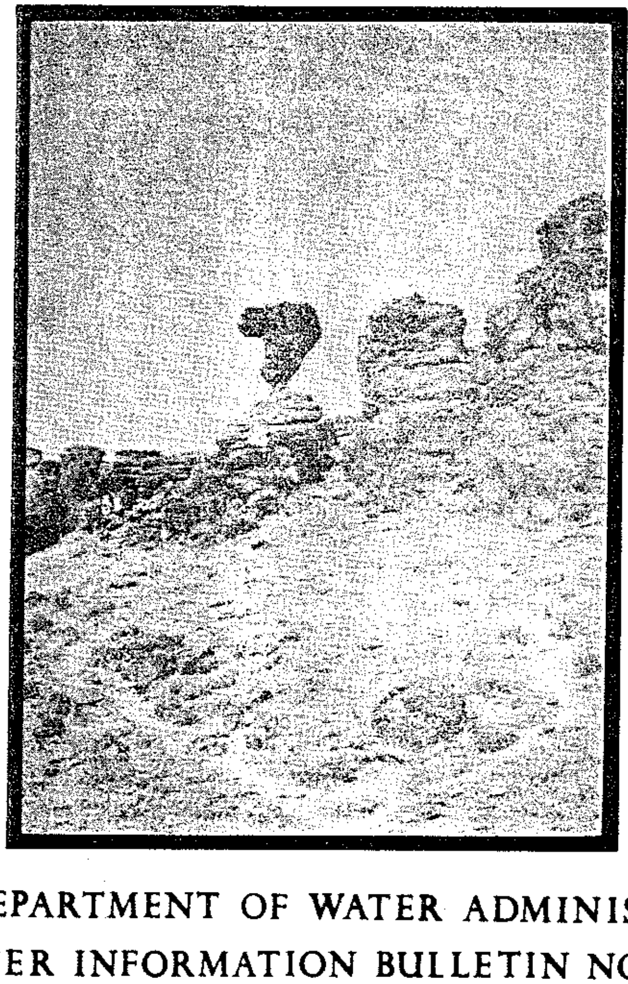
WATER RESOURCES
OF THE
BLUE GULCH AREA
EASTERN OWYHEE
AND
WESTERN TWIN FALLS COUNTIES, IDAHO



IDAHO DEPARTMENT OF WATER ADMINISTRATION
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GROUND–WATER RESOURCE OF THE BLUE GULCH AREA IN EASTERN OWYHEE AND WESTERN TWIN FALLS COUNTIES, IDAHO

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ABSTRACT

The study area is located in western Twin Falls and eastern Owyhee counties. It includes approximately 300 square miles and is composed of three geographic features: the Snake River canyon, the Salmon Falls Creek canyon, and a rolling plain. Surface drainage is to the Snake River or Salmon Falls Creek.

Only two of the several geologic units present are important as aquifers: the Idavada Volcanics and the Banbury Basalt. Both units are traversed by numerous northwest-trending faults. These faults and the adjacent fracture zones are the dominant factors controlling ground-water movement.

The development of the ground-water resource has been primarily for irrigation. Approximately 33 producing irrigation wells have been drilled and many more nonproductive wells exist in the area. Most wells are less than 1,000 feet deep, but one is 1,740 feet in depth.

Transmissibility of the aquifers varies from 3,800 to 840,000 gallons per day per foot. This wide range of transmissibility is believed to be the result of the discontinuity of the fractures and fault zones.Ground-water flow is believed to be generally from south to north with a gradient of approximately 25 feet per mile. The depth-to-water ranges from approximately 72 to 448 feet below land surface and the yield-to-wells varies from 339 to approximately 3,000 gallons per minute. Some of the factors causing the variations noted are well construction, depth of penetration of the aquifer and the degree of fracturing present in the aquifer material. Water-level fluctuations in the area show declines of from 3 to 17 feet per year for a long term period. Water-level declines for the period April 1969 to March 1970 were over 27 feet. Water levels have risen slightly in the northern portion of the study area.

Recharge to the aquifers is believed to be from the south. Discharge from the ground-water system is to Salmon Falls Creek, the Snake River, and by withdrawal by wells.

Ground-water quality is generally good. Most water is suitable for both domestic and irrigation usage. Only three wells do not meet U. S. Public Health drinking water standards.

The Department of Water Administration has 70 active permits and licenses on file for appropriation of ground water in the Blue Gulch area. These permits represent a potential withdrawal of 409 cubic feet per second for the irrigation of 29,140 acres of land. The major development has occurred in the southeastern portion of the area.

INTRODUCTION

The history of ground-water development in the State of Idaho has been characterized by rapid expansion. Most of this development has occurred in arid and semi-arid areas in southern Idaho. Problems of well interference, water-quality changes, and water-level declines have accompanied the increased usage of ground water for irrigation. The Director of the Department of Water Administration is aware of these problems and has realized the need for detailed information on the water needs, hydrology and ground-water geology of specific areas in order to effectively administer the use of the water resources of the state. He has authorized investigations of areas where existing or potential problems are located. This report is the fourth to result from such an investigation.

Ground-water development began in the mid-fifties in an area west of Buhl known locally as Blue Gulch, and has accelerated rapidly in the period since 1964. Water-level declines were first noted in 1967 and have continued since that time. This reconnaissance investigation was authorized to analyze the water resources and the extent of the problems in the Blue Gulch area.

Objectives

The objectives of this investigation were to determine the quantity, quality, and occurrence of ground water in the Blue Gulch area with special emphasis on the effect of present and future developments on the resource. The more specific objectives were to: (1) determine the extent and hydrologic characteristics of the aquifers beneath the area, (2) determine the geologic control of the movement and occurrence of ground water, (3) determine the availability and depth of ground water for large scale irrigation purposes, (4) determine the effect of recent ground-water development on the general ground-water system and the flow of Salmon Falls Creek, and (5) determine the quality of the ground water and its suitability for irrigation and domestic purposes.

Location and Extent

The study area includes approximately 300 square miles located in western Twin Falls and eastern Owyhee counties (fig. 1). It averages 18 miles in length and is from 14 miles to 19 miles wide. The area is bounded on the north by the line common to Townships 7 and 8 South, on the south by the line common to Townships 10 and 11 South, on the east by Salmon Falls Creek and the Snake River, and on the west by the line common to Ranges 10 and 11 East. These boundaries were determined by the present distribution of ground-water development and are not hydrologically significant, except for Salmon Falls Creek.

Field work was conducted from April 1969 through March 1970. Four mass-measurements of water levels were conducted during this period. Ground-water samples from 16 locations were collected and chemically analyzed, and field specific conductance values were obtained at 17 locations.

Previous Investigations

The geology of the study area was included in a reconnaissance geologic study and presented in a map published by Malde, Powers and Marshall (1963), and a geologic report,

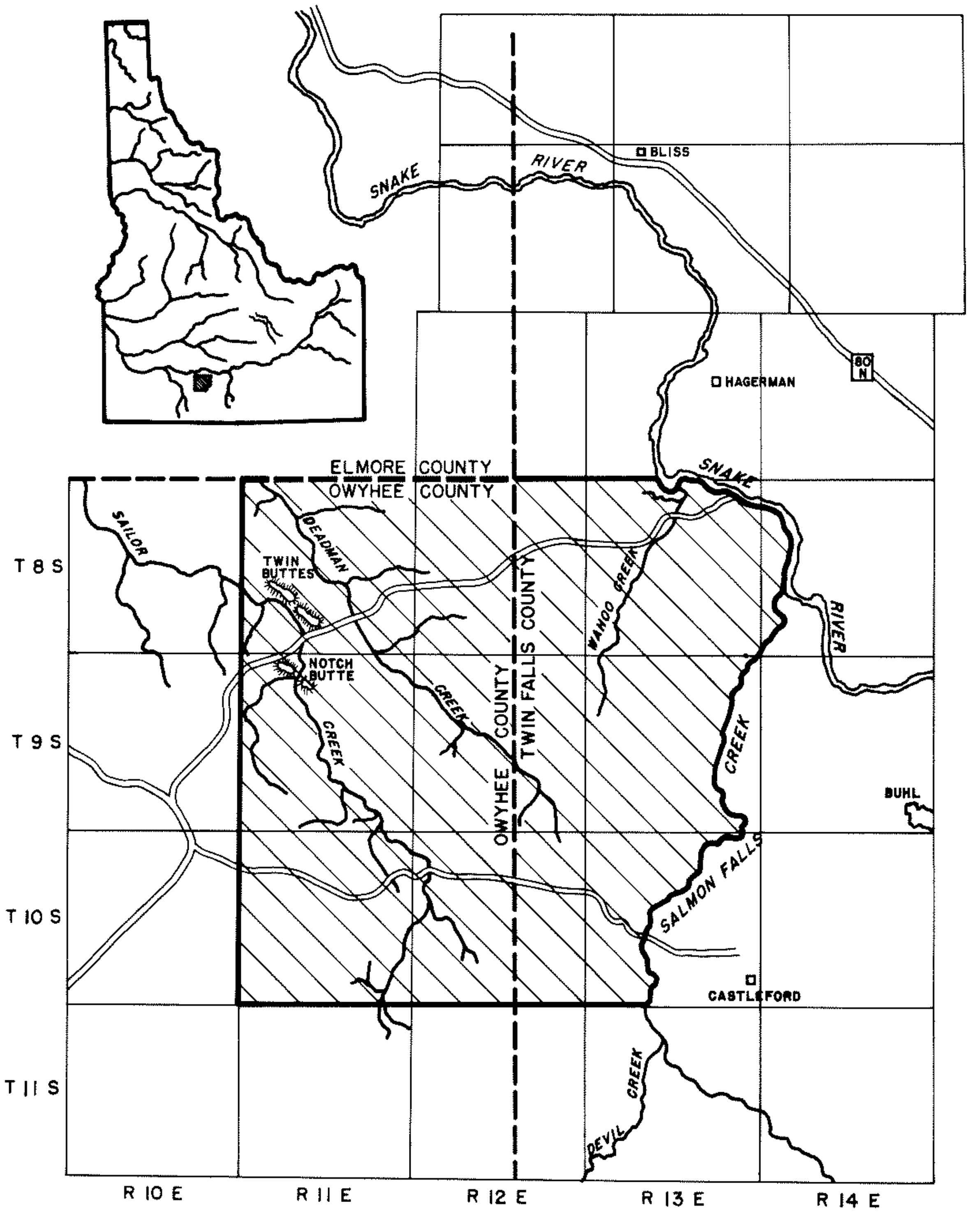

FIGURE 1. Index map showing the area covered by this report

Malde and Powers (1962). Previous investigations of the geology and hydrology have been conducted by Mundorff and others (1960), and Hadley and Sumsion (1958, 1959). The ground-water hydrology was studied as a part of a reconnaissance study of the Sailor Creek area conducted by E. G. Crosthwaite (1963).

Acknowledgments

The authors wish to acknowledge the technical assistance given by the Idaho Department of Health in analyzing the water samples from the study area. The U. S. Geological Survey provided valuable borehole geophysical data which assisted in interpretation of aquifer characteristics. The Agricultural Stablization and Conservation Service assisted in the determination of the irrigated acreage in the area. Mr. Tommy Thompson of Layne Bowler Pump Company provided data on pump tests which aided greatly. Mr. Eugene Kozak compiled and tabulated much of the basic data for this report. The cooperation of the many well drillers, tenants and landowners who provided information and allowed access to their wells is also gratefully acknowledged.

Well Numbering System

The well numbering system used in this study is the same as that used by the U. S. Geological Survey in Idaho (fig. 2). This system indicates the locations of the wells within the official rectangular subdivisions of the public lands, with reference to the Boise Base Line and Meridian. The first two segments of the number give the township and range, followed by the section number, and by two letters and a numeral, which indicate the quarter section, the forty-acre tract, and the serial number of the well within the tract. Quarter sections are lettered a, b, c, and d in counterclockwise order from the northeast quarter of each section. Within the quarter sections forty-acre tracts are lettered in the same manner. As an example, well 9S 12E 35cb1 is in the NW¼ SW¼ of Section 35, Township 9 South, Range 12 East, Boise Meridian, and is the first well designated in that tract.

Geographic Setting

The area is divided into three major geographic features: (1) the Snake River canyon, (2) the Salmon Falls Creek canyon, and (3) a rolling plain. The Snake River flows northwesterly along the northeast edge of the study area in a canyon cut over 400 feet deep in the lava and sedimentary rocks. Salmon Falls Creek has cut a narrow canyon in the lavas along the eastern boundary of the study area. This canyon is greater than 400 feet deep in places and averages about 1,400 to 2,000 feet wide. The canyon broadens near the mouth where the stream flows through weaker sedimentary rocks. The plain includes most of the study area. Numerous broad gulches separated by elongate steep-sided ridges traverse the plain. Many of these gulches are the erosional expression of numerous faults present within the area. Land development is located primarily in these areas. A fourth geographic feature of minor importance is a low bench in the northeastern portion of the study area adjacent to Salmon Falls Creek area. This land is irrigated by surface water from the creek and is

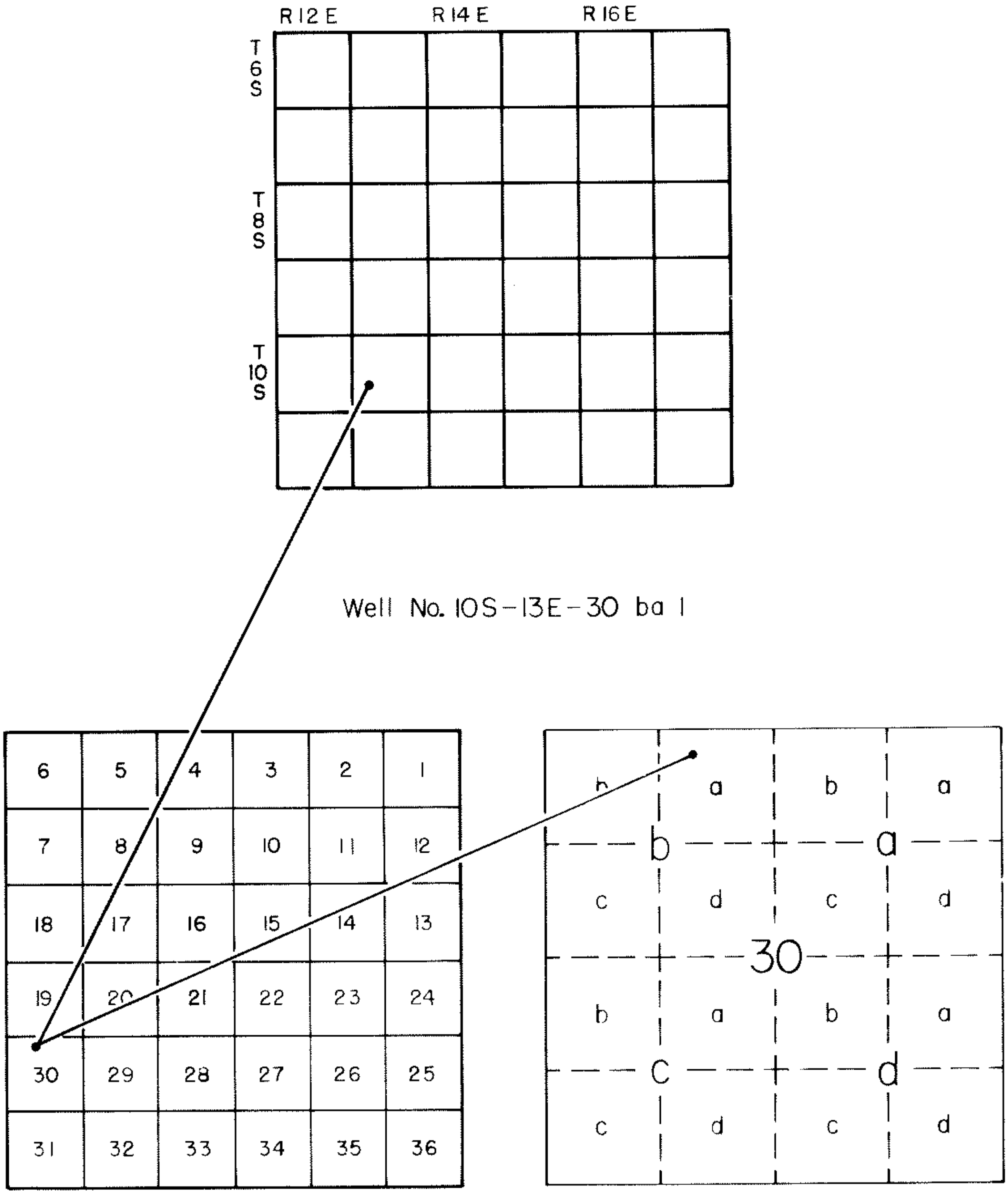

FIGURE 2. Well numbering system

almost entirely developed for agricultural purposes.

Only two perennial streams are present in or bound the study area: Salmon Falls Creek and the Snake River. Salmon Falls Creek is tributary to the Snake River. All of the other streams in the area are ephemeral and flow only after periods of precipitation, snowmelt or during the irrigation season when waste water is discharged. The general slope of the area is to the northwest from approximately 4,500 feet elevation on the upland to 2,800 feet elevation in the Snake River canyon.

The climate of the area is semi-arid with hot summers and cold winters. Average annual precipitation and temperature for six U. S. Weather Bureau stations nearest the study area are shown in table 1. The average annual temperature and precipitation for the area are estimated to be 48° Fahrenheit (F) and 9.6 inches.

Table 1

Average Annual Precipitation and Temperature

Data for Stations near the Blue Gulch Area

Station	Altitude (Ft. above MSL)	Average Annual Precipitation (Inches)	Years of Record	Mean Annual Temperature (° F)	Years of Record
Bliss	3296	8.57	49	50.3	49
Buhl	3500	8.21	42	50.1	42
Grasmere	5126	*9.29	13	47.5	13
Three Creek	5420	*13.55	27	43.5	4
Castleford	3825	9.57	6	48.6	4
Jerome	3893	8.70	41	49.5	34

* Partially estimated

Sagebrush is the dominant native vegetation in the area. Rabbit brush, cheat grass, and many other varieties of low brush and grass also inhabit the area.

Nearly all of the crops in the area are irrigated with the exception of some dry-land grain. The water utilized for irrigation is primarily from ground water with some diversion of surface water from the Salmon Falls Creek.

GROUND–WATER GEOLOGY

Introduction

The Blue Gulch study area is composed of several geologic formations (fig. 3). Only two of these are important as aquifers. The oldest unit present in the study area is the Idavada Volcanics, (Malde and Powers, 1962, p. 1,200), a series of silicic, welded ash flows. These rocks are considered to be the basement or deepest formation from which ground water may be derived. The overlying formation, the Banbury Basalt (Malde and Powers, 1962, p. 1,204) consists of three members, the upper two of which are important as aquifers. Nearly every well in the study area derives its water from one of these two geologic formations (fig. 4). Other formations present in the study area are the Glenns Ferry Formation, a thick sequence of bedded clay and silt overlain by a thin basalt member, the Tuana Gravel, an extensive pediment deposit and the Recent alluvium. None of the last three mentioned are important as major aquifers in the study area.

Idavada Volcanics

The Idavada Volcanics (Malde and Powers, 1962, p. 1,200) are the primary aquifer in the study area. The unit is exposed primarily in the southern half of the study area (fig. 3). The formation is composed of silicic welded ash flows, noted as "rhyolite" on well drillers' logs. The rocks are dark gray in color with small gray-white crystals of feldspar. When weathered the rocks are reddish-brown in color. Crude columnar jointing and horizontal fracturing are present in most of the exposures of the unit and drillers' logs indicate that this jointing and fracturing occurs at depth. The rocks are traversed by a large number of subparallel, northwest trending faults (fig. 4) which increases the fractured portion of the unit. The maximum thickness of the formation is unknown in the study area but well 9S 12E 24daa1 penetrated over 1,700 feet of these rocks without reaching the lower contact.

The Idavada Volcanics are important as an aquifer primarily in the southern and southeastern portion of the study area. Well yields as great as 2,400 gallons per minute (gpm) have been derived from wells penetrating the more fractured portions of the formation. The density of fracturing, however, is highly variable in the unit. Where wells penetrate the denser, less fractured portions of the formation, yields are usually insufficient for large-scale irrigation. Wells in the formation usually encounter artesian pressure from 5 to 30 feet of head. Water derived from the unit is generally warm (67° to 97° F) indicating some movement of hot water from greater depths, probably through fault zones.

The Idavada Volcanics are considered Lower Pliocene in age (Malde and Powers, 1962, p. 1,201) and are directly overlain by the Banbury Basalt.

Banbury Basalt

The Banbury Basalt (Malde and Powers, 1962, p. 1,204) is also important as a major aquifer in the study area. It consists of three members, the first of which is a lower basalt

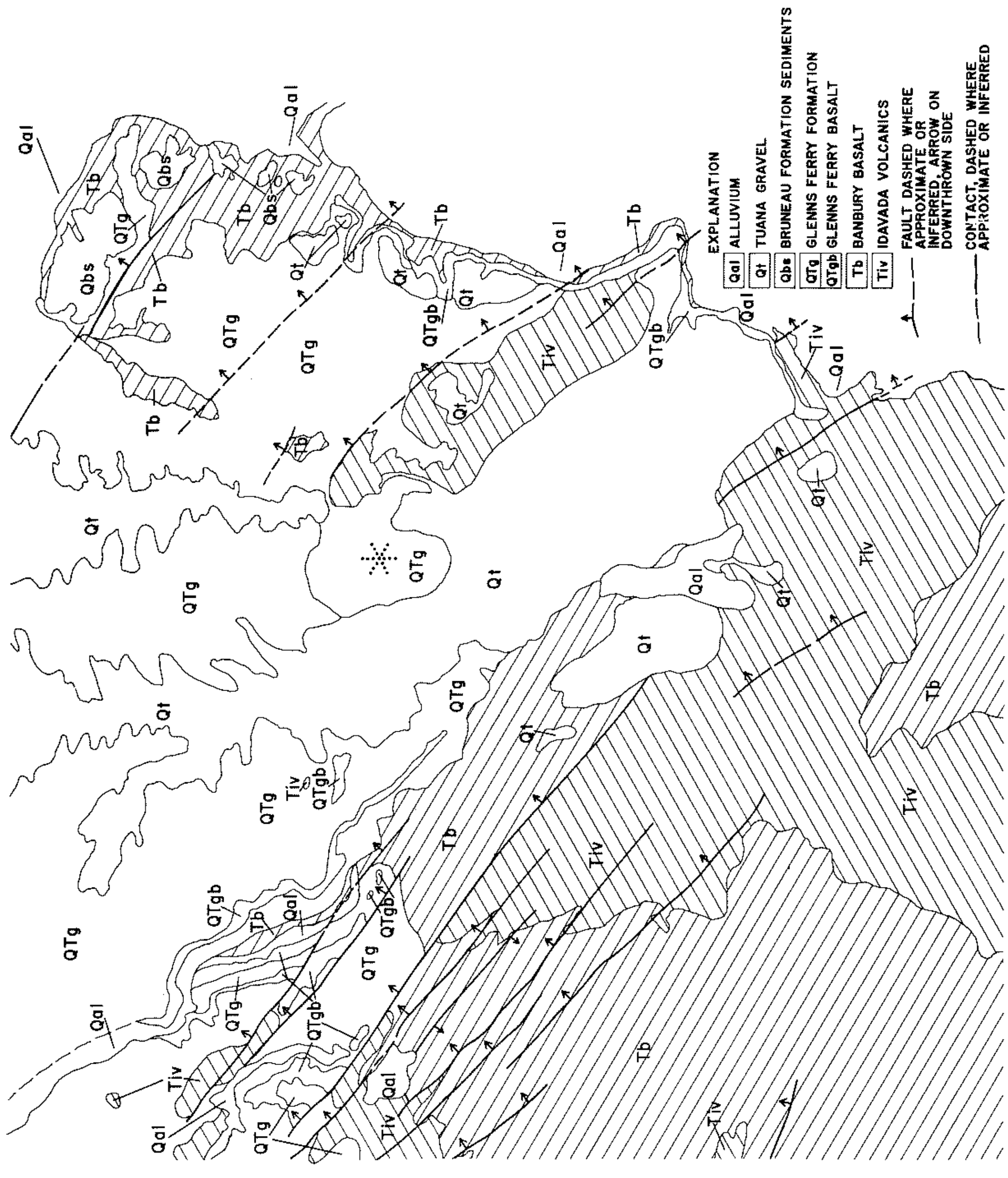

FIGURE 3. Generalized geologic map of the Blue Gulch study area after Malde, Powers and Marshall, 1963

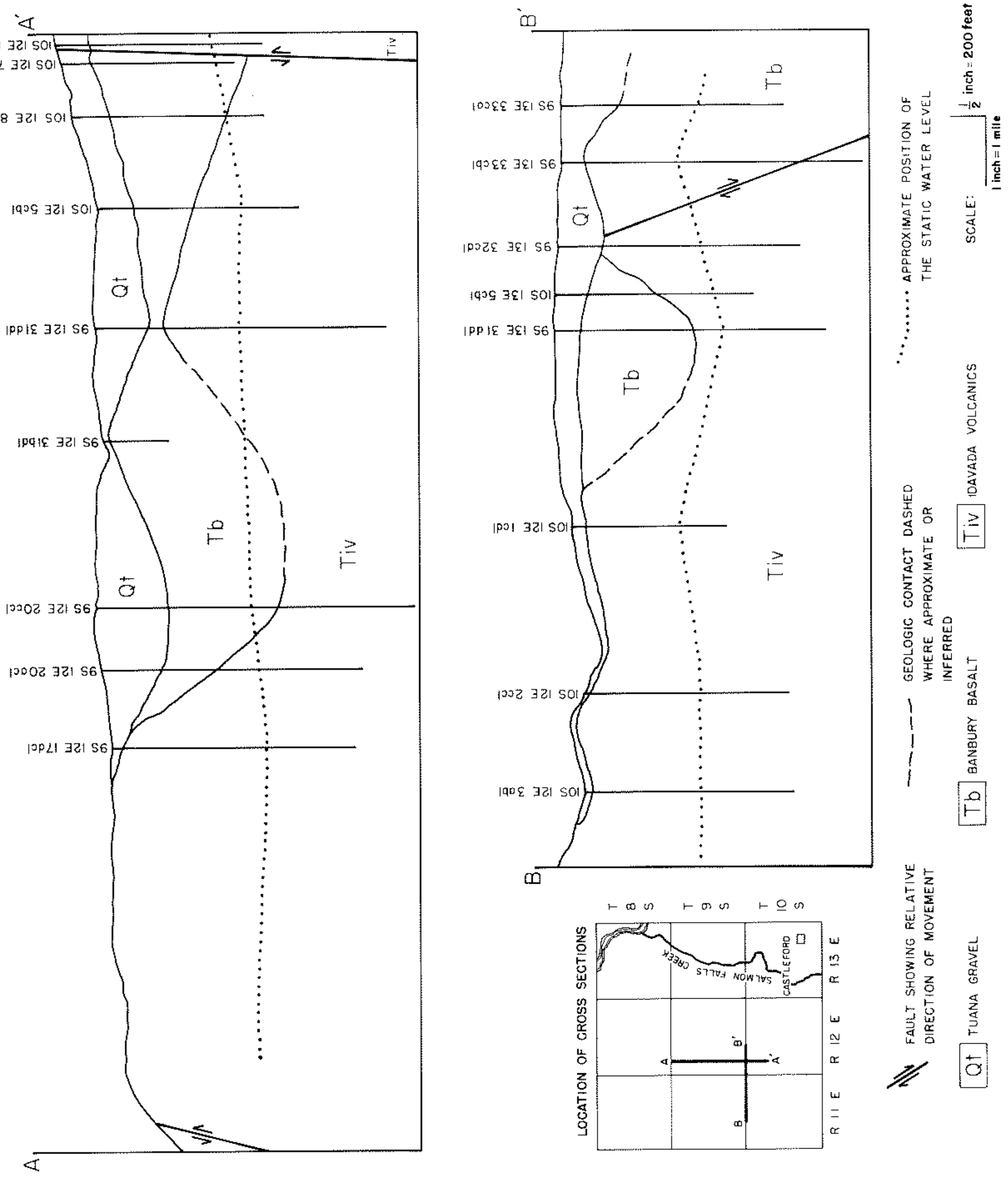

FIGURE 4. Generalized geologic cross sections of the Blue Gulch study area

member composed of several hundred feet of brownish, rubbly basalt which has been altered to such a degree that the fractures and vesicules have been filled with alteration products. This member is not important as a source of ground water in the study area.

The second, a sedimentary member, is composed of a layered sequence of clay, silt, sand and fine gravel. These sediments were deposited over the lower member of the Banbury Basalt and in places over the highly eroded Idavada Volcanics. The thickness of this member varies widely. The maximum thickness that has been encountered in the study area is approximately 600 feet in well 9S 12E 17db1. The sedimentary member is important as an aquifer primarily in Township 9 South, Range 12 East. Ground water is obtained from the sand and fine gravels in the member and yield-to-wells exceeding 2,000 gpm have been reported.

The third, an upper basalt member, consists of several hundred feet of fresh appearing, gray-black, olivine basalt. This member was deposited over an eroded topography on the Idavada Volcanics and Banbury sediments and, like the middle member of the formation, varies widely in thickness. The maximum known thickness in the study area is approximately 650 feet in well 9S 13E 33cb1. The basalt has well developed columnar jointing and is fractured at contacts between flows and where the unit is broken by faults. Locally, cinder beds or fine grained sediment lenses have been emplaced between individual lava flows. Vesicules, or gas pores, are usually present in zones along the top and bottom of the flows. Drillers' logs indicate that the jointing and fracturing extend throughout the upper member. This basalt member is most important as a source of ground water in the southeastern portion of the study area. Yield-to-wells of approximately 3,000 gpm have been reported.

The Banbury Basalt is reported to be Middle Pliocene in age (Malde and Powers, 1962, p. 1,204-1,205) and overlies the Idavada Volcanics. The formation is overlain by both the Glenns Ferry Formation and the Tuana Gravel.

Glenns Ferry Formation

The Glenns Ferry Formation consists of a basalt and a sedimentary member. Exposures of the unit occur primarily in the northern half of the study area (fig. 3). The sediments consist of white, brown, and blue clay, sand and fine gravel. The thickness of this member within the study area is unknown. The basalt member is composed of thin basalt flows and is not an important source of ground water. The formation is utilized north of the study area for domestic and stock supplies but is not important as an aquifer within the study area. Yield-to-wells are generally low where the unit is an aquifer.

The Glenns Ferry Formation is Plio-Pleistocene in age (Malde and Powers, 1962, p. 1,208), and overlies the Banbury Basalt. The formation is overlain in part by the Tuana Gravel.

Tuana Gravel

The Tuana Gravel (Malde and Powers, 1962, p. 1,209) consists of a thin sequence of clay, silt, sand and pebble gravel. The unit was deposited as a veneer of alluvium over the eroded surface of the older formations in the area and is quite extensive (fig. 3). The maximum known thickness in the area is approximately 220 feet at well 9S 12E 20cc1. The unit is early Pleistocene in age and is overlain only by Recent alluvium. The formation is not important as a ground-water source.

Recent Alluvium

Recent alluvium is present along the Snake River, Salmon Falls Creek and many of the ephemeral streams in the area. It consists of clay, silt, sand and gravel. These deposits are important as an aquifer only along the Snake River where shallow wells derive small supplies for domestic usage.

Geologic Structure

The study area lies on the south flank of a large structural trough called the Snake River downwarp. This downwarp was caused by subsidence of the Snake Plain accompanied by uplift of the mountains to the south and north. This crustal movement is expressed by a series of subparallel, northwest trending faults along both sides of the western Snake Plain, many of which pass through the study area (fig. 3). Intense fracturing on both sides of the faults occurred because of the brittle character of the silicic volcanics and basalt. These highly-fractured zones are extremely important as they have a major effect on the flow of ground water in the study area. Most of the wells with high yields penetrate these broken zones within the Idavada Volcanics or Banbury Basalt. Wells penetrating similar thicknesses of unfractured rock in the same formations a short distance away often have very low yields. These faults also provide avenues for the vertical movement of ground water. The deep circulation of ground water through these fault zones accounts for warm water derived at various locations. Other structural features present in the study area are low volcanic domes and a gentle 2-3° northward regional dip of the exposed formations.

GROUND-WATER HYDROLOGY

Well Development

The ground-water resource in the Blue Gulch area has been developed primarily for irrigation usage (fig. 5). Approximately 33 producing irrigation wells have been drilled since 1958, with the majority of this development occurring between 1965 and 1969. Many other wells were drilled but did not obtain sufficient water for irrigation development. Wells as deep as 1,740 feet have been drilled, but most are less than 1,000 feet in depth. The producing wells provide water for all of the irrigated acreage except for those lands irrigated by surface water from Salmon Falls Creek. All domestic supplies are from ground water.

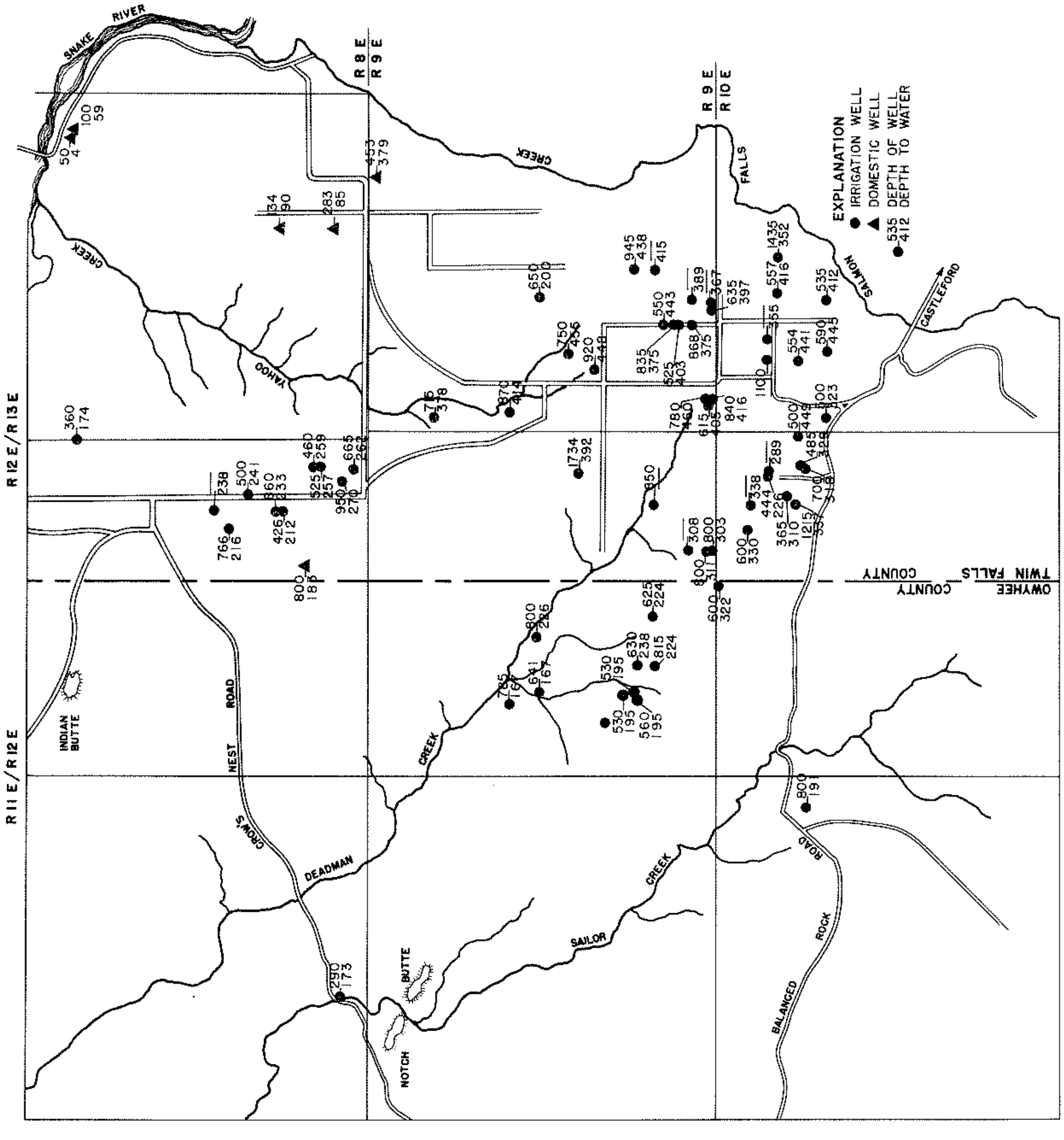

FIGURE 5. Location, depth, depth-to-water and usage of wells in the Blue Gulch study area

Most of the well development is located in the southern portion of the study area.

Hydrologic Characteristics of the Aquifers

The hydrologic characteristics of any water-bearing formation may be expressed by several terms. Perhaps the most useful of these is transmissibility (T). The transmissibility of an aquifer is the quantity of water in gallons per day that will flow through a strip one foot wide extending the full thickness of the aquifer. The relative magnitude of transmissibility of an aquifer may be estimated by the following relationship, (Theis, Brown and Meyer, 1963):

$$T = 2{,}000\ Sc$$

T = Transmissibility (capacity of the aquifer to transmit water) in gallons per day per foot (gpd/ft) at 100% hydraulic gradient.

Sc = Specific capacity (discharge of the well divided by the drawdown) in gallons per minute per foot (gpm/ft).

According to the above relationship and available specific capacity data from pumping well tests, the transmissibility of the Idavada Volcanics exceeds 100,000 gpd/ft at many locations and is approximately 840,000 gpd/ft in well 9S 12E 35cc2. Transmissibility values for the basalt member of the Banbury Basalt range from approximately 60,000 gpd/ft to 370,000 gpd/ft, and from approximately 3,800 gpd/ft to 21,000 gpd/ft for the sedimentary member. In order to test the above relationship for determining transmissibility, an alternate method of determination was used for well 9S 12E 29db1. The discharge of the well was estimated by utilizing the relationship between horsepower, pumping lift and assumed pump efficiency. The following equation may be used to determine transmissibility by using a plot of the distance from the pumped well to two observation wells nearby versus the drawdown in the observation wells on semi-logarithmic paper (Thiem, 1906).

$$T = \frac{527.7Q \log_{10}(r_2/r_1)}{S_1 - S_2}$$

Where: T = coefficient of transmissibility in gallons per day per foot
Q = rate of discharge of the pumped well in gallons per minute
r_1 and r_2 = distances from the pumped well to the first and second observation wells and
S_1 and S_2 = drawdowns in the first and second observation wells

The well had been pumping for a long period, therefore, time is considered constant for this equation. The calculated transmissibility of the aquifer at well 9S 12E 29db1 is 59,000 gpd/ft by this method. The estimated transmissibility using the specific capacity method is 62,000 gpd/ft which agrees closely with the calculated value. Based on this comparison, the specific capacity method of estimating transmissibility was concluded to be valid for the study area. It can be seen on figure 6 that the high transmissibility values are not concentrated in any particular area but are scattered randomly. This is to be expected where discontinuous fracture patterns are the primary control of ground-water movement.

Ground–Water Movement

The general direction of ground-water flow in the study area is from south to north (fig. 7). The gradient or slope of the ground-water surface averages approximately 25 ft/mi. The contours of water level elevation shown in figure 7 indicate the major source of recharge is south of the study area with some recharge from surface water irrigation in Township 9 South, Range 13 East. The contours also indicate discharge from the ground-water system to the north and to Salmon Falls Creek.

Depth–to–Water

The depth-to-water in the Blue Gulch study area ranges from 72 to 448 feet below land surface (fig. 8). Topography accounts for much of the variation in the depth-to-water as the ground-water gradient is fairly constant. The boundaries denoted on figure 8 are arbitrary and may change as additional data becomes available.

Yield–to–Wells

The yield-to-wells in the Blue Gulch study area vary from 369 gpm to approximately 3,000 gpm (fig. 9). Some of the factors causing the variations shown are well construction, depth of penetration of the aquifer, and the degree of fracturing present in the rock materials encountered. The latter factor is the most important as the more productive wells are believed to penetrate the highly fractured fault zones. These zones are generally very permeable and provide avenues for the movement of ground water. They do not, however, appear to extend any great distance on either side of the faults themselves. Two wells in Township 10 South, Range 12 East are examples of this discontinuity. Well 10S 12E 11dc1 penetrates 409 feet of fractured "rhyolite" and yields approximately 550 gpm. Well 10S 12E 11db1, less than 1/4 mile distant penetrates 566 feet of dense unbroken "rhyolite" and yields approximately 1.5 gpm. Geologic features indicate that well 10S 12E 11db1 is on the downthrown block of a high angle fault while well 10S 12E 11dc1 is on the upthrown side and penetrates the fractured zone.

Yield-to-wells from production wells in the Idavada Volcanics are reported to be as high as 2,400 gpm (fig. 9). The upper basalt member of the Banbury Basalt has reported yields of approximately 3,000 gpm. Wells deriving water from the sedimentary member of the Banbury have reported yields of over 2,200 gpm. The high yields reported are maximum discharge rates during test pumping, and production is generally lower.

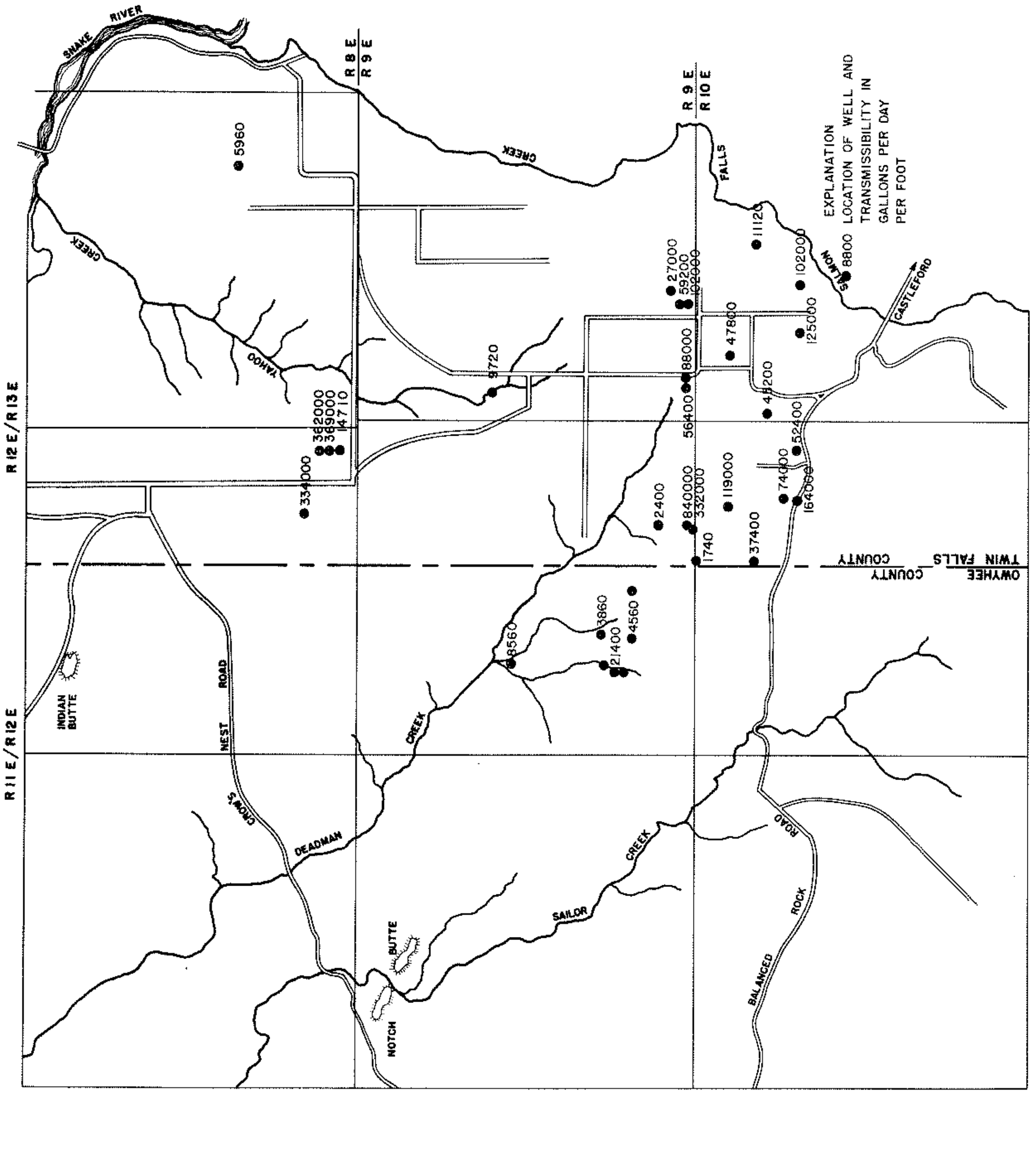

FIGURE 6. Estimated transmissibility of wells in the Blue Gulch study area

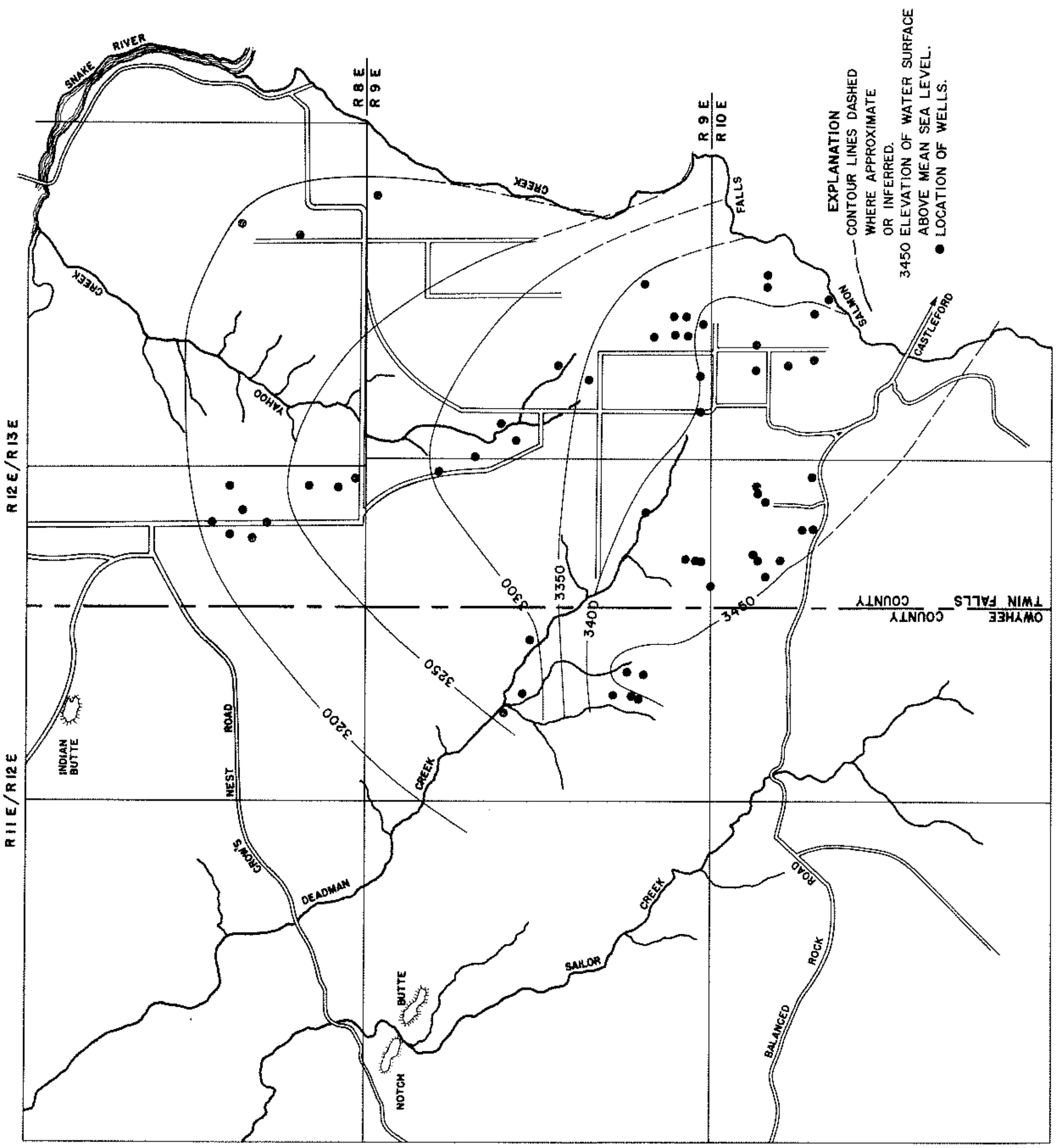

FIGURE 7. Contours of water-level elevation in the Blue Gulch study area

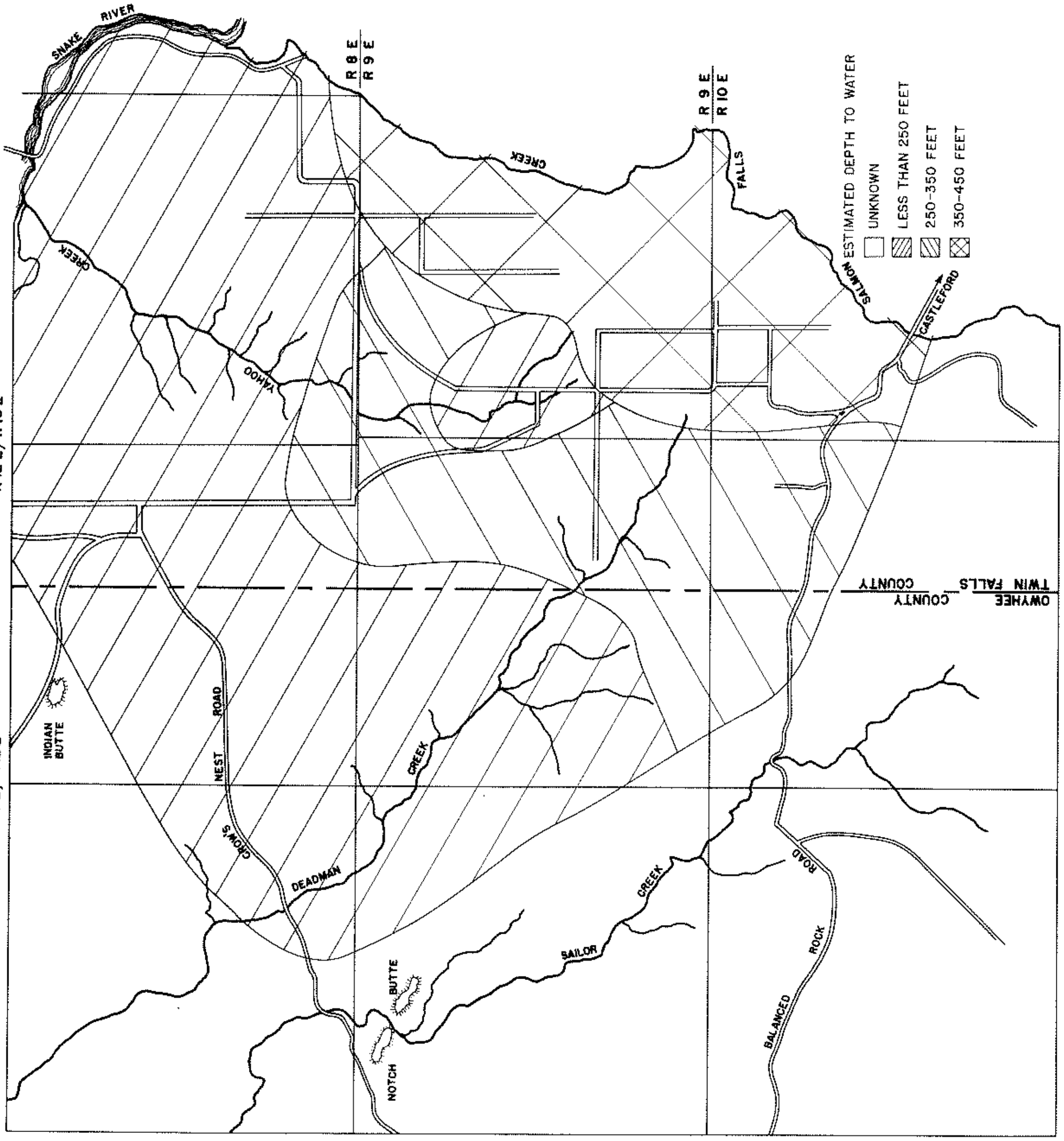

FIGURE 8. Estimated and known depth-to-water in wells in the Blue Gulch study area

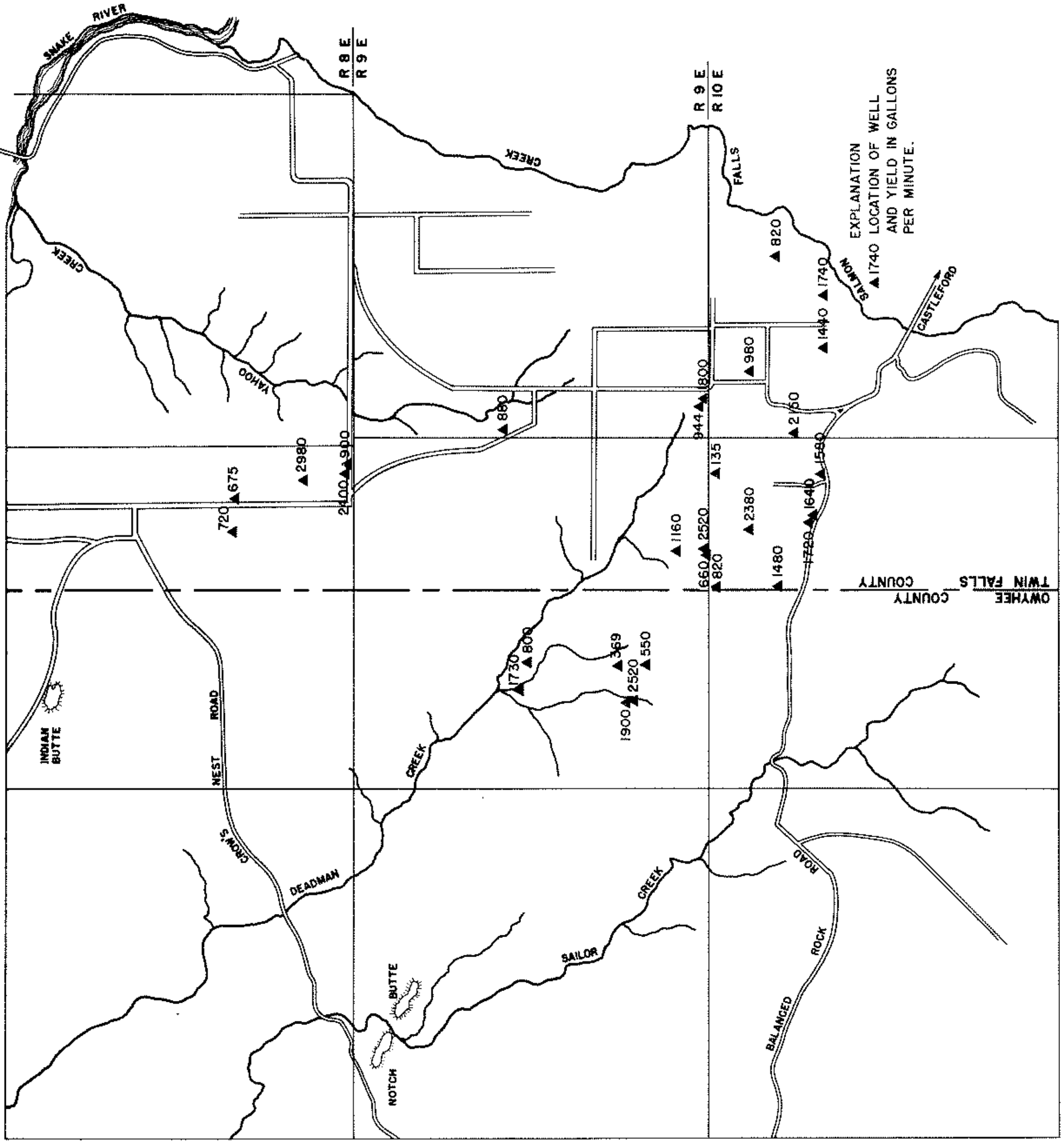

FIGURE 9. Yield-to-wells in the Blue Gulch study area

Water–Level Fluctuations

Records of water-level fluctuations have been obtained for five wells in the Blue Gulch study area. Eight years of record has been obtained on one well and three years of record has been obtained on the other four. A continuous water-level recorder on well 9S 13E 20ccd1 has been in operation since 1968. All of these observation wells, with the exception of 8S 13E 23ccd1, show water-level declines of approximately 3 feet to 17 feet per year for the period of record. Well 8S 13E 23ccd1 is a shallow well located in an area where there is no ground-water pumpage for irrigation and is influenced by the application of surface water by the Magic Water Company. The water level in this well has risen approximately 1.4 feet per year (fig. 10).

It is believed that the water-level declines in the study area are a result of the large scale pumpage of ground water for irrigation. The hydrographs of wells 9S 12E 29db2 and 10S 12E 3ba1 (fig. 10) show a decline in water levels in July as the pumping season is initiated and an abrupt rise in water levels in October at the end of the season. Although the amplitude of decline during the pumping season has not appeared to increase significantly, the water levels have not been recovering to the previous spring level, thus denoting an annual decline.

Data collected during mass water-level measurements in April 1969 and March 1970 allow analysis of the annual decline throughout the study area. The area of greatest water-level decline for the period April 1969 to March 1970, was in Township 10 South, Range 13 East where declines of over 27 feet were noted (fig. 11). This greater magnitude of decline is believed to be partially the result of a longer period of pumping from the wells in this vicinity than other wells in the study area. However, it is unlikely that recovery will be great enough to alleviate these significant declines. The average water-level decline for most of the area for the year was approximately 5 feet. Water levels rose slightly in some wells in the northern portion of the study area (fig. 11). These wells are irrigation wells that were not pumped during the 1969 season. Well 8S 12E 24cc1, which was heavily pumped, declined approximately 8 feet for the period April 1969 to March 1970. This apparent contradiction is believed to be the result of the extreme discontinuity in the fracture pattern of the aquifer material in the area, the Idavada Volcanics.

Recharge–Discharge Characteristics

The recharge to the aquifers in the Blue Gulch area is believed to be derived from precipitation on the uplands and Jarbidge Mountains to the south of the study area. Little is known about the ground-water resource in this vast area in Idaho and Nevada. Quantitative estimates of the recharge are thus not possible at the present time. Some recharge to the shallow aquifer in Township 9 South, Range 13 East is believed to be occurring from water applied on lands under the Magic Water Company. The hydrograph of well 8S 13E 23ccd1 (fig. 10) shows a rise in July which does not correspond with the general water-level fluctuations. This rise is believed to be due to downward percolation of irrigation water applied in excess of the consumptive use of crops. No quantitative estimate was made of this recharge because of the small areal extent of the land affected.

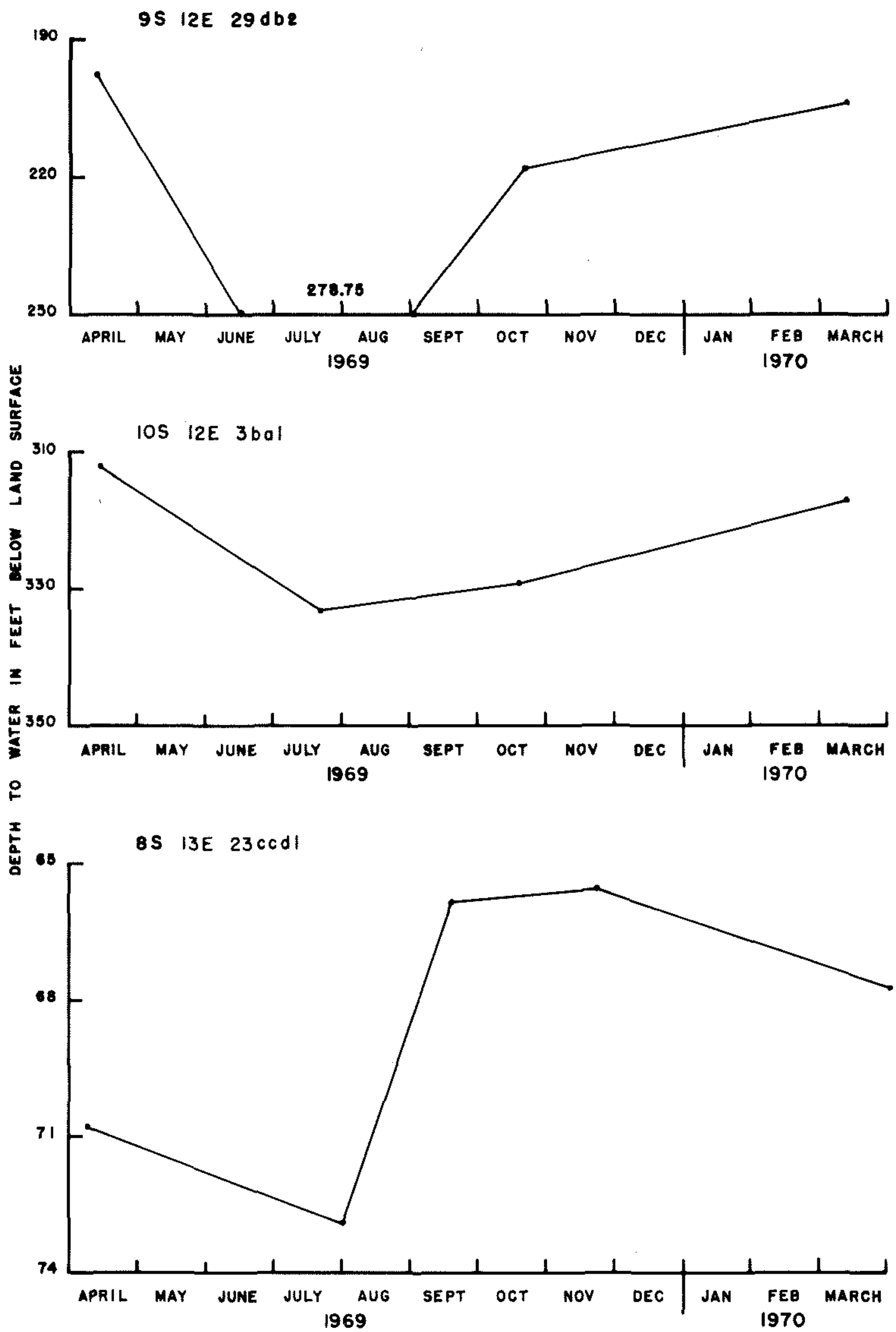

FIGURE 10. Hydrographs of wells 8S 13E 23ccd1, 9S 12E 29db2, and 10S 12E 3ba1

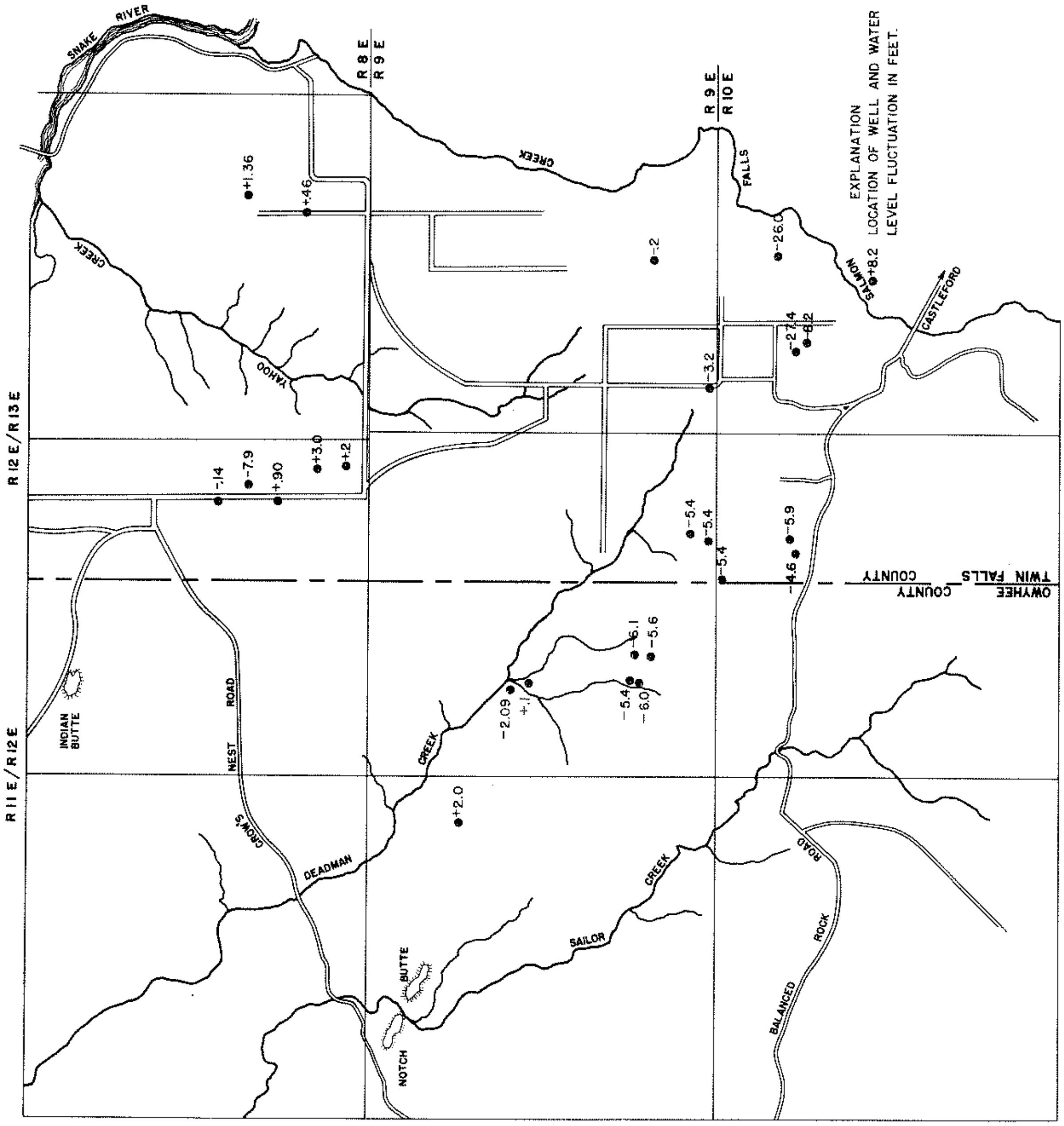

FIGURE 11. Water-level changes in the Blue Gulch study area

Discharge from the aquifers in the Blue Gulch study area may be from several sources: natural evapotranspiration, outflow to the Snake River and Salmon Falls Creek and well discharge. Natural evapotranspiration was considered to be negligible because of the large depth-to-water. Natural evapotranspiration could take place along Salmon Falls Creek, the Snake River and from the area irrigated by surface water in Township 9 South, Range 13 East. However, the quantity of water involved is considered to be insignificant. Discharge to the Snake River may occur as underflow along the northern edge of the study area. No springs or seeps were observed along the river, but sufficient head does exist for ground-water movement.

Inflow to Salmon Falls Creek from both east and west sides is depicted by the graph of the flow of the creek at six sites. Nine series of miscellaneous measurements were made for the period 1953 to 1955 (fig. 12). Flow in the creek near where it enters the study area in Section 19, Township 11 South, Range 14 East, (gage 0) averaged approximately 9.5 cubic feet per second (cfs) for this period. Flow at the mouth of the creek averaged approximately 149 cfs for the same period (gage 7). A spread in the flow curves may be observed downstream from gage 3 which indicates increased contribution to the creek from overland flow. The quantity of base flow entering the creek from the west side may be estimated by calculating the amount of inflow necessary from each side of the creek to attain the electrical conductivity (E.C.) in the creek for each reach. In order to calculate this balance, two assumptions must be made: (1) the relationship between E.C. and total dissolved solids is approximately linear, and (2) the E.C. of the water contributed from each side remains constant throughout this reach of the creek. An average E.C. of 350 mhos x 10^6/centimeter (mmhos/cm) was used for ground water on the west side and an average E.C. of 1,100 mmhos/cm for the ground and surface water on the east side. By utilizing the mathematical balance described above, an estimated 7,300 acre-feet per year is contributed to the creek as inflow from the study area on the west side. If the water-level declines in the area continue, the quantity of inflow will probably decrease because of the reduced gradient from the ground-water system to the stream. It is possible, in the extreme case, that the gradient could reverse and the creek could lose water to the aquifers in the area. The decline necessary for this to occur is unknown because of the lack of well data near the edge of Salmon Falls Creek Canyon.

The annual pumpage rate from irrigation wells in the study area in 1969 was estimated at 26,500 acre-feet. This estimate was based on information noted in water right files, field notes and questionnaires returned for the area in connection with a study of reasonable pumping levels, and is based on an application rate of about 3.5 acre-feet per acre. Because of the relatively short period the study area has been under irrigation, it is believed that any water applied in excess of the consumptive use of crops is perched above the regional water table.

The estimated natural discharge to Salmon Falls Creek and artificial discharge by pumping total approximately 34,000 acre-feet per year. The undetermined discharge by natural evapotranspiration and discharge to the Snake River would be in addition to this value. It should be noted that over 75 percent of the estimated discharge is from well development in the area. It can also be estimated that if all active permits in the area are developed there is a potential discharge of 110,000 acre-feet per year. By equating present

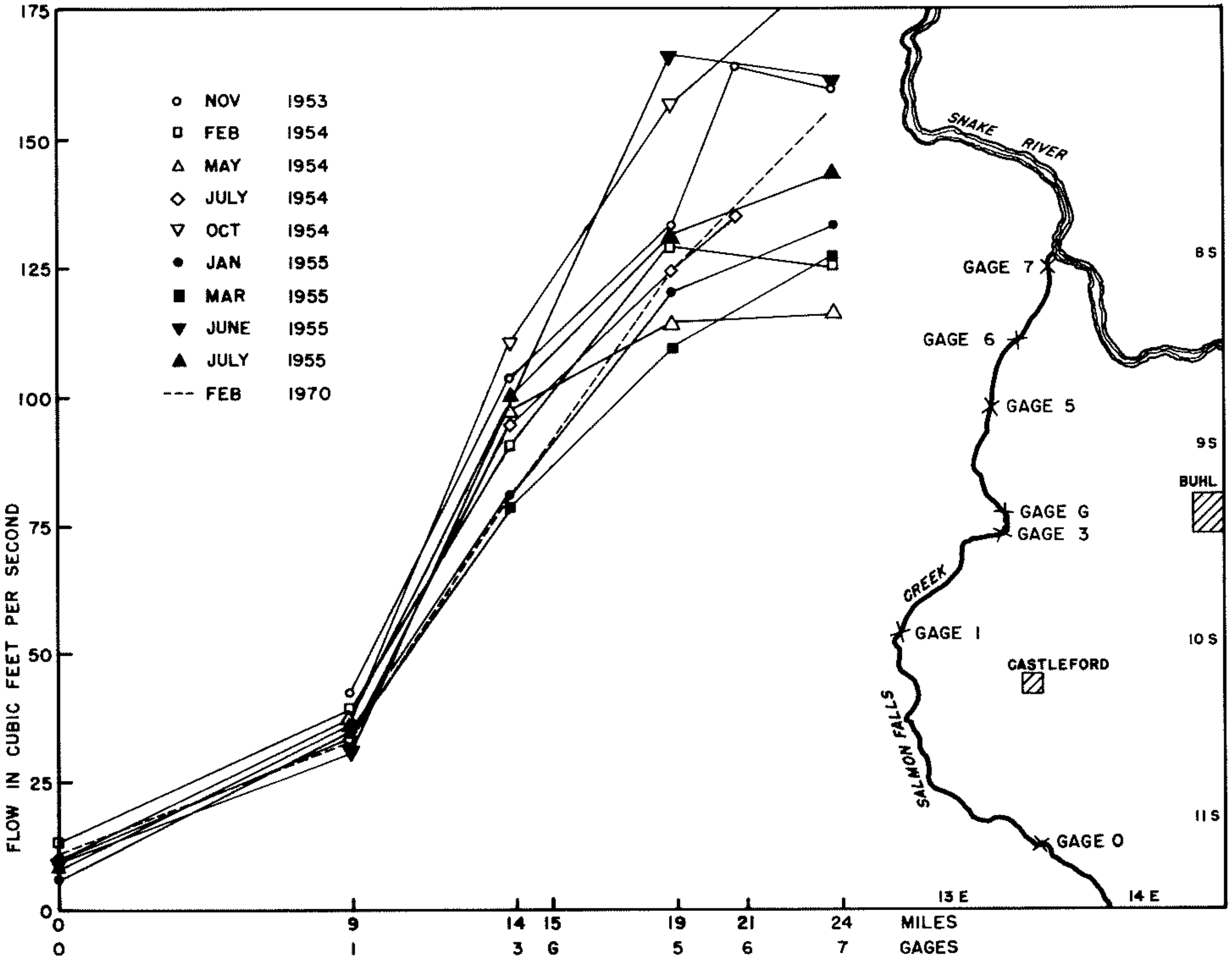

FIGURE 12. Discharge of Salmon Falls Creek

water-level decline and well discharge to future decline and discharge it is possible that the water-level declines may increase to as much as 21 feet per year.

GROUND-WATER QUALITY

The quality of the ground water in the study area is generally suitable for domestic and agricultural purposes. Sixteen samples of water collected from wells in the Blue Gulch were chemically analyzed by the Idaho Department of Health in connection with this study (table 2). Field observations of temperature and electrical conductivity were obtained for these same sites and for one additional site to supplement the chemical information and provide greater knowledge of the quality characteristics of the ground-water resource.

Electrical Conductivity

The field electrical conductivity data (approximately proportional to total dissolved solids) presented in figure 13 range from 260 to 950 mmhos. Most of the wells sampled had E.C. values in the range of 260 to 400 mmhos. The centers for higher E.C. are in the southeastern portion of the study area north of the Balanced Rock crossing. These values may be compared with the average E.C. of Salmon Falls Creek of approximately 850 mmhos. E.C. values in the Snake River at the King Hill gage average approximately 500 mmhos.

Temperature

The temperature of the ground water in the study area varies from 67° F to 97° F. The areal variation of ground-water temperature in figure 13 indicates a dominant range of 70° to 80° F with higher temperatures noted on the southwestern and northeastern side of the main development (fig. 13). A temperature log of the well 9S 12E 24daa1 drilled to a depth of 1,740 feet is presented in figure 14. This log indicates an increase in temperature from about 67° F at the static water level of 390 feet to approximately 97° F at 1,734 feet.

All of the temperatures reported from wells in the Blue Gulch area indicate the ground water is thermal in nature (warmer than the mean annual air temperature plus the normal geothermal gradient). A source of hot water must thus be present in the area. The most probable source of thermal water is from deep circulation of ground water through faults in the study area. These faults probably provide the avenues for upward movement of this hot water.

Chemical Characteristics

Sodium is the primary cation and bicarbonate is the primary anion of the ground water in the study area. The chemical data presented in table 2 are depicted graphically as pattern diagrams in figure 15. The patterns which indicate the concentrations of the six major ions

TABLE 2

WATER QUALITY ANALYSES

LOCATION	E.C.	TEMP.	pH	TOTAL SOLIDS	PARTS PER MILLION													SAR
					ALKALINITY $CaCO_3$	HARDNESS $CaCO_3$	Ca	Mg	Fe	Mn	Na	Cl	SO_4	NO_3	PO_4	F	NH_3	
1. 8S 12E 25bc	380	68°F	8.4	300	136	84	16	11	0.58	0.01	84	59	24	2.6	0.19	6.40	0.5	3.94
2. 9S 12E 17bc	325	60°F	7.8	285	132	132	30	13	0.24	0.01	20	61	17	6.1	0.01	0.74	0.46	0.77
3. 9S 12E 29ac	320	82°F	7.9	275	128	116	26	12	0.17	0.01	36	40	26	5.6	0.01	1.16	0.39	1.47
4. 9S 12E 34ad	350	76°F	8.0	290	108	136	24	18	0.21	0.01	60	53	30	7.0	0.01	1.31	0.39	2.25
5. 9S 12E 35bc	360	74°F	8.0	300	120	124	26	14	0.17	0.01	66	49	37	9.2	0.01	0.97	0.52	2.60
6. 9S 12E 35ccc	350	76°F	7.9	290	128	136	37	11	0.22	0.03	74	51	41	8.7	0.01	1.22	0.42	2.74
7. 9S 13E 18ac	270	80°F	7.9	270	120	124	19	18	0.14	0.01	32	42	21	7.2	0.04	0.95	0.47	1.26
8. 9S 13E 31dd	300	78°F	8.0	285	120	112	24	12	0.18	0.01	28	42	24	9.7	0.03	1.19	0.44	1.16
9. 9S 13E 33bc	320	88°F	8.2	275	116	132	26	16	0.18	0.01	52	42	34	6.6	0.01	1.37	0.42	1.97
10. 9S 13E 33cd	300	88°F	8.0	285	128	140	26	18	0.24	0.01	58	44	28	4.1	0.01	1.47	0.39	2.14
11. 10S 12E 1cd	400	79°F	8.1	330	120	100	38	1	0.19	0.01	53	57	53	15.8	0.01	1.04	0.39	2.32
12. 10S 12E 2cca	420	78°F	8.1	330	136	164	35	18	0.23	0.01	76	59	56	10.6	0.01	0.97	0.57	2.60
13. 10S 12E 11dc	340	76°F	8.1	290	148	136	30	14	0.19	0.01	64	44	40	8.2	0.01	1.16	0.46	2.42
14. 10S 12E 12cd	320	78°F	8.0	330	120	156	34	17	0.22	0.01	50	67	52	8.0	0.01	1.02	0.50	1.75
15. 10S 13E 5cd	530	77°F	7.9	365	140	224	42	29	0.19	0.01	78	65	85	11.9	0.01	0.92	0.53	2.26
16. 10S 13E 8dc	950	75°F	7.9	544	172	356	66	51	0.28	0.02	106	63	210	15.2	0.01	0.60	0.61	2.40

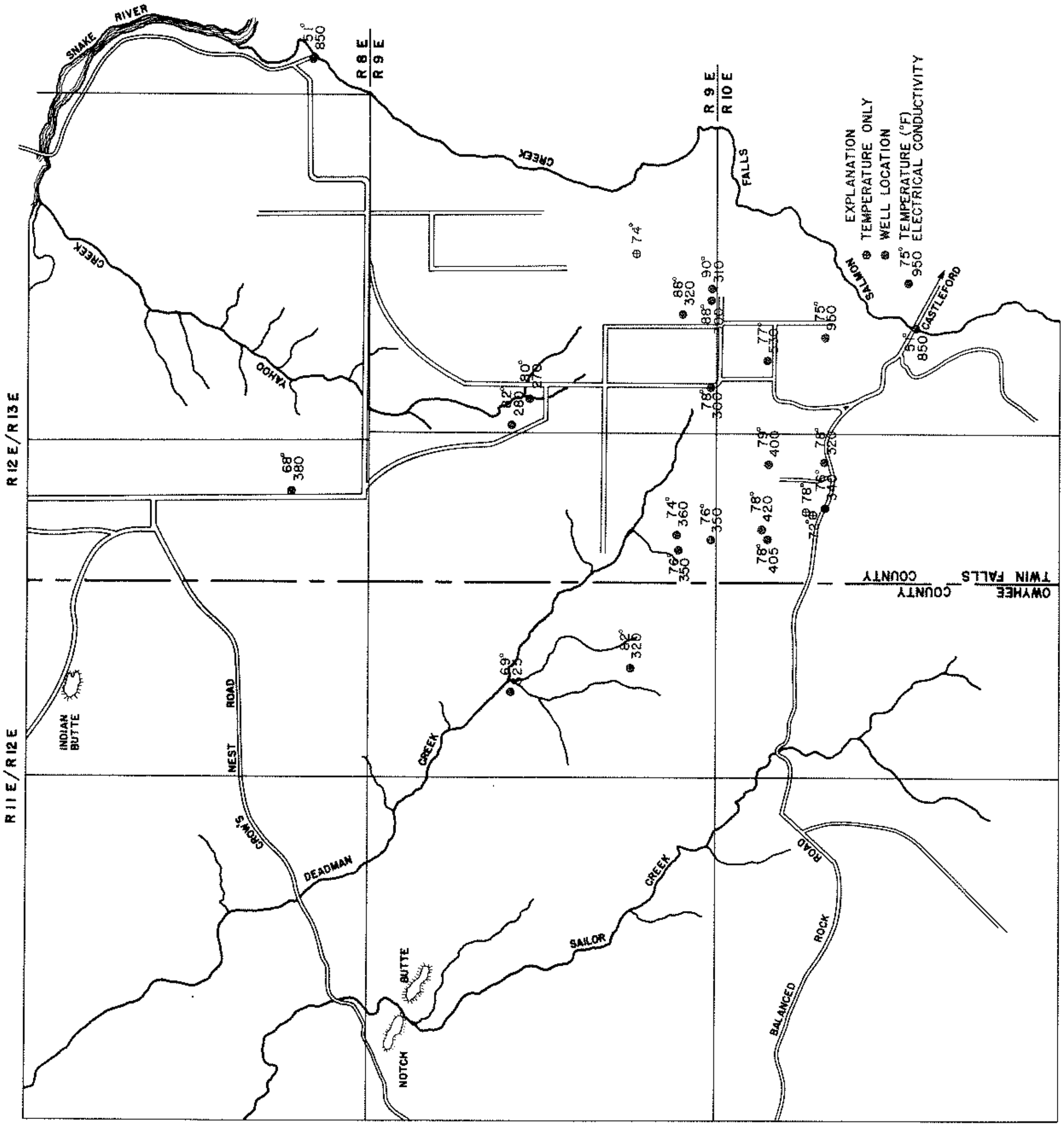

FIGURE 13. Electrical conductivity and temperature in wells in the Blue Gulch study area

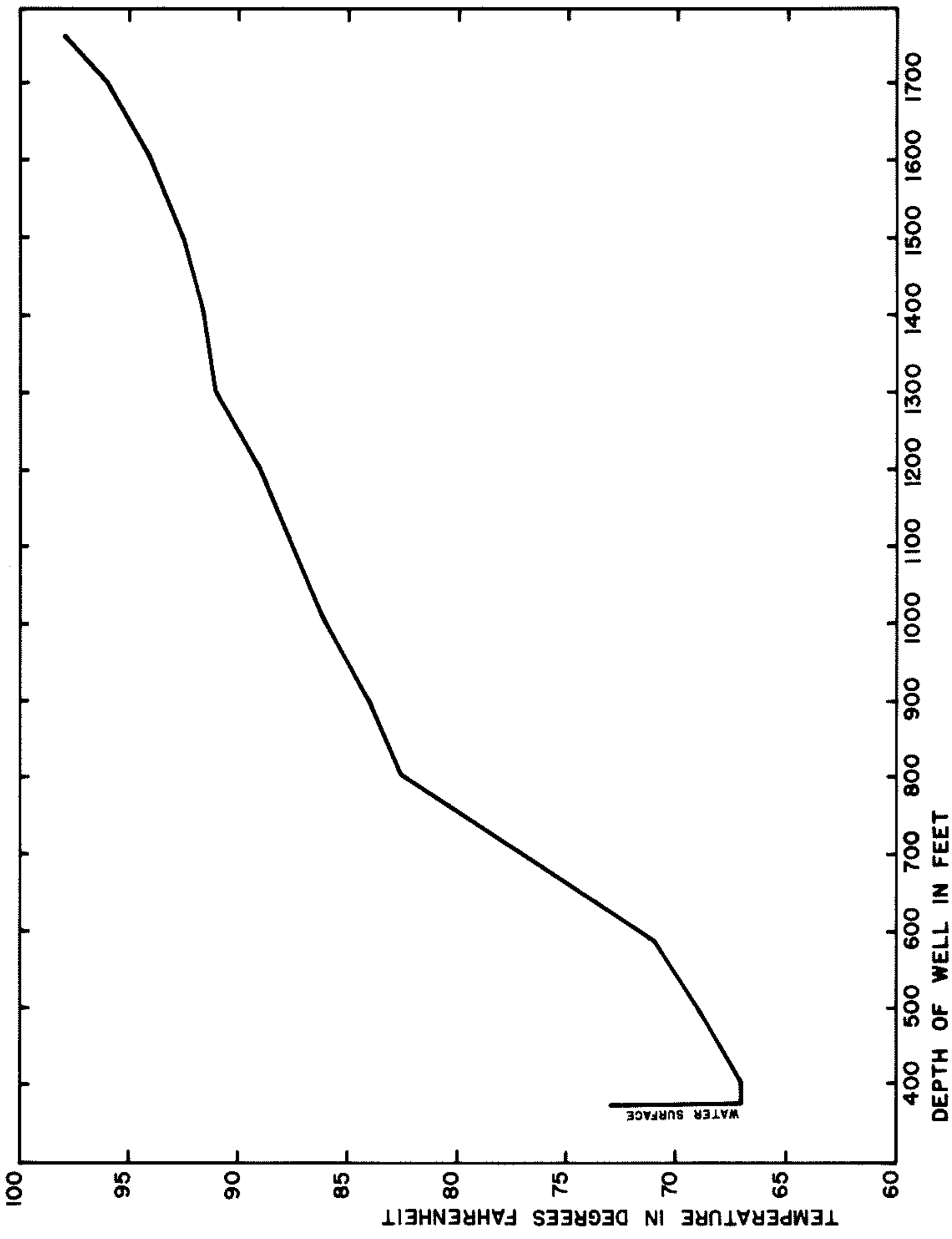

FIGURE 14. Temperature log of well 9S 12E 24daa1

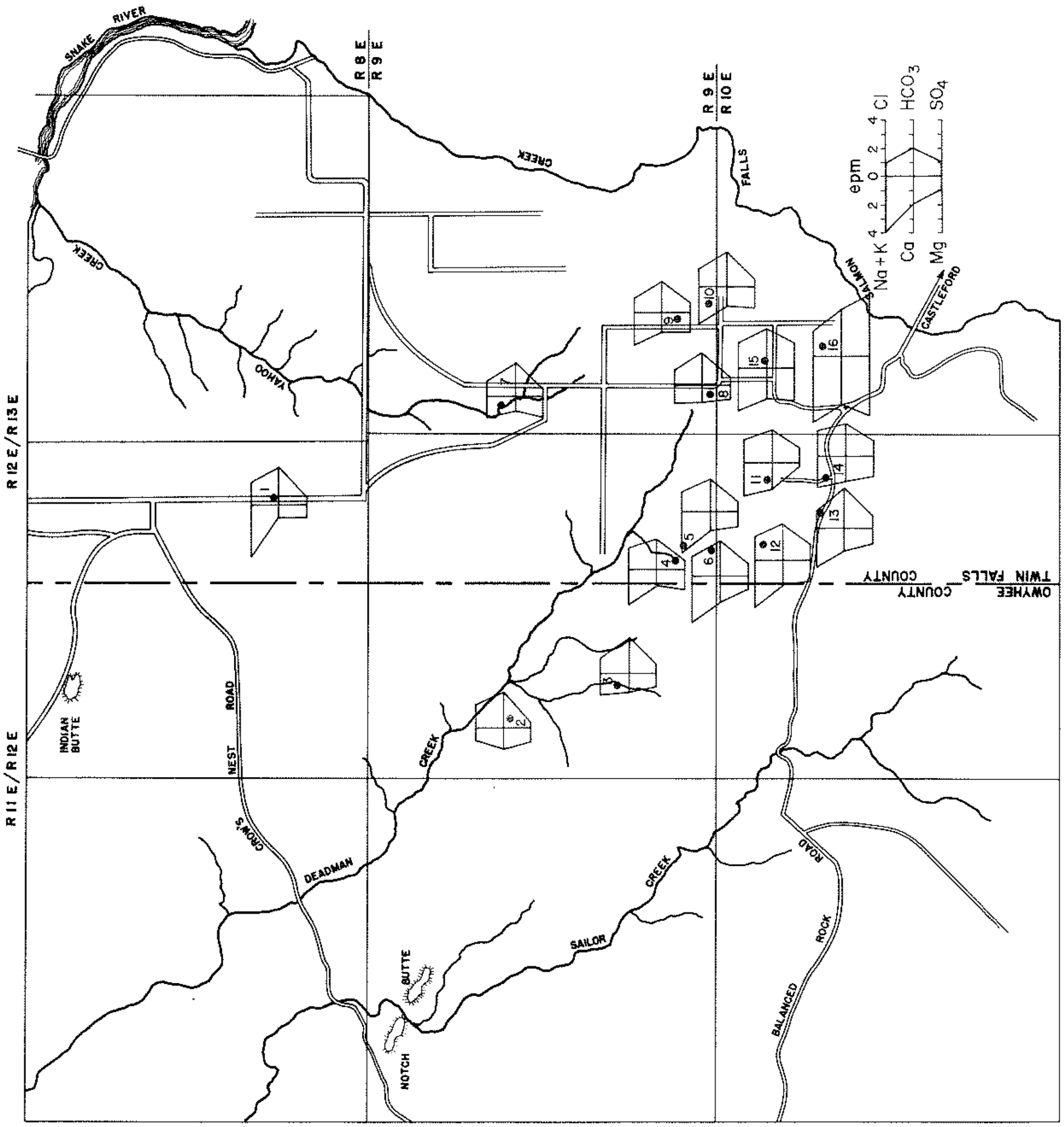

FIGURE 15. Pattern diagrams of ground-water quality in the Blue Gulch study area

in equivalents per million (epm) allow visual comparison of ground-water quality. The general pattern noted in all wells sampled in the area is quite different than that noted for Salmon Falls Creek at the mouth.

The suitability of water for irrigation is depicted in figure 16 by a plot of E.C. versus the factor sodium absorption ratio (SAR) developed by the U. S. Salinity Laboratory (1954). The latter term defined below relates percentage of sodium to the other major cations, calcium and magnesium (Hem, 1959, p. 148). All of the samples noted have a low sodium or alkali hazard as shown by the SAR. The salinity hazard related by electrical conductivity, however, is medium for all but one sample, which is high. Water from most of the wells is thus suitable for irrigation for all but crops such as green beans, some fruits, clover, and others that have a low tolerance to saline water and soils (Hem, 1959, p. 249).

Only three wells sampled in the study area do not meet U. S. Public Health Service drinking water standards (1962). Well 8S 12E 25bc1 has a slight excess of iron and a noticeable excess of fluoride. Wells 10S 13E 5cd1 and 10S 13E 8cd1 both exceed the recommended maximum limit of 500 parts per million (ppm) dissolved solids. The only excessive ion of concern is the fluoride in well 8S 12E 25bc1. The recommended limit of fluorides is 1.5 ppm while the concentration noted in this well is 6.4 ppm. In general, most of the ground water in the Blue Gulch area is suitable for domestic use.

WATER RIGHTS

The Idaho Department of Water Administration has 70 active permits and licenses for appropriation of ground water in the study area. This represents a potential withdrawal of ground water of 409 cfs for the irrigation of 29,140 acres of land (fig. 17). Forty-eight applications have been cancelled or relinquished. The major interest in development has been in Township 9 South, Ranges 12 and 13 East. The density of filings is moderate in the northeastern portion of the study area and thin in the far western portion. The greatest activity in filing for ground water was in 1968 when 25 applications were filed. The years 1963 and 1967 were second and third with 16 and 11 applications respectively.

SUMMARY

Two geologic formations are important as aquifers in the Blue Gulch study area: the Idavada Volcanics and the Banbury Basalt. The Idavada Volcanics are the most extensive rocks and the most important aquifer. Yield-to-wells of approximately 2,400 gpm have been reported from this formation. Water derived from the unit is usually warm (67^{o}-97^{o} F) and often under low artesian pressure. The Banbury Basalt is subdivided into three members: the lower basalt, the middle sediments, and the upper basalt. The sediments and the upper basalt are the productive members in the study area. Yield-to-wells of approximately 2,000 gpm from the sedimentary member and 3,000 gpm from the upper basalt have been reported. The temperature of the water ranges from 68^{o} to 82^{o} F and the water is often under low artesian pressure.

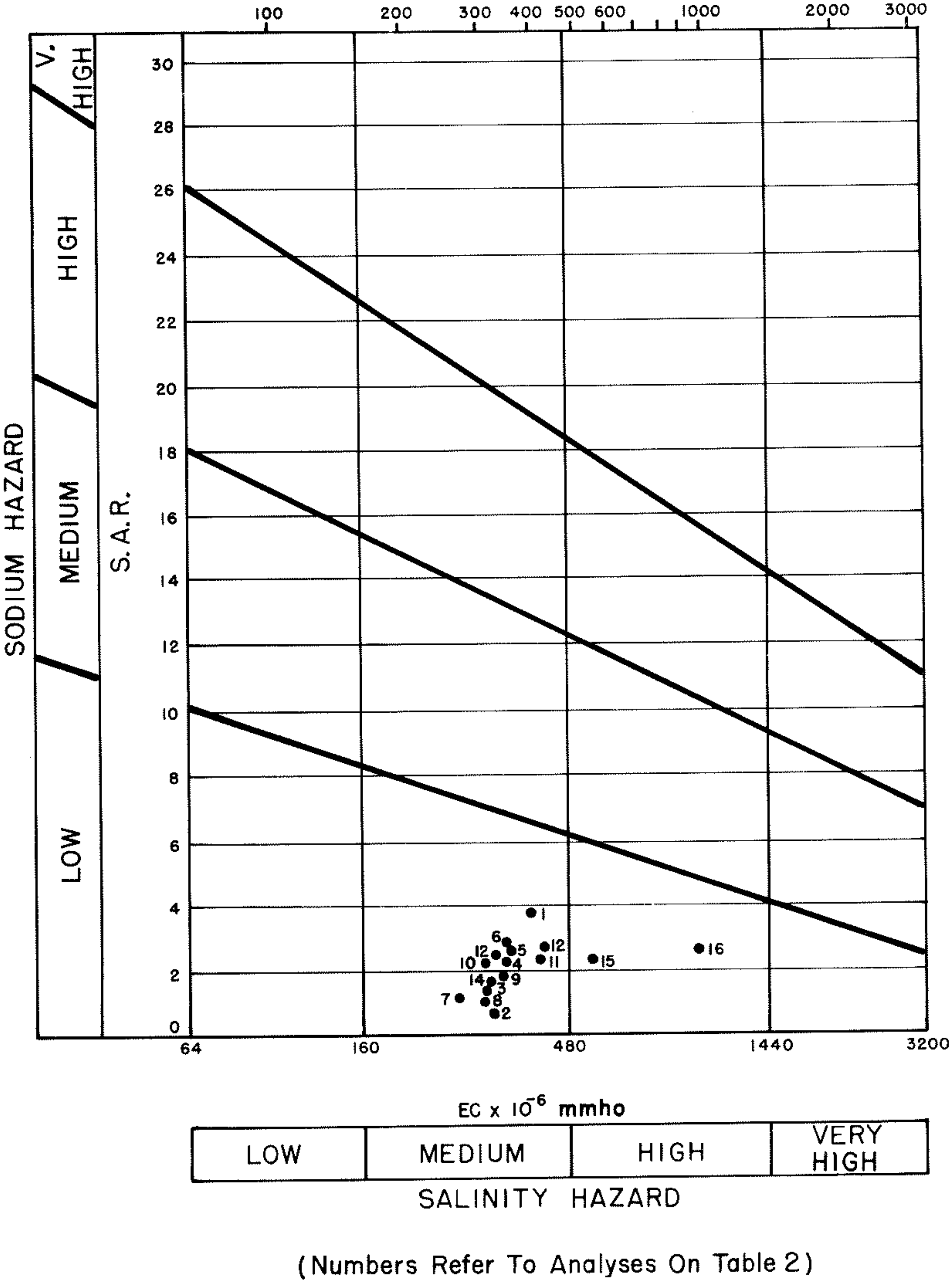

FIGURE 16. Classification of ground water for irrigation in the Blue Gulch study area

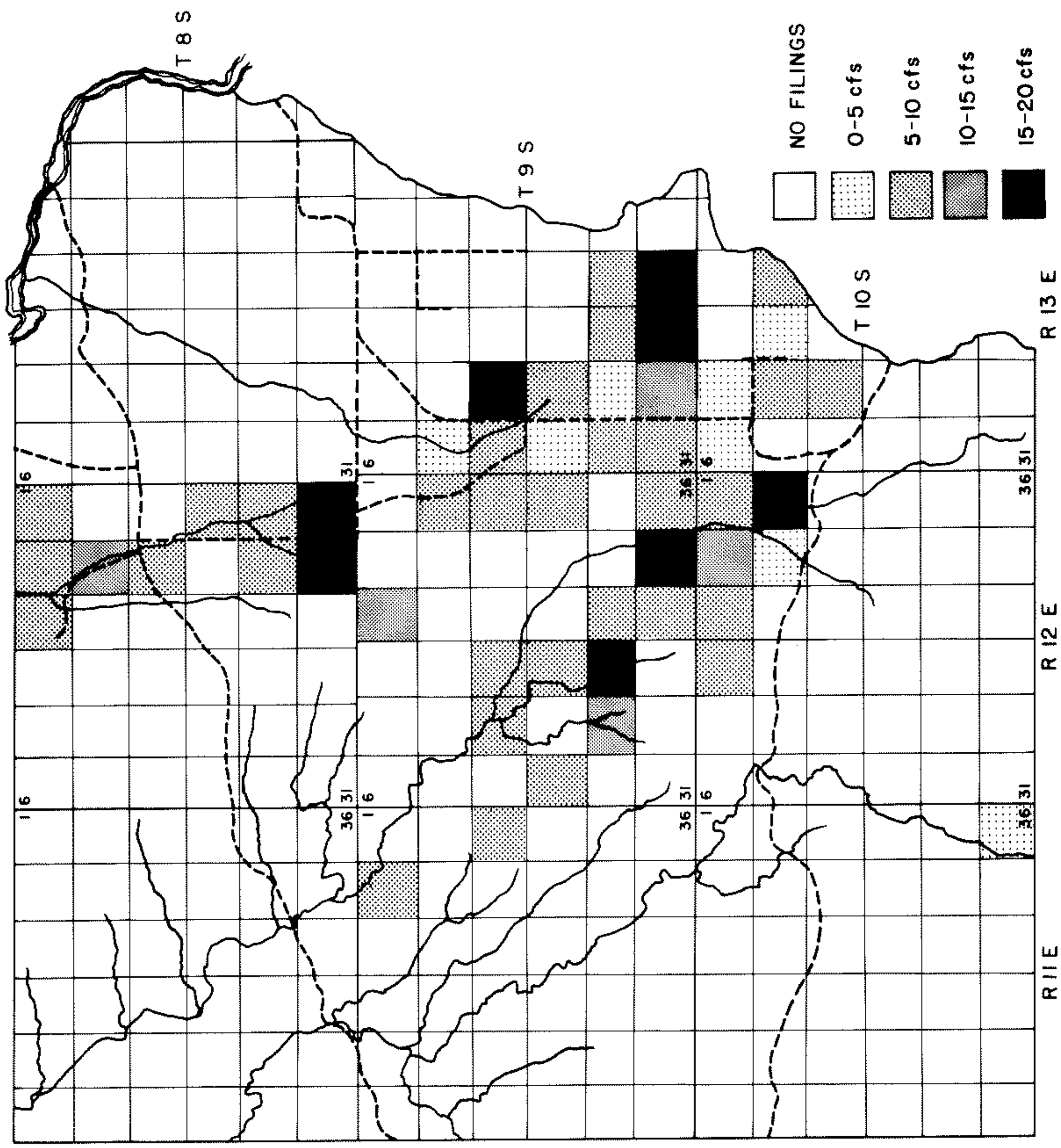

FIGURE 17. Approved applications for the Blue Gulch study area

Geologic structure is an important factor in yield-to-wells in the study area. Where wells are located on or very near fault zones, yields are generally higher than those located elsewhere because of the great amount of fracturing accompanying crustal movement.

Well development has occurred primarily in the southern portion of the study area. Most of the wells are utilized for irrigation with only a few domestic wells present. Wells as deep as 1,740 feet have been drilled but most are less than 1,000 feet.

The transmissibility of the aquifers was estimated where accurate specific capacity data was available. Transmissibility values for the Idavada Volcanics exceeds 100,000 gpd/ft in most cases. The Banbury sediments ranged in transmissibility from 3,800 gpd/ft to 21,000 gpd/ft, and the upper basalt member ranged from 60,000 gpd/ft to 370,000 gpd/ft.

Water-level declines of as much as 27 feet for a one-year period were noted in the southeastern portion of the study area. Records for a 2 to 3 year period indicate average yearly water-level declines ranging from 2.7 feet in well 9S 13E 20ccd1 to 17 feet in well 8S 12E 24ccc1. The average water-level decline for most of the area is approximately 5 feet per year for the period April 1969 to March 1970. The average water-level decline could increase to 21 feet per year if full development of the valid permits on file with the *Department of Water Administration occurs.*

Recharge to the aquifers within the study area is believed to originate from precipitation on the uplands to the south. A quantitative assessment of the amount entering the Blue Gulch study area from this area was not made. An undetermined amount of water is recharging the shallow aquifer beneath the lands irrigated by Magic Water Company. This water is believed to be the excess applied above the consumptive use of the crops. Ground-water discharge was estimated from two sources in the study area; well pumpage and outflow to Salmon Falls Creek. Approximately 26,500 acre-feet per year is withdrawn by 33 producing irrigation wells, and an estimated 7,300 acre-feet per year discharges into Salmon Falls Creek from the ground-water system for a total estimated discharge of 33,800 acre-feet per year. Some ground water may enter the Snake River as underflow but no quantitative estimate was made.

The ground water in the study area is generally low in sodium or alkali hazard and medium in salinity hazard. Water from nearly all of the wells is thus suitable for all crops but those especially sensitive to saline water and soils such as green beans, some fruits, clover and others. Three wells in the area do not meet U. S. Public Health drinking water standards. One has an excess of iron and the others exceed the recommended limit of dissolved solids. One of these also has an excess of fluoride.

CONCLUSIONS AND RECOMMENDATIONS

The aquifers in the Blue Gulch study area are an integral part of a large, generally undeveloped ground-water system with presently undefined boundaries to the south and west. The hydrologic characteristics of this large system are, to a large degree, unknown. These characteristics include transmissibility, geologic control, recharge and discharge. The ability of this hydrologic system to support large scale well development is, therefore, largely unknown. The conclusions noted below are based on the most recent data available on the Blue Gulch portion of this system. These data were collected from the existing wells and are limited by the depths of wells and pattern of development.

The following conclusions may be made as a result of this study:

1. The development of good producing wells in the Blue Gulch area is greatly dependent upon the penetration of fractured zones associated with faulting or areas of well developed joint sets in the two primary aquifers, the Idavada Volcanics and the Banbury Basalt.

2. Because of this major structural control, the ground-water resource is extremely variable with respect to long and short term yields and water-level fluctuations.

3. The present well development has resulted in differential water-level declines ranging from 0.2 feet to 27.4 feet and averaging approximately 5 feet per year.

4. A portion of this decline may be attributed to local hydrologic boundary conditions or changes in the areal aquifer transmissibility. However, because spring to spring water-level measurements have indicated a continuous lowering of water levels, most of the decline is believed to be the result of well discharge exceeding the rate of natural recharge.

5. Continuing declines will probably affect the estimated discharge to Salmon Falls Creek, and may, with time, reverse the ground-water gradient and result in stream loss to the ground-water system.

6. Valid applications for appropriation of ground water yet to be developed, total more than four times the existing well discharge and thus endanger the economic value of the resource.

7. Natural curtailment of development exists in the area because of the extreme variability of the aquifer materials and the high percentage of nonproducing wells.

On the basis of the above conclusions is recommended that:

1. A critical ground-water area be designated to include the land delineated as shown in figure 18.

2. This designation to continue until additional data are collected to show that the approval of new permits would not damage existing water right holders or cause reductions of water levels beyond the reasonable pumping level for this area (Idaho Code 42-226).

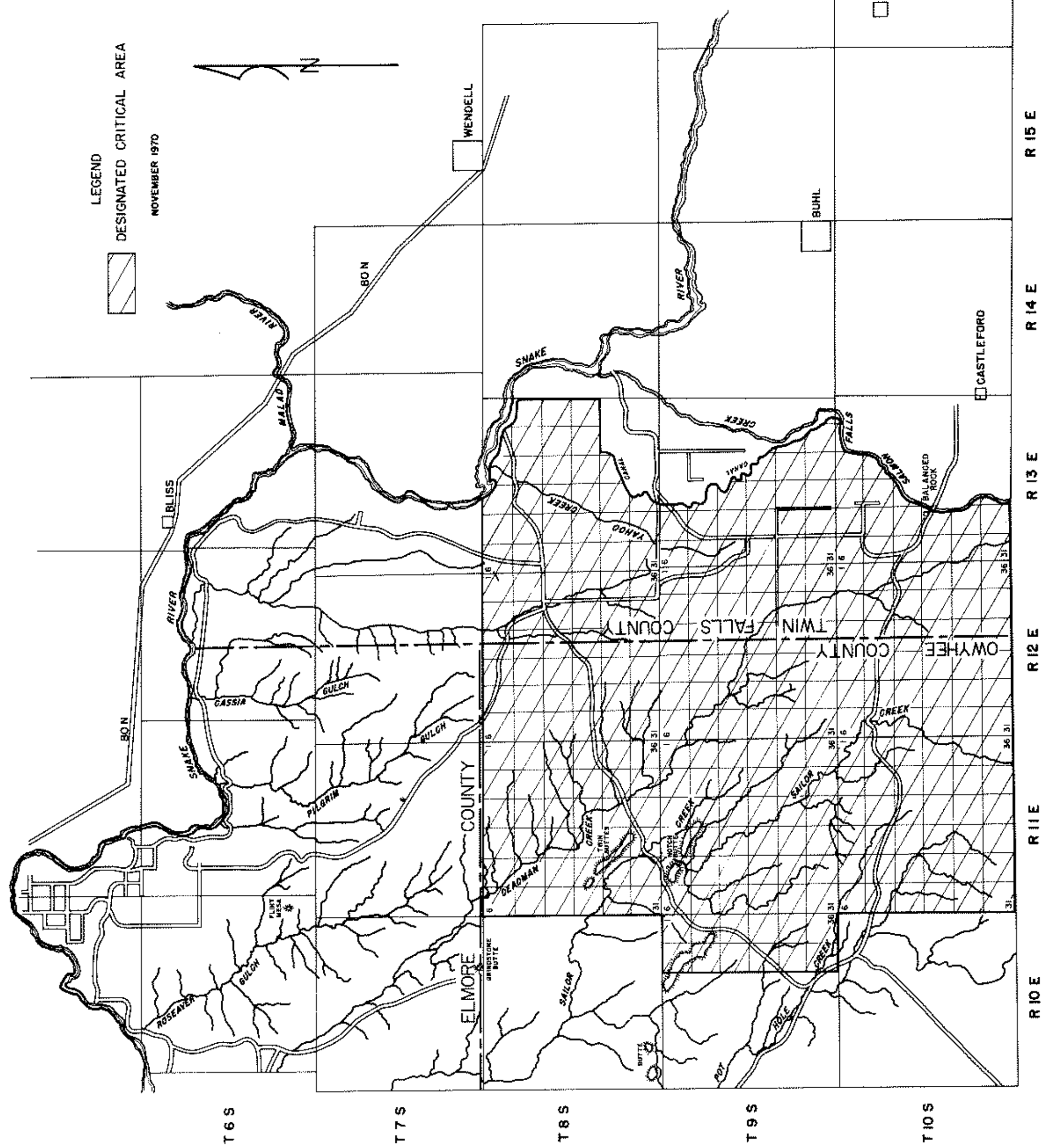

FIGURE 18. Delineation of the critical ground-water area, Blue Gulch study area

3. The present observation well network be expanded to better monitor the water-level fluctuations over a greater portion of the hydrologic system.

4. An additional, detailed investigation of the ground-water resource be initiated when sufficient new data have been generated. One portion of this later study should be a surface and borehole geophysical investigative program to determine the zones of faulting and geologic boundaries.

REFERENCES

Crosthwaite, E. G., 1963, Ground-Water Reconnaissance of the Sailor Creek area, Owyhee, Elmore, and Twin Falls Counties, Idaho: U. S. Geol. Survey open-file report, 53 p.

Hadley, R. F. and Sumsion, C. T., 1958, Examination of Proposed Well Sites in Grazing District 1, Owyhee and Twin Falls Counties, Idaho: U. S. Geol. Survey open-file report, 12 p., 1 fig.

______1959, Hydrology of Stockwater Development in Eastern Part of Owyhee Grazing District: U. S. Geol. Survey open-file report, 45 p., 1 fig.

Hem, J. D., 1959, Study and Interpretation of the Chemical Characteristics of Natural Water: U. S. Geol. Survey Water Supply Paper 1473.

Malde, H. E. and Powers, H. A., 1962, Upper Cenozoic Stratigraphy of Western Snake River Plain, Idaho: Geol. Soc. of America Bull., U 73, p. 1197-1220.

Malde, H. E., Powers, H. A. and Marshall, C. H., 1963, Reconnaissance Geologic Map of West-Central Snake River Plain, Idaho: U. S. Geol. Survey miscellaneous investigations map I-373.

Mundorff, M. J., Crosthwaite, E. G.. and Kilburn, Chabot, 1960, Ground Water for Irrigation in the Snake River Basin in Idaho: U. S. Geol. Survey open-file report, 201 p., 60 figs.

Thiem, G., 1906, in Methods of Determining Permeability, Transmissibility and Drawdown: U. S. Geol. Survey water supply paper 1536-E, p. 91.

Theis, C. V., Brown, R. H. and Meyer, R. R., 1963, in Methods of Determining Permeability, Transmissibility and Drawdown: Geol. Survey water-supply paper 1536-I, p. 331-336.

U. S. Public Health Service, 1962, Drinking Water Standards, 1962: U. S. Public Health Service Pub. 956, 61 p.

U. S. Salinity Laboratory Staff, 1954, Diagnosis and Improvement of Saline and Alkaline Soils: U. S. Department of Agriculture, Agriculture Handbook No. 60.