STATE OF NEVADA
OFFICE OF THE STATE ENGINEER

WATER RESOURCES BULLETIN No. 11

# Preliminary Report on Ground Water in Fish Lake Valley, Nevada and California

By T. E. EAKIN

With a statement on

## Reconnaissance Land Classification of Fish Lake Valley, Esmeralda County, Nevada

By HOWARD G. MASON

Prepared in cooperation with the
UNITED STATES DEPARTMENT OF THE INTERIOR
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# FOREWORD

Many people, seeking some measure of security in this uncertain age, are turning their eyes to the West in search of new land where they may put down roots in our social system, develop farms, raise their families, and to some extent find freedom from the increasing worry and grind of present-day life. The West, and States, like Nevada in particular, with vast areas of unclaimed and undeveloped public land beckon them.

Many of these pioneers are not well informed as to western land and water and are too willing to risk their hard-earned savings on land-development projects of little merit. There are hundreds of desert landscapes in the Western States dotted with crumbling, sunbaked and windswept ruins of little homestead houses, surrounded by acres of barren sandy land serrated by the plow—grim monuments to blasted hopes and wasted years of toil.

We want as little of this as possible in Nevada, which is a major reason why our Legislature in 1945 wisely established a cooperative program between the U. S. Geological Survey, Ground Water Branch, and the office of the State Engineer.

The first purpose of this cooperative group is to determine the location of underground water, to evaluate the resource so far as possible, and give this information to the public in printed form. To date, eight Water Resources Bulletins have been printed and several mimeographed and typewritten reports completed in regard to arid and semiarid valleys throughout the State. The magnitude of the task is apparent when it is stated that over 80 such valleys are in Nevada.

This bulletin covers an area in southern Nevada, Esmeralda County, named Fish Lake Valley. During the last few months, applications for ground water from Fish Lake Valley have poured into the office of the State Engineer until now 105 have been received, and the end is not yet in sight. Our examinations reveal that far more land has been applied for than can be irrigated with the quantity of water that can be developed. A careful land-classification survey by the Nevada Agricultural Experiment Station and the U. S. Bureau of Land Management further reveals that only about one-tenth of the land applied for is Class I, upon which, with careful farming, crops could be profitably raised, if supplied with sufficient water.

We hereby express our deep appreciation for the splendid cooperation of the U. S. Bureau of Land Management, U. S. Soil Conservation Service, and the Nevada Agricultural Experiment Station. Without their experienced technical aid it would have been difficult to obtain much of the information included in the report.

ALFRED MERRITT SMITH,
*State Engineer.*

May 16, 1950.

# PRELIMINARY REPORT ON GROUND WATER IN FISH LAKE VALLEY, NEVADA AND CALIFORNIA

By T. E. Eakin

## INTRODUCTION

Since July 1, 1945, the United States Geological Survey has been cooperating with the State Engineer of Nevada in a study of the ground-water resources of Nevada. The purpose of these studies is to evaluate the ground-water resources in the various valleys of the State. In the latter part of 1949, as a result of numerous ground-water applications and the prospect of expanded development of ground water for irrigation in Fish Lake Valley, the State Engineer requested the Geological Survey to make a study of ground-water resources in the valley. Collection of data on wells and water levels had been begun in 1946 by the Survey. The present study was directed toward an estimate of the average annual recharge and discharge of ground water, and the extent of present ground-water development. This preliminary report summarizes the ground-water conditions, on the basis of data available, as of December 1949.

The writer gratefully recognizes the considerable assistance and critical review of this report by his colleagues, T. W. Robinson and O. J. Loeltz.

## LOCATION AND GENERAL FEATURES

Fish Lake Valley lies principally in western Esmeralda County, Nevada but extends into the eastern parts of Mono and Inyo Counties, California (see Pl. 1). The valley floor, in the form of an irregular crescent, concave to the east, is about 45 miles long, and extends from a water gap on the north to a point about 8 miles south of Oasis, California. It ranges in width from about 1 to 5 miles. The outlet at the north end of the valley, known locally as the "Gap," is roughly 1 mile in length, its floor averaging a little less than one-eighth of a mile in width. It is the only surface outlet for water from Fish Lake Valley. However, according to reports, surface water from Fish Lake Valley discharges through the Gap only during periods of high runoff.

The altitude of the valley floor is about 5,000 feet in the vicinity of Oasis and about 4,700 feet in the Gap. The slope of the valley floor is northward, averaging about 11 feet per mile from Oasis to Fish Lake Spring near the central part of the valley, and about 5 feet per mile from Fish Lake Spring to the Gap.

The valley is enclosed by mountains except at the Gap. White Mountains on the west form a bold range extending south-southeast from Boundary Peak near the State line in the northwest part of the valley. The crest altitude is in excess of 10,000 feet for a distance of about 25 miles, and probably averages about 12,000 feet. White Mountain Peak, the highest point in the range, has an altitude of 14,242 feet.

North and east from Boundary Peak the crest altitude and drainage divide declines rapidly and follows a line of hills across the north end of the valley to the Gap.

Southeast from the Gap the drainage divide follows the very irregular crest of Silver Peak Range which lies on the east side of Fish Lake Valley. The Silver Peak Range has a crest altitude ranging from about 6,500 to 9,500 feet above sea level and averaging about 7,500 feet. Piper Peak, east of Fish Lake, is the highest point in the range. The Palmetto Mountains are a southeast extension of Silver Peak Range. From Palmetto Mountains the drainage divide extends southward through Magruder Mountain, thence generally west to the Sylvania Mountains. An alluvial divide connects the Sylvania Mountains with the southeast extension of the White Mountains to close the valley at the south end. The area included within the drainage boundary of Fish Lake Valley is about 965 square miles.

Principal access to the valley is Nevada State Highway 3A, which leaves U. S. Highway 6 about 7 miles west of Coaldale Junction, enters the valley from the north, and extends southward to the State line. From this point an undesignated California road continues southward to Oasis. At Oasis a road extends southwestward to Big Pine and Bishop, and eastward to the Nevada-California State line, where it joins Nevada State Highway 3. State Highway 3 extends eastward 42 miles to its junction with U. S. Highway 95 about 15 miles south of Goldfield.

Nevada State Highway 3A is paved from the junction with U. S. Highway 6 to about the south line of T. 3 S. Beyond this point to the State line it is a graded gravel road. Nevada State Highway 3 is a well-graded gravel road. In the California part of the valley the roads mentioned above are paved. Numerous other roads and trails make most parts of the valley accessible under favorable conditions.

## CLIMATE

Records of precipitation of moderate length are available for two stations, Oasis Ranch (Oasis) and Palmetto, in the southern part of Fish Lake Valley. There is only one short record, that for Dyer Post Office, in the central part of the valley and none for the northern part. The longer records include the period 1903 to 1919 for Oasis Ranch, and the periods 1890 to 1911, and 1945 to 1949 for Palmetto. The Palmetto station location and altitude were probably not the same for the two periods of record. This is indicated, in part, by the station altitude for the later period of record, which is 400 feet higher than for the early record. The normal monthly and annual precipitation, together with the precipitation for the maximum and minimum years of record for the stations, are shown in Table 1. Similar records are given also for the Goldfield station whose 44-year record includes the period 1906 through 1949.

The record of Oasis Ranch indicates that precipitation on the floor of Fish Lake Valley would generally be less than 5 inches per year. The records from 1890 to 1911 for Palmetto suggest either unusually high precipitation for the immediate area, or that the gage was subject to exposure which resulted in recording abnormally high amounts of precipitation. The precipitation record for the period 1945 to 1949 at Palmetto is obtained by the use of an automatic-weighing gage and, therefore, is more reliable than the early record. The recent record is shown in Table 2. The maximum annual precipitation during the recent period of record was 8.09 inches in 1946, and the minimum was 2.60 inches in 1948.

**TABLE 1**

**Summary of precipitation, in inches, at three stations in Esmeralda County, Nevada**

(Weather Bureau records)

| Station | Period | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oasis Ranch[1] | 1903–19 | Average | 0.66 | 0.57 | 0.35 | 0.41 | 0.47 | 0.26 | 0.40 | 0.41 | 0.28 | 0.27 | 0.27 | 0.42 | 4.77 |
| Altitude 5,106 | 1913 | Maximum | .13 | .87 | .09 | .27 | 1.83 | .76 | .95 | 1.55 | .30 | * | 1.65 | 1.43 | 9.83 |
| | 1917 | Minimum | * | .09 | .00 | .88 | .05 | .00 | .05 | .11 | * | .00 | .24 | .00 | 1.42 |
| Palmetto[2] | 1890–1911 | Average | 1.93 | 1.88 | 2.67 | 1.26 | 1.58 | .66 | 1.27 | 2.00 | .75 | 1.04 | .94 | 1.25 | 17.23 |
| Altitude 6,500 | 1906 | Maximum | .48 | 3.11 | 5.19 | 4.33 | 3.44 | .34 | 4.58 | 3.48 | * | .10 | 5.60 | 7.31 | 32.96 |
| | 1899 | Minimum | 1.20 | * | .30 | .30 | .63 | 1.13 | .01 | .96 | * | 1.05 | 1.55 | .60 | 7.73 |
| Goldfield | 1906–49 | Average | .67 | .64 | .70 | .46 | .43 | .29 | .38 | .58 | .33 | .50 | .30 | .44 | 5.72 |
| Altitude 5,700 | 1913 | Maximum | .25 | .58 | .48 | .37 | 1.80 | 1.84 | 1.03 | 1.71 | 2.20 | .02 | .83 | .32 | 11.43 |
| | 1924 | Minimum | .10 | .01 | .37 | .05 | * | .00 | .01 | .06 | .26 | .00 | .15 | .12 | 1.13 |

[1]Record for the period 1903 to 1910, inclusive, are for McAfee Ranch, now Bar Double Nine Ranch, about 15 miles northwest of Oasis Ranch.

[2]Record incomplete, 1908 to 1911, inclusive.

*Trace.

**TABLE 2**

**Precipitation, in inches, during the period 1945 to 1949, at Palmetto, Esmeralda County, Nevada**

| Station | Period | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Palmetto[1] | 1945 | 0.15 | — | 0.37 | 0.19 | 0.32 | 0.34 | 0.07 | 0.89 | — | — | — | 0.41 | |
| Altitude 6,900 | 1946 | .09 | .35 | .72 | .65 | .45 | .00 | 1.71 | .36 | .00 | .63 | 2.03 | 1.10 | 8.09 |
| | 1947 | .07 | .24 | .00 | 1.24 | .58 | .00 | .00 | .00 | .00 | .14 | .12 | .66 | 3.05 |
| | 1948 | .00 | .63 | .48 | .08 | .31 | .11 | .00 | .00 | .30 | .39 | .00 | .30 | 2.60 |
| | 1949 | .95 | .60 | .81 | .34 | .89 | .09 | .18 | .04 | .00 | .04 | .23 | | |
| | 1945–49, Average | .25 | .45 | .48 | .50 | .51 | .11 | .39 | .26 | .07 | .30 | .60 | .62 | 4.54 |

[1]Station location and altitude for the period 1945–1949 inferred, not the same as for the period 1890–1911.

Analysis of the records of six stations in the region around Fish Lake Valley indicates that precipitation for the period 1947 to 1949, inclusive, averaged about 50 percent of the normal precipitation. The data, based on records of the Weather Bureau, are summarized below:

| Station | Altitude (feet) | Period of record (years) | Precipitation normal (inches) | Precipitation for period 1947 to 1949, inclusive: Average annual (inches) | Precipitation for period 1947 to 1949, inclusive: Percent of normal |
|---|---|---|---|---|---|
| Ellery Lake | 9,600 | 23 | 29.90 | 14.83 | 45.5 |
| Gem Lake | 9,120 | 23 | 26.54 | 13.31 | 50.2 |
| Bridgeport | 6,440 | 29 | 10.70 | 5.83 | 54.5 |
| Goldfield | 5,700 | 44 | 5.72 | 1.97 | 34.4 |
| Mina | 4,350 | 53 | 3.73 | 2.68 | 71.8 |
| Bishop | 4,108 | 38 | 6.17 | 2.57 | 41.7 |
| Average | ---- | --- | ---- | ---- | 50.4 |

Goldfield is east, Mina is north, and the other four stations are generally west of Fish Lake Valley. Together, these stations with their different altitudes and different geographic positions with respect to Fish Lake Valley afford a reasonable basis for inferring that precipitation in the valley for the period 1947 to 1949, inclusive, was far below long-time normal.

The average temperature for 15 years of record at Oasis Ranch was 48.9° F., the average maximum was 67.5° F., and the average minimum was 30.4° F. (See Table 3.) The frost-free period at Palmetto averaged 96 days for 20 years of record ending in 1911. However, it is believed to be substantially longer on the floor of Fish Lake Valley, which is from 1,500 to 1,800 feet lower.

## ESTIMATE OF PRECIPITATION IN THE TRIBUTARY DRAINAGE AREA

A satisfactory estimate of the precipitation in the drainage area tributary to Fish Lake Valley is hampered by lack of adequate precipitation records within the valley. There are no records for the adjacent high mountain areas, where most of the water supply for the valley area originates as precipitation.

In the absence of basic data, an attempt has been made to estimate precipitation in the drainage area by applying the graph developed by Lee[1] showing relation of precipitation to altitude for the east (or lee) side of the Sierra Nevada where the average crest altitude is 12,000 feet. It is recognized that it is somewhat hazardous to transfer this relation to an area which is in the "storm shadow" of the Sierra Nevada without applying a factor to compensate for the "storm shadow" effect. However, there are no data presently available to indicate the order of magnitude

[1]Lee, C. H., Total evaporation for Sierra Nevada watersheds by the method of precipitation and runoff differences: Am. Geophys. Union Trans., pt. 1, fig. 3, p. 58, 1941.

**TABLE 3**

**Average, average maximum, and average minimum monthly and annual temperatures, in degrees Fahrenheit, Oasis Ranch, Esmeralda County, Nevada[1]**

(Weather Bureau records)

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 29.4 | 34.3 | 41.2 | 49.6 | 55.3 | 64.1 | 69.6 | 69.7 | 60.3 | 49.0 | 37.9 | 28.6 | 48.9 |
| Average maximum | 45.1 | 48.7 | 58.2 | 69.6 | 74.4 | 84.9 | 89.9 | 88.2 | 80.0 | 69.1 | 56.8 | 45.5 | 67.5 |
| Average minimum | 13.6 | 19.8 | 24.2 | 29.6 | 36.3 | 43.3 | 49.4 | 47.8 | 40.5 | 28.9 | 19.1 | 11.7 | 30.4 |

[1]Length of record 15 years, actual years uncertain, but within the period 1903–1919. Part of record probably obtained at McAfee Ranch, now Bar Double Nine Ranch, about 15 miles northwest of Oasis Ranch. Record lists Oasis Ranch in Nevada although the actual location is in Mono County, California.

of such a correction for this area and, therefore, none will be applied in this report. The graph developed by Lee is based upon numerous precipitation records which were systematically adjusted to a common 60-year period.

To estimate the precipitation in the drainage area of Fish Lake Valley, zones were arbitrarily established between selected contours on U. S. Geological Survey topographic maps. Thus, the several zones adopted occupied the areas between the 5,500- and 7,000-foot contours, the 7,000- and 7,500-foot contours, the 7,500- and 8,500-foot contours, and above the 8,500-foot contour. On the basis of Lee's graph, the average precipitation in the successive zones was assumed to be 9, 12, 14, and 20½ inches, respectively.

Precipitation at comparable altitudes in the mountains along the east, southeast, and southwest sides of Fish Lake Valley is known to be far less than that in the White Mountains. These areas are generally in the "storm shadow" of the White Mountains. Although the difference of precipitation between the east and west sides of the valley is not known, personal observations and reports of local residents suggest that the precipitation on the east side of the valley is about one-half that of the White Mountains. Accordingly, the precipitation in the various zones was reduced by 50 percent for the mountain areas other than the White Mountains.

The area for each zone in the several drainage units of Fish Lake Valley is given in Table 4, and the data used for estimating the average annual precipitation are given in Table 5. The total precipitation in the tributary drainage area is estimated to be about 364,000 acre-feet a year.

Precipitation below the 5,500-foot contour which includes the area of the valley floor, according to Lee's graph, is less than 7 inches. Lee's graph is, in part, substantiated by the record for Oasis Ranch, altitude about 5,000 feet. The precipitation shown by the graph for this altitude is about 5.5 inches, whereas, the average for the period of record is 4.77 inches. Precipitation occurring on the floor of the valley has not been included in the estimate because in Fish Lake Valley it is believed to be a negligible part of the ground-water recharge.

## TABLE 4

**Areas, in acres, of precipitation zones for drainage units in Fish Lake Valley, Nevada and California**

| Drainage unit | 5,500- to 7,000-foot zone | 7,000- to 7,500-foot zone | 7,500- to 8,500-foot zone | Above 8,500-foot zone | Total precipitation area of unit |
|---|---|---|---|---|---|
| Wildhorse Flat | 31,500 | 3,700 | 5,400 | 4,700 | 45,300 |
| Chiatovich Creek | 7,600 | 2,000 | 5,800 | 20,200 | 35,600 |
| Indian Creek | 4,900 | 1,200 | 2,600 | 6,600 | 15,300 |
| Leidy Creek | 5,700 | 1,700 | 3,400 | 10,200 | 21,000 |
| South of Leidy Creek | 2,400 | 1,100 | 2,200 | 1,400 | 7,100 |
| Perry Aiken Creek | 3,200 | 1,800 | 3,200 | 8,200 | 16,400 |
| McAfee Creek | 2,000 | 1,000 | 1,500 | 5,900 | 10,400 |
| Furnace, Taber, and other Creeks | 13,500 | 4,100 | 6,400 | 4,700 | 28,700 |
| Cottonwood Creek | 13,100 | 2,800 | 6,400 | 22,700 | 45,000 |
| Mountains south of lat. 37°30′ N. | 37,600 | 17,000 | 7,700 | 800 | 63,100 |
| Silver Peak Range north of lat. 37°30′ N.[2] | 72,600 | 30,200 | 33,400 | 5,400 | 141,600 |
| Total | 194,100 | 66,600 | 78,000 | 90,800 | 429,500 |

## TABLE 5

**Estimated average annual precipitation, in acre-feet, by zones, for drainage units in Fish Lake Valley, Nevada and California[1]**

| Drainage unit | 5,500- to 7,000-foot zone | 7,000- to 7,500-foot zone | 7,500- to 8,500-foot zone | Above 8,500-foot zone | Total (approx.) precipitation (acre-feet) |
|---|---|---|---|---|---|
| Wildhorse Flat | 23,620 | 3,700 | 6,320 | 8,040 | 41,700 |
| Chiatovich Creek | 5,700 | 2,000 | 6,790 | 34,540 | 49,000 |
| Indian Creek | 3,680 | 1,200 | 3,040 | 11,290 | 19,200 |
| Leidy Creek | 4,280 | 1,700 | 3,980 | 17,440 | 27,400 |
| South of Leidy Creek | 1,800 | 1,100 | 2,570 | 2,390 | 7,900 |
| Perry Aiken Creek | 2,400 | 1,800 | 3,740 | 14,020 | 22,000 |
| McAfee Creek | 1,500 | 1,000 | 1,760 | 10,090 | 14,400 |
| Furnace and other Creeks | 10,120 | 4,100 | 7,490 | 8,040 | 29,700 |
| Cottonwood Creek | 9,820 | 2,800 | 7,490 | 38,820 | 58,900 |
| Mountains south of lat. 37°30′ N. | 14,100 | 8,500 | 4,500 | 680 | 27,700 |
| Silver Peak Range north of lat. 37°30′ N.[2] | 27,220 | 15,100 | 19,540 | 4,620 | 66,500 |
| Total (approximate) | 104,000 | 43,000 | 67,000 | 150,000 | 364,000 |

[1]Based on data from Lee, C. H., Total evaporation for Sierra Nevada watersheds by the method of precipitation and runoff differences: Am. Geophys. Union Trans., pt. 1, fig. 3, p. 58, 1941.

[2]Precipitation reduced 50 percent for each of the zones on the basis of local reports of "far less" precipitation in the Silver Peak Range, indication by vegetation of much less precipitation, and "storm shadow" effect in the Silver Peak Range as compared with precipitation conditions in the loftier White Mountains.

## STREAM FLOW

There are six perennial streams in Fish Lake Valley, all of which head in the higher parts of the White Mountains. In order, from the north these are Chiatovich, Indian, Leidy, Perry Aiken, McAfee, and Cottonweed Creeks. Miscellaneous discharge measurements or estimates have been made on Chiatovich, Indian, and Leidy Creeks. However, the best available information is a 3-year record, 1947 to 1949, inclusive, based on staff readings for McAfee Creek. The flow of McAfee Creek is diverted to a small forebay at about the contact of the bedrock and alluvial deposits, and thence over a 3-foot contracted rectangular weir into an open, lined ditch. In general, the flow is well controlled except possibly for short periods when conditions permit some water to bypass the weir. The staff readings and equivalent discharges are shown in Table 6.

Table 7 lists measurements of other streams together with several staff readings for a recently installed 5-foot contracted rectangular weir on Chiatovich Creek.

For the period 1947–1949, the records at stations in the region adjacent to Fish Lake Valley (see p. 11) indicate that precipitation, on the average, was about 50 percent of the long-time normal. Since stream flow is related to precipitation, total stream flow for the period undoubtedly was substantially below average. During periods of high runoff, stream flow reaches the playa area in the northeastern part of the valley, and according to reports, occasionally part of this is discharged through the Gap to the Columbus Marsh basin. The frequency of discharge through the Gap is not known.

**TABLE 6**

**Staff readings, in feet, and discharges, in second-feet, of McAfee Creek, Fish Lake Valley, Nevada and California[1]**

(Staff readings by G. A. Riley)

| Date | Staff reading | Discharge | Date | Staff reading | Discharge | Date | Staff reading | Discharge |
|---|---|---|---|---|---|---|---|---|
| 1946 | | | 1948 | | | 1949 | | |
| December 12 | 6.38 | 2.28 | April 7 | 6.42 | 2.65 | April 15 | 6.4 | 2.5± |
| | | | April 9 | 6.48 | 3.22 | May 1 | 6.4 | 2.5± |
| 1947 | | | April 20 | 6.42 | 2.65 | May 12 | 6.4 | 2.5± |
| March 1 | 6.42 | 2.65 | April 28 | 6.42 | 2.65 | May 15 | 6.44 | 2.83 |
| March 31 | 6.5 | 3.4± | May 9 | 6.40 | 2.46 | May 20 | 6.38 | 2.28 |
| April 15 | 6.42 | 2.65 | May 16 | 6.4 | 2.5± | May 27 | 6.48 | 3.22 |
| May 1 | 6.6 | 4.5± | June 1 | 6.4 | 2.5± | May 28 | 6.56 | 4.04 |
| May 10 | 6.52 | 3.62 | June 10 | 6.4 | 2.5± | June 3 | 6.4 | 2.5± |
| May 22 | 6.76 | 6.33 | July 1 | 6.4 | 2.5± | June 8 | 6.6 | 4.5± |
| May 23 | 6.82 | 7.08 | July 10 | 6.4 | 2.5± | June 9 | 6.68 | 5.38 |
| June 1 | 6.74 | 6.09 | July 25 | 6.38 | 2.28 | June 12 | 6.8 | 6.8± |
| June 23 | 6.66 | 5.15 | August 1 | 6.36 | 2.11 | June 14–18 | [2]7.0 | 9.5± |
| July 3 | 6.62 | 4.69 | August 3 | 6.32 | 1.77 | June 22 | 6.6 | 4.5± |
| July 30 | 6.6 | 4.5± | August 15 | 6.36 | 2.11 | July 1 | 6.55 | 3.94 |
| August 15 | 6.58 | 4.26 | August 29 | 6.36 | 2.11 | July 10 | 6.48 | 3.22 |
| August 27 | 6.56 | 4.04 | September 5 | 6.35 | 2.02 | July 27 | 6.42 | 2.65 |
| September 3 | 6.56 | 4.04 | September 19 | 6.35 | 2.02 | August 3 | 6.45 | 2.93 |
| September 10 | 6.55 | 3.94 | September 28 | 6.37 | 2.20 | August 15 | 6.4 | 2.5± |
| September 18 | 6.54 | 3.83 | October 8 | 6.35 | 2.02 | September 1 | 6.4 | 2.5± |
| September 27 | 6.53 | 3.73 | October 17 | 6.36 | 2.11 | September 15 | 6.42 | 2.65 |
| October 8 | 6.50 | 3.42 | November 1 | 6.4 | 2.5± | October 1 | 6.45 | 2.93 |
| October 18 | 6.50 | 3.42 | November 15 | 6.38 | 2.28 | October 18 | 6.48 | 3.22 |
| October 23 | 6.50 | 3.42 | | | | November 1 | 6.45 | 2.93 |
| October 26 | 6.52 | 3.62 | 1949 | | | November 10 | 6.475 | 3.17 |
| November 13 | 6.6 | 4.5± | March 15 | 6.38 | 2.28 | | | |
| November 25 | 6.5 | 3.4± | April 1 | 6.38 | 2.28 | | | |

[1]Discharge flows over 3-foot contracted rectangular weir; 6.00 feet on staff equals 0.00 head on weir.
[2]About the same amount bypassing in natural channel.

**TABLE 7**

**Miscellaneous discharge measurements for streams in Fish Lake Valley, Nevada and California**

| Stream | Date | | Discharge (second-feet) | Point of measurement |
|---|---|---|---|---|
| Chiatovich Creek | October 11, 1949 | | 7.14 | Weir 200 feet east of highway. |
| Chiatovich Creek | November 10 | | 6.60 | Weir 200 feet east of highway. |
| Chiatovich Creek | November 29 | | 6.43 | Weir 200 feet east of highway. |
| Chiatovich Creek | December 2 | 10:10 a. m. | 6.01 | Weir 200 feet east of highway. |
| Chiatovich Creek | December 2 | 12:20 p. m. | 6.01 | Weir 200 feet east of highway. |
| Chiatovich Creek | December 2 | 2:45 p. m. | 6.01 | Weir 200 feet east of highway. |
| Chiatovich Creek | December 2 | 11:45 a. m. | 7.10 | 4.7 Miles upstream from highway. |
| Leidy Creek | December 12, 1946 | | 2.9 | About 4 miles upstream from highway. |
| Indian Creek | December 2, 1949 | | 1.93 | 2.6 miles upstream from McNett Ranch. |

## GENERAL GEOLOGY AND WATER-BEARING CHARACTERISTICS OF THE ROCKS

Rocks of Palezoic age, including limestone, sandstone (quartzite), and shale (or slate), crop out in the White Mountains and in parts of the Silver Peak Range. Limestone, lava, and tuff of Jurassic age may crop out locally in the White Mountains. The rocks of Jurassic and older age have been metamorphosed adjacent to Jurassic (?) granitic intrusives which are exposed in the White Mountains.

Tertiary lacustrine sediments of the Esmeralda formation crop out prominently in the hills across the north end of Fish Lake Valley, in the north end of the Silver Peak Range, and locally in the mountains along the east side of the valley. Lava (basalt?) of post-Esmeralda age also is exposed in the hills at the north end of the valley and in the mountains along the east side of the valley.

The valley fill which underlies Fish Lake Valley consists of gravel, sand, silt, and clay. These sediments are younger than the post-Esmeralda lava and probably range in age from late Tertiary to Recent.

On the whole, the rocks that form the mountain areas surrounding the valley are much less permeable than the relatively unconsolidated valley fill. Locally, secondary openings in the older rocks may transmit large quantities of water. Thus Fish Lake Spring rises in alluvium adjacent to Paleozoic limestone. It seems most likely that this water is transmitted through solution openings in the limestone to a point not far below land surface, then rises in the alluvium to the surface.

Beds of sand and gravel in the valley fill are the most favorable for obtaining water by wells. This has been proved, in part, by several successful wells in Tps. 2 and 3 S., R. 35 E., and in T. 5 S., R. 37 E. Water-bearing beds of different thicknesses have been encountered by these wells at depths to as much as 700 feet.

The consolidated rocks of the mountains act as a barrier to the movement of ground water into or out of the valley. Within the valley they tend to divert underflow laterally to the ground-water reservoir in the valley fill. The geologic, hydrologic, and topographic evidence indicates that under natural conditions the possibility of water entering Fish Lake Valley from outside its drainage basin is very remote.

## GROUND WATER

### GENERAL CONDITIONS

The source of the ground water in Fish Lake Valley is primarily precipitation in the White Mountains and, to a lesser extent, in the Silver Peak Range and other mountains surrounding the valley. Precipitation on the valley floor and the lower parts of the alluvial apron averages less than 7 inches a year. The greater part of this precipitation ordinarily is utilized by plants or is lost by evaporation. Consequently, recharge to the ground-water reservoir from this source is believed to be negligible.

The slope of the water table, and hence the general direction of movement of the water, conforms in a subdued form to the slope of the land surface; that is, the slope is toward the central part of the valley and northward along the axis of the valley.

The water level is at or near land surface in the lowest part of the valley northward from a point west of Fish Lake Spring. It increases in depth toward the margins of the valley and southward along the valley axis.

Essentially all the ground water is discharged from the valley by transpiration of vegetation and evaporation from the soil and free-water surfaces. Underflow from the valley through the Gap is very minor. During years in which surface water is discharged through the Gap, a small part of the discharge may be derived from the ground-water reservoir.

### RECHARGE

The ground-water reservoir is recharged from precipitation within the drainage area of Fish Lake Valley. The recharge may result from direct downward percolation into the bedrock of the mountains, thence by lateral movement into the reservoir in the valley fill, or from deep percolation into the alluvium after the precipitation has been concentrated into streams. In the latter instance the recharge may be effected anywhere that the water flows, but generally the rate is greatest in the higher parts of the alluvial slopes.

Although the amount of average annual recharge to the ground-water reservoir cannot be determined definitely, evaluation by several methods gives figures that may be considered reasonable under natural conditions.

#### Evaluated Runoff From the Bedrock Area

The annual increment to ground-water storage may be estimated, in part, by evaluation of stream runoff from the bedrock area in the mountains. The evaluated runoff minus the consumptive use by irrigated crops and also losses from evaporation and transpiration will give a residual amount of water that is available for ground-water recharge.

Stream runoff of McAfee Creek in Fish Lake Valley has been evaluated on the basis of the 3-year staff record. From this, an annual unit runoff of 175 acre-feet per square mile was determined. For Chiatovich Creek an approximate agreement with this unit runoff was obtained from the spot measurements made in 1949, which were adjusted with due regard to seepage loss along the alluvial fan, and to the fact that November stream flow on McAfee Creek approximated the average flow for the period of record. A lesser agreement was obtained by similar treatment of the spot measurements on Indian and Leidy Creeks. However, it should be recognized that adequate data may warrant a revision of this unit runoff. When applied to the drainage area, the unit runoff indicated an annual runoff of 48,800 acre-feet (see Table 8). The unit value obtained appears very low when compared to other drainage areas along the east side of the Sierra Nevada. General consideration of the several factors in Fish Lake Valley suggests, however, that the unit runoff in the valley would not be as large as that for basins on the east flank of the Sierra Nevada for which information is available. It seems reasonable, though, that runoff during the period of record was much below the long-time average because of below-average precipitation during the same period.

**TABLE 8**

**Evaluated annual runoff, in acre-feet, for restricted drainage basins in Fish Lake Valley, Nevada and California[1]**

| Drainage basin (restricted[2]) | Area of basin (square-miles) | Evaluated annual runoff (acre-feet) |
|---|---|---|
| Wildhorse Flat | 21.5 | 3,760 |
| Chiatovich Creek | 33.6 | 5,880 |
| Indian Creek | 13.9 | 2,430 |
| Leidy Creek | 19.6 | 3,430 |
| South of Leidy Creek | 7.5 | 1,310 |
| Perry Aiken Creek | 20.7 | 3,620 |
| McAfee Creek | 14.8 | 2,590 |
| Furnace, Taber, and other Creeks | 23.8 | 4,160 |
| Cottonwood Creek | 49.8 | 8,720 |
| Mountain area south of lat. 37°30′ N. | 39.8 | [3]3,480 |
| Silver Peak Range, north of lat. 37°30′ N. | 107.9 | [3]9,440 |
| Total estimated annual runoff (approximate) | | 48,800 |

[1]Evaluated runoff unit is 175 acre-feet per square mile, based on analysis of available stream-flow data principally from the 3-year period of staff readings, 1947–1949, for McAfee Creek.

[2]The restricted basin designates that area lying upstream from the approximate bedrock-alluvial contact or upstream from the actual or assumed points past which all the evaluated runoff on McAfee, Chiatovich, Indian, and Leidy Creeks flows. Because of lack of runoff data, the restricted area for the other drainage basins is taken as the total precipitation area minus the area of the 5,500- to 7,000-foot zone, as this will approximate the area upstream from the contact of the bedrock and alluvial deposits.

[3]Evaluated runoff unit of 175 acre-feet per square mile is reduced by 50 percent for these areas, in accordance with discussion on page 13.

The records for six stations in the region around Fish Lake Valley indicate that precipitation for the period 1947 to 1949, inclusive, has averaged about 50 percent of the normal for the periods of record (see p. 11). Also, runoff during the two years 1947 and 1948 of the West Walker River and of the East and West Forks of the Carson River has averaged about 64 percent of the mean runoff for periods of record. Thus, the runoff in McAfee Creek for the period 1947 to 1949, inclusive, may range from 50 to 64 percent of the long-time mean. Using an average of 57 percent, the unit runoff per square mile would be increased from 175 to approximately 300 acre-feet and would indicate a long-time mean annual runoff of about 86,000 acre-feet.

As was stated, the mean annual runoff minus that water utilized for irrigated crops is the amount of water available for ground-water recharge, and any evaporation and transpiration losses. It is estimated that about 5,000 acres of land are irrigated with an annual crop use of 2½ acre-feet per acre. Thus, about 12,500 acre-feet of water are used annually for irrigation. This would indicate that during the period of record the quantity of water annually available for recharge, and any evaporation and transpiration losses, was about 36,000 acre-feet, and that for the possible long-time mean about 73,500 acre-feet would be available. The losses by evaporation and transpiration depend largely on the quantity of water passing onto the heavy soils below the irrigated lands where the opportunity for recharge to the ground-water reservoir is poor. In the absence of detailed information, it is difficult to estimate the magnitude of these losses.

### Seepage Loss From Streams

The amount of water being lost by seepage from streams can be estimated by making measurements of discharge along the stream at two or more points under relatively constant-flow conditions, when losses by evaporation and transpiration are negligible.

A seepage run was made on Chiatovich Creek, December 2, 1949. The flow as measured by current meter, was 7.1 second-feet at a point 4.7 miles upstream from the 5-foot contracted rectangular weir which had been installed late in 1949. The weir is about 200 feet east of State Highway 3A. Discharge at the weir was checked several times during the day and a constant flow of 6.01 second-feet was indicated for the period. Temperatures were sufficiently low to make evaporation and transpiration losses negligible between the two points. According to miscellaneous measurements, the rate of flow prior to the discharge on December 2 had been more or less maintained for about a month. The loss indicated by the measurements probably is near a minimum because during low-flow periods the stream is in a relatively tight channel which results, in part, from silting that occurs after a period of high runoff. Rate of loss undoubtedly is considerably greater during heavy spring runoff as the wetted area of the channel is much greater and additional stream turbulence tends to scour the bed of the channel. These factors greatly favor an increased rate of deep percolation in any stream channel during periods of high runoff.

On Chiatovich Creek the measured loss was 1.1 second-feet in a distance of 4.7 miles or an average rate of a little less than one-quarter second-foot per mile. The measurements were made on the intermediate slope of the alluvial fan. Near the head of the fan the rate of loss ordinarily would be somewhat greater and on the lower slope the rate of loss would be somewhat less. On this basis, the measured rate of loss represents about an average for the stream across the alluvial fan. Chiatovich Creek and its principal tributary Middle Creek, flow across the alluvial fan a distance of about 10 miles. Applying a seepage loss rate of one-quarter second-foot per mile, a loss of 2½ second-feet is indicated for Chiatovich Creek at the time of measurement. This method could be extended to all the streams in the valley to obtain a minimum value for the potential average annual recharge from seepage across the alluvial apron. Most of the discharge of Leidy, McAfee, and Cottonwood Creeks is conducted across the alluvial apron by pipes or lined ditches, which would greatly complicate any estimate by this method and would require a great deal of study to evaluate the net effect of the pipe lines on ground-water recharge.

Indian Creek was measured near the contact of the bedrock and alluvial deposits 2.6 miles upstream from the McNett Ranch on December 2, 1949. At that time the discharge was 1.93 second-feet and water was being spread over the land at the McNett Ranch. The water from Indian Creek is used largely for irrigation at the McNett Ranch, but part of it sinks into the ground. According to report, the creek almost never crosses the highway about 3.5 miles downstream from the McNett Ranch.

### Recharge as a Percentage of Precipitation

The method of estimating average annual ground-water recharge as a percentage of precipitation in the several effective zones in the mountains has been described in another report[1]. The general characteristics of Fish Lake Valley suggest that application of this method is reasonable. As the method is based on an assumed long-time average annual precipitation, it should yield a higher value than the estimate of ground-water discharge, which is believed to reflect the substantially deficient precipitation for the 3-year period 1947 to 1949, inclusive. According to this method, the average annual recharge to ground water is estimated to be about 54,000 acre-feet, as shown in Table 9. If this actually is representative of long-time average recharge, it affords an upper limit to the amount of ground water that may be developed by wells. It should be recognized, however, that the safe potential development of the ground-water reservoir in Fish Lake Valley will be something less than the average annual ground-water recharge and discharge, as development by wells is unlikely to be as efficient in the recovery of ground water as phreatophyte transpiration and evaporation processes.

**TABLE 9**

**Estimated average annual ground-water recharge, in acre-feet, as a percentage of precipitation from drainage units in Fish Lake Valley, Nevada and California.**

| Drainage basin (restricted) | 5,500- to 7,000-foot zone[1] (acre-feet) | 7,000- to 7,500-foot zone[2] (acre-feet) | 7,500- to 8,500-foot zone[3] (acre-feet) | Above 8,500-foot zone[4] (acre-feet) | Recharge approximate (acre-feet) |
|---|---|---|---|---|---|
| Wildhorse Flat | 710 | 260 | 950 | 2,010 | 3,930 |
| Chiatovich Creek | 170 | 140 | 1,020 | 8,640 | 9,970 |
| Indian Creek | 110 | 80 | 460 | 2,820 | 3,470 |
| Leidy Creek | 130 | 120 | 600 | 4,360 | 5,210 |
| South of Leidy Creek | 50 | 80 | 390 | 600 | 1,120 |
| Perry Aiken Creek | 70 | 130 | 560 | 3,500 | 4,260 |
| McAfee Creek | 40 | 70 | 260 | 2,520 | 2,890 |
| Furnace and other Creeks | 300 | 290 | 1,120 | 2,010 | 3,720 |
| Cottonwood Creek | 300 | 200 | 1,120 | 9,700 | 11,320 |
| Mountains south of lat. 37°30′ N.[5] | 420 | 600 | 680 | 170 | 1,870 |
| Silver Peak Range north of lat. 37°30′ N.[5] | 820 | 1,060 | 2,930 | 1,160 | 5,970 |
| Total (approximate) | 3,100 | 3,000 | 10,100 | 37,500 | 53,700 |

[1]Recharge, 3 percent of total precipitation.
[2]Recharge, 7 percent of total precipitation.
[3]Recharge, 15 percent of total precipitation.
[4]Recharge, 25 percent of total precipitation.
[5]On basis of precipitation reduction (see Table 5, footnote 2).

**DISCHARGE**

Water is withdrawn from the ground-water reservoir by wells and springs, by transpiration of phreatophytes (water-loving plants), by evaporation from soil and free-water surfaces, and by discharge through the Gap at the north end of the valley. All the discharge from wells, except that used for stock and domestic purposes, is used to irrigate crops, and only the discharge from

[1]Maxey, G. B., and Eakin, T. E., Ground water in White River Valley, White Pine, Nye, and Lincoln Counties, Nevada: State of Nevada, Office of the State Engineer, Water Resources Bull. 8, p. 40, 1949.

the McNett flowing well, in sec. 19, T. 1 S., R. 36 E., reaches the area of transpiration in quantity. Ground-water discharge through the Gap is believed to be very minor. Most of the discharge from springs and the McNett flowing well is dissipated by evaporation and transpiration and thus may be included in the latter estimates. Thus, the average annual ground-water discharge from Fish Lake Valley may be obtained by estimating evaporation and transpiration losses and the amount of water pumped by wells, with the exception of the McNett flowing well.

### Transpiration and Evaporation

Field reconnaissance during this investigation indicated an area of about 48,600 acres from which water is discharged by transpiration and evaporation processes. The average annual discharge from this area has been estimated to be about 30,000 acre-feet, most of which is discharged in the area north of T. 4 S. (see Table 10).

**TABLE 10**

**Estimated annual discharge of ground water, in acre-feet, by transpiration and evaporation in Fish Lake Valley, Nevada and California**

| Vegetation type | Area (acres) | Discharge (acre-feet) |
|---|---|---|
| Area north of T. 4 S.— | | |
| Rabbit brush, greasewood, etc. Moderate to low density. Depth to water, 10 to 40 feet, average about 20 feet. Average rate of use, 0.3 foot per year. | 26,300 | 7,890 |
| Salt grass, rabbit brush, grasses, etc. Moderate to optimum density. Depth to water, 2 to 10 feet, average about 5 feet. Average rate of use, 1.0 foot per year. | 13,900 | 13,900 |
| Bare playa. Land surface intercepts the capillary fringe all year. Depth to water, 0 to 5 feet. Average rate of evaporation, 1.0 foot per year. | 2,400 | 2,400 |
| Reeds, rushes, dense mixed grasses. Some free-water surface. Water table at or near land surface all year. Average rate of use, 5.0 feet per year. | 800 | 4,000 |
| Area south of T. 3 S.— | | |
| Rabbit brush, greasewood, etc. Moderate to low density. Depth to water, 10 to 40 feet, average about 25 feet. Average rate of use, 0.3 foot per year. | 5,200 | 1,560 |
| Total discharge by transpiration and evaporation (approximate) | ------ | 30,000 |

The scope of this investigation precluded any detailed studies of evapo-transpiration rates in Fish Lake Valley. Therefore, etismates of the rates of evapo-transpiration are based on data obtained from studies made in other parts of the West, especially those made by Lee[2] and White[3] in the Great Basin. These esti-

[2]Lee, C. H., An intensive study of the water resources of a part of Owens Valley, California: U. S. Geol. Survey Water-Supply Paper 294, 135 pp., 1912.

[3]White, W. N., A method of estimating ground-water supplies based on discharge of plants and evaporation from soil: U. S. Geol. Survey Water-Supply Paper 659-A, 105 pp., 1932.

mates were adapted to the climatic and hydrologic conditions of Fish Lake Valley and compare favorably with the values of consumptive use estimated by Piper, Robinson, and Park[4] for the Harney Basin, Oregon. Consideration was given to area of discharge, and to type, density, and distribution of plants. Under average conditions, the annual transpiration by plants is more or less uniform, but will decrease as the water supply becomes inadequate. Thus, to satisfy their water requirements during extended dry periods, the plants utilize water that ordinarily would be discharged by soil evaporation, and evaporation from free ground-water surfaces, and/or would draw from ground-water storage insofar as possible. Accordingly, after several dry years the average water table might be lowered several feet and the rate of evaporation from the soil would be reduced, as would the area of free-water surfaces. As of late 1949, this condition is considered to be in effect because of the 3-year period (1947–49) during which precipitation was about 50 percent of the long-time normal. Therefore, it is logical to assume that the long-time average annual ground-water discharge in Fish Lake Valley is substantially greater than the estimated 30,000 acre-feet in 1949.

On the bases of the stream flow of the West Walker River and of the East and West Forks of the Carson River (flow during 1947 and 1948, 64 percent of normal) and precipitation in the region adjacent to Fish Lake Valley (50 percent of the long-time normal) the ground-water discharge in 1949 may have been between 50 and 64 percent of the long-time average annual discharge. Using the mean of these two values, the average annual discharge would be on the order of magnitude of 50,000 acre-feet.

#### Wells

Withdrawal in 1949 from 17 irrigation wells in Fish Lake Valley is estimated at about 3,100 acre-feet (see Table 11). Of this amount about 2,250 acre-feet was withdrawn north of T. 4 S. The amount of water discharged by wells in 1949 probably about equals the average annual use under existing conditions.

With the exception of the McNett flowing well, all the water withdrawn is used for irrigation, stock, or domestic purposes, and does not materially supply water to the area of transpiration and evaporation. Thus, the estimated 2,800 acre-feet of ground water

[4]Piper, A. M., Robinson, T. W., and Park, C. F., Jr., Geology and ground-water resources of the Harney Basin, Oregon: U. S. Geol. Survey Water-Supply Paper 841, 189 pp., 1939.

that was withdrawn by pumped wells in 1949 is not included in the amount discharged by evaporation and transpiration.

**TABLE 11**

**Well number, owner, reported rate of discharge, and total estimated withdrawal of ground water for irrigation during 1949 in Fish Lake Valley, Nevada and California.**

| Well No. | Owner | Rate of discharge (gallons per minute) | Estimated discharge, 1949 (acre-feet) |
|---|---|---|---|
| 1S/36-19A3 | McNett (flowing well) | 195 | 314 |
| 2S/35-33A1 | E. L. Cord | 200 | 198 |
| 2S/35-33A2 | E. L. Cord | 110 | 127 |
| 2S/35-33A4 | E. L. Cord | 150 | 134 |
| 2S/35-33A5 | E. L. Cord | 150 | 124 |
| 2S/35-33A8 | E. L. Cord | 200 | 198 |
| 2S/35-33A9 | E. L. Cord | 130 | 68 |
| 2S/35-34B2 | E. L. Cord | 110 | 106 |
| 3S/35-4D3 | S. Folwick | 250 | 5 |
| 3S/35-14C1 | C. Parkinson | 460 | 341 |
| 3S/35-24C1 | Bar Double Nine Ranch | 400 | 30 |
| 3S/35-25C1 | F. Ferris | 540 | 150 |
| 3S/25-26A2 | Bar Double Nine Ranch | 650 | 126 |
| 3S/35-26B1 | Bar Double Nine Ranch | 1,350± | 356 |
| 5S/37-27B1 | F. Alexis | 1,400 | 475 |
| 5S/37-27B2 | F. Alexis | 1,000 | 340 |
| 5S/37-27B3 | Scott | 650 | 50 |
| Total from pumped and flowing wells (approximate) | | | 3,100 |
| Total from pumped wells (approximate) | | | 2,800 |

**Springs**

The principal discharge from springs is that from Fish Lake Spring and closely related springs extending northeast from Fish Lake Spring for about 2½ miles. The average annual discharge from this area is believed to be about 4,000 acre-feet, or approximately 5½ second-feet. Fish Lake Spring was estimated to be discharging 3 second-feet on December 1, 1949, on the basis of measurements of all the distributary channels about half a mile downstream from the main pool. Additional discharge from the spring area at the Old McNett Ranch, near the northeast corner of sec. 19, T. 1 S., R. 36 E., may average about 700 acre-feet a year. Thus, a total of about 4,700 acre-feet of water is discharged annually from the two spring areas into the area of transpiration and evaporation. As such, it is included in the estimate of discharge by transpiration and evaporation. According to report, several temporary springs of moderate discharge occur southwest of the spring area at the Old McNett Ranch. The flow of these springs is reported to be greater than the main spring at Old McNett Ranch, but the discharge occurs only during the spring of the year.

These springs may act as local overflow outlets when the water table is raised above a certain level. The rate and duration of discharge from such springs depends upon the amount of recharge in excess of that required to fill the ground-water reservoir to a certain level. This would tend to limit, in part, an estimate of the discharge from the ground-water reservoir based upon transpiration and evaporation. The discharge of such springs is believed to come at the time of excess surface runoff, and probably results in mixing of the water from the two sources. Thus, to determine the quantity discharged would be difficult. Whatever the amount of this possible "rejected" recharge, it could be salvaged under moderate to full development of the ground-water reservoir by lowering the water table to a point below the outlet level of the temporary springs.

The several springs in the Gap have a small aggregate discharge. The source of the water of these springs probably is related to faulting and localized recharge in the vicinity of the Gap. Sand Spring issues from near the contact of the bedrock and alluvial deposits in the northwestern part of the valley (SE¼, T. 1 N., R. 34 E.). The spring area was partly developed many years ago. The water is spread over several acres but the principal use apparently is to water stock. When visited November 28, 1949, the discharge was 10 to 15 gallons per minute.

## POTENTIAL DEVELOPMENT

In this preliminary report, the amount of ground water that may be available for potential development can be based most reasonably upon the amount of water that was discharged from the ground-water reservoir in 1949—that is, upon the natural losses by transpiration from phreatophytes and by evaporation from soil and free-water surfaces. As the estimated ground-water discharge is based upon conditions during an extended "dry period," the estimate is considered to be conservative. It is recognized that under conditions of average precipitation for a long-time period, ground-water recharge and discharge would be balanced at a higher annual amount than the 1949 estimate of ground-water discharge. Rather than making an estimate, without reasonable basis, of the amount of ground water that may be developed under long-time average discharge conditions, it appears more reasonable to base an estimate of potential development upon the 1949 discharge estimate, and subsequently to reevaluate that figure upon an annual inventory of pumpage and an analysis of water-level fluctuations.

Accordingly, in this report the estimate for potential ground-water development by wells is based upon the estimate of ground-water discharge under existing conditions.

Not all the natural losses from the ground-water reservoir can be recovered by withdrawals from wells. A relatively high recovery can be obtained by the strategic location of wells along the west side of the area of transpiration. Such wells would intercept a large fraction of the underflow from the principal source of recharge, precipitation in the White Mountains.

Included in the estimated annual discharge, about 30,000 acre-feet from the valley, is about 5,000 acre-feet discharged from Fish Lake and related springs and the springs and flowing well at the Old McNett Ranch, but not the discharge from pumped wells. Of the remaining 25,000 acre-feet, an additional development by wells of 15,000 to 20,000 acre-feet per year seems possible under present conditions. Available information is inadequate to indicate the specific amounts of ground water available for development by wells in different parts of the valley. However, much the greater part of the estimated 15,000 to 20,000 acre-feet can be obtained in the area north of T. 4 S. As the estimated 15,000 to 20,000 acre-feet is based upon the estimate of discharge in 1949, it may be assumed that this amount could be evaluated upward in accordance with the method used in evaluating long-time average runoff. On this basis, the long-time average for potential development would be 26,000 to 35,000 acre-feet.

The average annual discharge of Fish Lake and other related springs of the system cannot be materially increased by pumping, although redistribution of the total annual discharge could be made by pumping part of the year. Pumping water in excess of the average natural discharge would result in a below-average discharge during the nonpumping season. For the full year there would be little if any more water discharged by pumping than by the natural regimen of the spring. With continuous pumping it is not likely that a significant increase in average annual discharge could be maintained, as discharge of the spring system over a long period must be balanced by recharge. It would, however, tend to reduce seepage losses in the spring area by diverting water to the principal spring orifice.

### ARTIFICIAL RECHARGE

Artificial recharge or the practice of spreading water into artificial basins to induce maximum infiltration to the ground-water reservoir has been practiced successfully in many areas. There are favorable areas for artificial recharge in the higher parts of the alluvial fans in Fish Lake Valley. It is believed that relatively high rates of infiltration can be obtained with proper construction of spreading areas and control of applied water.

An example of artificial recharge was observed at the Oasis Ranch. Here, part of the discharge of Cottonwood Creek is diverted to a reservoir adjacent to the road turnoff toward Big Pine. When visited December 1, 1949, about 2 second-feet were entering the reservoir and there was no surface discharge from it, indicating that all the inflow was seeping underground. The reservoir was about 250 feet square but the water surface covered only a fraction of the reservoir area. The effect of this recharge to ground water was indicated by depth-to-water measurements in two wells, about 1,000 and 2,000 feet north of the reservoir. The depth to water in the well nearest the reservoir was about 19 feet below land surface, and that of the other well about 38 feet. The land surface slopes to the north about 10 feet in 1,000 feet, thus indicating a water-table gradient of about 30 feet in 1,000 feet. It would appear, therefore, that this artificial recharge developed a ground-water mound generally extending northward from the reservoir.

Artificial recharge on a large scale would be impractical in Fish Lake Valley until there was a relatively heavy annual draft on the ground-water reservoir. Such draft would lower the water table sufficiently to permit accommodation of the supplemental recharge. The amount of water available for artificial recharge would be limited to runoff subject, in part, to existing vested or permitted surface-water rights.

## CHEMICAL QUALITY

Samples of water collected during the current study from two springs and six wells have been analyzed in the Salt Lake City laboratory of the U. S. Geological Survey, Quality of Water Branch. The results are given in Table 12.

## TABLE 12

**Chemical analyses of water from six wells and two springs in Fish Lake Valley, Nevada and California**

(Analyses by Geological Survey, United States Department of the Interior)

(Parts per million)

| Lab. No.[1] | 3902 | 3906 | 3905 | 3903 | 3907 | 3908 | 3909 | 3904 |
|---|---|---|---|---|---|---|---|---|
| Date of collection | Nov. 29, 1949 | Nov. 29, 1949 | Nov. 30, 1949 | Nov. 30, 1949 | Nov. 30, 1949 | Nov. 30, 1949 | Nov. 30, 1949 | Dec. 1, 1949 |
| Temperature (°F.) | 77 | 69 | 70 | 55 | 51 | 51 | 54.5 | 57 |
| Silica ($SiO_2$) | 112 | — | 58 | 29 | 32 | 44 | 21 | 43 |
| Iron (Fe) | .17 | — | .05 | .04 | — | — | — | .08 |
| Calcium (Ca) | 49 | — | 18 | 91 | 94 | 73 | 51 | 89 |
| Magnesium (Mg) | 9.6 | — | 4.8 | 21 | 18 | 34 | 22 | 36 |
| Sodium and potassium (Na & K) | 268 | — | 59 | 5.1 | 2.3 | 15 | 4.6 | 26 |
| Bicarbonate ($HCO_3$) | 614 | 150 | 166 | 330 | 340 | 376 | 222 | 466 |
| Sulfate ($SO_4$) | 120 | 21 | 42 | 34 | 25 | 35 | 36 | 35 |
| Chloride (Cl) | 74 | 31 | 7 | 5 | 3 | 4 | 4 | 4 |
| Fluoride (F) | 4.3 | — | .9 | .4 | — | — | — | .4 |
| Nitrate ($NO_3$) | .0 | .4 | .4 | 13 | 6.5 | 5.8 | 3.3 | 2.2 |
| Boron (B) | 1.0 | — | .04 | .02 | — | — | — | .02 |
| Dissolved solids— | | | | | | | | |
| —ppm | 940 | 250 | 272 | 361 | 348 | 396 | 251 | 465 |
| —tons per acre-foot | 1.28 | — | .37 | .49 | .47 | .54 | .34 | .63 |
| Hardness as $CaCO_3$— | | | | | | | | |
| Total | 162 | — | 65 | 314 | 308 | 322 | 218 | 370 |
| Noncarbonate | 0 | — | 0 | 43 | 30 | 14 | 36 | 0 |
| Specific conductance (micromhos at 25° C.) | 1,340 | 358 | 356 | 574 | 553 | 623 | 414 | 724 |
| Percent sodium | 78 | — | 66 | 3 | 2 | 9 | 4 | 13 |
| pH | 7.0 | — | 7.8 | 7.6 | — | — | — | 7.4 |

[1]See following page.

**TABLE 12—Continued**

| Lab. No. | Description |
| --- | --- |
| 3902 | 1S/36–19A3. NE¼ sec. 19, T. 1 S., R. 36 E. Owner, McNett, old ranch. Drilled, diameter 8 inches, measured depth 258 feet (reported 488 feet). Flow 195 gallons per minute, Nov. 29, 1949. |
| 3906 | 1S/36–19A1. NE¼ sec. 19, T. 1 S., R. 36 E. Owner, McNett, old ranch. Spring 400 feet north of cottonwoods. Flow 250 gallons per minute, Nov. 29, 1949. |
| 3905 | 2S/36–25C1. SW¼ sec. 25, T. 2 S., R. 36 E. Fish Lake Spring. Flow 3 second-feet, Nov. 30, 1949. |
| 3903 | 2S/35–33A1. NE¼ sec. 33, T. 2 S., R. 35 E. Owner, E. L. Cord. Drilled, diameter 12 inches, depth 120 feet. Depth to water 63.67 feet below top of casing, Nov. 30, 1949. Pumping rate 200 gallons per minute. |
| 3907 | 2S/35–33A2. NE¼ sec. 33, T. 2 S., R. 35 E. Owner, E. L. Cord. Drilled, diameter 12 inches, depth 122 feet. Depth to water 44.58 feet below top of casing, Nov. 30, 1949. Pumping rate 110 gallons per minute. |
| 3908 | 2S/35–34B2. NW¼ sec. 34, T. 2 S., R. 35 E. Owner, E. L. Cord. Drilled, diameter 12 inches, depth 100 feet. Depth to water 18.92 feet below top of casing, Nov. 30, 1949. Pumping rate 110 gallons per minute. |
| 3909 | 2S/35–34A1. NE¼ sec. 34, T. 2 S., R. 35 E. Owner, E. L. Cord. Drilled, diameter 12 inches, depth 50 feet. Depth to water 10.50 feet below top of casing, Nov. 30, 1949. Pumping rate 2–3 gallons per minute. |
| 3904 | 3S/35–26A2. NE¼ sec. 26, T. 3 S., R. 35 E. Owner, Bar Double Nine Ranch. Drilled, diameter 16 inches, depth 125 feet. Depth to water reported 15 feet below land surface. Pumping rate 650 gallons per minute. |

The U. S. Public Health Service has set the following recommended limits on certain chemical constituents commonly found in drinking water used on interstate carriers: 0.3 part per million for iron and manganese, 125 parts per million for magnesium, 250 parts per million each for sulfate and chloride, 1.5 parts per million for fluoride, and 1,000 parts per million for dissolved solids. On this basis, the water from all sampling points in Fish Lake Valley is satisfactory with the exception of that from the McNett flowing well. Water from this well has a high fluoride content and if used continuously would have a harmful effect on teeth of young children. It is possible too that a relatively high fluoride content would have been found in the water from the spring on the Old McNett Ranch if that water had been analyzed. However, it should be less than that of the nearby well. The waters analyzed were moderately to very hard, which would have a bearing on their use for domestic purposes.

Magistad and Christiansen[5] have given tentative standards for irrigation waters, but they indicate that consideration should be given to the characteristics of the type of soil and the soil solution in evaluating the effect of a given chemical composition of water on a given soil.

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[5]Magistad, O. C., and Christiansen, J. E., Saline soils, their nature and management: U. S. Dept. Agr. Circ. 707, pp. 8–9, 1944.

**Standards for Irrigation Waters**

| Water class | Conductance (K x 10[5] at 25° C.)[1] | Salt Content: Total (p. p. m.) | Salt Content: Total per acre-foot (tons) | Sodium (percent)[2] | Boron (p. p. m.) |
|---|---|---|---|---|---|
| Class 1[3] | 100 | 700 | 1 | 60 | 0.5 |
| Class 2[4] | 100–300 | 700–2,000 | 1–3 | 60–75 | 0.5–2.0 |
| Class 3[5] | 300 | 2,000 | 3 | 75 | 2.0 |

[1]To compare directly with conductance as shown in actual analyses multiply conductance shown in this table by 10.

[2]The percentage of sodium is calculated from the analytical results expressed in milligram equivalents. The results are obtained by dividing the parts per million of sodium, potassium, calcium, and magnesium by 23, 39, 20, and 12, respectively; then 100 times the milligram equivalents of sodium is divided by the sum of milligram equivalents of sodium, potassium, calcium, and magnesium. In milligram equivalents, $\frac{100\ Na}{Na + K + Ca + Mg}$ = percentage of sodium.

[3]Excellent to good, suitable for most plants under most conditions.

[4]Good to injurious, probably harmful to the most sensitive crops.

[5]Injurious to unsatisfactory, probably harmful to most crops and unsatisfactory to all but the most tolerant. If a water falls in Class 3 on any basis, i. e., conductance, salt content, percentage of sodium, or boron content, it should be classed as unsuitable under most conditions. Should the salts present be largely sulfates, the value for salt content in each class can be raised 50 percent.

On the basis of the analyses in Table 12, the waters sampled appear to be satisfactory for irrigation use according to the above standards for irrigation water, with the following exceptions: The water from the McNett flowing well is in Class 2 when classified according to specific conductance, salt content, and boron, and in Class 3 when classified according to percent sodium. The water from Fish Lake Spring is in Class 1 for all constituents analyzed except percent sodium for which it is in Class 2.

The other well-water analyses suggest that water suitable for irrigation can in general be obtained in the lower part of the alluvial apron in Tps. 1 to 3 S., R. 35 E.

The chemical character of the water from the McNett flowing well suggests that the water is supplied, at least in part, from sources related to volcanic activity.[6] Water from such sources commonly is relatively high in chloride, fluoride, and boron, compared to normal ground water. The lower, but still relatively high, chloride content indicated by the partial analysis for the spring on the Old McNett Ranch suggests that it may represent a mixing of water similar to that of the McNett flowing well with shallow ground water of considerably lower dissolved solids.

## SUMMARY

The results of the preliminary study of ground-water resources in Fish Lake Valley suggest that under present conditions 15,000 to 20,000 acre-feet of water per year can be withdrawn by wells in addition to the amount pumped in 1949. This is based upon the estimated annual ground-water discharge of 30,000 acre-feet after a 3-year period of substantially deficient precipitation. The

[6]White, D. E., oral communication.

estimate is believed to be conservative for long-time average conditions of recharge to and discharge from the ground-water reservoir. Revision of the preliminary estimate can be made best upon a quantitative basis using an inventory of annual pumpage and analysis of water-level fluctuations. However, it is believed that, excluding spring discharge, the long-time average annual amount of ground water available to wells is on the order of magnitude of 30,000 acre-feet under natural conditions of recharge. The collection of pertinent data upon which to base a possible revision of the preliminary estimate is a part of the future study.

The estimate of 15,000 to 20,000 acre-feet per year for potential development by wells is in addition to the discharge from Fish Lake and related springs, from the springs and flowing well at the Old McNett Ranch, and from wells that were pumped in 1949. The discharge from Fish Lake and related springs and from the springs and flowing well at the Old McNett Ranch was estimated to be about 5,000 acre-feet in 1949, and the discharge from the pumped wells in the valley was estimated to be 2,800 acre-feet in 1949.

Although the relative amounts of ground water available in the different parts of the valley cannot be evaluated at the present time because of insufficient information, the greater part of the ground water estimated to be potentially available to wells under present conditions can be obtained north of T. 4 S.

Artificial recharge with excess surface water should be practical by spreading water on the most permeable parts of the alluvial apron. However, this would be of little value until withdrawals by pumping was sufficient to lower the water level in the ground-water reservoir to a point where supplemental recharge could be accommodated.

The most favorable area for effective recovery of ground water by wells is on the lower slopes along the west side of the valley—generally in the eastern part of R. 35 E. between the mid-part of T. 1 S. and T. 4 S. This area is between the principal area of recharge in the White Mountains and the principal area of discharge in the valley lowland. As such, it is favorably situated to intercept a large part of the annual recharge under full development by strategic spacing of wells and control of withdrawals.

On the basis of chemical analyses of ground water, the quality may be generally satisfactory beneath the lower parts of the alluvial apron from the mid-part of T. 1 S. to T. 3 S., inclusive. Ground water of relatively poor quality may be encountered in the vicinity of the Old McNett Ranch in the western part of T. 1 S., R. 36 E., and possibly in other parts of the valley lowland adjacent to the playa.

## RECONNAISSANCE LAND CLASSIFICATION OF FISH LAKE VALLEY, ESMERALDA COUNTY, NEVADA

By Howard G. Mason[1]

### INTRODUCTION

Fish Lake Valley is located in the western part of Esmeralda County about 50 airline miles west of Goldfield. It is reached by Nevada State Highway 3A, which runs south to the valley from Nevada U. S. 6 from a point 7 miles west of Coaldale Junction. There is a post office, Dyer, but no town or village in the valley.

The altitude of the valley floor is approximately 5,000 feet. From the limited climatic data available for the area, growing season temperatures appear to be about the same as at Reno and Yerington and a little lower than at Fallon. There are no records of the frost-free period for the valley floor, but it is unlikely that there is any significant difference between climatic conditions in Fish Lake Valley and the large agricultural valleys in western Nevada.

Fish Lake Valley is a portion of a larger enclosed basin which over relatively recent geological time has had a number of periods of inundation and dessication. The potential agricultural soils covered by this survey are a product of erosion of the White Mountains, possibly with some modification. The surface of the lowest part of the valley is almost flat and made up mainly of lake sediments with some slight deposition of material carried by winds. To the west of the valley floor there is a plain of recent alluvial material, sloping upward rather gently at first but more steeply toward the west side of the valley. There also appears to be some remnants of an old erosion surface along the junction of the alluvial plain with the valley floor. All of the potential agricultural lands recognized by this survey are located on this alluvial plain. The land classification is based primarily on soil texture and profile, plus consideration of surface relief and drainage conditions.

The major proportion of the alluvial material constituting the soils is rather coarse. Wind and stream erosion, and possibly considerable reworking of the material during periods of inundation, has transported most of the limited portion of finer particles well down toward the valley floor and over it to some extent.

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Along the margin of the valley floor where the relatively impermeable lake sediments are overlaid with a thin mantle of alluvial sand and silt there results in a strip of varying width, depending upon the slope, of land which has restricted drainage and an accumulation of alkali on the surface.

## LAND CLASSIFICATION

The valley was covered by a reconnaissance-type survey in which the lands on the valley floor within the area of conceivably feasible development by pumping from ground water were classified. In conformance with previous similar surveys by the Nevada Agricultural Experiment Station in cooperation with the office of the State Engineer the land was separated into three classes (See Pl. 2). Soil texture and profile, topography, present and future drainage conditions, and the presence or absence of harmful mineral salts were the major factors determining land class, as follows:

Class I land is considered suitable for immediate development.

Class II land is doubtful present agricultural value.

Class III land is considered definitely unsuitable for development.

The lower limit of the area of Class I land was drawn on a contour where it is believed from observation and existing development that some difficulty would begin to result from a restricted root zone and deficient drainage and salt removal, because of the shallow depth to the impermeable or water-logged and alkaline underlying basin sediments. The upper limit of the area of Class I land was established arbitrarily along a line where the finer soil graded into material considered too coarse for satisfactory use for general farm crops. No measurement was made of the proportion of finer soil particles (very fine sand, silt, possibly traces of clay) which determined the lower limit of Class I land but it is estimated to be about 15 percent of the 5-foot profile.

The Class II land on the one hand includes a narrow belt of land adjoining the lower limit of the area of Class I land. On the other, it includes a broad expanse of generally coarse-textured soils lying above the Class I land. Some parts of the lower lying Class II land may be susceptible to development as irrigated pastures subject to possible economic limits of such use. The feasible utilization of the higher lying, coarse-textured portions seems very doubtful.

Class III land mapped includes an area of sand dunes located in secs. 9 and 10, T. 2 S., R. 35 E., the valley bottom, and the upper portion of the alluvial slope into the valley. The valley bottom soils are higher alkaline and appear to be entirely impracticable of reclamation. The higher slopes have coarse, shallow, and stony soils and rough topography.

As can be seen by reference to the land classification map (Pl. 2), the occurrence of Class I lands is limited almost entirely to Tps. 1 and 2 S. In this portion there appears to be an ample quantity of this grade of land to accommodate full use of all potential recoverable ground water. In the southern part of the valley, mostly in T. 3 S., there is very little undeveloped Class I land available for future reclamation.

Of approximately 8,500 acres of Class I delimited on Plate 2, not less than 3,500 acres are now privately owned by the established ranches. Approximately 14,500 acres of Class II land are shown on the map, and a considerable part of this acreage is also in private ownership. About 1,500 acres of the Class II land is located in the alkali-drainage problem area, some of which may prove feasible of reclamation, and the balance is considered marginal because of its coarse texture. No definite outside boundary was set for the Class III land so no acreage figure for it is given.

In interpretation of the classification map the limitation of reconnaissance methods should be fully recognized. Alluvial soils in the lower part of an enclosed basin are likely to be quite variable in character and distribution. It seems quite certain that such is the case in this instance. It is highly probable that an intensive survey would disclose much greater irregularity of the boundaries between Class I and Class II, and probably some inclusion of small areas of Class II within larger areas of Class I. Such irregularities are particularly indicated along the border between the lower limit of Class I and the valley floor.

## ECONOMIC CONDITIONS AFFECTING DEVELOPMENT

No special study was made of economic conditions favorable or unfavorable to agricultural development in Fish Lake Valley, but casual observation gives a somewhat unfavorable impression. The valley has no special climatic advantage over other nearby intermountain irrigated valleys. It may have above average disadvantage in production of specialty crops in the combination of high-wind movement and light soils subject to excessive wind erosion. The soils are also of a character to make the efficient distribution and application of irrigation water quite expensive. Field crop adaptation may be limited largely to alfalfa, potatoes, and irrigated pastures. The susceptibility to wind erosion of the predominantly light-textured soils suggests a minimum use of grain or intertilled crops in rotation with alfalfa or other erosion resistant ground cover. The valley has but a slight advantage over other areas capable of producing similar crops in the cost of transportation to the Los Angeles market, and a relative disadvantage in reaching other markets. The potential producing area is probably too small to support a stable local agricultural economy and a satisfactory social environment.

There is very little evidence of a sound local basis for a prosperous community. It probably was prosperous when Tonopah and Goldfield were booming, and during World War II, but now it seems to be running largely on imported capital.

It appears that this would always be a high-cost operation, including the high cost of maintaining the fertility of light-textured soils in an arid climate, with nothing in sight as a potential high value commodity to be produced.

(30)

U. S. GEOLOGICAL SURVEY STATE ENGINEER OF NEVADA WATER RESOURCES BULLETIN 11
PLATE 1