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REPORT 42

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WATER-RESOURCES APPRAISAL OF STEPTOE VALLEY,
WHITE PINE AND ELKO COUNTIES, NEVADA

By
Thomas E. Eakin, Jerry L. Hughes
and
Donald O. Moore

Prepared cooperatively by the
Geological Survey, U.S. Department of the Interior

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WATER-RESOURCES APPRAISAL OF STEPTOE VALLEY,

WHITE PINE AND ELKO COUNTIES, NEVADA

By

T. E. Eakin, J. L. Hughes, and D. O. Moore

SUMMARY

Steptoe Valley in eastern Nevada has a drainage area of 1,975 square miles. It extends northward from the southern end of White Pine County for about 110 miles into the southern part of Elko County. From Currie the valley axis rises southward from an altitude of 5,800 feet to about 7,000 feet at the southern end. Schell Creek Range bounds the east side of the valley and the Egan and Cherry Creek Ranges form the western boundary. Commonly the crests of these ranges are 3,000 to 4,000 feet above the valley axis. East of McGill, the crest of the Schell Creek Range is about 11,000 feet for several miles.

Precipitation ranges from as little as 6 inches in the valley lowland to more than 20 inches in the higher parts of the mountains. Most of the runoff from the mountains above 7,000 feet is derived from snowmelt in the spring months. Nearly half of the 78,000 acre-feet of runoff is generated in the drainage areas of Duck and Steptoe Creeks in the Schell Creek Range and about one-fifth is generated in the drainage areas of Goshute and McDermitt Creeks in the Cherry Creek Range.

Additional runoff generated below 7,000 feet in the alluvial apron and valley lowland occasionally may reach high rates for short periods but this runoff generally is erratic and commonly is not susceptible to management for use.

A large quantity of ground water is stored in the valley-fill reservoir, as is suggested by the 2.1 million acre-feet estimated to be stored in the upper 100 feet of saturated deposits beneath the principal area of ground-water evapotranspiration. Additional ground water also is stored and transmitted in the consolidated rocks. Natural discharge from lowland springs is on the order of 22,000 acre-feet. In turn, this is removed from the lowland by evapotranspiration and is included in the 70,000 acre-feet of annual evapotranspiration from the valley lowland.

The chemical quality of ground water generally is good in Steptoe Valley, but locally, it may not be suitable for all uses.

Copper production at McGill requires about 20 cfs, about 14,500 acre-feet a year, for plant operation. The principal communities, Ely, East Ely, McGill, and Ruth, obtain their public supplies mostly from springs, but a minor part comes from wells. The combined requirements for public supply may be on the order of 1,200 acre-feet a year.

To date, most of the water used for agriculture in the valley is derived from streams and springs. Much of the water is used on natural pasture or meadow land. However, the acreage of cultivated crops and improved meadow is increasing. Pumping ground water for irrigation has been practiced to a limited degree for many years, commonly to supplement other supplies but partly as the principal supply. In the last few years pumping ground water for irrigation has been 2,000 to 3,000 acre-feet a year. Further development of wells is in process following the release of Federal land under provisions of the Desert Land Act.

The general effect of pumping on the ground-water system is shown by hypothetical examples in which four pumping centers distributed along the valley lowland might withdraw water under either continuous or cyclic pumping patterns. Part of the water would be supplied by salvage of natural discharge, but a significant part would be derived from ground-water storage and some from water recycled within the well fields. With appropriate spacing of wells and of pumping centers drawdowns may remain moderate for several tens of years, with annual withdrawals of about 70,000 acre-feet.

INTRODUCTION

Steptoe Valley lies almost entirely within White Pine County (fig. 1). U. S. Highways 6, 50, and 93 provide ready access to other parts of Nevada and beyond. Secondary paved or graveled roads provide access to all sections of the valley under most weather conditions. The Nevada Northern Railroad links the Ely-McGill area with the Western Pacific Railroad at Shafter and the Southern Pacific Company Railroad at Cobre.

Ely, East Ely, McGill, and Ruth are the principal communities in the valley. Their economy is closely tied to the mining and ranching activities in the county.

Mining activity began with the discovery of gold in 1863 in Egan Canyon. Of the eight mining districts subsequently established within the drainage area of Steptoe Valley, the Ely (Robinson) district has had the most sustained and largest production. Minerals produced in the Ely district for the period 1908-60 have a reported value of \$814 million (Bauer, Cooper, and Breित्रich, 1960, fig. 1). Copper production has supplied more than 90 percent of the dollar value and gold and silver production the rest. Processing of the copper ore at McGill makes that industry the largest single user of water in the valley.

Ranching and farming began in the early days of mining to supply local needs in the valley. Livestock production gradually increased to supply more distant markets. In recent years farming too has been expanding through withdrawals of Desert Land for agriculture. Increased activity in recreation and tourism in recent years has added income to the area. Three oil tests drilled in the valley in 1965 attest to continued interest in the potential development of oil in eastern Nevada.

Purpose and Scope of the Report

Brief investigations are being made by the U. S. Geological Survey, in cooperation with the Department of Conservation and Natural Resources, to provide reconnaissance information on water resources for essentially the entire State. Previous reports of the Reconnaissance Series are listed at the end of this report. Areas discussed in the previous reports are shown in figure 2, which precedes the list of reports. This report on Steptoe Valley is the 42d of the reconnaissance series. It is based on a few weeks field investigation, mostly during 1965. The report provides preliminary evaluations of the ground-water system, including estimates of average natural recharge and discharge, surface-water runoff from the mountains, and chemical quality of the water.

Previous Reports

The principal previous report on the water resources of Steptoe Valley is that of Clark and Riddell (1920). They described general ground-water conditions and the location of then-existing wells, and measured the discharge of many streams and

springs in the valley. Their principal effort, however, was test drilling northwest of McGill to explore the possibility of developing ground water for irrigation in favorable desert valleys.

Acknowledgments

Many people in Steptoe Valley kindly supplied information pertinent to this investigation, for which the authors are most appreciative. Mr. Duane E. Everett and Mr. Otis Purkiss of the Geological Survey also assisted the authors, both in field and office operations, in this study.

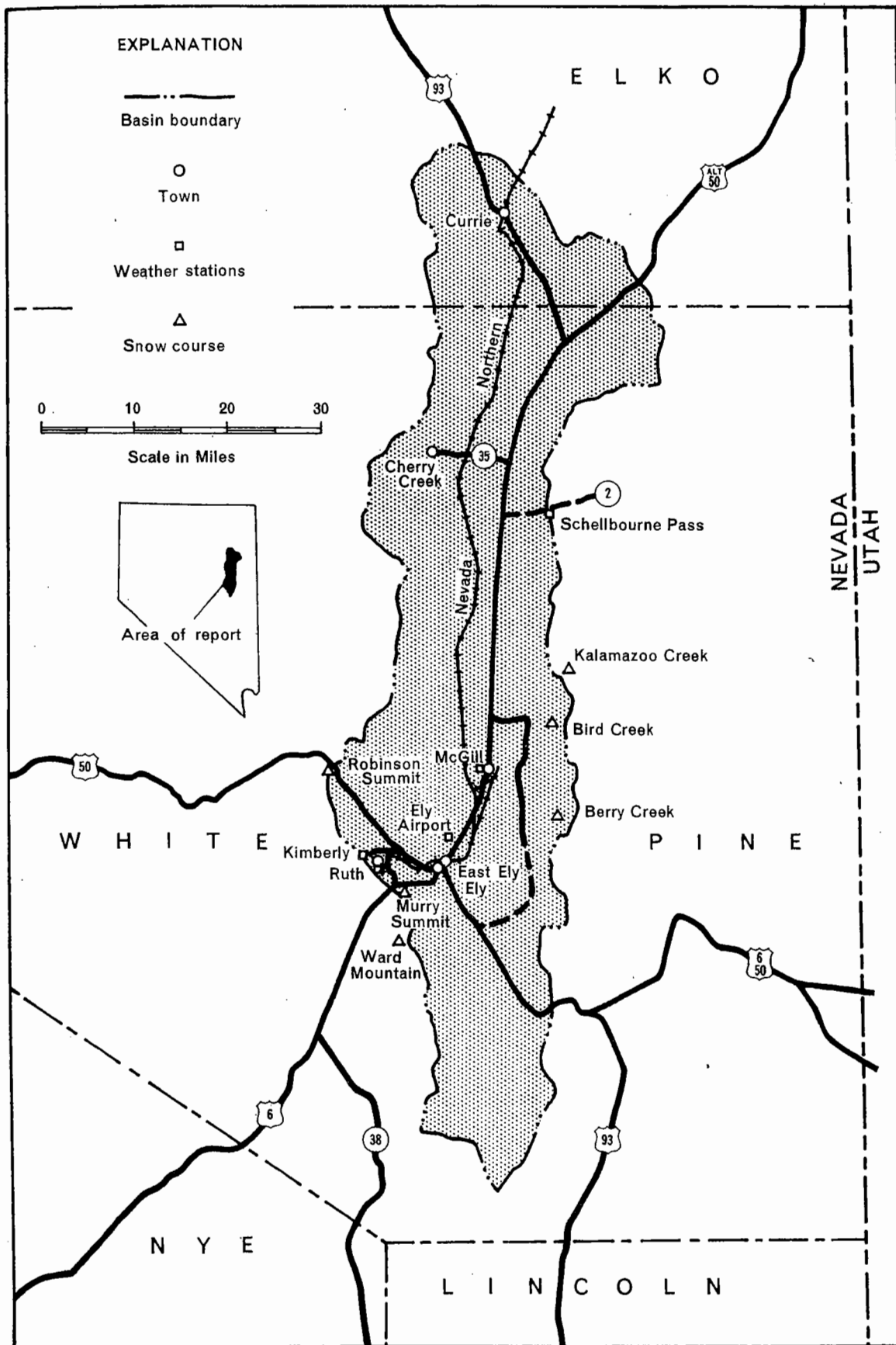


Figure 1.—Map of east-central Nevada showing principal roads, communities, weather stations, and snow courses in Steptoe Valley

PHYSICAL SETTING

Climate

Annual precipitation at the Ely Airport on the lowlands generally is less than 9 inches. Annual precipitation may average as little as 6 inches in the other lowland areas toward the north end of the valley. Precipitation at the higher altitudes in both the Egan and Schell Creek Ranges averages more than 20 inches, and locally may exceed 30 inches. Table 1 gives monthly and annual precipitation at five stations in Steptoe Valley. The winter accumulation of snow in the mountains is an important indication of runoff conditions in the spring. Table 2 gives the April 1 water content for the period of record at six snow courses in or adjacent to the drainage area of Steptoe Valley.

Steptoe Valley is characterized by a wide range in daily and seasonal temperatures. At McGill, the average annual temperature is 47.4°F. January and July have the lowest and highest average monthly temperatures. The average January temperature is 16.5°F, and the average July temperature is 71.2°F. McGill has recorded a maximum temperature of 100°F on several dates; the lowest recorded temperature was -25°F on January 20, 1937. At Ely Airport the average annual, January, and July temperatures are 44.1°F, 23.2°F, and 67.1°F, respectively. Daily ranges in temperature commonly are 30 degrees or more.

Houston (1950, p. 16) indicated the growing season for this area to be about 119 days. However, the average growing season may vary significantly, depending upon the relative topographic location in the valley. The growing season also varies substantially from year to year at a given location.

Table 1. Average monthly and annual precipitation, in inches,
at five stations
[From published records of the U. S. Weather Bureau]

| Station | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---------------------------------|------|------|------|------|------|------|------|------|-------|------|------|------|--------|
| Ely Airport ^{1/} | 0.68 | 0.62 | 0.97 | 1.05 | 0.93 | 0.83 | 0.57 | 0.48 | 0.64 | 0.71 | 0.61 | 0.58 | 8.65 |
| Kimberly ^{2/} | 1.50 | 1.45 | 1.57 | 1.28 | 1.07 | .67 | .86 | .90 | .69 | .88 | .82 | 1.41 | 12.77 |
| McGill ^{3/} | .71 | .68 | .77 | 1.00 | 1.05 | .78 | .67 | .83 | .57 | .75 | .55 | .62 | 8.91 |
| Ruth ^{4/} | .84 | 1.48 | 1.02 | 1.30 | .79 | 1.27 | .33 | .67 | .66 | .48 | .84 | .59 | 10.27 |
| Schellbourne Pass ^{5/} | .94 | 1.10 | 1.30 | 1.39 | 1.59 | .72 | .52 | .93 | .78 | .56 | .73 | .69 | 11.02 |

| <u>Altitude</u> | <u>Location</u> | <u>Period of record</u> | <u>Remarks</u> |
|-----------------|-----------------|-------------------------|--------------------------|
| 1. 6,257 feet | 17/63-35d | 25 years, 1939-64 | |
| 2. 7,232 feet | 16/62-8c | 30 years, 1928-58 | Gage moved to Ruth, 1958 |
| 3. 6,340 feet | 18/64-28c | 52 years, 1913-64 | |
| 4. 6,832 feet | 16/62-4d | 7 years, 1958-64 | |
| 5. 8,150 feet | 22/65-8a | 11 years, 1954-64 | |

Table 2.--Water content, in inches, as of April 1, at six snow courses

[From published records of the Soil Conservation Service]

| Year | Berry Creek ^{1/} | | Bird Creek ^{2/} | | Kalamazoo Creek ^{3/} | |
|------|---------------------------|------------------------|--------------------------|------------------------|-------------------------------|------------------------|
| | Date | Water content (inches) | Date | Water content (inches) | Date | Water content (inches) |
| 1948 | 3-29 | 14.2 | 3-29 | 6.8 | -- | -- |
| 1949 | 3-30 | 18.9 | 3-29 | 7.3 | -- | -- |
| 1950 | 4-03 | 16.7 | 4-03 | .0 | -- | -- |
| 1951 | 4-02 | 12.2 | 4-02 | .0 | -- | -- |
| 1952 | 4-01 | 30.7 | 3-31 | 11.3 | -- | -- |
| 1953 | 3-31 | 12.7 | 3-31 | .0 | -- | -- |
| 1954 | 4-01 | 17.6 | 4-01 | 4.6 | -- | -- |
| 1955 | 3-29 | 15.8 | 3-29 | 4.2 | -- | -- |
| 1956 | 3-27 | 17.9 | 3-27 | .0 | -- | -- |
| 1957 | 3-25 | 12.4 | 3-29 | .0 | -- | -- |
| 1958 | 3-24 | 16.4 | 3-24 | 6.0 | -- | -- |
| 1959 | 3-26 | 9.9 | 3-26 | .0 | 3-27 | 3.6 |
| 1960 | 3-28 | 10.9 | 3-28 | 1.0 | 3-30 | 2.6 |
| 1961 | 3-28 | 14.9 | 3-28 | 3.7 | 3-29 | 6.8 |
| 1962 | 3-29 | 24.0 | 3-29 | 5.3 | 3-30 | 10.4 |
| 1963 | 3-29 | 8.3 | 3-28 | 1.4 | 4-02 | 1.6 |
| 1964 | 4-01 | 11.3 | 4-01 | 2.7 | 3-27 | 7.3 |
| 1965 | 4-01 | 16.6 | 4-01 | 2.5 | 3-29 | 6.4 |

1. Berry Creek, altitude 9,100 feet, sec. 26, T. 17 N., R. 65 E.
2. Bird Creek, altitude 7,500 feet, sec. 34, T. 19 N., R. 65 E.
3. Kalamazoo Creek, altitude 7,400 feet, sec. 34, T. 20 N., R. 65 E.

Table 2.--Continued

| Murray Summit ^{4/} | | Robinson Summit ^{5/} | | Ward Mountain #2 ^{6/} | | |
|-----------------------------|------|-------------------------------|------|--------------------------------|------|------------------------|
| Year | Date | Water content (inches) | Date | Water content (inches) | Date | Water content (inches) |
| 1937 | 4-01 | 5.1 | -- | -- | -- | -- |
| 1938 | 4-01 | 2.3 | -- | -- | -- | -- |
| 1939 | -- | -- | -- | -- | -- | -- |
| 1940 | 4-01 | .4 | -- | -- | -- | -- |
| 1941 | 4-01 | 4.8 | -- | -- | -- | -- |
| 1942 | 4-02 | 2.8 | -- | -- | -- | -- |
| 1943 | 4-01 | .0 | -- | -- | -- | -- |
| 1944 | 4-01 | 5.6 | -- | -- | -- | -- |
| 1945 | 4-04 | 4.8 | -- | -- | -- | -- |
| 1946 | 4-02 | 3.0 | -- | -- | -- | -- |
| 1947 | 4-02 | .0 | -- | -- | -- | -- |
| 1948 | 3-29 | 4.2 | -- | -- | -- | -- |
| 1949 | 3-31 | 5.8 | -- | -- | -- | -- |
| 1950 | 4-03 | .0 | 4-01 | .0 | -- | -- |
| 1951 | 4-02 | .0 | 4-02 | .0 | -- | -- |
| 1952 | 3-30 | 12.7 | 3-30 | 14.0 | -- | -- |
| 1953 | 4-01 | .0 | 4-01 | .0 | -- | -- |
| 1954 | 3-31 | 4.5 | 3-31 | 2.9 | -- | -- |
| 1955 | 3-28 | 4.2 | 3-28 | .0 | -- | -- |
| 1956 | 3-29 | .0 | 3-29 | .0 | -- | -- |
| 1957 | 3-29 | .0 | 3-29 | .0 | 3-28 | 8.5 |
| 1958 | 3-25 | 2.7 | 3-25 | 1.0 | 3-25 | 14.0 |
| 1959 | 3-25 | .0 | 3-25 | .0 | 3-25 | 8.4 |
| 1960 | 3-29 | .0 | 3-29 | .0 | 3-29 | 8.7 |
| 1961 | 3-27 | 2.0 | 3-31 | 1.8 | 3-27 | 7.6 |
| 1962 | 3-28 | 4.4 | 3-30 | 1.8 | 3-28 | 21.9 |
| 1963 | 3-26 | .0 | 3-26 | .0 | 3-26 | 3.9 |
| 1964 | 4-02 | 3.3 | 4-03 | 2.8 | 4-02 | 8.2 |
| 1965 | 4-02 | T | 3-29 | T | 4-02 | 12.2 |

4. Murray Summit, altitude 7,250 feet, sec. 25, T. 16 N., R. 62 E.

5. Robinson Summit, altitude 7,600 feet, sec. 34, T. 18 N.,
R. 61 E.

6. Ward Mountain #2, altitude 8,900 feet, sec. 25, R. 15 N.,
R. 62 E.

Landforms and Drainage

Steptoe Valley, as used in this report, essentially is the same as used by Clark and Riddell (1920) in their study. However, in the present study the northern boundary was shifted northward to cross the axial drainage through the gap about 5 miles north of Currie. The drainage area added to that used by Clark and Riddell includes McDermitt and Cottonwood Creeks, Twin Springs about 7 miles northwest of Currie, and the spring areas on the alluvial apron and lowlands south and west of Currie. The Steptoe Valley drainage area as thus defined provides a more complete hydrologic entity. It is noted however that many maps show Steptoe Valley as extending northward to perhaps the vicinity of Shafter. Such extension tends to weaken the value of using the name of Steptoe Valley as a topographic and hydrologic unit.

Steptoe Valley, as restricted (pl. 1), extends from its southern boundary northward 110 miles to the bedrock narrows 5 miles north of Currie. Between drainage divides, the valley is about 30 miles wide near McGill, but commonly its width is less than 20 miles. The total drainage area of the valley is 1,975 square miles.

The lowest point is somewhat less than 5,800 feet above sea level near Currie. North Schell Peak, altitude 11,890 feet, east of McGill is the highest point.

Steptoe Valley may be divided into three general physiographic units--the mountains, alluvial apron, and the valley lowland.

Mountains

The crest of the Schell Creek Range, east of McGill, exceeds an altitude of 11,000 feet for a distance of more than 10 miles. Elsewhere the higher peaks of the Schell Creek and Egan Ranges and Cherry Creek Mountains commonly exceed 10,000 feet. These mountains are 3,000 to 5,000 feet higher than the adjacent valley floor. The flanks of the mountains generally are deeply incised. The gradients of the canyons draining the mountains usually exceed 500 feet per mile and locally exceed 1,000 feet a mile.

The steep slopes aid the production of runoff. However, some upland areas have much flatter slopes, a condition which tends to reduce runoff. The most extensive area of low-gradient upland is in the Currie and Boone Spring Hills and Antelope Range. Other areas are in the south end of the valley and northwest of Ely.

Alluvial Apron

The alluvial apron occupies an area of intermediate slope between the mountains and the valley lowland. Surface gradients commonly are 200 to 300 feet per mile but are as much as 500 feet per mile adjacent to the mountains.

Some parts of the alluvial apron are veneered by unconsolidated deposits overlying an eroded surface of consolidated or partly consolidated rock. These surfaces, called pediments, occur opposite mountain segments with poorly developed canyons and between some of the principal canyons. There are large alluvial fans at the mouths of some of the principal canyons. The alluvial fan formed by deposits from the Duck Creek drainage area is of remarkable size. The fan extends westward 7 miles from the apex at Gallagher Gap. It displaces the axis of valley drainage westward several miles. It is estimated that the maximum thickness of the alluvial deposits forming the fan may exceed 300 feet near the apex. For the most part, however, the thickness of unconsolidated alluvium underlying the surface of much of the alluvial apron probably is 200 feet or less.

Valley Lowland

The valley lowland has a general northward gradient of a little more than 9 feet per mile. The gradient, however, is not uniform. It is about 15 feet per mile for several miles south of Comins Lake. Between Comins Lake and Ely it increases to about 18 feet per mile. The gradient further increases to about 30 feet per mile between Ely Airport and west of McGill. Northward from the latitude of McGill the gradient decreases. Between Warm Springs Station and Schellbourne the gradient is about 5 feet per mile. Between Cherry Creek highway and Currie, the gradient averages about 3 feet per mile although in the Goshute Lake segment the gradient probably is less than one foot per mile.

The lowland ranges in width from about one-quarter mile in the restricted flood-plain segments south of Ely to more than 7 miles in the Goshute Lake area in the north.

Most of the valley lowland is a flood plain incised in the lower parts of the alluvial apron by streamflow through the valley in late Pleistocene time. The bluffs, bounding the flood plain, are most prominent and the flood plain is narrowest south of Ely and in the narrow part of the valley in the vicinity of Warm Springs Station. Tributary stream channels are graded to the valley lowland.

Drainage

Duck and Steptoe Creeks which drain the higher parts of the Schell Creek Range, are the principal streams in the valley. Several smaller creeks, such as Wilson and Big Indian Creeks, drain the Schell Creek Range north of Duck Creek. Murry and Gleason Creeks drain the Egan Range in the vicinity of Ely. Goshute and McDermitt Creeks drain parts of the Cherry Creek Mountains in the northern part of the valley. Flow in most streams reaches the valley lowland only during periods of high runoff from snowmelt or high-intensity precipitation. However, Steptoe Creek is perennial to the floor of the valley. Water from Duck Creek is routed

pipeline through the smelter at McGill, but then is discharged into the valley lowland. A through-flowing stream drained Steptoe Valley through the gap north of Currie during parts of Pleistocene time. Now, flow occurs from Steptoe Creek through the valley and beyond Currie only when runoff is large.

During early March 1966, lowland snowmelt, together with runoff from Steptoe and Duck Creeks, produced a flow of 15 cfs or more, in the lowland at least as far north as the Cherry Creek road.

Geology and Water-Bearing Character of the Rocks

Consolidated rocks exposed in the mountains include clastic, carbonate, and intrusive and extrusive igneous rocks. These rocks range in age from Precambrian to Tertiary. Unconsolidated and some partly consolidated deposits of Quaternary silt, sand, and gravel underlie most of the alluvial apron and valley lowland.

As much as 12,500 feet of Precambrian and Cambrian partly metamorphosed clastic rocks have been described by Woodward (1964) in the northern Egan Range and by Young (1960) in the northern Schell Creek Range. A middle Paleozoic carbonate section has been described in several localities; the stratigraphic thickness is about 21,000 feet in the southern Egan Range (Kellogg, 1966), 16,100 feet in the northern Egan Range (Woodward, 1964), 15,000 feet in the northern Schell Creek Range (Young, 1960), and 16,000 feet in Spruce Mountain about 20 miles north of Currie (Harlow, 1956). Woodward (1964) described 4,100 feet of shale, siltstone, and limestone overlying the Paleozoic carbonate section in the northern Egan Range. Shale and limestone of early Mesozoic age, possibly exceeding 3,000 feet in thickness, have been reported by Snelson (1955) north of Currie. Young (1960) has described a volcanic rock assemblage of Tertiary age as much as 3,500 feet thick, and about 1,000 feet of conglomerate which unconformably overlies the volcanic rocks in the northern Schell Creek Range. An unknown thickness of unconsolidated to partly consolidated clay, silt, sand, and gravel of Tertiary and Quaternary age underlies the floor of Steptoe Valley. Clark and Riddell (1920, p. 22) reported that well 19/63-12a1, 915 feet deep, encountered prevalently clayey deposits below 124 feet. They interpreted these clayey deposits as lake beds.

For hydrologic purposes, the consolidated rocks are grouped into four units on plate 1. The Precambrian and Lower Cambrian clastic rocks and the Cretaceous or Tertiary intrusive rocks are two units generally considered to be a barrier to lateral ground-water movement. The Precambrian and Lower Cambrian clastic rocks provide the lower limit to ground-water circulation. The extensive occurrence of these clastic rocks in the headwater tributary streams of Duck Creek undoubtedly is a significant factor in the relatively large runoff from this area. Another unit of generally limited capacity to transmit water includes volcanic and sedimentary rocks principally of Tertiary age but includes some rocks of

mesozoic age north of Currie. Volcanic rocks are the most widely distributed rocks of this unit, particularly in the Schell Creek Range north of Duck Valley and in the Currie and Boone Spring Hills.

The fourth unit of consolidated rocks consists mostly of paleozoic carbonate rocks. In part, these rocks transmit water slowly, especially where they are metamorphosed. However, secondary fractures or solution openings in the carbonate rocks locally transmit substantial quantities of water. In Steptoe Valley, as in much of eastern Nevada, ground water transmitted in carbonate rocks is the principal supply for Murry, McGill Warm Springs, and many other large springs.

The valley fill is of Quaternary age in most of the area shown on plate 1. It is divided into two units--older and younger. The older valley fill includes unconsolidated to partly consolidated silt, sand, and gravel mainly forming the surface of the alluvial apron. The maximum thickness probably is more than 1,000 feet. Most of the older valley fill probably has a moderate to low permeability. However, these deposits have a large saturated volume and thus contain a large quantity of ground water in storage.

The younger valley fill consists of Recent silt, sand, and gravel along the valley lowland and the flood-plain segments of tributary channels. In the wider parts of the lowland in the north half of the valley the younger valley fill may include lacustrine clays. Limited information suggests that the younger valley fill may not exceed 150 feet in thickness. The saturated sand and gravel deposits of the younger valley fill yield water freely to wells.

HYDROLOGY

The water in the hydrologic system of Steptoe Valley is supplied by precipitation. Evaporation and transpiration are the dominant processes by which water is removed from the valley, although a minor amount leaves the valley either as streamflow or underflow in the gap north of Currie. Between the time of precipitation and evapotranspiration the permeability of the soil and rocks provides a significant control on the distribution and movement of both surface water and ground water in the valley. Most of the precipitation is removed by evapotranspiration from where it falls either immediately or after a period of temporary storage principally as snow or soil moisture. The remainder enters the streamflow or ground-water systems from which it is later removed by evapotranspiration.

Precipitation

The distribution and amount of precipitation are influenced significantly by topography in Steptoe Valley. Average monthly and annual precipitation for five stations were given previously in table 1. Figure 3 shows the annual trend of precipitation as cumulative departure from average precipitation at three of these stations for their respective periods of record. The 53-year period of record for McGill shows two relatively wet periods--1915 to 1923 and 1935 to 1947, and two relatively dry periods--1925 to 1935 and 1947 to 1962. The early record for Ely indicates a wet period from 1893 to 1900 followed by a dry period. The shorter Kimberly and Ely Airport records generally are consistent with the longer McGill record for the periods of overlap. The Ely Airport record is not shown on figure 3.

Variation in precipitation also is shown by the tabulation of quartile distribution and maximum and minimum monthly and annual precipitation for Ely Airport, Kimberly, and McGill stations in table 3. The median and quartile values divide the period of record into four equal parts, that is, 25 percent of the years (or individual months) of record have values between the maximum year and the upper quartile, between the upper quartile and median, between the median and lower quartile, and between the lower quartile and the minimum. Thus, annual precipitation at McGill was between 16.21 inches (maximum) and 11.29 inches (upper quartile) during 25 percent of the 53 years of record. Similarly, precipitation was between 8.58 inches (median) and 7.01 inches (lower quartile) during 25 percent of the 53 years of record.

Half of the annual precipitation occurs during the period December through May. Much of the winter precipitation accumulates as snow which, when it melts, contributes significantly to the spring runoff.

The precipitation at the several stations listed in table 1 shows a general increase with altitude. It is evident that this

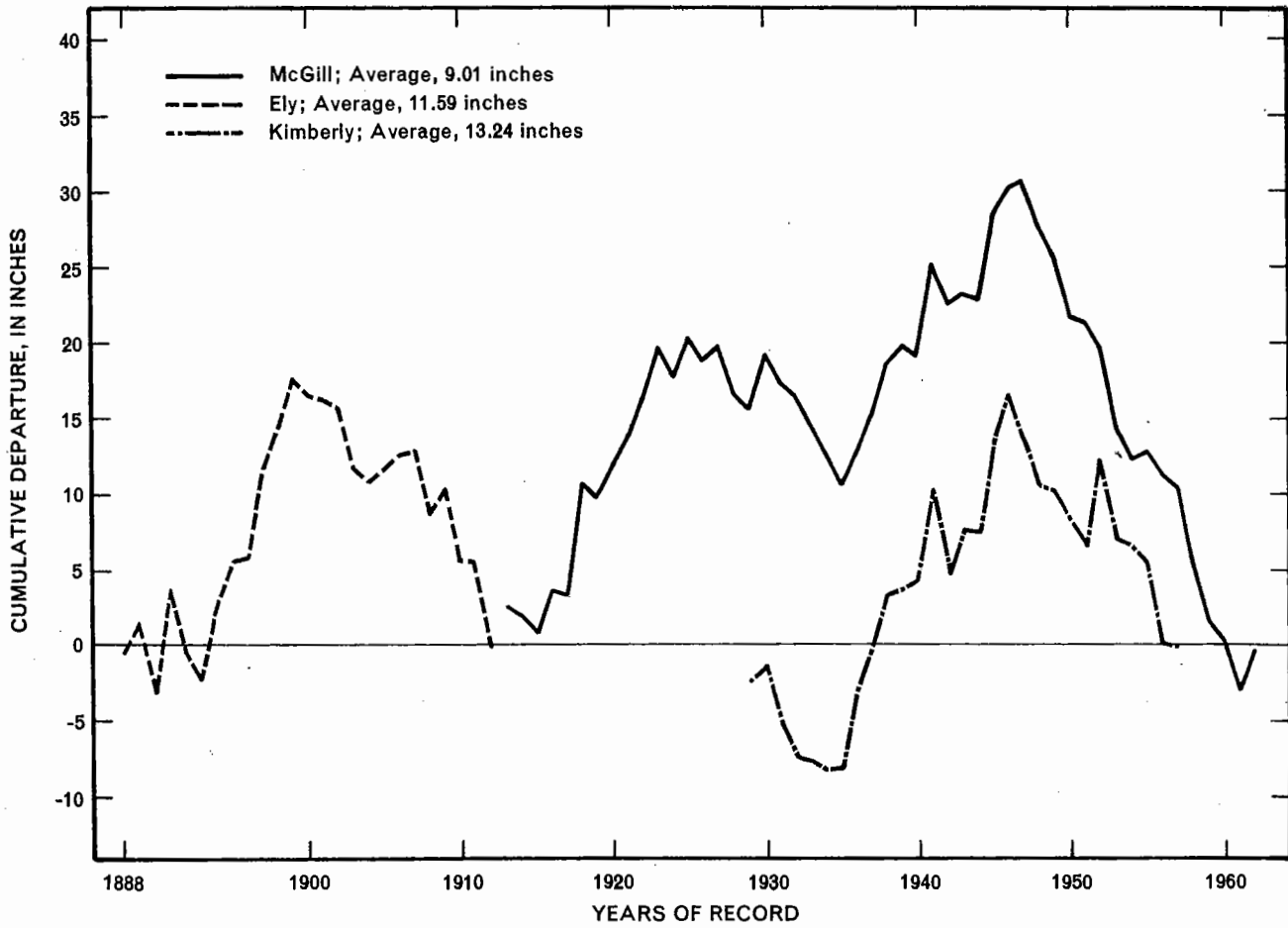


Figure 3.—Cumulative departure from average annual precipitation at McGill (1913-63), Ely (1888-1912) and Kimberly (1929-57)

relation is not uniform. Further, variation occurs at a given altitude due to differences of exposure, orientation, local relief, and other factors. However, for general purposes, the magnitude of average precipitation can be estimated from the precipitation map of Hardman and Mason (1949, p. 11), revised by Hardman in 1964.

The average volume of precipitation on the 1,975 square-mile drainage area of Steptoe Valley is estimated to be on the order of 870,000 acre-feet. This is obtained by multiplying the value for average precipitation of the several zones times the acreages of the respective zones, as shown on table 7 in the section on ground-water recharge. Actual precipitation in a given year may be greater or less than this amount, but the value indicates that a substantial amount of precipitation falls on the valley.

Surface Water

Duck and Steptoe Creeks are the principal streams in Steptoe Valley. They drain the highest yielding part of the Schell Creek Range (pl. 1). Duck Creek is diverted by pipeline to supply the requirements for copper production at McGill, and a significant quantity of the waste water from the plant operations reaches the valley lowland. Steptoe Creek is perennial to the valley lowland in the Comins Lake area. During periods of high flow, Steptoe Creek flows northward along the valley axis and is joined by water of Duck Creek west of McGill.

Bassett Lake, about 6 miles northwest of McGill, is formed by a small dam across the valley lowland. The lake is supplied by water from Steptoe Creek, Duck Creek, outflow from the McGill plant, McGill springs, and springs in the lowland west of McGill. Outflow from the lake in part is diverted to a ditch along the east side of the lowland for irrigation.

Under favorable runoff conditions, outflow from Bassett Lake may flow northward to Goshute Lake. This flow may be augmented from tributary flow north of Bassett Lake. Flow through the gap north of Currie generally is derived from runoff generated in the north end of the valley. The amount ordinarily is not large and may average on the order of 1,000 acre-feet per year.

Several small streams, partly maintained by springs in the Schell Creek Range between Duck Creek and Schellbourne Pass, supply ranch needs in that area. Their flows may reach the valley lowland during spring runoff.

McDermitt and Goshute Creeks are the principal streams draining parts of the Cherry Creek Mountains at the north end of the valley. Egan Creek drains a small high tributary valley between the north end of the Egan Range and the south end of the Cherry Creek Range. Most of the low flow of Egan Creek is sustained by flow from a mine adit. Elsewhere, streamflow largely

limited to seasonal runoff in the spring or for short periods after high-intensity rainfall.

Springs supply significant quantities of water for irrigation along the west side of the valley in several areas northward from Cherry Creek, southward from Steptoe, and in the Comins Lake area. Murry Springs in Murry Canyon south of Ely are the principal source of public supply for Ely and East Ely. Unused or waste water from the public-supply system discharges to the lowland northeast of Ely where it is used, at least in part, for irrigation. McGill Warm Springs (inside cover photograph) provide water for a municipal swimming pool and part is used for copper production; the unused part discharges to the valley lowland. Smaller springs occur elsewhere and are used for irrigation, livestock, or ranch supplies.

Available Records

Miscellaneous discharge measurements of streams and springs made during this investigation are listed in table 4. The locations of the 53 points are shown on plate 1. Clark and Riddell (1920) measured streams and springs at 36 points during their investigation in 1918. These miscellaneous measurements were used in estimating runoff from the mountains within the drainage area of Steptoe Valley. In 1966 a gaging station was installed on Steptoe Creek.

Some additional records of flow have been obtained for operational purposes. Thus, the flow of Murry Springs has been recorded at various times. Figure 4 shows the general flow of Murry Springs during an interval of good control. A partial record of flow of Steptoe Creek was obtained during the period 1961-64 by R. W. Millard and Associates, Inc., in a water-use study for the CCC Ranch.

Records of flow of Duck Creek, which includes that of its principal tributaries, Berry and Timber Creeks, have been kept for some 30 years in connection with plant operations at McGill. Generally, flow in excess of 20 cfs (cubic feet per second) is diverted past the point of measurement just upstream from Duck Creek Reservoir. Much of the low flow of Duck Creek tributaries, such as Timber Creek shown in the cover photograph, is carried in pipelines across the alluvial fans to reduce low-flow losses. Thus, the record only approximately represents natural flow conditions.

Table 4.--Miscellaneous measurements of selected springs and streams, October 1965

| Name | Approximate number of springs | Location ^{1/} | Discharge (cfs) | Temperature (°F) | Sampled ^{2/} | Remarks |
|---------------------------------|-------------------------------|------------------------|-----------------|------------------|-----------------------|---|
| Lower Cattle Camp Spring | 1 | 11/65-7d | 0.01 | 53 | Yes | |
| White Rock Springs | 3 | 12/63-1,2,12a | .01 | 46 | Yes | Issues from Quaternary alluvium, tuff and limestone crops out nearby. |
| Cold Springs | 2 | 12/65-11c | .01 | 41 | No | |
| Spring | 1 | 12/65-17d | .01 | 46 | No | |
| Horse Corral Springs | 4 | 12/65-21b | .07 | 42 | No | Issues from Quaternary alluvium, limestone crops out nearby. |
| Upper Cattle Camp Spring | - | 12/65-27a | .01 | 46 | No | |
| Cabin Spring | 1 | 13/63-14d | .01 | 43 | No | |
| Willow Creek Springs | 2 | 14/63-35a | 1.39 | -- | Yes | |
| Springs | - | 15/64-5,8 | 1.00 | -- | -- | |
| Comins Lake Springs | - | 15/64-28b,29a | .71 | -- | -- | |
| North Fork Steptoe Creek | 3 | 15/65-5c | 5.28 | 43 | No | Gaining stream. |
| Cave Creek | 1 | 15/65-17c | 2.80 | 44 | Yes | |
| Lackawanna Springs | 5 | 16/63-3a | .30 | 90-95 | Yes | Measured at Silver King water tanks. |
| Murry plus Georgetown Springs | 5 | 16/63-10a | 3.40 | 46 | Yes | Measured below railroad tracks. |
| Murry Spring overflow | 1 | 16/63-10c | .79 | 52 | Yes | Measured above railroad tracks. |
| Spring | 1 | 17/63-9c | .03 | -- | No | |
| Berry Creek | - | 17/65-11c23b | 5.68 | -- | -- | |
| Spring | - | 18/62-3d | .01 | 41 | No | |
| Cottonwood Spring | 1 | 18/62-6b | .11 | 40 | -- | |
| Springs | 2 | 18/62-12c,18a | .01 | 40 | No | |
| McGill Springs | - | 18/64-21b | 10.20 | -- | Yes | |
| Timber Creek | - | 18/65- | 2.52 | -- | -- | Measured at three sites, (refer to map). |
| Campbells embayment | - | 19/63- | 10.6 | -- | Yes | Sum of approximately 60 springs measured at 25 sites. |
| Bassett Lake Outlet | - | 19/63-35b | 14.96 | 52 | Yes | |
| Spring (Descio Ranch) | 1 | 19/64-25a | .18 | -- | -- | |
| Duck Creek overflow | - | 19/64-25c | .74 | -- | -- | |
| North Creek | - | 19/65-9,10 | .27 | -- | -- | Measured at 19/65-7a. |
| East Creek | - | 19/65-22 | 1.15 | -- | -- | |
| Third Creek Springs | - | 20/65-8c | .18 | 43 | No | |
| Second Creek Springs | 2 | 20/65-28c | .22 | 42 | Yes | |
| Wilson Creek Springs | 2 | 21/65-18c | .59 | 44 | No | |
| Big Indian Creek Springs | 2 | 21/65-30c | .95 | 44 | No | Measuring site 21/64-26d. |
| Lambert Ranch Springs | 5 | 22/64-36d | .01 | -- | No | |
| Upper Schellbourne Pass Spring | 1 | 22/65-5c | .54 | 71 | No | |
| Lower Schellbourne Pass Springs | 3 | 22/65-7b | .70 | -- | -- | |
| Spring | - | 22/65-19 | .39 | -- | -- | |
| Lambert Ranch Springs | 2 | 22/65-31b | .46 | 43 | No | |
| Egan Creek Springs | 2 | 23/65-14a,c | .86 | 57 | Yes (adit) | Mine adit measured 0.67 cfs; stream, 0.19 cfs. |
| Spring | 1 | 24/63-30a | .02 | 42 | No | Water discharges from adit. |
| Springs | 3 | 24/64-25a | .25 | -- | -- | |
| Goshute Creek | - | 25/63-12c | 1.74 | 52 | Yes | |
| Springs | - | 25/64-5,8 | -- | -- | -- | |
| Springs | 5 | 25/64-30a,c | .67 | -- | No | |
| Becky Springs | 4 | 25/65-13a | .02 | 52 | -- | |
| Indian Canyon Springs | - | 26/64-19d,22c | .46 | 47 | No | |
| Spring | - | 26/64-33 | 2.1 | -- | -- | |
| Collar and Elbow Spring | 1 | 26/65-33a | .01 | -- | No | |
| Spring | - | 27/63-6b | .02 | -- | -- | |
| McDermitt Ranch Springs | 2 | 27/63-34c | 6.01 | 50 | No | Measured at 27/63-34a, d. |
| Currie Springs | - | 27/64-4,9,10 | 3.00 (est.) | -- | No | |
| Springs | - | 28/63-36 | -- | -- | -- | |
| Springs | 2 | 28/64-16c,d | .01 | -- | -- | |
| Twin Springs | 2 | 29/63-35a | 2.5 (est.) | 61 | Yes | |

1. Measuring points shown on plate 1. Measurements expressed as 0.01 indicates very small discharge.

2. Sampled for chemical analysis. Refer to table 11. Sample sites shown on plate 1.

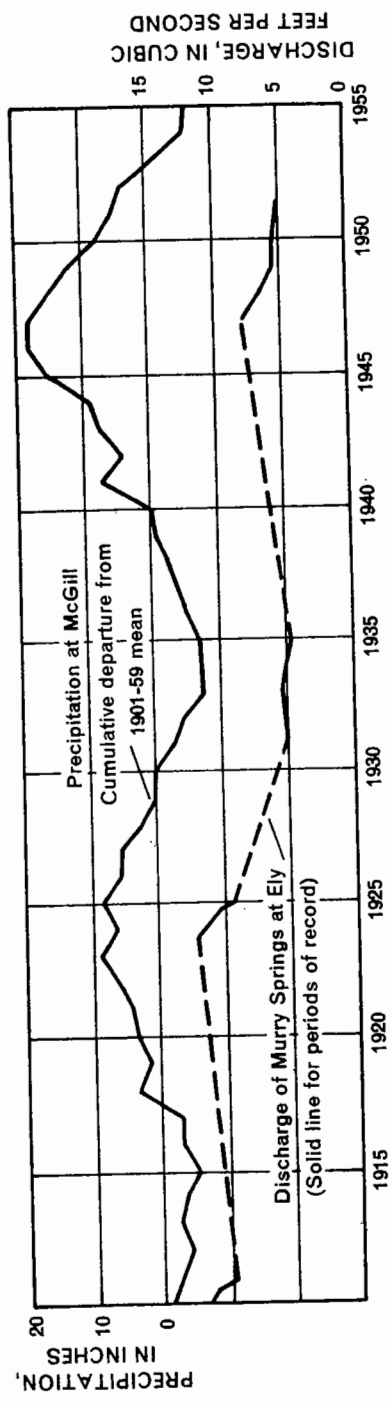


Figure 4.—Hydrograph of Murry Springs at Ely, (After Thomas, 1963)

Estimated Runoff from the Mountains

A reconnaissance technique for estimating runoff from mountain areas recently has been developed for areas where few streamflow data are available. The general method has been described by Riggs and Moore (1965, p. D199-D202). By means of short-period or miscellaneous measurements, adjustments of regional values can be made to compensate for local variations in precipitation, geology and soils, topography, and vegetation.

The estimated average annual runoff from the mountains is 78,000 acre-feet (table 5). Nearly half the runoff comes from the drainage areas of Duck and Steptoe Creeks. About 20 percent of the runoff is derived from the Cherry Creek Range and most of this is developed in the areas drained by McDermitt and Goshute Creeks.

The above estimate is for runoff from the mountain areas generally above 7,000 feet. Runoff also occurs from precipitation on the alluvial apron and valley lowland, although generally this runoff is erratic and less susceptible to management for use. An impressive example of lowland runoff occurred in early March 1966. Accumulated snow on the valley lowland melted during a several-day period of mild temperatures. The rapid melting resulted in a large volume of water thinly spread over much of the lowland. Part of this melt-water collected into channels as lowland runoff. Runoff so generated contributed significantly to the flow of Steptoe and Duck Creeks in their lowland segments.

Table 5. -- Estimated average annual runoff

(Based on record at Cleve Creek near Ely extended to 1915-23, 1945-65)

| Mountain segment | Location | Area | | Estimated runoff (percent of (Acre-feet per year) total runoff) |
|---|--|----------|--------------------------|--|
| | | Acres | (percent of runoff area) | |
| Schell Creek Range (including Luck Creek Range) | West flank of mountain above 7, 000 feet | 286, 000 | 53 | a 52, 000 67 |
| Egan Range | East flank of mountains above 7, 000 feet | 162, 000 | 30 | 11, 000 14 |
| Cherry Creek Range | East flank of mountains above 7, 000 feet | 95, 000 | 17 | 15, 000 19 |
| Total | | 543, 000 | 100 | 78, 000 100 |

a. Of this total about 37, 000 acre-feet is derived from the drainage area between and including Steptoe Creek and East Creek, a tributary of Duck Creek.

For the most part, however, usable streamflow is derived by runoff from the mountains. Limited data for Duck and Steptoe Creeks indicate that most of the runoff from these mountains is supplied from snowmelt during the spring months. This is better illustrated by the record of Cleve Creek, the nearest stream for which published records are available. Cleve Creek drains a part of the east flank of the Schell Creek Range. Its drainage divide in part is coincident with those of Duck and Steptoe Creeks.

The monthly distribution of streamflow of Cleve Creek is given in table 6. The graphs of monthly discharge in percent of mean annual discharge are shown in figure 5. The data show that about 45 percent of the mean annual runoff occurs in the three spring months, April through June. Of course, in a given year, runoff may be distributed quite differently than for the average conditions. Thus, mild winter temperatures may result in distributing much of the snowmelt through several months preceding April. On the other hand, if much of the annual precipitation occurs as summer thundershowers, a significant part of the annual runoff may occur during the summer months.

The disposal of the indicated runoff was not measured directly for the purposes of showing the general proportions of the hydrologic system in the budget discussed later in the report. However, some of the runoff, (a) is lost by evapotranspiration as it flows on the valley fill and as diversion to irrigate cultivated crops, wet meadow, or pasture, either directly or after a period of retention as soil moisture, (b) recharges the groundwater reservoir and, (c) reaches the valley lowland where it is lost by evapotranspiration either directly or after a period of retention as soil moisture or ground water or, to a minor amount, becomes outflow through the gap at the north end of the valley. A general evaluation of the flow system in Steptoe Valley suggests that the approximate average magnitude may be about 26,000, 24,000, and 28,000 acre-feet per year for item (a), (b), and (c), respectively. The proportionally large value of 28,000 acre-feet for runoff to the valley lowland results from a significant part of the flow of Duck Creek being routed to the valley lowland and a large part of the flow of Steptoe Creek being used for irrigation on the valley lowland.

Table 6. -- Summary of streamflow of Cleve Creek near Ely

(Discharge in cubic feet per second; periods of record, 1915-16 and 1960-65)

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Year |
|---------------|------|------|------|------|------|------|------|------|------|------|------|-------|--------|
| Average | 5.93 | 6.15 | 5.64 | 5.41 | 6.09 | 7.14 | 11.6 | 16.9 | 16.3 | 8.04 | 6.45 | 5.90 | 8.46 |
| Maximum month | 3.76 | 8.97 | 7.25 | 8.09 | 8.05 | 14.8 | 24.4 | 24.2 | 27.2 | 10.1 | 8.79 | 8.23 | a 10.7 |
| Minimum month | 4.56 | 4.53 | 4.27 | 4.05 | 4.42 | 4.65 | 6.34 | 8.58 | 6.25 | 4.96 | 3.99 | 3.75 | b 5.15 |

a. Average for maximum recorded water year.

b. Average for minimum recorded water year.

Ground-Water

The principal ground-water reservoir is in the valley-fill deposits of Steptoe Valley. Water occupies the open spaces between the individual particles of the unconsolidated to partly consolidated silt, sand, and gravel. The top of the zone of saturation or water table is within a few feet of land surface throughout most of the valley lowland northward from McGill. It also is shallow in the lowland near Ely and Comins Lake, but is deeper along the valley axis southward from the Comins Lake area. The depth to water generally increases toward the mountains beneath the alluvial apron. The water-level contours (see pl. 1) show the general form of the water table. The water-level gradient slopes toward the valley axis from the mountains and northward along the axis of the valley and conforms in a subdued way to the general slope of the land surface.

Ground water also occurs in fractures or solution openings in the consolidated rocks, especially the Paleozoic carbonate rocks. Ground water has been encountered extensively in drilling and underground mining operations in the Ruth-Kimberly area. Many of the springs in the mountains attest to the fact that ground water occurs and is transmitted in the consolidated rocks. The large yields of Murry and McGill Springs indicate that the consolidated rocks locally transmit substantial quantities of water. However, water occurs in and is transmitted through only a small fraction of the total volume of consolidated rocks.

Ground water in the consolidated rocks and in the valley fill is supplied by recharge from precipitation. The higher average precipitation in the mountains and its accumulation as snow during the winter months is favorable for recharge to the ground-water reservoir in the valley fill. Water moves from the high areas in the mountains toward the valley lowland where most of the ground water is discharged by evapotranspiration. The natural recharge to a ground-water system tends to equal natural discharge during extended periods of climatic equilibrium. Within such periods, however, intervals occur when recharge is greater than or less than discharge, and these will be reflected in corresponding increases or decreases in ground-water storage.

The extensive spring area along the west side of the lowland in Campbell Embayment has given rise to speculation that some or most of the water of the springs is supplied from Butte Valley to the west. Data and estimates obtained in this investigation suggest there is sufficient recharge within the drainage area of Steptoe Valley to supply the estimated discharge; indeed, the recharge estimate is higher than the natural discharge estimate. The altitude of the water level in the valley-fill reservoir of Butte Valley is roughly 6,125 feet at the topographically low part of the valley floor in T. 21 N., R. 61 E. This altitude is only slightly higher than the approximate 6,100-foot altitude of the western line of springs in Campbell Embayment in Steptoe Valley. The distance between the two areas is at least 12 miles. The indicated potential gradient between these two areas toward

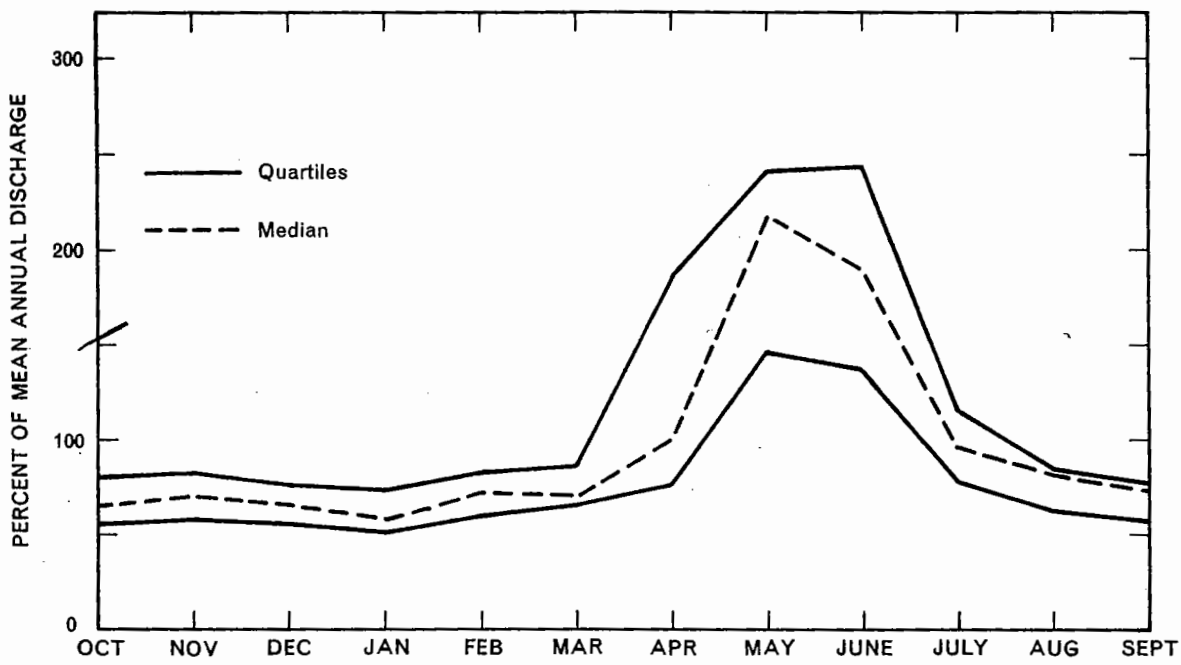


Figure 5.—Monthly discharge in percent of mean annual discharge of Cleve Creek

Steptoe Valley, is very low. Further, the Egan Range, which is between the two areas, receives moderate precipitation. The proportionally small runoff from the range suggests that ground-water recharge may be proportionally high. Thus, Egan Range is inferred to represent an hydraulic high, and be an effective barrier to ground-water flow between the valley-fill ground-water reservoirs in Butte and Steptoe Valleys.

Estimated Average Annual Recharge

An empirical method has been used (Eakin and others, 1951) to estimate ground-water recharge. Precipitation is assumed generally to increase with altitude, and the proportion of precipitation reaching the ground-water reservoir is assumed generally to increase with increased precipitation. The lowest zone in which effective precipitation occurs is considered to be the middle to upper segments of the alluvial apron. The precipitation map of Nevada (Hardman and Mason, 1949, p. 10) modified by Hardman in 1964 is used for delineation of the precipitation zones. Areas of the precipitation zones are determined approximately at altitude increments of 1,000 feet. The area of these zones times the average precipitation times the assumed percentage of recharge equals the estimated recharge from precipitation in that zone. The sum for the several zones then gives the average annual recharge for the valley. Table 7 gives the pertinent values. The estimated average annual recharge to Steptoe Valley of 85,000 feet is 7 percent of the total precipitation, this is somewhat higher than the percentages for most valleys in this part of the State, which commonly average about 5 percent. This in turn suggests that the estimate of recharge may be high.

Table 7. -- Estimated average annual precipitation and ground-water recharge

| Precipitation range (inches) | Approximate equivalent altitude zone (feet) | Effective area represented by this zone (acres) | Average annual precipitation | | Estimated recharge |
|------------------------------|---|---|------------------------------|-----------------------------|----------------------|
| | | | (feet) | (acre feet) | |
| | | | Percentage of precipitation | Percentage of precipitation | (acre-feet per year) |
| > 20+ | above 9,000 | 57,000 | 1.75 | 100,000 | 25,000 |
| 15 to 20 | 8,000 to 9,000 | 156,000 | 1.46 | 230,000 | 34,000 |
| 12 to 15 | 7,000 to 8,000 | a 266,000 | 1.12 | 300,000 | 21,000 |
| 8 to 12 | 6,000 to 7,000 | b 213,000 | 0.83 | 180,000 | 5,400 |
| < 8 | below 6,000 | 573,000 | 0.6 | 340,000 | -- |
| Total (rounded) | -- | 1,265,000 (1,975 sq. mi.) | -- | 1,200,000 | 85,000 |

a. About 29,000 acres of the zone was shifted to the 6,000-to 7,000-foot zone for computing recharge on the basis that the next lower zone was more typical of recharge conditions; additionally, about 184,000 acres of this zone were considered to have essentially no effective recharge and thus were shifted to the lowest zone for computing valley area.

b. About 340,000 acres of this zone are on the lower part of the alluvial apron and were considered out of the topographic position of assumed effective recharge; the area was shifted to the less-than-6,000-foot zone for purposes of computing valley area.

Estimated Average Annual Discharge

Ground water is discharged naturally from the valley-fill reservoir almost entirely by evapotranspiration in the lowland of Steptoe Valley. Only a small amount may be discharged by underflow or surface flow through the gap north of Currie. The estimated discharge, summarized in table 8, is about 70,000 acre-feet a year. Spring discharge in the valley lowland is estimated to be about 22,000 acre-feet, which in turn is lost by evapotranspiration largely from the wet-meadow and saltgrass area listed in table 8. Some ground water is discharged from springs in the mountains in addition to that discharged from the valley lowland. For the most part, spring discharge in the mountains becomes a part of the streamflow or is removed by evapotranspiration in the mountain canyons. Ground water discharged in the mountains is not included in the estimates in table 8.

In addition to ground water discharged by evaporation and transpiration from the valley lowland, surface water supplied by overland runoff from the mountains, by snowmelt on the valley lowlands, and by occasional high-intensity showers also is evaporated or transpired from the valley lowland.

Storage

The volume of ground water stored in the valley fill of Steptoe Valley is many times the volume annually recharged to and discharged from the ground-water reservoir. Although the total volume of ground water in storage is not known, the following calculation illustrates that the quantity is very large. On the assumption that the average drainable pore space (specific yield) of the upper part of the saturated valley fill is 15 percent, the volume of ground water in storage in the saturated upper 100 feet beneath a one-township area (about 23,000 acres) is about 35,000 acre-feet. Beneath the 143,000-acre evapotranspiration area, indicated in table 8 and shown on plate 1, the volume of ground water stored in the upper 100 feet of saturated valley fill would be about 2.1 million acre-feet. As the depth to water below land surface generally is less than 20 feet, the indicated 2.1 million acre-feet of stored water is within 120 feet of land surface in most of the evapotranspiration area.

Perennial Yield

The perennial yield of a ground-water system may be taken as the amount of water that can be withdrawn from the system for an indefinite period without causing continuing depletion of storage or a deterioration of the water quality beyond the limits of economic recovery. Economic feasibility involves factors other than those of the hydrologic system. However, based on the hydrologic system, the perennial yield may be taken to be a quantity of water equivalent to the average annual natural recharge to or

Table 8. -- Estimated average annual ground-water discharge
by evapotranspiration in the valley lowland

| Phreatophyte | Area (acres) | Assumed average rate of evapotranspiration (feet) | Estimated evapotranspiration (acre-feet) |
|--|-----------------|--|--|
| Wet-meadow and saltgrass areas, including lowland spring areas. Water table generally at or near land surface | 18,000 | 1.5 | 27,000 |
| Saltgrass, rabbitbrush, some greasewood, and playa areas, including Goshute Lake playa. Water table generally less than 10 feet below land surface | 50,000 | .5 | 25,000 |
| Greasewood-rabbitbrush areas with some saltgrass; commonly marginal to the first two areas above. Water table generally less than 20 feet below land surface | 53,000 | .3 | 16,000 |
| Scattered saltgrass, rabbitbrush, and greasewood area. Water table generally less than 12 feet below land surface | 22,000 | .1 | 2,200 |
| Total (rounded) | 143,000 | | 70,000 |

discharge from that system, based on a one-time use of the stored water. In effect this can be accomplished most efficiently by developing ground water in or adjacent to areas of natural discharge.

In Steptoe Valley, the average annual recharge and natural discharge were estimated to be 85,000 and 70,000 acre-feet per year, respectively (tables 7 and 8). Because as previously mentioned, the estimated recharge may be somewhat high and because the estimated natural discharge is considered to be better controlled, the perennial yield provisionally may be taken to be about 70,000 acre-feet.

Effects of Pumping in the Valley-Fill Reservoir

Withdrawals from wells in areas of natural discharge permit direct salvage of that discharge and impose a minimum effect on the ground-water system. The greater the distance the wells are from natural discharge areas the greater the percentage of pumped water that comes from storage and the less the salvage of natural discharge. To date, sufficient data are not available to demonstrate fully the effects of pumping from wells in Steptoe Valley. However, aquifer response to pumping varies with the quantity pumped, the duration of pumping, the distribution of wells, and the storage and transmissive characteristics of the aquifer. The effects of varying some of these factors can be illustrated by assuming certain conditions that might reasonably be expected to occur in this area.

Assume that pumping rates are 1,000 gallons a minute; the upper part of the saturated valley fill generally has coefficients of storage between 0.1 and 0.2 and transmissibility values between 10,000 and 100,000 gallons per day per foot. By further assuming that the valley-fill ground-water reservoir grossly functions as an approximate equivalent of a thick, unbounded, and relatively uniform aquifer, the Theis non-equilibrium formula (Theis, 1935, and Theis in Bentall and others, 1965) can be used for illustrative computation. Table 9 illustrates the effects on drawdown and radius of influence resulting from successively varying several of the factors.

Table 9. -- Effects of pumping from an unbounded aquifer

a. Effect of varying coefficient of storage (S). $\frac{1}{S}$
 (Assume T = 50,000; Q = 1,000; t = 10,000 (27.4 years))

| Coefficient of storage | Drawdown(s), in feet, at distance (r) from well | | | Approximate distance from well where drawdown = 0 ft. | |
|------------------------|---|-----------|------------|---|-------|
| | r = 1 ft | r = 10 ft | r = 100 ft | feet | miles |
| 0.1 | 48.3 | 37.9 | 27.4 | 70,000 | 13.25 |
| 0.15 | 47.4 | 37.0 | 26.5 | 58,000 | 11 |
| 0.2 | 46.7 | 36.3 | 25.8 | 53,000 | 10 |

b. Effect of varying coefficient of transmissibility (T).
 (Assume S = 0.15; Q = 1,000; t = 10,000)

| Coefficient of transmissibility | Drawdown(s), in feet, at 100 feet from well | Approximate distance from well where drawdown = 0 ft. | |
|---------------------------------|---|---|-------|
| | | feet | miles |
| 10,000 | 113.5 | 29,000 | 5.5 |
| 50,000 | 26.5 | 58,000 | 11 |
| 100,000 | 14.0 | 80,000 | 15 |

c. Effect of varying rate of pumping (Q).
 (Assume T = 50,000; S = 0.15; t = 2,000 (5.48 years))

| Rate of pumping Q, in gpm | Drawdown(s), in feet, at distance (r) from well | | | Approximate distance from well where drawdown = 0 ft. | |
|---------------------------|---|-----------|------------|---|-------|
| | r = 1 ft | r = 10 ft | r = 100 ft | feet | miles |
| 1,000 | 43.6 | 33.2 | 22.6 | 29,000 | 5.5 |
| 2,000 | 87.2 | 66.4 | 45.2 | 29,000 | 5.5 |
| 4,000 | 174 | 133 | 90.4 | 29,000 | 5.5 |
| 8,000 | 348 | 266 | 181 | 29,000 | 5.5 |
| 16,000 | 696 | 532 | 362 | 29,000 | 5.5 |

(table continued)

Table 9. -- Continued

d. Effect of varying duration of continuous pumping (t).
 (Assume $T = 50,000$; $S = 0.15$; $Q = 1,000$)

| Duration of pumping | | Drawdown(s), in feet, at distance (r) from well | | | Approximate distance from well where drawdown = 0 ft. | |
|---------------------|-------|---|-----------|------------|---|-------|
| days | years | r = 1 ft | r = 10 ft | r = 100 ft | feet | miles |
| 100 | .27 | 37.0 | 26.5 | 15.8 | 5,500 | 1 |
| 500 | 1.37 | 40.2 | 29.6 | 19.5 | 13,000 | 2.5 |
| 1,000 | 2.74 | 42.2 | 31.6 | 21.2 | 21,000 | 4 |
| 2,000 | 5.48 | 43.6 | 33.2 | 22.6 | 29,000 | 5.5 |
| 5,000 | 13.7 | 45.8 | 35.4 | 24.7 | 39,000 | 7.4 |
| 10,000 | 27.4 | 47.4 | 37.0 | 26.5 | 58,000 | 11 |
| 18,000 | 49.3 | 48.0 | 37.8 | 26.4 | 70,000 | 13.2 |

e. Effect of cyclic pumping, 100 days per year.
 (Assume $T = 50,000$; $S = 0.15$; $Q = 1,000$)

| Pumping for 100 days a year, beginning with the day pumping began | | Drawdown(s), in feet, where radius = 100 feet |
|---|----------------------|---|
| At end of | 100 days | a 15.8 |
| Do. | 360 days (1 year) | .7 |
| Do. | 720 days (2 years) | .9 |
| Do. | 1,080 days (3 years) | 1.0 |
| Do. | 1,440 days (4 years) | b 1.1 |
| Do. | 1,800 days (5 years) | 1.1 |

- a. Refer also to item 1 in table 9d above.
- b. After 4 years, maximum effect of cyclic pumping in antecedent years is reached at this radius.

1. Notations for table 9.

- T = The coefficient of transmissibility, in gallons per day per foot (gpd per ft) of the aquifer;
- S = The coefficient of storage of the aquifer, a dimensionless ratio;
- Q = The rate of discharge in gallons per minute (gpm), of the pumped well;
- s = The water-level drawdown, in feet, in the pumped well, in an observation well, or at any point in the vicinity of the pumped well;
- r = The distance, in feet, from the pumped well to an observation well or to a point for which the drawdown is to be determined;
- t = The time, in days, since pumping began.

Table 9a indicates that, other things being equal, the lower the value of the coefficient of storage, the greater the drawdown and the greater the radius of influence that is required to yield the same amount of water from storage. Initial responses to pumping from valley-fill deposits, such as occur in Steptoe Valley, commonly indicate that the ground water is under artesian conditions. That is, apparent values of the coefficient of storage are significantly smaller than those used in the examples. For the same pumping rates, the early periods of pumping probably would develop larger drawdowns than are indicated by the examples herein. However, over long pumping periods the apparent coefficient of storage gradually would increase to values characteristic of unconfined conditions, such as those used as examples in this report.

Table 9b shows that low values of transmissibility result in large drawdowns with a small radius of influence, whereas for large values of transmissibility drawdowns are small but the radius of influence is very large. Increasing the pumping rate results in larger drawdowns within the same areas of influence as those shown in table 9c. Increasing the duration of pumping increases both the drawdown and the radius of influence, as shown in table 9d, where water is derived entirely from storage and other factors remain constant.

The effect of noncontinuous pumping is illustrated in table 9e where a cyclic pumping pattern of 100 days a year is used. Thus, after 100 days of pumping the drawdown at 100 feet from the well is shown as 15.8 feet; at the end of one year, or 260 days after pumping ceased the residual drawdown is shown as 0.7 foot. The residual drawdown due to pumping in antecedent years increases to a maximum of about 1.1 feet at a radius of 100 feet at the end of four years. For example, at the end of the sixth pumping cycle (1900 days) the drawdown at 100-foot radius would be 15.8 feet (as at the end of the first pumping cycle) plus the residual drawdown from antecedent pumping (1.1 feet) or a total drawdown of about 17 feet. This may be compared with the 22.6-foot drawdown at a radius of 100 feet for the 2,000-day continuous pumping period shown in table 9. Thus, a cyclic or intermittent pumping schedule results in less drawdown at the 100-foot radius than would occur had the pumping been continuous.

From the information in table 9, it is evident that the area of influence of individual wells would overlap somewhat between wells in irrigated areas, where well-spacing of $\frac{1}{4}$ - to $\frac{1}{2}$ -mile is common. This can result in a pattern of drawdown and area of influence that is difficult to identify accurately in detail. However, a general pattern can be described that illustrates the magnitude of effect of pumping several wells at the same time. Assume that there are 16 wells spaced on $\frac{1}{2}$ -mile centers forming a square of four rows of four wells each, as would occur with wells in the center of one-quarter sections in a 4-square-mile area. Assume further, that each well is pumped at the rate of 1,000

gallons a minute continuously for 10,000 days (27.4 years). The combined pumping rate for the 16 wells is equivalent to a withdrawal of about 25,000 acre-feet per year. The assumed aquifer characteristics are $T = 50,000$ and $S = 0.15$, the same as generally assumed for computations in table 9. Under these conditions at the end of 10,000 days of pumping, the distance to zero drawdown would be about 12 miles from the center of pumping. Closer to the well field, drawdown would be about 5, 10, 40, 50, 75, and 100 feet at distances from the center of pumping of about 9, 7.75, 3.85, 3.3, 2.3, and 1.5 miles, respectively. Drawdowns of about 160 feet would occur adjacent to the wells at the corners of the well field, and drawdowns on the order of 190 feet would occur adjacent to the four inside wells of the well field.

These effects, as noted above, are for continuous pumping. If the same annual quantity (about 25,000 acre-feet) were pumped under a 100-day per year cyclic pattern, about 58 wells pumping at the rate of 1,000 gpm would be required. Using the same spacing as in the previous example $\frac{1}{2}$ -mile centers, the well field would occupy a 14-square mile area. Analysis of this cyclic pattern is more difficult than in the previous example. Generally, though, a larger proportion of water would be withdrawn from the larger area of the well field, and the radius of influence would be somewhat less than half the 12 miles computed for the continuous pumping patterns, both patterns being for 10,000-day, elapsed-time periods.

Further, if the well field and area of significant pumping influence are in an area of natural discharge by evapotranspiration, the drawdowns would be reduced in proportion to the amount of salvage of the natural discharge. After the amount of salvage is equal to the net amount of water pumped, the drawdowns and area of influence will be only of the magnitude necessary to divert the amount of water salvaged through the wells. Thus, in this use the water withdrawn by the wells is supplied by recharge to the area of pumping influence rather than from storage within the area of influence as in the circumstances previously assumed.

It should be recognized that the chemical quality of water obtained in areas of natural discharge may not be as good as in other parts of the ground-water system; it may in fact be unsuitable for the intended use. However, development in or closely adjacent to the areas of natural discharge would result in a minimum effect on the ground-water system.

Drawing upon the illustrative computations of the effects of pumping discussed above, we may consider briefly the effects of particular pumping patterns in Steptoe Valley. For this purpose, four areas are used to represent various segments of Steptoe Valley: (a) Adjacent to and east of Goshute Lake at the north end of the valley; (b) the area in and adjacent to the lowlands southeast of Cherry Creek; (c) the Duck Creek fan and adjacent lowlands to the west and northwest; and (d) the lowland between Ely and McGill. The general assumptions used in computations for table 9 also serve as the reference for the discussion

of pumping effects for these areas; that is, $T = 50,000$, $S = 0.15$, $Q = 1,000$ gpm per well, $t = 10,000$ days. Further, a well field comprises either 16 wells on $\frac{1}{2}$ -mile centers in a 4-square-mile area for continuous pumping, or about 58 wells on $\frac{1}{2}$ -mile centers in a 14-square-mile area for cyclic pumping of 100 days a year. A withdrawal of 25,000 acre-feet a year by either continuous or cyclic pumping also is assumed.

The continuous pattern of pumping in area (a) would result in modifying the illustrative example somewhat as follows. As the radius of influence expanded into fine-grained deposits and volcanic bedrock, actual values of transmissibility would be lower than those used in the computation. This influence would be reflected in larger drawdowns, as suggested by table 9b, if the annual quantity of water withdrawn were maintained. Drawdowns after 10,000 days of pumping could be several tens of feet greater than the 160 to 190 feet indicated in the illustrative examples for the idealized well field providing all water were withdrawn from storage. However, a large area of natural discharge lies adjacent to and west of the hypothetical well field. As the area of pumping influence expanded into the area of natural discharge an increasing amount of water would be salvaged. In time, as much as 40 percent of the amount of water pumped annually might be supplied by salvaged water. This is equivalent to reducing by 40 percent the draft on stored water, as suggested by table 9c, and consequently drawdowns would be less than those in the illustrative example. The two effects, that is, the lower value of transmissibility and the salvage of natural discharge, would tend to be mutually compensating, and it is probable that the drawdowns in the well field would be generally comparable to those given in the illustrative example.

The radius of influence of a continuous pumping pattern in area (a) could finally extend several miles southward in the lowland. However, it is not likely that pumping in area (a) could cause significant drawdown in area (b), about 20 miles away, before the economic limits of pumping were reached in area (a).

Area (b) is centrally located in an extensive lowland area of natural ground-water discharge. Accordingly, the effects of salvage of natural discharge would begin early in the pumping period, although initial withdrawals from storage would be required before the natural discharge could be diverted through the wells. Under the continuous pumping pattern as discussed for area (a), the proportion of pumped water derived from salvage could be 50 percent or more. Under the cyclic pumping pattern, the much larger well field and the area of significant drawdown would be distributed largely within the area of natural discharge. If the pumping season coincided with or immediately preceded the seasonal period of principal natural discharge, the proportion of salvaged ground water would be greater than under the continuous pumping pattern.

The ground water directly salvaged from natural evapotranspiration may be of inferior chemical quality for use. The

suitability of the water for the intended use becomes increasingly important as the proportion of salvaged water to total withdrawal increases. Further, if the water is used for irrigation within the area of the well field, a part of the water spread on the fields will return to the ground-water reservoir by deep infiltration. This recycled water will have a higher concentration than the initially pumped water. In time, water recycled in the well field may supply a significant percentage of the amount of water pumped. As this percentage increases the pumped supply would deteriorate further. This should not negate the possibility of development for irrigation, but it does indicate that possible changes of chemical quality with time should be considered.

Area (c) occupies the lower part of the Duck Creek fan northwest of McGill. The adjacent lowland area is relatively wet, being supplied with water from the large spring area south from Steptoe, and from Steptoe Creek, Duck Creek, and McGill Spring through Bassett Lake. Long-time pumping in area (c) would expand the area of influence to the lowland area of natural discharge by evapotranspiration. After the initial period of withdrawal from storage, lowering of water levels in the natural discharge area would begin to salvage some natural losses. Further lowering of water levels in the lowland area would induce recharge from overland runoff in the lowlands supplied by springs south of Steptoe, outflow from Bassett Lake, and perhaps from local runoff. If significant drawdowns were achieved in the natural discharge area, water obtained by salvage, induced recharge, and recycling could provide a large fraction of the annual withdrawal. If the cyclic pattern of pumping were used, the water stored beneath the larger area of the well field would supply most of the water pumped for many years before the salvaged water became a significant proportion of the total pumpage. The radius of measurable pumping influence would be restricted on the northwest, west, and south by the wet lowland which finally would act as a recharge boundary to the area of pumping. On the east the bedrock which crops out in the mountains would function as a partial barrier boundary due to lower transmissibility of the bedrock.

In area (d), between Ely and McGill, natural discharge of ground water by evapotranspiration is small compared to that in area (c). Most of the water withdrawn under a continuous pumping pattern would be from storage. Consolidated rocks of relatively low transmissibility are at the surface within about three miles of the center of pumping. As the area of influence reached rocks of lower transmissibility, withdrawals could be maintained only by increased drawdown. The cyclic pattern of pumping with its much larger well-field area, would obtain a larger percentage of its supply from storage beneath the well-field area. The intervals of nonpumping would permit partial recovery of water levels within the well field, by recharge from underflow and runoff from the southern or upgradient part of Steptoe Valley. Finally, if the annual withdrawal were 15,000 acre-feet a year instead of the 25,000 acre-feet used in the computation, the rate of drawdown

would be reduced and pumping could be sustained over a longer period of time.

The assumed conditions, computations, and their application to selected parts of Steptoe Valley discussed above generally indicate the response to pumping that might be expected. These responses may be summarized as follows:

(1) The early years of pumping would tend to have greater drawdowns than indicated in the examples, because initial apparent coefficients of storage would be less than those determined after long-time periods of pumping;

(2) The water pumped would be withdrawn largely from storage during the early years of pumping. As water levels were drawn down in areas of natural discharge, an increasing proportion of water pumped would be supplied by salvage of natural discharge. Perhaps salvaged water would approach half of the total withdrawals after 10 to 20 years of pumping;

(3) The degree to which natural discharge of ground water can be salvaged by pumping is dependent upon the effectiveness with which pumping can lower water levels in the areas of natural discharge. Direct salvage of ground water by pumping in the area of natural evapotranspiration discharge may not be entirely desirable if the water in the area of evapotranspiration is of poor chemical quality;

(4) Pumping centers adjacent to natural discharge areas with the initial withdrawals largely from storage would minimize the potential problem of chemical suitability of salvaged water and permit a gradual increase in the proportion of salvaged water should that prove satisfactory; otherwise there would be some latitude to shift the pumping somewhat farther away to maintain the quality;

(5) The pumping distribution used for illustration in Steptoe Valley is partly dictated by practical problems of development. The use of several centers of pumping would distribute total withdrawal through the valley. Consequently, drawdowns in the well fields would be less than if pumping were concentrated in a single field. Using similar reasoning, wide spacing of wells within centers of pumping would reduce the interference among wells and help to keep drawdowns nominal; and,

(6) The combined withdrawal of the illustrative examples is 90,000 acre-feet a year. A reduction of 5,000 acre-feet a year in the pumping from each center of pumping would result in a withdrawal of about 70,000 acre-feet of water a year, equivalent to the preliminary estimate of perennial yield. The effect of a lesser quantity of water withdrawn would be a proportional reduction of the drawdown from those of the examples. However, the

calculations suggest that pumping at an annual rate of about 70,000 acre-feet could be maintained for several tens of years at least if pumping were distributed in several centers in the valley.

Provisional Budget for the Valley-Fill Hydrologic System

The budget for the valley-fill hydrologic system given in table 10 is provisional in that it represents a general evaluation of gross conditions. Time was not available in this investigation to make direct determinations or field controlled estimates of details of certain items of the budget. Thus, the amount of precipitation, streamflow, and ground water consumptively used for irrigated crops was not determined. Rather, these losses were included in the broader categories of evapotranspiration from different sources (budget items 4, 5, and 6, table 10). Excess water in the mountains and alluvial apron moves downgradient toward the lowland, either as runoff or infiltration into the ground-water system. Thus, most of the water loss represented by each of the outflow budget items occurs in the valley lowland, whether or not the water is beneficially used.

The relatively large value for estimated subsurface inflow to the ground-water reservoir (item 3, table 10) is supported indirectly by the fact that many large springs in the valley issue from or adjacent to consolidated rocks. These springs occur both in the mountains and in the valley lowland. They indicate that the consolidated rocks, particularly the carbonate rocks are capable of transmitting significant quantities of water. In this case it is inferred that usually most of the ground-water recharge to the valley-fill system is supplied by water moving through the consolidated rocks and into the valley fill below land surface.

The relative balance between the inflow and outflow items in table 10 is due largely to the fact that several items are obtained by difference, in the absence of appropriate data. However, though the items may be in error to a degree, it is believed that the estimates provide a reasonable quantitative distribution of the major elements of the hydrologic system. Thus, the estimates provide an initial hydrologic framework from which the potential for development may be evaluated.

Table 10. -- Provisional budget for valley-fill hydrologic system

| | Estimated average annual amount of acre-feet per year | |
|--|---|---------|
| <u>INFLOW:</u> | | |
| (1) Precipitation on valley fill (table 7 - equivalent of lower two zones) | 520,000 | |
| (2) Runoff from mountains (table 5) | 78,000 | |
| (3) Ground-water inflow across subsurface contact of consolidated rock and valley fill [item 6 below minus 24,000 acre- feet of estimated recharge from runoff to the valley-fill (see section on runoff) and minus 5,400 of recharge from pre- cipitation on the valley fill (table 7, recharge from lower two zones)] . . . | <u>41,000</u> | 639,000 |
| <u>OUTFLOW:</u> | | |
| (4) Evapotranspiration from precipitation on the valley fill [precipitation on valley fill (item 1 above) minus estimated (5,400 acre-feet) recharge from precipitation on valley fill (table 7, recharge from lower two zones)] . . | 515,000 | |
| (5) Evapotranspiration from runoff (see section on runoff) | 54,000 | |
| (6) Evapotranspiration from ground water. . (table 8) | 70,000 | |
| (7) Discharge through gap north of Currie. . | <u>1,000</u> | 640,000 |
| <u>IMBALANCE:</u> Outflow greater than inflow | | 1,000 |

CHEMICAL QUALITY

Twenty water samples were analyzed to provide information on the chemical quality of water and for a generalized appraisal of suitability of water for use. Table 11 lists the results of the analyses.

According to the Salinity Laboratory Staff, U.S. Department of Agriculture (1954, p. 69), the most significant factors with regard to the chemical suitability of water for irrigation are dissolved-solids content, the relative proportion of sodium to calcium and magnesium, and the concentration of elements and compounds that are toxic to plants. Dissolved-solids content commonly is expressed as "salinity hazard," and the relative proportion of sodium to calcium and magnesium as "alkali hazard."

The Salinity Laboratory Staff suggests that salinity and alkali hazards should be given first consideration when appraising the quality of irrigation water, then consideration should be given to boron or other toxic elements and bicarbonate, any one of which may change the quality rating.

Table 12 indicates the relative characteristics of the water analyzed. The reported values for RSC (residual sodium carbonate) are well below the marginal values of 1.25 to 2.5, which are reported to be unsuitable for irrigation (Eaton, 1950).

The public water supplies for the principal communities have been used for many years and apparently are generally acceptable. However, the analyses indicate that the water is hard. Two of the analyses indicate sulfate content above the 250 ppm value which is the upper limit for that constituent suggested by the U.S. Public Health Service (1962).

Water Quality and its Relation to the Ground-Water System

The concentration of dissolved chemical constituents generally tends to increase as water moves from areas of recharge to areas of discharge. The concentration of individual constituents is controlled in part by their relative solubility and the kinds of rock through which the water moves. Temperature and pressure of the system also affect the degree to which the constituents are dissolved in the water. For the most part the samples of water from Steptoe Valley have low to moderate concentrations as indicated by the specific conductance.

Sample 19/63-35b1 has the highest values (1,710) for specific conductance. It is water flowing from Bassett Lake which is supplied to a considerable extent by waste water from the McGill operations. The increased concentration is largely due to increases in calcium, magnesium, and sulfate. Other relatively high specific conductance values were obtained for samples 16/63-10a1, and 10d1, which include waste water from Ely.

Table 11.--Field chemical analyses of water from selected wells, springs, and streams

[Analysis by the U.S. Geological Survey]

| Location (well or spring no.) | Date of collection | Source type | Tem- per- ature (°F) | Parts per million (upper number) and equivalents per million (lower number) for indicated cations and anions | | | | | | | | | Hardness as CaCO ₃ (ppm) | | | Specific conduct- ance (micro- mhos at 25°C) | | | Salinity hazard | Alkalinity hazard |
|-------------------------------------|-----------------------|----------------|-------------------------------|--|-----------------------------|--|-------------|---|--------------------------------------|------------------------------------|-----------------------|--|--|-----|-----|---|--------|--------|--------------------|----------------------|
| | | | | Cal- cium (Ca) | Mag- ne- sium (Mg) | Sodium (Na) + potas- sium _{1/} | | Bicar- bonate (HCO ₃) | Carbon- ate (CO ₃) | Sul- fate (SO ₄) | Chlo- ride (Cl) | Cal- cium, Non- mag- ne- sium | Non- car- bon- ate | pH | SAR | RSC | | | | |
| | | | | | | (K) | | | | | | | | | | | | | | |
| 11/65-7d1 | 10-17-65 | Spring | 53 | 23 1.15 | 23 1.89 | 15 0.67 | 166 2.72 | 3 0.10 | 24 0.50 | 14 0.39 | 152 | -- | 305 | 8.4 | 0.5 | 0.00 | Medium | Low | | |
| 12/63-1d1 | 10-17-65 | Spring | 52 | 48 2.40 | 8.8 0.72 | 12 0.52 | 183 3.00 | 0 0.00 | 25 0.52 | 4.2 0.12 | 156 | -- | 296 | 8.0 | .4 | .00 | Medium | Low | | |
| 13/64-9d1 | 7-29-65 | Well | 60 | 39 1.95 | 28 2.29 | 5.5 0.24 | 228 3.74 | 0 0.00 | 22 0.46 | 10 0.28 | 212 | 25 | 379 | 8.2 | .2 | .00 | Medium | Low | | |
| 14/63-35a1 | 9-23-65 | Creek | 54 | 25 1.25 | 14 1.19 | 7.8 0.34 | 143 2.34 | 0 0.00 | 15 0.31 | 4.6 0.13 | 122 | -- | 225 | 8.1 | .3 | .10 | Low | Low | | |
| 14/64-36a1 | 7-29-65 | Well | 60 | 31 1.55 | 20 1.65 | 8.7 0.38 | 174 2.85 | 0 0.00 | 20 0.42 | 11 0.31 | 160 | 18 | 332 | 8.2 | .3 | .00 | Medium | Low | | |
| 15/65-10d1 | 10-18-65 | Creek | -- | 32 1.60 | 18 1.52 | 11 0.47 | 175 2.87 | 0 0.00 | 28 0.58 | 4.8 0.14 | 156 | -- | 305 | 8.0 | .4 | .00 | Medium | Low | | |
| 16/63-3a1 | 9-21-65 | Spring | 95 | 32 1.60 | 25 2.02 | 19 0.82 | 148 2.43 | 0 0.00 | 83 1.73 | 10 0.28 | 181 | -- | 391 | 8.0 | .6 | .00 | Medium | Low | | |
| 16/63-10a1 | 10- 4-65 | Spring | 46 | 75 3.74 | 44 3.65 | 16 0.68 | 204 3.34 | 0 0.00 | 193 4.02 | 25 0.71 | 370 | -- | 714 | 8.0 | .4 | .00 | Medium | Low | | |
| 16/63-10d1 | 10- 4-65 | Spring | 52 | 103 5.14 | 45 3.69 | 25 1.07 | 153 2.51 | 0 0.00 | 340 7.08 | 11 0.31 | 442 | -- | 813 | 8.0 | .5 | .00 | High | Low | | |
| 16/63-20a1 | 4-16-63 | Spring | 57 | 49 2.45 | 18 1.51 | (a) (a) | 232 3.80 | 0 0.00 | 9.8 0.20 | 1.3 0.04 | 190 | 8 | 374 | 7.6 | .1 | .00 | Medium | Low | | |
| 19/63-5c1 | 5-16-66 | Spring | -- | 53 2.64 | 20 1.64 | (b) (b) | 261 4.28 | 0 0.00 | 19 0.40 | 3.4 0.10 | 214 | 0 | 432 | 7.8 | .3 | .00 | Medium | Low | | |
| 19/63-5d1 | 10- 8-65 | Spring | -- | 21 1.05 | 22 1.79 | 18 0.79 | 178 2.92 | 0 0.00 | 27 0.56 | 5.2 0.15 | 142 | -- | 300 | 7.9 | .7 | .08 | Medium | Low | | |
| 19/63-35b1 | 9-21-65 | Pond | 52 | 173 8.63 | 132 10.89 | 39 1.69 | 117 1.92 | 0 0.00 | 882 18.36 | 22 0.93 | 977 | -- | 1,710 | 7.9 | .5 | .00 | High | Low | | |
| 20/64-6a1 | 7-31-65 | Well | 57 | 61 3.04 | 31 2.57 | 29 1.24 | 332 5.44 | 0 0.00 | 50 1.04 | 13 0.37 | 281 | 9 | 590 | 7.8 | .7 | .00 | Medium | Low | | |
| 20/65-20c1 | 10-17-65 | Spring | 42 | 31 1.55 | 2.8 0.23 | 17 0.73 | 109 1.79 | 0 0.00 | 29 0.60 | 4.4 0.12 | 89 | -- | 207 | 7.9 | .8 | .01 | Low | Low | | |
| 23/62-14a1 | 10- 5-65 | Mine adit | 58 | 23 1.15 | 20 1.61 | 13 0.56 | 159 2.61 | 0 0.00 | 23 0.48 | 8 0.23 | 138 | -- | 273 | 8.2 | .5 | .00 | Medium | Low | | |
| 23/63-2b1 | 7-29-65 | Well | -- | 42 2.10 | 26 2.14 | 21 0.93 | 256 4.20 | 0 0.00 | 28 0.58 | 14 0.29 | 212 | 2 | 452 | 8.1 | .6 | .00 | Medium | Low | | |
| 25/63-12b1 | 10- 5-65 | Creek | 52 | 24 1.20 | 22 1.84 | 65 2.81 | 172 2.82 | 0 0.00 | 140 2.91 | 4.4 0.12 | 152 | -- | 276 | 8.1 | 2.3 | .00 | Medium | Medium | | |
| 27/65-29c1 | 7-28-65 | Well | 62 | 23 1.15 | 19 1.57 | 36 1.56 | 190 3.11 | 0 0.00 | 28 0.58 | 21 0.59 | 136 | 0 | 401 | 8.2 | 1.3 | .39 | Medium | Low | | |
| 28/64-28d1 | 7-28-65 | Stream | 63 | 29 1.45 | 52 4.30 | 33 1.43 | 293 4.80 | 0 0.00 | 56 1.17 | 43 1.21 | 288 | 48 | 644 | 8.2 | .8 | .00 | Medium | Low | | |
| 29/23-35a1 | 10-22-65 | Spring | 64 | 29 1.45 | 21 1.71 | 12 0.52 | 174 2.85 | 0 0.00 | 33 0.69 | 5.0 0.14 | 158 | -- | 296 | 8.1 | .4 | .00 | Medium | Low | | |

1. Computed by difference.

a. Sodium 3.5 ppm, 0.15 epm; potassium 0.7 ppm, 0.02 epm; fluoride 0.2 ppm, 0.01 epm; nitrate 2.5 ppm, 0.04 epm; boron 0.1 ppm; determined.

b. Sodium 11.0 ppm, 0.48 epm; potassium 3.7 ppm, 0.09 epm; fluoride 0.4 ppm, 0.02 epm; nitrate 1.7 ppm, 0.03 epm; boron 0.0 ppm; determined.

Table 12.--Continued

| Well number and location | Owner or name | Date drilled | Depth (feet) | Diameter of casing (inches) | Principal water-bearing zone (feet) | Altitude (feet) | Measuring point | | Water level | | Date | Temperature (°F) | Remarks |
|--------------------------|---------------------------------|--------------|--------------|-----------------------------|-------------------------------------|-----------------|---------------------------------|------------------------------|-------------|----------|------|------------------|---|
| | | | | | | | Above land surface datum (feet) | Below measuring point (feet) | M or R | Use | | | |
| 18/63-25a1 | George Millas | -- | 10 | Dug well | -- | -- | -- | 7 | M | 7-23-18 | -- | D,S | Published WSP 467 |
| 25a2 | Romeo | -- | 15 | Dug well | -- | -- | TC | 1 | M | 7-28-65 | -- | D | -- |
| 25d | -- | -- | -- | -- | -- | 6,260 | TC | .5 | M | 7-28-65 | -- | -- | -- |
| 36a1 | Albert Romeo | 1945 | 130 | 14 | 14-64 | -- | TC | 1.5 | M | 7-28-65 | -- | I | Log |
| 36a2 | -- | -- | 10 | Driven well | -- | -- | -- | -- | M | 7-1-49 | -- | S | -- |
| 36b1 | W. S. Douval | -- | 19 | Driven well | -- | -- | -- | 15.1 | M | 7-27-18 | -- | I | Published WSP 467 |
| 36cc | Pescio Bros. | 1963 | 102 | 13 3/4 | 76-102 | -- | -- | 18 | R | 5-20-63 | 60 | I | Log 5918 |
| 18/64-3ac | Mrs. Mary Fields | 1958 | 310 | 16 | 230-270 | -- | TC | .6 | M | 7-28-65 | -- | I | Log 4306 |
| 6cc1 | Glenn Station | -- | -- | 8 | -- | -- | -- | 3 | R | 1918 | -- | -- | Published WSP 467 |
| 7b1 | A. E. Leet | -- | -- | -- | -- | -- | -- | 7.3 | M | 6-18-18 | -- | -- | Published WSP 467 |
| 31d | Romeo and Elliott | -- | 14 | Dug well | -- | -- | TC | .8 | M | 7-28-65 | -- | I | -- |
| 19/63-12a1 | U.S. Geological Survey | -- | 915 | 8 | -- | -- | Top pump support | 1.5 | M | 9-14-45 | 56 | S,O | Published WSP 467. Other meas. 10-13-62 |
| 12a2 | BLM | -- | -- | 10 | -- | 6,005 | -- | 21 | M | -- | -- | S | Windmill |
| 24a1 | Steptoe Station (old) | -- | 51 | Dug well | -- | 5,869 | -- | 47.8 | M | 4-10-18 | -- | -- | Published WSP 467. Caved 7-6-49, dry at 30 ft. |
| 19/64-25a1 | J. B. Pescio | 1959 | 30 | 18 | 5-15 | -- | -- | 5 | R | 6-9-49 | -- | I | -- |
| 20/64-6a1 | Thomas Thornel | -- | 52 | 7 | -- | -- | TC | 5 | M | 7-7-49 | -- | D | -- |
| 7b1 | -- | -- | 25 | Dug well | -- | 5,985 | TC | .8 | M | 7-30-65 | -- | S | Windmill |
| 8b | -- | -- | -- | Dug well | -- | 5,960 | -- | 3.9 | M | -- | -- | D,S | Windmill |
| 8c | -- | -- | 11.5 | Dug well | -- | -- | Top wood crib | .6 | M | 7-6-49 | -- | -- | Abandoned |
| 20a | Noel Williams, Jr. | 1965 | 158 | 16 | 118-158 | -- | TC | .5 | M | 10-1-65 | -- | I | Log 8415 |
| 32b1 | R. Findley | -- | -- | Dug well | -- | -- | -- | 12.2 | M | 5-15-18 | -- | -- | Published WSP 467. |
| 32c1 | U.S. Geological Survey | 1918 | 97 | 6 | 57-71 | -- | LS | 12.37 | M | 7-31-65 | -- | O | Published WSP 467. Other meas. 10-13-62 |
| | Test Well #1 | | | 8 | | | TC | 2.3 | M | 7-31-65 | | | |
| 32c2 | U.S. Geological Survey | 1918 | 122 | 10 | -- | -- | TC | 1.5 | M | 7-31-65 | -- | O | Published WSP 467. Other meas. 10-13-62 |
| | Test Well #3 | | | | | | | | | | | | |
| 32c3 | -- | -- | 94 | -- | -- | 6,045 | -- | 12.3 | M | -- | -- | -- | Unused |
| 21/63-13c1 | E. B. Young | -- | 47 | Dug well | -- | -- | -- | 12. | M | 7-15-18 | -- | -- | Published WSP 467 |
| 13d1 | -- | -- | 11.5 | Dug well | -- | -- | TC | 0 | M | 7-7-49 | -- | -- | Abandoned |
| 23a | -- | -- | 30 | Dug well | -- | 6,060 | LS | 1.8 | M | 7-30-65 | -- | D | -- |
| 25a1 | -- | -- | 13 | Dug well | -- | -- | TC | 0.1 | M | 7-11-49 | -- | -- | Well caved in 7-30-65 |
| 25c1 | Warm Springs Station | -- | 10 | 60 | -- | -- | -- | 5.5 | R | 1918 | -- | RR | Published WSP 467 |
| 25c2 | -- | -- | 31 | Dug well | -- | -- | Crack in plank | 1 | M | 7-6-49 | -- | -- | -- |
| 35c | Austin Flint | -- | 250 | 16 | 210-225 | -- | -- | 40.0 | R | 8--65 | cool | I | Log |
| 21/64-30c | -- | -- | 8 | Dug well | -- | -- | TC | 0 | M | 7-14-49 | -- | S | -- |
| 22/64-3c1 | Nevada State Highway Department | -- | 173 | -- | -- | -- | TC | 0.3 | -- | -- | -- | D | -- |
| 23/63-2b1 | Cherry Creek Station | -- | 100 | 6 | -- | -- | TC | 2.5 | M | 7-29-65 | -- | -- | Published WSP 467 |
| 23/64-19dd | -- | -- | -- | Dug well | -- | 5,895 | Top of plank | 0.4 | M | 7-29-65 | -- | S | Windmill |
| 21b1 | -- | -- | 6.5 | Dug well | -- | -- | Top of plank | .75 | M | 7-14-49 | -- | S | -- |
| 24/63-2d1 | Star Mine | -- | 485 | Driven well | -- | -- | -- | 20 | R | 1918 | -- | -- | Published WSP 467. Well caved in |
| 11d | -- | -- | 16 | Dug well | -- | 5,835 | Top of platform | 2.9 | M | 7-29-65 | -- | -- | Windmill (not used) |
| 33a | Foppiano | -- | 40 | Dug well | -- | -- | TC | 0 | M | 7-29-65 | -- | D | -- |
| 24/64-16c | Ken Barton | 1948 | 65 | 6 | 45-48 | -- | LS | 0.5 | M | 7-30-65 | -- | -- | Log |
| 24/64-29a | Government | -- | 12 | Dug well | -- | -- | LS | 1.2 | M | 7-30-65 | -- | S | Windmill |
| 25/63-26a1 | -- | -- | 34 | Dug well | -- | -- | -- | 27.5 | M | 8-8-18 | -- | -- | Published WSP 467. Caved in 7-29-65 |
| 25/64-20b1 | Greens Station (NRRR) | -- | 12 | Dug well | -- | -- | -- | 7 | M | 8-8-18 | -- | -- | Published WSP 467. Dry hole 7-29-65 |
| 30cd | Murry Ranch | -- | -- | -- | -- | -- | LS | 1 | M | 7-29-65 | -- | -- | -- |
| 25/65-5b1 | J. B. Coats | 1966 | 460 | 16 | -- | -- | -- | 15 | R | 10-12-66 | -- | I | Log 9230 |
| 30a | -- | -- | -- | -- | -- | 5,910 | -- | 50.8 | M | -- | -- | -- | Unused |
| 31a | Silver State Construction Co. | 1951 | 220 | 8 | 50-52 | -- | -- | 50 | R | 1-27-51 | -- | -- | Log 1560; used for road construction |
| 31b1 | -- | -- | 62 | 8 | -- | -- | TC | .7 | M | 7-28-65 | -- | S | -- |
| 26/64-28d1 | Cordano Bros. | 1949 | 250 | 16 | 27-100 | -- | TC | 1 | M | 7-29-65 | -- | I | Log |
| 28d2 | Cordano Bros. | 1949 | 60 | 10 | -- | -- | TC | 6.1 | M | 7-29-65 | -- | I | Log 1019 |
| 26/65-15 | William Cooper | 1967 | 200 | 10 | 60-200 | -- | -- | 58 | R | 3--67 | -- | D | 30 gpm with 2.5 ft. drawdown; log |
| 25c1 | -- | -- | -- | 8 | -- | 5,985 | TC | 1 | M | 7-28-65 | -- | -- | -- |
| 32a1 | N. M. Coats | 1966 | 260 | 16 | -- | -- | TC | 10 | R | 9-16-66 | -- | 1 | Log 9205 |
| 27/64-25d | Goshute Station (NRRR) | -- | 60 | 10 | -- | -- | TC | .5 | M | 7-28-65 | -- | -- | Published WSP 467 |
| 27/65-29c1 | Nevada State Highway Department | -- | -- | 8 | -- | -- | TC | 1.0 | M | 7-28-65 | 62 | O | Highway constr. well |
| 28/64-27c3 | Goshute Store | -- | 13 | Dug well | -- | -- | TC | .7 | M | 7-28-65 | -- | D,S | Five additional dug wells in this quarter section |

Some increase in concentration is indicated in water from discharge areas, such as samples from wells 20/64-6a1 and 23/63-2b1. However, these concentrations are not as high as would ordinarily be expected in natural discharge areas. This probably results from local recharge by seasonal flooding with fresh water of the lowland in these areas and partial removal of some of the salts accumulated at the surface during hot summer months.

USE OF WATER

Present Use

Water currently is used for public supply, industry, agriculture, livestock, and recreation in Steptoe Valley. Information for most wells is listed in tables 12 and 13.

Municipal supplies for Ely, East Ely, McGill, and Ruth are obtained from springs and wells. Annual use may be on the order of 1,200 acre-feet. Murry Springs, fed by water from carbonate rocks, supplies most of the requirements of Ely and East Ely. The average flow of the springs is estimated to be 6 to 8 cfs, roughly 2,700 to 3,600 gallons per minute, but in recent years appears to have been considerably less. Some variation in flow is expected, but well-controlled measurements are not easily made to verify the full characteristics of the spring flow. In recent years, wells have been pumped during peak demand periods. The McGill municipal supply is provided by a well in town. Public-supply requirements for the Ruth area have been met partly from springs several miles to the south and high on the west side of the Egan Range. Water from these springs is brought to the Ruth area by pipeline. Water pumped from the underground mines in that area previously was used to some extent for public supply or mining requirements.

Mining and processing of copper ore is the principal industrial use of water in Steptoe Valley. Water is supplied for plant operations at McGill from Duck Creek, McGill Springs, and water recirculated from settling ponds and tailings disposal (Holmes, 1966, p. 17 and fig. 10). An average of about 15 cfs is supplied from the Duck Creek system, and 5 cfs (of 10 cfs flow) is supplied from McGill Springs. Thus, 20 cfs, or an average of about 14,500 acre-feet of new water a year, may be used in the overall operations at McGill. Additionally, much water is recirculated in the plant. For example, about $13\frac{1}{2}$ cfs is recirculated through the concentrator and about 67 cfs is recirculated as cooled condensing water.

The Silver King Mines, Inc., north of Ely, uses the Lackawanna Springs, discharge about 0.3 cfs, for milling operations. Other industrial use of water is relatively small and largely depends on the municipal supply of Ely for its requirements.

Agricultural needs for water are supplied principally from streams and springs. Most of this water has been used to irrigate meadow hay and pasture. However, irrigation of cultivated crops is increasing. Some ground water has been pumped for irrigation for many years from a few scattered wells in the Ely-McGill part of the valley. This pumpage probably has not averaged more than about 1,000 acre-feet a year. In recent years the number of wells has increased and consequently pumpage has increased to about 3,000 acre-feet a year.

The release of Federal land under the Desert Land Act is stimulating additional irrigation development south of Warm Springs Station, and in the north part of the valley east of Goshute Lake.

Potential Use

Increased requirements for water in Steptoe Valley can be supplied by additional ground-water development, by increasing the efficiency of use of water, and by reuse of water. The means by which increased water requirements are met commonly are controlled by the degree of need and economics.

In Steptoe Valley, the efficiency in the use of water will increase as the need for water increases. Thus the need for water to maintain plant operations at McGill led to an increase in the efficiency and a substantial re-use of water to meet requirements. Also, some of the waste water from the Ely public supply is reused for irrigation.

However, much additional ground water can be developed. As previously discussed, ground-water withdrawals at the rate of about 70,000 acre-feet a year could be maintained for several decades; however, the manner in which withdrawals were distributed in the valley would be an important factor in determining how long that amount of withdrawal could be maintained. If all the water were withdrawn from a single localized area, water levels probably would be lowered beyond economic limits within 10 years. However, if withdrawals were distributed in the four areas described in the valley, withdrawals of 70,000 acre-feet a year probably could be maintained for 50 years or more.

DESIGNATION OF WELLS AND SPRINGS

The numbering system for wells and springs is based on the rectangular subdivision of public lands, and in Nevada is referenced to the Mount Diablo base line and meridian. The number consists of three units; the first is the township north of the base line; the second unit, separated from the first by a slant, is the range east of the meridian; and the third unit, separated from the second by a dash, designates the section number. The section number is followed by one or two letters. The first letter designates the quarter section, the letters a, b, c, and d respectively designate the northeast, northwest, southwest, and southeast quarter sections. In a similar manner, if a second letter is shown, it designates the quarter-quarter section location. Following the letter, a number indicates the order in which the well or spring was recorded within the quarter section. For example, well 19/63-12a1 is the first well recorded in the northeast quarter of sec. 12, T. 19 N., R. 63 E., Mount Diablo base line and meridian.

Well numbers on plate 1 only give the section number, quarter section letter (some also give quarter-quarter section letters), and final number by the well symbol. The township and range numbers are shown along the margins of the valley area on plate 1.

Table 13.--Drillers' logs of selected wells

| Material | Thick- ness (feet) | Depth (feet) | Material | Thick- ness (feet) | Depth (feet) |
|--|--------------------------|-----------------|--|--------------------------|-----------------|
| <u>14/64-9a BLM</u> | | | <u>15/64-17ba C-B Ranch Co.</u> | | |
| Sand, cemented, and gravel | 80 | 80 | Silt | 25 | 25 |
| Sand and gravel | 5 | 85 | Gravel | 5 | 30 |
| Clay, sandy | 50 | 135 | Gravel, cemented | 50 | 80 |
| Sand and gravel | 5 | 140 | Silt | 40 | 120 |
| <u>14/64-36a BLM</u> | | | <u>15/64-17bc C. B. Land & Cattle Co.</u> | | |
| Soil | 3 | 3 | Silt | 25 | 25 |
| Gravel, cemented | 227 | 230 | Gravel | 5 | 30 |
| Sand and gravel | 2 | 232 | Gravel, cemented | 50 | 80 |
| Sand and gravel, cemented | 31 | 263 | Silt | 35 | 115 |
| Sand and gravel | 2 | 265 | Silt, cemented | 15 | 130 |
| Gravel, cemented | 13 | 273 | Gravel | 5 | 135 |
| Sand and gravel | 6 | 284 | Cement | 5 | 140 |
| | | | Silt | 5 | 145 |
| | | | Silt and clay | 25 | 170 |
| | | | Gravel | 5 | 175 |
| | | | Gravel and silt | 5 | 180 |
| | | | Gravel | 15 | 195 |
| | | | Gravel and silt | 8 | 203 |
| <u>14/65-29bc BLM</u> | | | <u>16/62-12ca Isbell Construction Co.</u> | | |
| Topsoil | 1 | 1 | Mine dump fill | 10 | 10 |
| Gravel, hard, cemented | 45 | 46 | Silt - valley loam | 5 | 15 |
| Gravel, cemented, little white clay | 4 | 50 | Silt and light gravel | 15 | 30 |
| Gravel, cemented | 23 | 73 | Gravel, washed | 50 | 80 |
| Clay, tan, gravel | 2 | 75 | Limestone | 4 | 84 |
| Gravel, cemented | 18 | 93 | | | |
| Gravel, cemented, little white clay | 15 | 108 | | | |
| Gravel, cemented, little tan clay | 22 | 130 | | | |
| Gravel and tan clay | 7 | 137 | | | |
| Gravel, cemented | 34 | 171 | <u>16/63-2a State Fish and Game Commission</u> | | |
| Gravel and tan clay | 3 | 174 | Soil | 3 | 3 |
| Gravel, cemented | 29 | 203 | Gravel, cemented | 72 | 75 |
| Gravel and tan clay | 36½ | 239½ | Sand and gravel | 21 | 96 |
| Limestone, very hard | 5½ | 245 | | | |
| Clay, tan, gravel | 18 | 263 | <u>16/63-2db Harvey W. Young</u> | | |
| Gravel, cemented | 18 | 281 | Soil | 3 | 3 |
| Rock | 1 | 282 | Gravel, cemented | 77 | 80 |
| Clay, tan, gravel | 26 | 308 | Sand and gravel | 5 | 85 |
| Gravel, cemented little tan clay | 37 | 345 | Clay | 30 | 115 |
| Gravel, cemented, hard, tan clay | 33 | 378 | Sand and gravel | 5 | 120 |
| Gravel, cemented | 28 | 406 | | | |
| Gravel, cemented soft clay | 24 | 430 | | | |
| Gravel, cemented | 75 | 505 | | | |

Table 13.--Continued

| Material | Thick- ness (feet) | Depth (feet) | Material | Thick- ness (feet) | Depth (feet) |
|--------------------------------|--------------------------|-----------------|-----------------------------------|--------------------------|-----------------|
| <u>63-2dc1 James E. Duvall</u> | | | <u>16/63-14a1 William Goodman</u> | | |
| d | 140 | 140 | Clay and loam | 21 | 21 |
| y | 40 | 180 | Gravel, fine, and sand | 12 | 33 |
| nd | 10 | 190 | Clay | 4 | 37 |
| d and gravel | 20 | 210 | Gravel, fine, sand | 11 | 48 |
| | | | Silt and sand | 37 | 85 |
| <u>63-2dc2 J. E. Doutré</u> | | | Sand and gravel | 1 | 86 |
| d | 137 | 137 | Silt and sand | 4 | 90 |
| y | 13 | 150 | Sand and gravel | 2 | 92 |
| avel | 15 | 165 | Silt and sand | 3 | 95 |
| | | | Sand | 4 | 99 |
| <u>63-9cc James Katsaros</u> | | | Silt and sand | 6 | 105 |
| il, sandy | 17 | 17 | Sand | 2 | 107 |
| avel | 12 | 29 | Silt and sand | 7 | 114 |
| avel, cemented | 36 | 65 | Sand and fine gravel | 3 | 117 |
| avel, cemented, small | | | Clay and sand layers | 2 | 119 |
| streaks of water | 40 | 105 | Gravel, fine, sand | 11 | 130 |
| l and sand | 55 | 160 | <u>16/63-14a2 William Goodman</u> | | |
| avel, cemented, small | | | Soil | 5 | 5 |
| streaks of water | 100 | 260 | Clay, gray | 24 | 29 |
| <u>63-11ab C. W. Swain</u> | | | Sand and gravel | 10 | 39 |
| il | 3 | 3 | Clay | 9 | 48 |
| avel, cemented | 57 | 60 | Sand and gravel | 2 | 50 |
| nd and gravel | 10 | 70 | Clay | 29 | 79 |
| avel, cemented | 30 | 100 | Sand and gravel | 2 | 81 |
| nd and gravel | 20 | 120 | Clay | 27 | 108 |
| | | | Sand and gravel | 1 | 109 |
| | | | Clay | 11 | 120 |
| <u>63-11d William Goodman</u> | | | Sand | 1 | 121 |
| avel, cemented | 5 | 5 | Clay | 7 | 128 |
| ilt | 35 | 40 | | | |
| nd and gravel (water) | 5 | 45 | | | |
| lay and gravel mixed | 10 | 55 | | | |
| lay | 15 | 70 | | | |
| lay and gravel | 15 | 85 | | | |
| nd and gravel (water) | 5 | 90 | | | |
| lay | 5 | 95 | | | |
| nd, gravel, and water | 5 | 100 | | | |
| ilt | 15 | 115 | | | |
| nd and gravel | 5 | 120 | | | |

Table 13.--Continued

| Material | Thick- ness (feet) | Depth (feet) | Material | Thick- ness (feet) | Depth (feet) |
|--|--------------------------|-----------------|--|--------------------------|-----------------|
| <u>16/63-15ba City of Ely, Municipal Water District</u> | | | <u>16/63-16cc2 City of Ely, Municipal Water District</u> | | |
| Gravel, cemented | 52 | 52 | Silt | 20 | 20 |
| Gravel and water | 2 | 54 | Gravel, loose | 26 | 46 |
| Gravel, cemented | 4 | 58 | Gravel, cemented | 20 | 66 |
| Gravel | 1 | 59 | <u>16/63-17a White Pine County Schools</u> | | |
| Gravel, cemented | 6 | 65 | | | |
| Gravel | 1 | 66 | Topsoil | 4 | 4 |
| Gravel, cemented | 6 | 72 | Clay | 8 | 12 |
| Gravel | 1 | 73 | Sand | 5 | 17 |
| Gravel, cemented | 9 | 82 | Clay and gravel | 41 | 58 |
| Gravel | 1 | 83 | Gravel | 6 | 64 |
| Gravel, cemented | 3 | 86 | <u>16/64-6dc BLM</u> | | |
| Gravel | 1 | 87 | | | |
| Gravel, cemented | 10 | 97 | Gravel, cemented | 275 | 275 |
| Gravel | 2 | 99 | Gravel | 10 | 285 |
| Gravel, cemented | 9 | 108 | Gravel, cemented | 21 | 306 |
| Gravel | 1 | 109 | <u>17/63-1bc W. B. Wright</u> | | |
| Gravel, cemented | 16 | 125 | | | |
| Gravel | 1 | 126 | Soil | 5 | 5 |
| Gravel, cemented | 27 | 153 | Gravel | 114 | 119 |
| Gravel | 2 | 155 | <u>17/63-7ab A. J. Mellow</u> | | |
| Gravel, cemented | 15 | 170 | | | |
| Gravel | 1 | 171 | Soil, sandy | 31 | 31 |
| Gravel, cemented | 19 | 190 | Gravel | 36 | 67 |
| Gravel | 1 | 191 | Gravel | 61 | 128 |
| Gravel, cemented | 9 | 200 | Clay and gravel | 48 | 176 |
| Gravel | 4 | 204 | Clay and silt | 124 | 300 |
| Gravel, cemented | 21 | 225 | Clay with gravel seams | | |
| <u>16/63-16cc1 City of Ely, Municipal Water District</u> | | | <u>17/64-6bc Robert Choat</u> | | |
| Silt | 40 | 40 | Topsoil, brown | 4 | 4 |
| Gravel, cemented | 20 | 60 | Gravel, loose, dry | 24 | 28 |
| Gravel with water | 1 | 61 | Sand, gravel, cobbles | 74 | 102 |
| Gravel, cemented | 4 | 65 | Clay, brown | 12 | 114 |
| Gravel with water | 5 | 70 | Sand and gravel, cemented | 3 | 117 |
| Gravel, cemented | 10 | 80 | Gravel, loose | 4 | 121 |
| Gravel with water | 1 | 81 | | | |
| Gravel, cemented | 5 | 86 | | | |
| Gravel | 4 | 90 | | | |
| Gravel, cemented | 8 | 98 | | | |
| Gravel | 1 | 99 | | | |
| Gravel, cemented | 13 | 112 | | | |
| Gravel and sand | 6 | 118 | | | |
| Silt | 17 | 135 | | | |
| Gravel, cemented, gravel, streaks of water | 165 | 300 | | | |

Table 13.--Continued

| Material | Thick- ness (feet) | Depth (feet) | Material | Thick- ness (feet) | Depth (feet) |
|------------------------------------|--------------------------|-----------------|-----------------------------------|--------------------------|-----------------|
| <u>17/64-8bal N. K. Sundrud</u> | | | <u>18/63-36a1 Albert Romeo</u> | | |
| Soil | 5 | 5 | Clay | 6 | 6 |
| Sand and gravel, cemented | 41 | 46 | Gravel, water-bearing | 2 | 8 |
| Gravel | 1 | 47 | Clay, sand, yellow | 6 | 14 |
| Sand and gravel, cemented | 39 | 86 | Gravel and sand, water- | | |
| Gravel | 1 | 87 | bearing | 10 | 24 |
| Clay | 11 | 98 | Sand and gravel, mixed with | | |
| Gravel | 1 | 99 | clay, water-bearing | 19 | 43 |
| Sand and gravel, cemented | 4 | 103 | Clay, sand, yellow | 21 | 64 |
| Gravel | 1 | 104 | Clay, sandy | 55 | 119 |
| Clay | 46 | 150 | Gravel, water-bearing | 6 | 125 |
| Cement | 1 | 151 | Clay | 5 | 130 |
| Gravel | 1 | 152 | | | |
| Clay | 32 | 184 | <u>18/63-36cc Pescio Bros.</u> | | |
| Cement | 2 | 186 | Soil | 4 | 4 |
| Clay | 18 | 204 | Hardpan | 4 | 8 |
| <u>17/64-19ca J. R. Walcutt</u> | | | Gravel, coarse, water | 22 | 30 |
| Gravelly soil | 22 | 22 | Silt, light, clay | 8 | 38 |
| Gravel, cemented | 65 | 87 | Silt, clay, and gravel mixed | 7 | 45 |
| Gravel, loose water-bearing | 21 | 108 | Gravel, medium coarse, water | 5 | 50 |
| | | | Clay | 7 | 57 |
| | | | Gravel, coarse, water | 7 | 64 |
| <u>17/64-30ba LeRoy Manning</u> | | | Clay | 12 | 76 |
| Soil | 4 | 4 | Sand, coarse, water | 26 | 102 |
| Sand and gravel | 88 | 92 | <u>18/64-3ac Mrs. Mary Fields</u> | | |
| Gravel | 1 | 93 | Soil | 5 | 5 |
| Cement | 5 | 98 | Boulders, cemented | 225 | 230 |
| Gravel | 2 | 100 | Sand and gravel | 40 | 270 |
| Cement | 6 | 106 | Boulders, cemented | 40 | 310 |
| Gravel | 2 | 108 | | | |
| Cement | 7 | 115 | | | |
| Gravel and sand | 19 | 134 | | | |
| <u>17/64-30bd Earl N. Williams</u> | | | | | |
| Soil | 3 | 3 | | | |
| Sand and gravel, cemented | 90 | 93 | | | |
| Gravel | 1 | 94 | | | |
| Cement | 2 | 96 | | | |
| Gravel | 2 | 98 | | | |
| Cement | 7 | 105 | | | |
| Gravel | 5 | 110 | | | |
| Cement | 3 | 113 | | | |
| Gravel | 1 | 114 | | | |

Table 13.--Continued

| Material | Thick- ness (feet) | Depth (feet) | Material | Thick- ness (feet) | Depth (feet) |
|-------------------------------------|--------------------------|-----------------|--|--------------------------|-----------------|
| <u>20/64-20a Noel Williams, Jr.</u> | | | <u>24/64-16c Ken Barton</u> | | |
| Topsoil | 2 | 2 | Soil | 6 | 6 |
| Hardpan | 4 | 6 | Clay | 39 | 45 |
| Clay and gravel | 14 | 20 | Sand and gravel | 3 | 48 |
| Gravel, cemented | 4 | 24 | Clay | 12 | 60 |
| Clay and gravel | 23 | 47 | Sand and gravel | 5 | 65 |
| Gravel | 2 | 49 | | | |
| Clay and gravel | 1 | 50 | <u>25/65-5b1 J. B. Coats</u> | | |
| Gravel | 2 | 52 | Sand, yellow | 15 | 15 |
| Clay and gravel | 5 | 57 | Clay, blue with gravel and | | |
| Clay | 3 | 60 | clay layers | 430 | 445 |
| Gravel, hard | 2 | 62 | Clay, lake bottom | 15 | 460 |
| Clay and gravel | 6 | 68 | | | |
| Gravel, some clay | 2 | 70 | <u>25/65-31a Silver State Construction Co.</u> | | |
| Clay and gravel (lots of clay) | 17 | 87 | Sand and gravel, cemented | 50 | 50 |
| Gravel | 4 | 91 | Gravel and water | 2 | 52 |
| Clay and gravel layers | 9 | 100 | Clay, sandy | 168 | 220 |
| Clay | 2 | 102 | | | |
| Clay and gravel | 3 | 105 | <u>26/64-28d1 Cordano Bros.</u> | | |
| Clay | 2 | 107 | Soil | 27 | 27 |
| Clay and gravel | 6 | 113 | Sand, gravel, water | 3 | 30 |
| Clay | 10 | 123 | Clay | 15 | 45 |
| Gravel | 2 | 125 | Sand, gravel, water | 2 | 47 |
| Clay and gravel | 6 | 131 | Clay | 28 | 75 |
| Gravel | 2 | 133 | Sand and gravel | 1 | 76 |
| Clay and gravel | 2 | 135 | Clay | 22 | 98 |
| Clay | 7 | 142 | Sand and gravel | 2 | 100 |
| Gravel | 4 | 146 | Clay | 150 | 250 |
| Clay and gravel | 2 | 148 | | | |
| Gravel | 3 | 151 | <u>26/64-28d2 Cordano Bros.</u> | | |
| Clay and gravel | 7 | 158 | Clay | 10 | 10 |
| | | | Sand and gravel | 50 | 60 |
| <u>21/63-35c Austin Flint</u> | | | <u>26/65-15 William Cooper</u> | | |
| Gravel, fine | 30 | 30 | Surface deposits | 10 | 10 |
| Cobblestone | 5 | 35 | Gravel | 20 | 30 |
| Clay and gravel | 10 | 45 | Quicksand | 30 | 60 |
| Boulders | 5 | 50 | Clay, yellow, and gravel | 140 | 200 |
| Gravel, fine | 20 | 70 | | | |
| Clay and gravel, fine | 15 | 85 | <u>26/65-32a1 N. M. Coats</u> | | |
| Gravel, medium | 15 | 100 | Clay, sandy | 15 | 15 |
| Clay and gravel, fine | 15 | 115 | Clay, yellow | 15 | 30 |
| Gravel, sandy | 5 | 120 | Clay, blue with gravel and | | |
| Gravel, fine | 30 | 150 | clay layers | 230 | 260 |
| Clay and gravel, fine | 5 | 155 | | | |
| Gravel, fine | 5 | 160 | | | |
| Gravel, sandy | 5 | 165 | | | |
| Gravel, medium | 20 | 185 | | | |
| Gravel, fine | 10 | 195 | | | |
| Clay and gravel, fine | 15 | 210 | | | |
| Gravel, fine | 15 | 225 | | | |
| Clay and gravel | 25 | 250 | | | |

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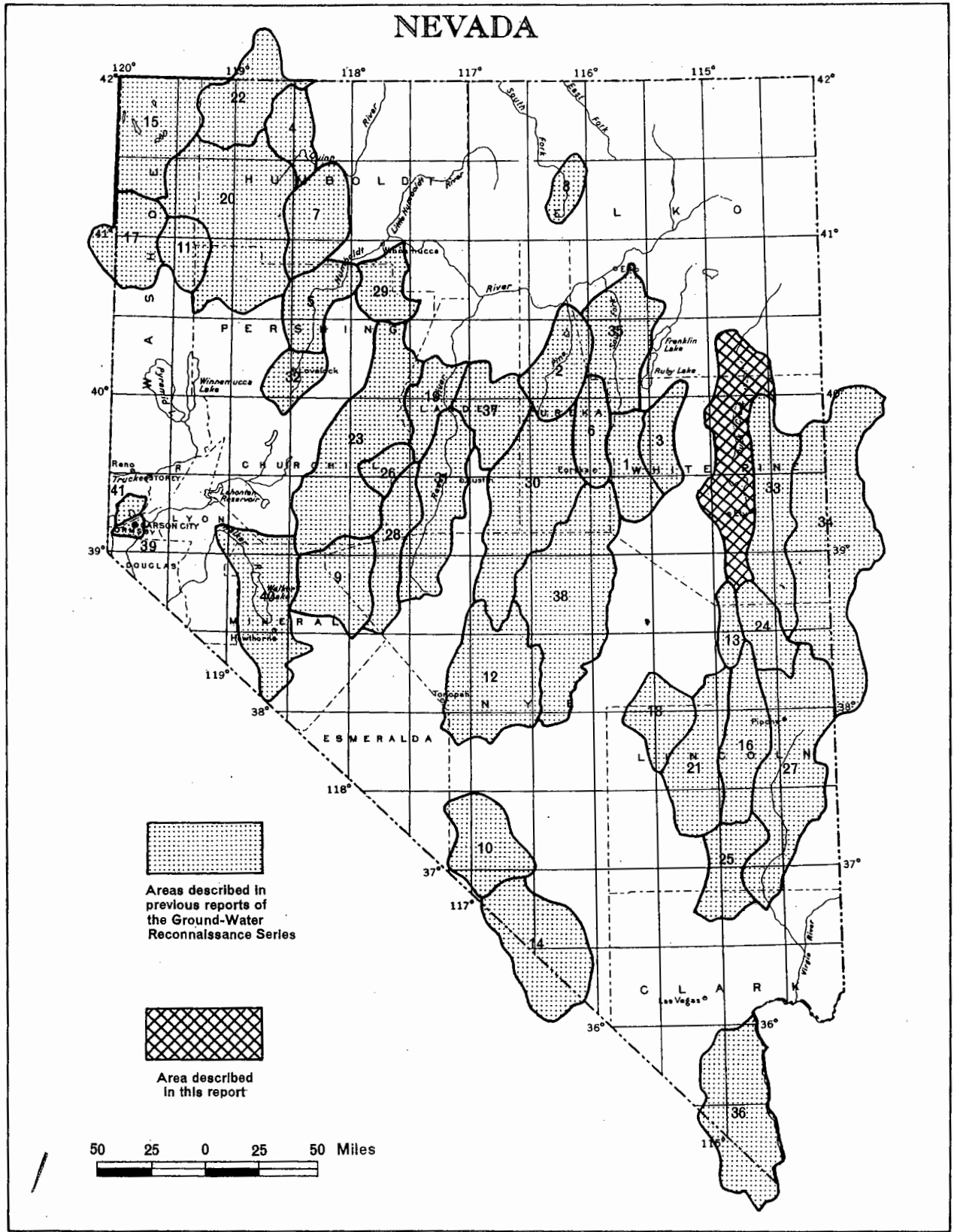


Figure 2.—Areas in Nevada described in previous reports of the Water Resources Reconnaissance Series and the area described in this report

LIST OF PUBLISHED REPORTS IN THE
WATER RESOURCES - RECONNAISSANCE SERIES

| Report No. | Valley | Report No. | Valley |
|---------------|----------------------------|---------------|-------------------------------------|
| 1 | Newark (out of print) | 27 | Lower Meadow Patterson |
| 2 | Pine (out of print) | | Spring (near Panaca) Panaca |
| 3 | Long (out of print) | | Eagle Clover |
| 4 | Pine Forest (out of print) | | Dry |
| 5 | Imlay area (out of print) | 28 | Smith Creek and Ione |
| 6 | Diamond (out of print) | 29 | Grass (near Winnemucca) |
| 7 | Desert | 30 | Monitor, Antelope, and Kobeh |
| 8 | Independence | 31 | Upper Reese |
| 9 | Gabbs | 32 | Lovelock |
| 10 | Sarcobatus and Oasis | 33 | Spring (near Ely) (out of print) |
| 11 | Hualapai Flat | 34 | Snake (out of print) |
| 12 | Ralston and Stonecabin | | Hamlin |
| 13 | Cave | | Antelope |
| 14 | Amargosa | | Pleasant |
| 15 | Long Surprise | | Ferguson Desert |
| | Massacre Lake Coleman | 35 | Huntington (out of print) |
| | Mosquito Guano | | Dixie Flat |
| | Boulder | | Whitesage Flat |
| 16 | Dry Lake and Delamar | 36 | Eldorado - Piute Valley |
| 17 | Duck Lake | | (Nevada and California) |
| 18 | Garden and Coal | 37 | Grass and Carico Lake |
| 19 | Middle Reese and Antelope | | (Lander and Eureka Counties) |
| 20 | Black Rock Desert | 38 | Hot Creek |
| | Granite Basin | | Little Smoky |
| | High Rock Lake | | Little Fish Lake |
| | Summit Lake | 39 | Eagle Valley |
| 21 | Pahranagat and Pahroc | | (Ormsby County) |
| 22 | Pueblo Continental Lake | 40 | Walker Lake Area |
| | Virgin Gridley Lake | | (Mineral, Lyon, Churchill Counties) |
| 23 | Dixie Stingaree | 41 | Washoe Valley |
| | Fairview Pleasant | 42 | Steptoe Valley |
| | Eastgate Jersey | | (White Pine and Elko Counties) |
| | Cowkick | | |
| 24 | Lake | | |
| 25 | Coyote Spring | | |
| | Kane Spring | | |
| | Muddy River Springs | | |
| 26 | Edwards Creek | | |

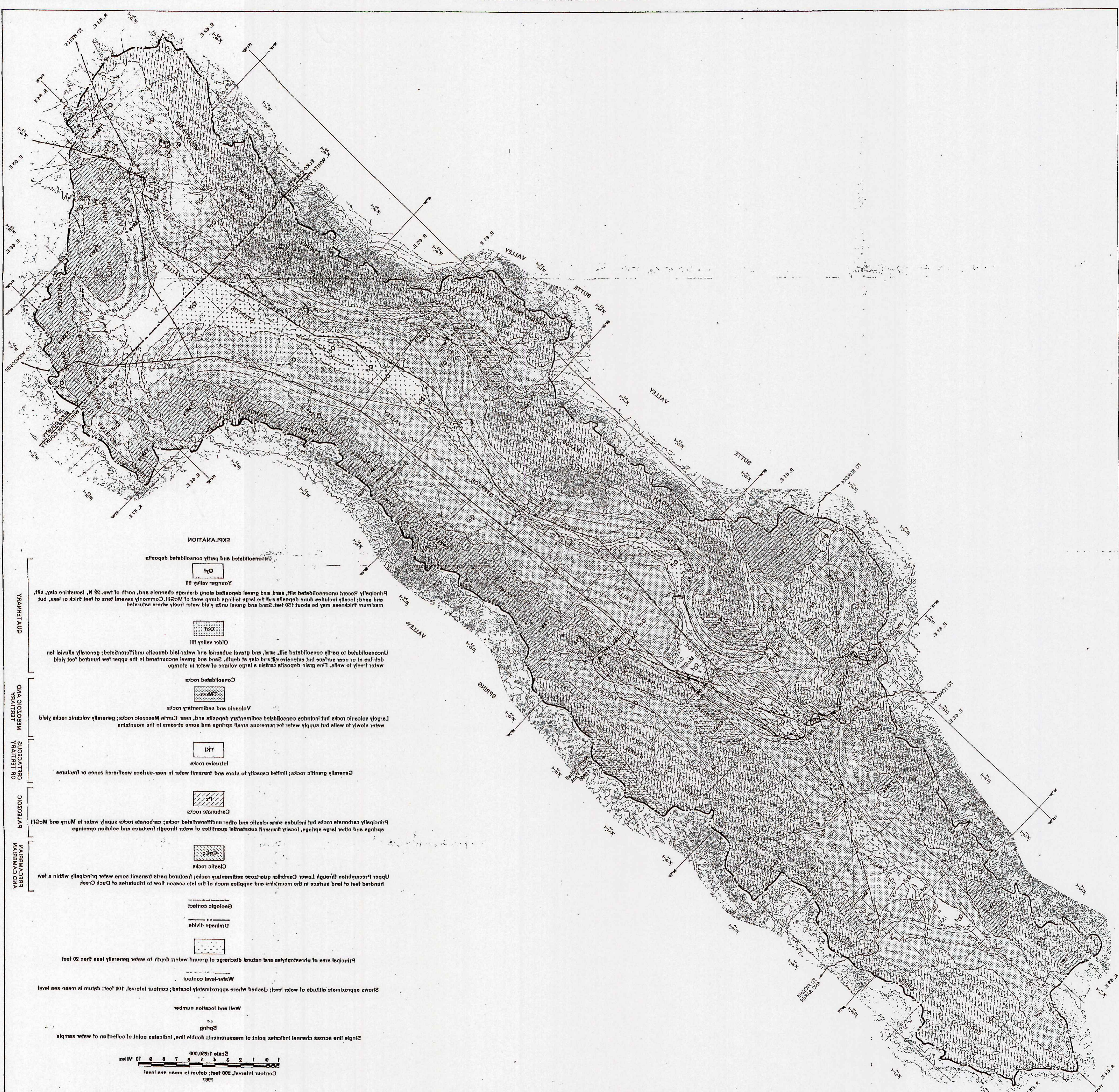
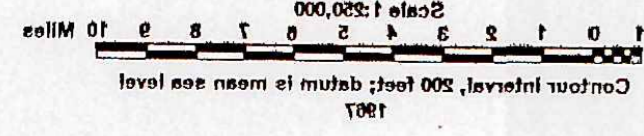


PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF STEPPOE VALLEY, NEVADA

Geology by J. L. Hughes (1922); Hydrology by T. E. Egan and J. L. Hughes (1922). Consolidated rock geology after Tapp and others (1924); unconsolidated



Single line across channel indicates point of measurement; double line, indicates point of collection of water sample
Spring

Well and location number

Shows approximate altitude of water level; dashed where approximately located; contour interval, 100 feet; datum is mean sea level

Principal area of phreatophytes and natural discharge of ground water; depth to water generally less than 50 feet



Drainage divide



Geologic contact



Clastic rocks

Upper Precambrian through Lower Cambrian detritaceous sedimentary rocks; fractured parts transmit some water principally within a few hundred feet of land surface in the mountains and supplies much of the late season flow to tributaries of Duck Creek



Carbonate rocks

Principally carbonate rocks but includes some clastic and other unfractured rocks; carbonate rocks supply water to Mury and McGill Springs and other large springs; locally transmit substantial quantities of water through fractures and solution openings



Intrusive rocks

Generally granitic rocks; limited capacity to store and transmit water in near-surface weathered zones or fractures



Consolidated rocks

Largely volcanic rocks but includes consolidated sedimentary deposits and, near Curry Mountains, generally volcanic rocks; water slowly to wells but supply water for numerous small springs and some streams in the mountains



Older valley fill

Unconsolidated to partly consolidated silt, sand, and gravel deposited along drainage channels and, north of twp. 22 N., lacustrine clay, silt, and sand; locally includes dune deposits and large talus fans west of McGill. Commonly several tens of feet thick or less, but maximum thickness may be about 150 feet. Sand and gravel units yield water freely where saturated



Younger valley fill

Unconsolidated and partly consolidated deposits



Unconsolidated and partly consolidated deposits

QUATERNARY
MESOZOIC AND PALEOZOIC
MESOZOIC AND PALEOZOIC
MESOZOIC AND PALEOZOIC