about 3 feet of water was put on the fields by use of ditches flowing by gravity. The reported yield of grain from the first year of operation in 1963 ranged from 10 to 40 bushels per acre, and may have averaged about 30 bushels per acre.

It is not known to what extent the irrigation water may have penetrated the zone of aeration and returned to the underlying zone of saturation at the water table.

Perennial Yield:

The perennial yield is the maximum amount of water that can be withdrawn from the ground-water system for an indefinite period of time without causing a permanent depletion of the stored water or causing a deterioration in the quality of the water. It is ultimately limited by the amount of water annually recharged to or discharged from the ground-water system through natural process.

In an estimate of perennial yield, consideration should be given to the effects that ground-water development may have on the natural circulation in the ground-water system. The location of the development in the ground-water system may permit optimum utilization of the available supply or at the other extreme may be ineffective in the utilization of the water supply. The location of the wells may favor improving the initial quality with time or may result in deterioration of quality under continued withdrawals. Development by wells may or may not induce recharge in addition to that received under natural conditions. Part of the water discharged by wells may re-enter the ground-water reservoir by infiltration of excess irrigation or waste water and thus be available for re-use. Ground water discharged by wells eventually reduces the natural discharge. In practice, decreasing natural discharge by pumping is difficult, except when the wells are located where the water table can be lowered to a level that eliminates evapotranspiration in the area of natural discharge or outflow from the basin.

Ground-water outflow from a basin further complicates the final determination of perennial yield. The numerous pertinent factors are so complex that in effect specific determination of the perennial yield of a valley requires a very extensive investigation, based in part on data that can be obtained best only after there has been substantial development for a number of years.

The estimate of recharge and discharge for Lake Valley are nearly equal, 13,000 acre-feet a year and 12,000 acre-feet a year, respectively. The perennial yield tentatively is estimated to be about 12,000 acre-feet.

Storage:

A considerable amount of ground water is stored in the valley fill in Lake Valley. It is many times the volume of the average annual recharge to the ground-water reservoir. The magnitude of this stored ground water may be estimated by the following calculation:. The surface area of the valley fill below the 6,000-foot contour is about 111,000 acres. If it is assumed that this area overlies a reasonably thick section of valley fill that is saturated and if a value of 10 percent is assumed as the specific yield (drainable pore space) of the saturated deposits, then about 11,000 acre-feet of water is in storage for each foot of saturated valley fill. Thus, the amount of water in storage in the upper 100 feet of saturated valley fill would be at least a million acre-feet or 85 times the estimated average annual recharge to the ground-water reservoir.

The principal point to be recognized is that the volume of ground water in storage provides a reserve for maintaining an adequate supply for pumping during protracted periods of drought or for temporary periods of high demand under emergency conditions. This reserve, in effect, increases the reliability of ground water as a dependable source of supply and is an important asset in semiarid regions where suface-water supplies vary widely from year to year.

Chemical Quality:

The chemical quality of the water in most ground-water systems in Nevada varies considerably from place to place. In the areas of recharge the dissolved-solid content of the water normally is low. However, as the ground water moves through the system to the areas of discharge it is in contact with rock materials which have varying solubilities. The extent to which the water dissolves chemical constituents from the rock material is governed in large part by the solubility, volume, and distribution of the rock material, by the time the water is in contact with the rocks, and by the

Specific conductance of water was measured for several wells. The specific conductance provides a simple measure of the mineral content of the water. The value of the specific conductance multiplied by a factor ranging from 0.5 to 1.0 will approximate the dissolved-solids content of the water in parts per million. A factor of 0.7 is commonly used. The specific conductance of water ranges from 31 micromhos at North Creek Spring near Mount Grafton in the northwestern part of the valley to 2,470 micromhos at a stock-watering well near the center of the valley. Most of the values were in the range from 350 to 650 micromhos. The individual values are listed in tables 6 and 7.

Development:

Present development.--Ground water presently is used for irrigation of native pasture and stock-feed, stock watering, and domestic supply, and in 1963 for irrigation of small grain.

For many years ground-water use was centered around the spring complex at the Geyser Ranch and was directed largely to the raising of cattle. Development of the spring area largely involved the construction of ditches to collect spring discharge for better control of the water. Later, a pipe line was laid to conduct part of the flow of North Creek Springs to a reservoir near the ranch. This reduced seepage loss in the segment of the alluvial apron over which the pipe line was laid. Subsequently four shallow irrigation wells were drilled in the lower area at the Geyser Ranch. However, total pumpage from these wells has been small and apparently the wells have not been pumped for several years. The water from the springs in the vicinity of Geyser Ranch is only partly used and most of it is discharged to the meadow and saltgrass areas during the winter months.

It is estimated that the average discharge of the Geyser, North Creek Springs and the spring complex at Geyser Ranch probably is in the order of 4,500 acre-feet a year--only a small part of which is used at the present time.

During 1963 two irrigation wells (6/66-22b1 and b2) were used to irrigate about 600 acres of newly reclaimed land in the southern part of the valley. The estimated discharge from these wells was about 1,900 acre-feet; the total discharge from all wells in the valley was about 2,000 acre-feet in 1963.

Potential Development:--The potential development of ground water in Lake Valley is limited by the quantity and possibly to some extent by the quality of the water. Under the strict concept of the State law, the development would be limited to the perennial yield of the valley, which tentatively is estimated to be about 12,000 acre-feet. Of this amount roughly 4,500 acre-feet could be obtained by full development of the springs presently supplying the Geyser Ranch area in the northwestern part of the valley. Assuming that