PHYSICAL CHARACTERISTICS AND CHEMICAL QUALITY OF SELECTED SPRINGS IN PARTS OF JUAB, MILLARD, TOOELE, AND UTAH COUNTIES, UTAH

by Dale E. Wilberg and Bernard J. Stolp

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 85-4324

Prepared in cooperation with the

U.S. BUREAU OF LAND MANAGEMENT

Salt Lake City, Utah

1985

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

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ABSTRACT

The purpose of the study was to provide the U.S. Bureau of Land Management with geohydrologic information for 90 selected springs for use by that agency in resource evaluation, environmental assessment, and water-rights application. The area of study in west-central Utah is within the topographically diverse Basin and Range physiographic province.

The report presents hydrologic, geologic, and partial water-quality data collected at 90 selected springs and chemical analyses of water samples from 62 of the springs. Descriptions of the physiographic and geologic conditions, climate, and vegetation patterns for the study area are included. Allowable limits of certain chemical constituents in water for human and livestock consumption are included with the water-quality data. Three classifications of springs were established based on physical characteristics of the springs and chemical composition of the springflow: (1) mountain springs, (2) non-thermal valley springs, and (3) thermal valley springs.

Mountain springs are in and near recharge areas, have seasonal variations of discharge and temperature, typically discharge from extrusive and metamorphic geohydrologic units, and generally discharge freshwater. Non-thermal valley springs are peripheral to recharge areas, have seasonal variations of discharge and temperature, typically discharge from a variety of geohydrologic units, and have variable water composition. Thermal valley springs are near topographic low areas of valleys, and have little seasonal variation of discharge or temperature. They typically discharge from unconsolidated deposits (but the discharge probably has flowed through buried carbonate geohydrologic units). They also have a considerable range of water composition that reflects the relative complexity of the ground-water system.

INTRODUCTION

Purpose, Scope, and Method of Study

The purpose of the study was to provide the U.S. Bureau of Land Management with pertinent information about selected springs for use by that agency in resource evaluation, environmental assessment, and water-rights application. The U.S. Geological Survey, in cooperation with the U.S. Bureau of Land Management, collected discharge, specific-conductance, pH, and temperature measurements at 90 selected springs in Juab, Millard, Tooele, and Utah Counties (fig. 1), and evaluated geohydrologic conditions of those springs. The site inventory was done periodically from December 1983 to November 1984. Water samples were collected from 62 springs for chemical analysis; previous chemical analyses were available for 7 of these springs. The study was conducted during unusually wet climatic conditions when annual precipitation was much more than the 1951-80 normal annual precipitation.

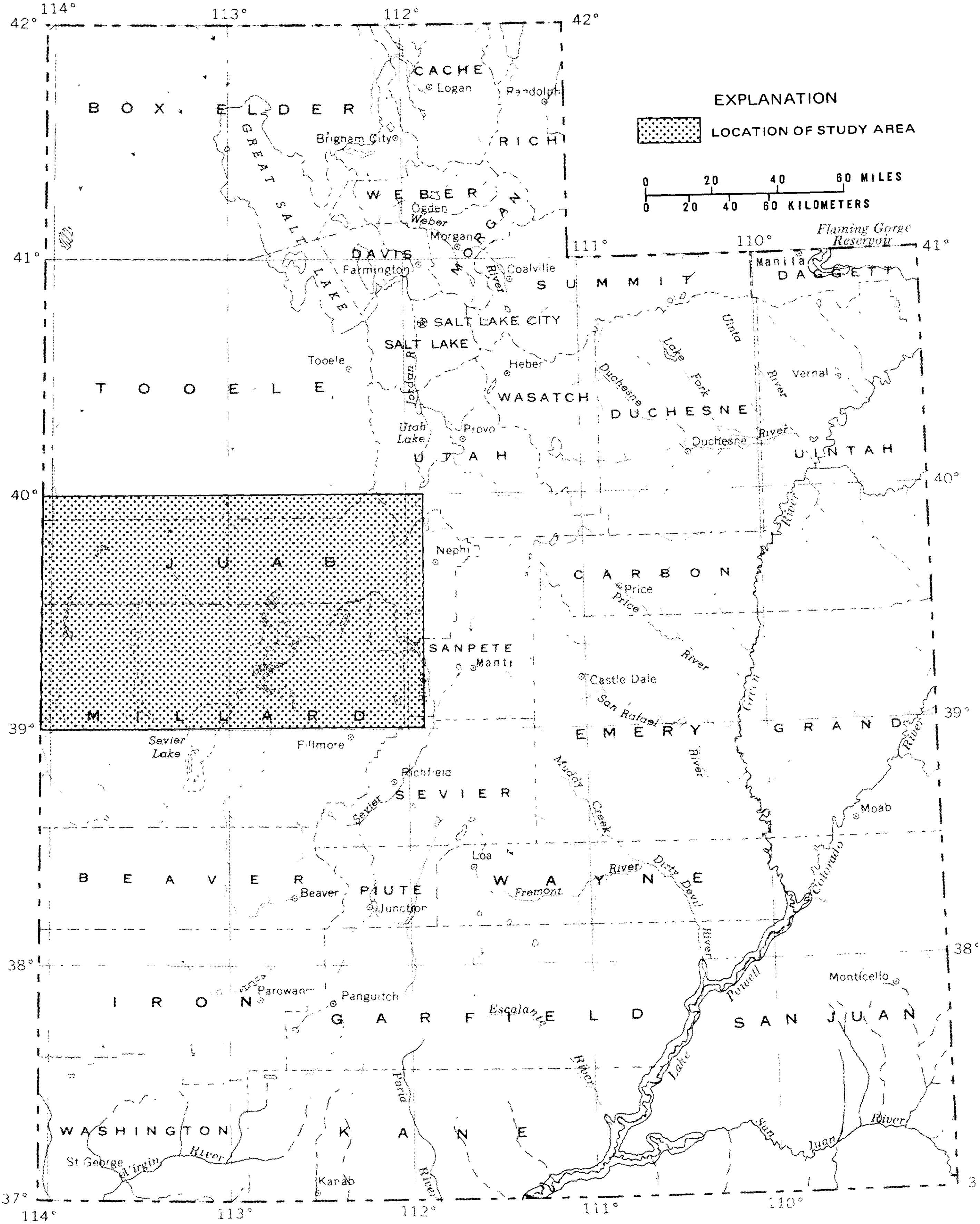


Figure 1.—Location of study area.

The geohydrologic evaluation of each spring included a determination of the rock type from which the spring discharges and a judgement about the factors and conditions that control the spring's location and character. In most instances, two visits were made to each spring site to document changes in discharge, specific conductance, pH, and temperature of the spring.

Water samples were collected as near as possible to the spring's orifice. Measurements of discharge were obtained by impounding and diverting the spring-flow through a pipe. After the level of the spring impoundment became stabilized, a 1- or 3-gallon calibrated bucket and a stopwatch were used to measure the flow (actual springflow) from the pipe. For springs where discharges were too large to measure using the above method, a current meter was used where the springflow was channeled. Specific conductance and pH were determined with appropriate portable field meters. Temperatures were measured near the spring orifice using a calibrated Celsius thermometer. Carbonate alkalinity, using field titrations, was determined for each spring that was sampled for chemical analysis in the laboratory. The samples were filtered and acidified at the sampling site and placed on ice to preserve the water composition. The samples were then sent to the U.S. Geological Survey laboratory in Denver, Colorado, for chemical analysis.

Previous Studies

Among the earliest ground-water studies in west-central Utah was a study by Meinzer (1911). During 1965-81 a series of hydrologic reconnaissance and ground-water studies in selected western basins of Utah were published.

Those reports compiled by the U.S. Geological Survey are identified below (in the order completed) by area of study, author(s), and date published:

Area of study	Author(s) and date published
Sevier Desert, Utah	Mower and Feltis (1964, 1968)
Snake Valley, Utah and Nevada	Hood and Rush (1965)
Deep Creek Valley, Utah and Nevada	Hood and Waddell (1969)
Tule Valley, Utah	Stephens (1977)
Fish Springs Flat, Utah	Bolke and Sumsion (1978)
Southern Great Salt Lake Desert and west-central Utah	Gates and Kruer (1981)
Sevier Desert, Utah	Enright and Holmes (1982)
Do.	Holmes (1984)

Acknowledgments

The authors acknowledge Kendall Thompson, Carole Burden, and Michael Enright of the U.S. Geological Survey for their assistance with the data collection, and Walter Holmes, also of the U.S. Geological Survey, for his technical advice and suggestions. Philip Zieg and Birrell Hershey of the U.S. Bureau of Land Management were helpful in relocating misplotted springs.

Numbering system for hydrologic-data sites

The system of numbering hydrologic-data sites in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating a site as a spring, describes its position in the land net. By the land-survey system, the state is divided into four quadrants by the Salt Lake base line and meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. An uppercase letter R preceding the parentheses indicates that the range number is one-half, for example, R(C-12-2)12cbd-S1 means the same as (C-12-2 1/2)12cbd-S1. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section, generally 10 acres; the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the data site, within the 10-acre tract; the letter S preceeding the serial number denotes a spring. Thus (C-12-14)23dcc-S1 designates the first spring visited in the SW 1/4, SW 1/4, SE 1/4, sec. 23, T. 12 S., R. 14 W. The numbering system is illustrated in figure 2.

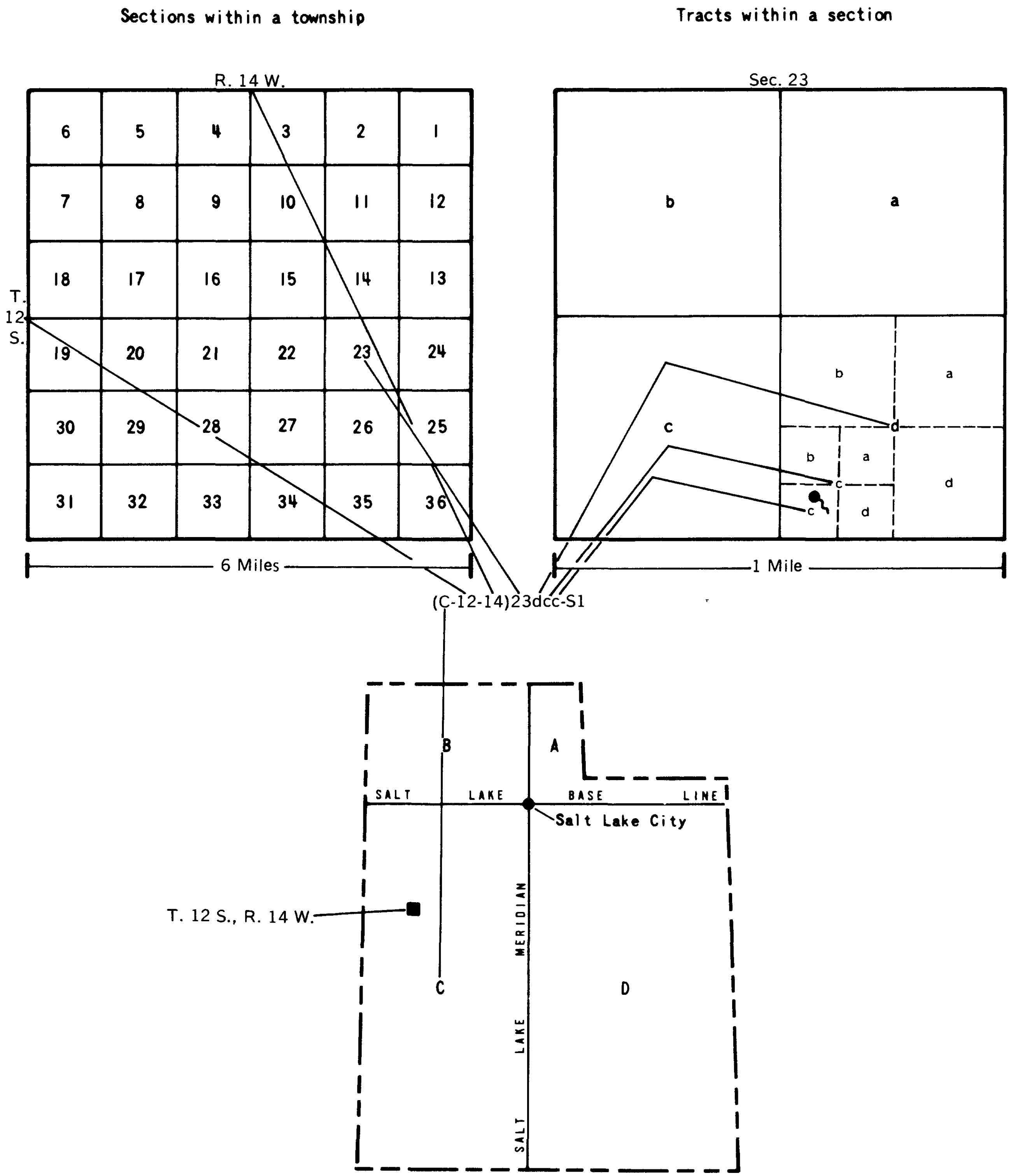


Figure 2.—Numbering system for hydrologic-data sites.

PHYSICAL SETTING

Physiographic and Geologic Conditions

The study area consists of about 8,000 square miles of west-central Utah and is within the Bonneville Basin subdivision of the Great Basin section of the Basin and Range physiographic province (Hunt, 1974, p. 495). The east and west boundaries are, respectively, the Salt Lake Meridian (111° 52' W) and the Utah-Nevada State line (114° 04' W). The north and south boundaries are, respectively, the 40th and 39th parallels (pl. 1). The area is characterized by isolated mountain blocks and by topographically closed desert basins with playas and alluvial fans (bajadas). The broad, flat basins and gently sloping alluvial fans comprise more than 60 percent of the total area, and the altitudes generally are less than 6,000 feet. The remaining area is occupied by asymmetrically-tilted mountain blocks. The relationship between a typical desert basin and adjacent mountain blocks in the study area is shown in figure 3. Relief and altitude extremes occur in the Deep Creek Range part of the study area and range from 12,087 feet atop Ibapah Peak to 4,254 feet at the southern part of the Great Salt Lake Desert, an altitude change in excess of 7,800 feet. Local relief, however, generally is less than 5,000 feet (Hunt, 1974, p. 6).

The physiography of the study area is derived from late Cenozoic crustal extension of the western North American continent that produced fragmentation and collapse of crustal material (Hintze, 1973, p. 113). This resulted in a series of fault-bounded, north-trending basins and ranges. These structurally dropped basins became depositional areas for unconsolidated sediment eroded from adjacent mountains, and many of them were inundated by prehistoric Lake Bonneville. Previous to the extensional and normal faulting, during the late Mesozoic Era, compressional forces along a generally east-trending axis complexly folded and thrust faulted the pre-existing Paleozoic miogeoclinal sedimentary rocks and Precambrian metamorphic rocks. Associated with both the extensional and compressional forces were: (1) The intrusion of igneous stocks during the Jurassic and early Tertiary Periods in the House Range, Sheeprock Mountains, and Deep Creek Range, and (2) the extrusion of igneous rocks, mostly during the late Cenozoic Era, locally throughout the study area.

The rocks in the study area are grouped into six geohydrologic units based on dominant lithology and general water-yielding characteristics (pl. 2 and table 1). The six units are unconsolidated sedimentary deposits, extrusive igneous rocks, intrusive igneous rocks, carbonate sedimentary rocks, clastic sedimentary rocks, and metamorphic rocks. Those rocks represent all geologic time periods. The structural complexity of the geology is indicated by the diversity of rock types and distribution of rock outcrops. Most of the unconsolidated sedimentary deposits are found in the basins throughout the study area, but minor fluvial deposits are found along the mountain streams. Glacial deposits are found locally in the Deep Creek Range. The extrusive igneous rocks of mafic composition primarily are limited to the eastern one-third of the study area, but a few exposures are found east of Snake Valley in the northern part of the Confusion Range. The intrusive igneous rocks include the Jurassic quartz monzonite stock exposed near Notch Peak in the House Range and the early Tertiary granitic intrusion in the Deep Creek Range. Middle Tertiary intrusions are exposed in parts of Keg Mountain, Desert Mountain, the Sheeprock Mountains, and the East and West Tintic Mountains. The carbonate

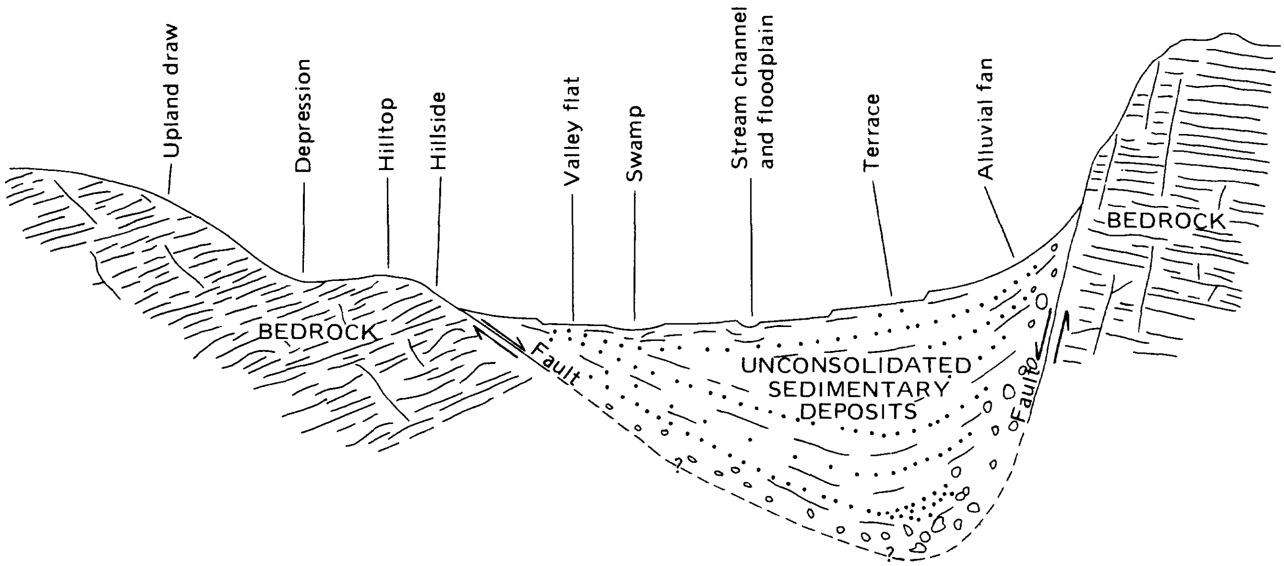


Figure 3.—Diagrammatic section showing typical physiographic and geologic features in the study area.

sedimentary rocks range in age from the Middle Cambrian Tatow member of the Pioche Formation to the Tertiary Flagstaff Limestone, and they crop out in several noncontiguous north-trending mountain ranges. The clastic sedimentary rocks range in age from the Precambrian and Cambrian Prospect Mountain Quartzite (or Tintic Quartzite) to Late Cretaceous and early Tertiary North Horn Formation. The Prospect Mountain Quartzite crops out in several ranges in the western two-thirds of the study area, whereas the North Horn Formation outcrops are limited to the eastern boundary of the study area. The folded metamorphic rocks are limited to isolated exposures in the Deep Creek Range, Simpson Mountains, Sheeprock Mountains, and Canyon Mountains.

Table 1.--Occurrence, lithology, age, rock-stratigraphic unit, and water-yielding characteristics of geohydrologic units

Geohydrologic unit and identification number on Plate 2.	Occurrence, lithology, age, and rock-stratigraphic unit	Water-yielding characteristics and general water quality
Unconsolidated sedimentary deposits (1)	Includes clay to boulder lacustrine deposits of Pleistocene Lake Bonneville and limited to areas below altitudes of about 5,200 feet. Sand- to boulder-sized fluvial, alluvial, colluvial, and glacial detrital material; glacial material limited to Deep Creek Range. Fluvial, alluvial, and colluvial detritus in basins, slopes, and mountain valleys. Semiconsolidated mudstone, sandstone, and lacustrine deposited pyroclastic material of the upper Tertiary Salt Lake Formation, surface exposure is limited to Tintic Valley, western slopes of the Canyon Mountains, Deep Creek Valley, and Long Ridge.	Fine-grained lake bottom deposits are slightly permeable; beach and bar deposits, and eolian deposits are slightly to very permeable depending on the degree of sorting. Most precipitation and runoff from higher altitude pools on the lake-bottom deposits in the lower parts of the basins and remains until evaporated. Some of the precipitation or runoff that accumulates on the permeable beach or bar deposits or eolian deposits or all three is absorbed and transpired by phreatophytes; some moves downward to the underlying ground-water system. The poorly sorted fluvial, alluvial, and colluvial deposits located adjacent to the source areas are slightly to very permeable. Some precipitation and runoff infiltrates these deposits and moves downward to underlying aquifers. The Salt Lake Formation is slightly to very permeable depending on clast size, degree of sorting, and state of diagenesis.
Extrusive igneous rocks (2)	Includes andesite, latite, trachyte, rhyolite and tuffaceous flows on Long Ridge, Smelter Knolls, the East and West Tintic Mountains, Simpson Mountains, Keg Mountain, Thomas Range, and Little Drum Mountains; basalt flows associated with eruptive centers near Pahvant Butte, Black Rock Hills, Fumerole Butte, and northern part the Confusion Range.	Primary permeability generally is slight except between individual flows and on basalt flows. Secondary permeability is substantial where rocks are fractured, faulted, or jointed. Springs discharging from extrusive rocks in the East and West Tintic Mountains generally are fresh but discharge can be variable.
Intrusive igneous rocks (3)	Includes middle Tertiary intrusions exposed in parts of the Sheeprock Mountains, the East and West Tintic Mountains, Keg Mountain, and Desert Mountain; early Tertiary granitic intrusions exposed in the Deep Creek Range, and Jurassic quartz monzonite intrusion exposed in the House Range near Notch Peak.	Primary permeability is neglibile, secondary permeability is moderate to substantial in faulted and fractured zones and exfoliated surfaces.
Carbonate sedimentary rocks (4)	Includes limestone and dolomite ranging in age from the Tertiary Flagstaff Limestone to the Middle Cambrian Tatow Member of the Pioche Formation but principally of Paleozoic age, that crop out in several noncontiguous north-trending mountain ranges.	Primary permeability is slight but secondary permeability is moderate to substantial along fractures, faults, and interconnected solution cavities. Probable conduit for regional subsurface movement of water between individual basins. Source for largest springs discharging in the study area. Quality of water varies from fresh tc very saline.
Clastic sedimentary rocks (5)	Includes interbedded mudstone, siltstone, and sandstone of the North Horn Formation of Palescene and Cretaceous age, and the Price River Formation and Indianola Group of Cretaceous age, Pilot Shale of Mississippian age and Wheeler and Pioche Shales of Cambrian age, and Prospect Mountain and Tintic Quartzites of Cambrian and Precambrian age. The North Horn and Price River Formations and Indianola Group are limited to the eastern part of the study area.	Primary permeability is very small except in faulted and fractured zones. Water from spring in the shale unit is slightly saline.
Metamorphic rocks (6)	Includes schist, phyllite, metamorphic quartzite, and argillite in the Deep Creek Range and Simpson Mountains; argillite, metaconglomerate, and diamictite of the Sheeprock Group (Cohenour, 1959) and quartzite of the Mutual Formation both of Late Proterozoic age in the Sheeprock Mountains; and undifferentiated metasedimentary rocks, chiefly quartzite and metaconglomerate, in the Canyon Mountains.	Primary permeability is slight but secondary permeability ranges from moderate to substantial in areas of extensive fractures. The fracture zonea provide easy access for local recharge to the ground water system. Water from springs in the Deep Creek Range and Sheeprock Mountains is fresh.

Climate

The study area includes the desert or arid, steppe or semiarid, and highland climatic zones. The desert and steppe climatic zones, where annual potential evapotranspiration exceeds average annual precipitation (Trewartha, 1968, p. 370), include most of the study area and make it one of the driest parts of Utah. The highland zone, where average annual precipitation exceeds potential evapotranspiration, has limited areal extent in the Deep Creek, House, and Pahvant Ranges, and the Canyon, Simpson, and Sheeprock Mountains.

Topographic variation controls the climatic dissimilarity within the study area. Mountains impede the generally west to east movement of air masses in the storm track and cause them to rise over the mountains. This orographic lifting on the windward (generally west) side of the mountains results in increased precipitation with increased altitude. The leeward (generally east) side of the mountains has warmer and drier descending air with decreased precipitation. This is referred to as the mountain rain-shadow effect.

Approximately the western two-thirds of the study area is dominated by the desert or arid climatic zone, where the average annual precipitation is 5 to 8 inches, and is less than one-half the average annual evapotranspiration rate (Murphy 1981, p. 55). The eastern one-third of the study area, with an average annual precipitation ranging from 8 to 14 inches (pl. 1) is in the steppe or semiarid climatic zone.

In general, only those areas with altitudes higher than 7,000 feet receive sufficient annual precipitation to exceed potential annual evapotranspiration (Richardson and others, 1981, p. 65). Therefore, the areal extent of the widely distributed, undifferentiated highland climatic zone is limited to only a small part of the study area.

Precipitation in the basin areas, usually in the form of rain, reflects three seasonal peaks--generally May, August, and October. The May and October peaks are associated with synoptic upper-level lows in atmospheric pressure that occur during shifts of the polar and mid-latitude jet streams. The August peak is associated with thundershower activity that results principally from the northward flow of warm moist air masses generated in the Gulf of Mexico (Jeppson and others, 1968, p. 1). In addition, the higher altitudes receive snow in the winter months from eastward advancing Pacific frontal storms.

Normal annual precipitation, based on the 30-year average for 1951-80, ranges from 5.14 inches at Callao to 16.8 inches at Eureka (U.S. Department of Commerce, 1982). Additional precipitation values for sites in the study area are given in table 2, along with selected air-temperature data. The study was conducted during a wet-cycle when annual precipitation was much greater than 1951-80 normal. For example, precipitation during for 1981-83 exceeded the 1951-80 normal by about 150 percent at Eskdale and by 175 percent at Partoun.

Vegetation

Five vegetation zones--upper Sonoran, Transition, Canadian, Hudsonian, and Artic-Alpine tundra--exist within the study area (Merrian, 1898). The vegetation zones are principally controlled by altitude, type of soil, availability of soil moisture, and temperature. The lowest vegetation zone in the study area, the upper Sonoran, has vertical zonation and consists of the shadscale, sagebrush, and pinyon-juniper associations. The shadscale association (*Atriplex confertifolia*), found in the lowest parts of the basins and alluvial slopes is characterized by drought-resistant and salt-tolerant grasses and shrubs. Greasewood (*Sarcobatus vermiculatus*), pickleweed (*Allenrolfea occidentalis*), and saltgrass (*Distichlis stricta*) are typical of low areas where soils have large salt concentrations and the water table is near the land surface. Blackbrush (*Coleogyne ramosissima*) is typical of areas with nonalkaline soils and meager precipitation. The sagebrush association (*Artemisia rothrockii, A. spinescens*, *A. tridentata*), is found on the gravelly, well drained, non-alkaline middle and upper alluvial fans and higher basins where annual precipitation is at least 8 inches (pl. 1). The boundary between sagebrush and pinyon (*Pinus sedulus*)-juniper (*Juniperus communis, J. osteosperma, J. scopulorum*) is a level where annual precipitation is at least 12 inches (pl. 1) (Murphy, 1981, p. 31). The Transition zone, with a lower altitude boundary of 7,500 feet and a mean temperature of the warmest month of 72 °Fahrenheit, is dominated by mountain brush and isolated stands of ponderosa pine (*Pinus ponderosa*). The Canadian zone, between the altitudes of 8,000 and 10,000 feet with a mean temperature of the warmest month of 64 °Fahrenheit, typically has mixed or isolated stands of Douglas fir (*Pseudotsuga taxifolia*) and white fir (*Abies concolor*).

In the House Range, stands of fir are found on the north-facing slopes of Notch Peak and Swasey Peak. Still higher in altitude is the Hudsonian zone where Englemann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), limber pine (*Pinus flexilis*), and bristlecone pine (*Pinus aristata*) plant communities are found. The Hudsonian zone includes all mountain areas where the mean temperature for the warmest month is 57 °Fahrenheit or less. The highest vegetation zone in the study area, the Arctic-Alpine tundra, exists only above treeline and is limited to the higher parts of the Deep Creek Range where the mean temperature of the warmest month is 50 °Fahrenheit or less. At this high altitude only hardy moss, sedges, and herbs can grow in the rocky, well-drained soils and survive the extreme climatic conditions.

Table 2.--Selected climate data (1951-80)

[Data from U.S. Department of Commerce, 1982, and Stevens and others, 1983]

Climatic station	Altitude (feet)	Normal annual temperature (degrees Fahrenheit) Maximum	Minimum	Mean	Freeze-free period (days)	Normal annual precipitation (inches)
Callao	4,320	64.1	34.6	49.4	118	5.14
Delta	4,623	65.3	34.7	50.0	142	7.51
Deseret	4,585	65.6	32.8	49.2	128	7.33
Elberta	4,690	64.6	36.0	50.3	140	10.46
Eskdale	4,980	67.6	33.4	50.5	138	5.51
Eureka	6,480	59.2	33.9	46.6	90	16.80
Garrison	5,275	66.2	34.7	50.4	135	7.30
Ibapah	5,280	64.9	26.9	45.9	77	8.40
Oak City	5,070	66.3	38.8	52.6	165	12.15
Partoun	4,750	66.7	33.1	49.9	123	6.19
Scipio	5,306	63.9	31.0	47.4	112	12.15

WATER RESOURCES

Surface Water

Precipitation that exceeds soil-moisture requirements and is not consumed by evapotranspiration, or does not enter a ground-water system, becomes overland runoff. In the study area, most overland runoff results from seasonal melting of mountain snowpacks. A few perennial streams originate in the higher mountains within the study area, however, the streamflow is depleted by seepage to the local ground-water system or is diverted for irrigation, within a short distance of the source. The Sevier River, which has headwaters outside the study area, is the area's largest perennial stream. Average discharge of the Sevier River near Lynndyl, Utah, was 235 cubic feet per second for 47 years of record during 1914-84.

Ground Water

Ground water in the study area occurs in the consolidated rocks of the mountains and the unconsolidated sedimentary deposits of the basins. The mountain areas consist mainly of consolidated rocks that in places are covered by veneers of soil and alluvium. Water moves through the consolidated rocks in open joints, fractures, vesicles, solution channels, contacts, and bedding planes. Most individual consolidated rock units do not store or transmit large quantities of water. Combined with secondary porosity, however, they do store and transmit appreciable quantities of water. The consolidated rocks provide conduits through which ground water can move down gradient to areas of lower hydraulic head. Mountain springs are most likely to occur where a fracture, fault, or contact intersects the land surface allowing water to discharge at the surface.

The unconsolidated sedimentary deposits in the basins store and transmit large quantities of water. Each basin ground-water system is recharged by seepage of precipitation directly through the basin floor, by seepage of surface runoff from the adjacent mountains, and by subsurface inflow from the adjacent mountain blocks.

There is evidence that at least some of western Utah's basins and ranges are in interconnected regional ground-water systems which transmit water long distances through the rocks that form the mountain ranges. Paleozoic carbonate rocks, that are predominant in the area, are thought to contain solution-formed conduits (Gates and Kruer, 1981, p. 33), in these regional ground-water flow systems.

Water is discharged from the ground-water systems chiefly by evapotranspiration, springs seeping to streams, and pumped wells. More specific information about the water budget for most basins shown on plates 1 and 2 is given in the reports listed in the Previous Studies section. The above-cited Gates and Kruer (1981) report contains more information about the regional ground-water flow.

Many springs were visited and inventoried during the study. Physical characteristics and chemical quality of most of those springs are described in the following sections.

DESCRIPTION OF SELECTED SPRINGS

Physical characteristics

A spring is, by definition, a place where ground water flows naturally from a rock or the soil onto the land surface or into a body of surface water. Its occurrence depends on the nature and relationship of rocks, on the position of the water table, and on the topography (Bates and Jackson, 1980, p. 604). Selected springs inventoried during this study are listed in table 3 and shown on plate 1. The closely-spaced springs are also shown in figures 4-9.

The classification scheme of Meinzer (1923, p. 50-55) is the basis for the spring inventories and evaluations done during this study. Thus, the 90 springs visited during the study are described by several characteristics, among which are the character of: (1) The orifices through which the springs discharge, (2) rock structure and resulting forces that bring water to the surface, (3) probable geohydrologic source of the springflow, (4) temperature of the springflow, and (5) rate and variability of springflow. A summary of the inventory data for each spring visited is given in table 3. A brief description of the physical characteristics and an assessment of pertinent springs follows.

Character of Orifice

Based on the character of the orifice(s) through which they discharge, springs can be grouped into two broad classes: (1) Seepage or filtration springs, and (2) fracture springs. A seepage or filtration spring discharges from permeable material through several small orifices. Seepage springs have small discharges, whereas filtration springs (figure 10, diagram S) have no discharge limits . Fracture springs discharge from joints or fracture openings in the rock (figure 10, diagram F). Death Creek Spring, (C-11-3)20bbb-S1, (table 3) is an example of a seepage spring and Dave Egar Spring, (C-11-5)10abb-S1, is an example of a fracture spring.

Rock Structure and Forces That Bring Water to the Surface

Rock structure and forces that bring water to the surface is the combined effect of geologic structure and gravity; it results in either gravity springs or artesian springs. Gravity springs include depression springs and contact springs. Depression springs result when the land surface is depressed or eroded sufficiently to intersect the water table as in a depression or stream channel (figure 10, diagram D). An example is Schoenburger Spring, (C-14-11)22bac-S1.

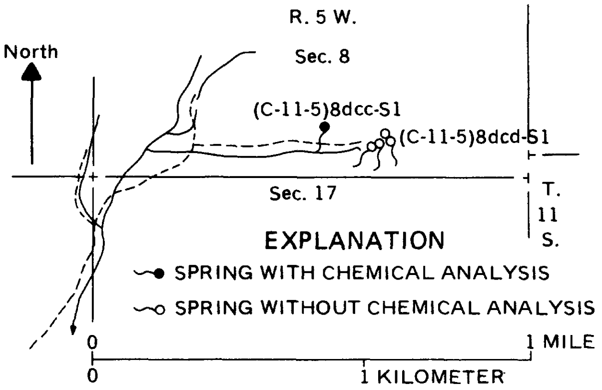


Figure 4.—Indian Springs complex. Four springs on the right are grouped as one spring.

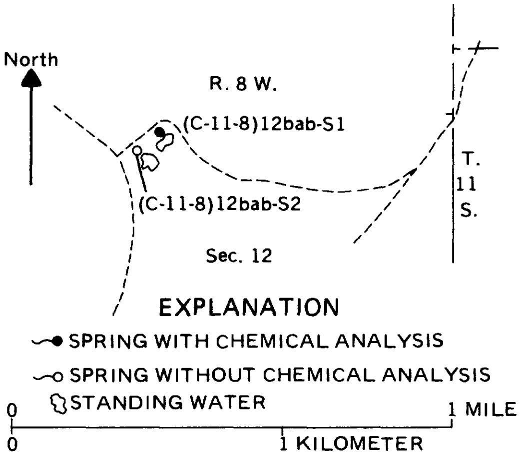


Figure 5.—Antelope Springs complex.

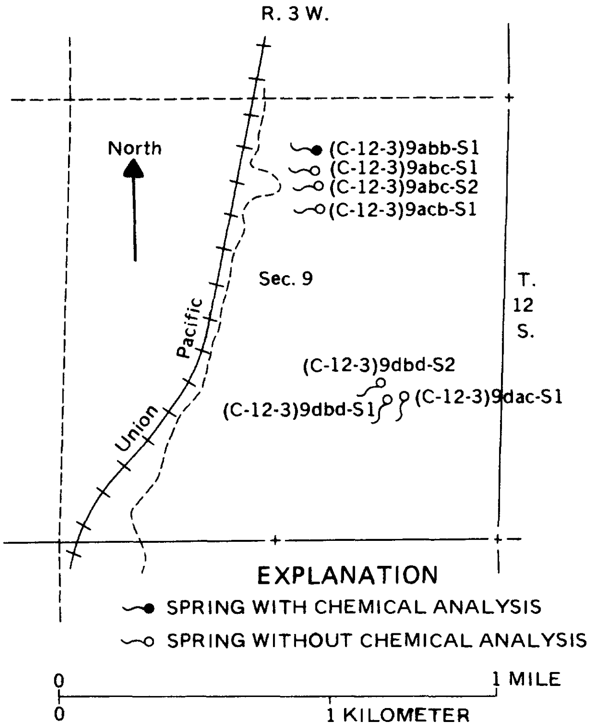


Figure 6.—Railroad Springs complex.

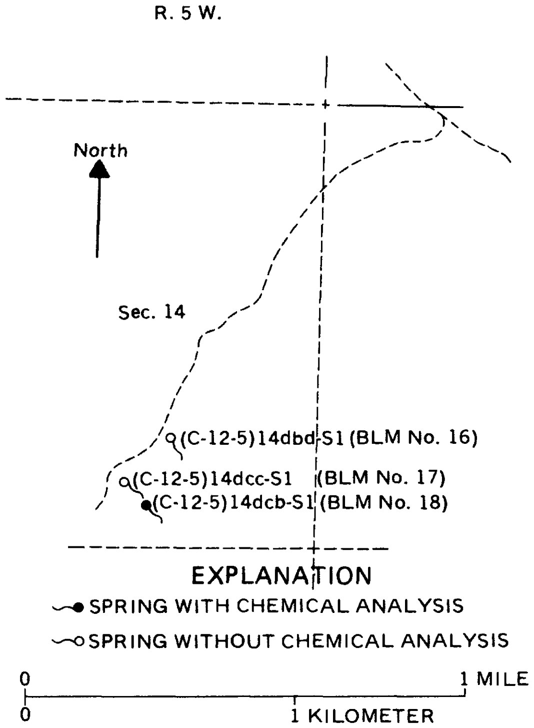


Figure 7.—Bureau of Land Management (BLM) spring numbers 16, 17, and 18.

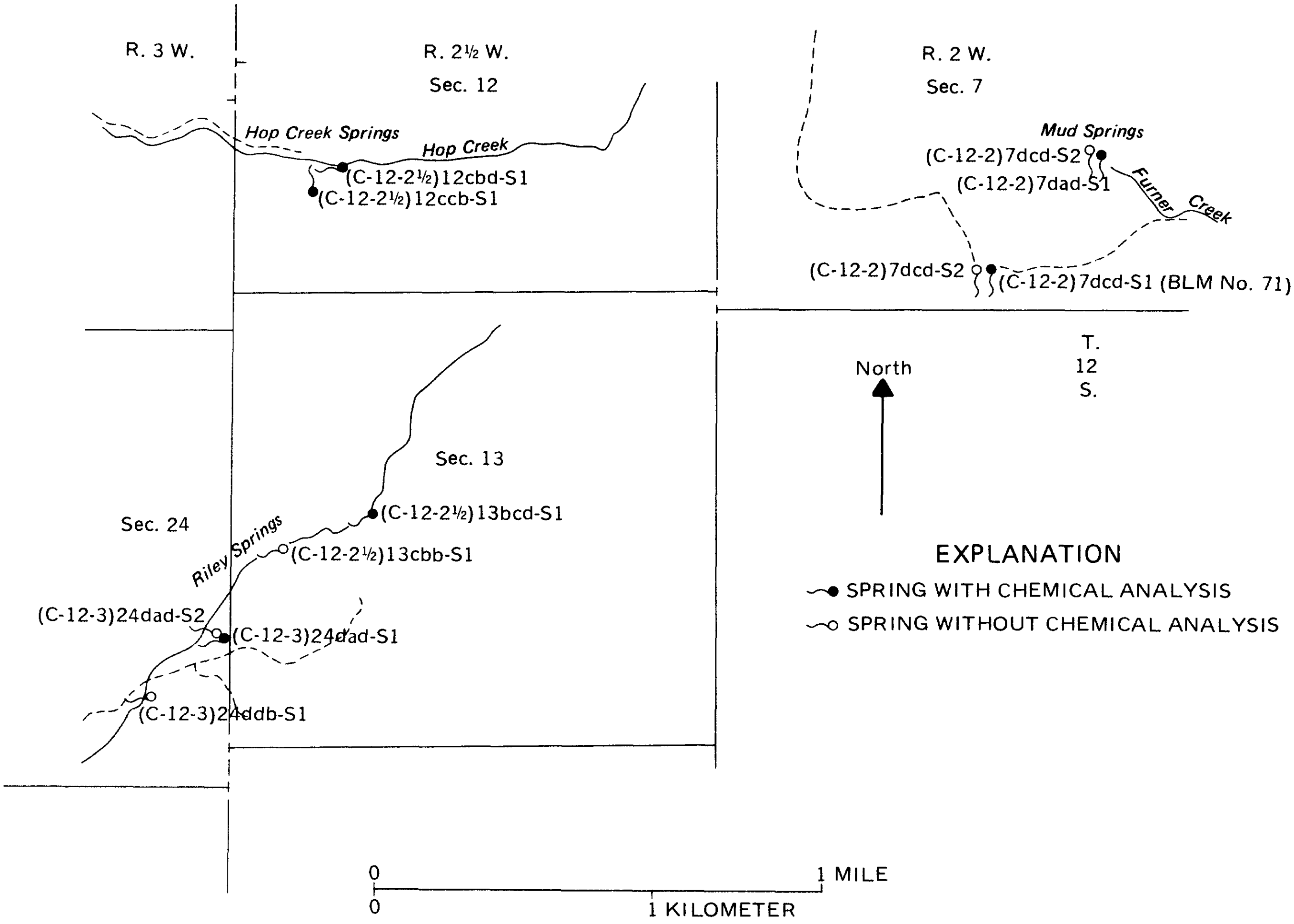


Figure 8.– Riley, Hop Creek, Mud, and Bureau of Land Management (BLM) number 71 spring complexes.

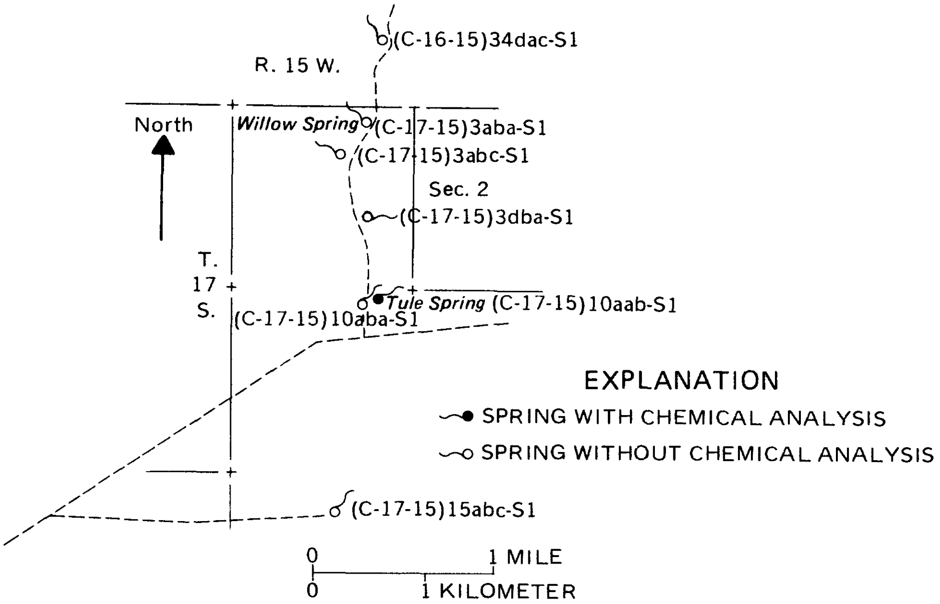
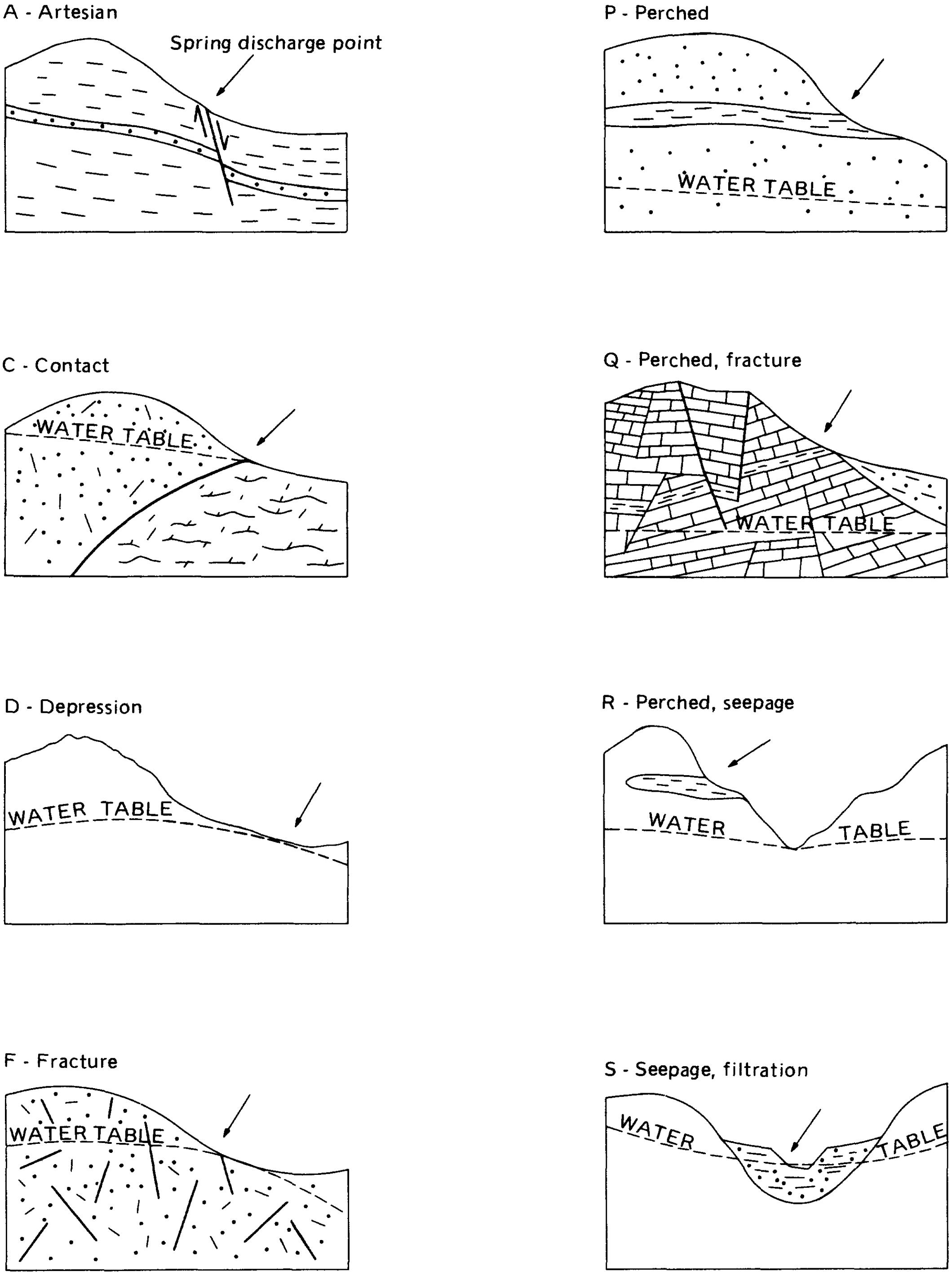


Figure 9.—Tule Springs complex.



A - Artesian

P - Perched

C - Contact

Q - Perched, fracture

D - Depression

R - Perched, seepage

F - Fracture

S - Seepage, filtration

Figure 10.—Principal types of springs.

Contact springs occur when impermeable material prevents the downward movement of water and deflects it laterally to the surface (figure 10, diagram C), as at West Brush Spring, (C-10-4)17ddb-S1, and Coyote Spring, (C-14-19)23bdb-S1. Contact springs are further subdivided according to the character of the features that bring the water to the surface (Meinzer, 1923, p. 51). The majority of the inventoried springs in the study area are gravity contact or depression springs.

Artesian springs flow from confined aquifers where the potentiometric surface is above the land surface; they rise through openings in the confining beds. In the study area artesian springs generally are related to faults and fractures and are represented by the spring complexes in Tule Valley, Fish Springs Flat, and Snake Valley. Data collected during this study (table 3) indicate that the artesian springs have higher temperatures and more uniform discharges than the other inventoried springs.

Geohydrologic Unit at Spring Source

The geohydrologic unit is the rock type from which the spring probably discharges (table 1 and pl. 2). The six geohydrologic units include groupings of unconsolidated, extrusive, intrusive, carbonate, clastic, and metamorphic rock types. Unconsolidated sedimentary deposits are the source of 16 of the inventoried springs that typically are found on the alluvial slopes of the individual basins. The 29 springs that discharge from extrusive igneous rocks (generally latites, trachytes, or ash flow tuffs) are predominantly in the East and West Tintic Mountains. Four inventoried springs discharge from the intrusive Ibapah stock in the Deep Creek Range. Carbonate sedimentary rocks of Paleozoic age are the probable source of 28 of the inventoried springs and principally underlie unconsolidated deposits in Tule Valley, Fish Springs Flat, Snake Valley, and the Swasey Mountain area. One of the inventoried springs discharges from the clastic Wheeler Shale on the west side of Swasey Mountain. Twelve inventoried springs flow from metamorphic rocks in the Sheeprock Mountains and the Deep Creek Range.

Temperature

The temperature of springflow is used to differentiate thermal and non-thermal springs. Thermal springs have temperatures that are 5.6° Celsius greater than the mean annual air temperature of the surrounding area (Mundorff, 1970, p. 7). Thermal springs are further divided into warm springs (temperature of spring 5.6 to 37.8° Celsius greater than the mean annual temperature of the surrounding area) and hot springs (temperature of spring more than 37.8° Celsius greater than the mean annual temperature). Springs in the study area are considered to be warm springs if they are warmer than 17° Celsius and have little or no seasonal temperature variation. This study indicates that warm springs are limited to areas in Fish Springs Flat and Tule and Snake Valleys. The occurrance of thermal springs is significant because it indicates deep circulation of the ground water (Stephens, 1977, p. 16). Non-thermal springs with large seasonal temperature variations probably are associated with local ground-water circulation.

Rate and Variability of Spring Discharge

The rate and variability of a spring's discharge indicates the potential utility and permanence of the spring. Discharge from the inventoried springs range from less than 1 gallon per minute at 26 springs to more than 1,000 gallons per minute at Twin Spring, (C-16-18)22cab-S1. Of the 170 measurements or estimates of discharge made during the study, 131 or 77 percent were less than 20 gallons per minute (table 3). Two springs, (C-11-17)22bab-S1 and (C-12-3)9dac-S1, were dry when visited. Two other springs, (C-12-3)24ddb-S1 and (C-14-11)22bac-S1, had no visible discharge from the collection boxes. As noted in the climate section, the study was conducted during a wet cycle when annual precipitation was considerably greater than normal. The effect of the wet cycle on the springs is not well known but long-term monitoring at certain springs could provide a better understanding of climatic effects on respective ground-water flow systems. For example, some of the small-yield springs listed in table 3 may cease to flow during drier cycles. This would indicate that they are discharge points of small, local ground-water systems.

Chemical Quality

Chemical analyses of 69 samples from 62 respective springs are presented in table 4. Allowable recommended limits of physical properties and chemical constituents for human and livestock consumption and possible sources of those properties and constituents are detailed in table 5.

Chemical constituents in the sampled springs as plotted on Piper diagrams (Hem, 1970, p. 268) depict a variety of water compositions. Piper diagrams illustrate the percentages rather than concentrations of cations and anions in the lower two triangular fields and the combined percentages of major ions in the upper diamond-shaped field. (See figs. 11-15.)

Classification of the Inventoried Springs

Based on similarities between chemical composition and physical characteristics, the springs inventoried during this study are grouped into three broad classifications: (1) Mountain springs, (2) non-thermal valley springs, and (3) thermal valley springs.

Mountain Springs

Mountain springs are further grouped into three categories based on apparent relationships between the water composition and the geohydrologic unit at the probable spring source. The three categories are springs that discharge from: (1) The extrusive geohydrologic units, (2) the metamorphic, intrusive, and carbonate geohydrologic units, and (3) the carbonate and clastic geohydrologic units in the Swasey Mountain area. Mountain springs are in or near ground-water recharge areas at altitudes of more than 5,380 feet, and have seasonal variations of temperature and discharge. Excluding the springs in the Swasey Mountain area, the mountain springs are fresh, with specific conductance values of less than 1,110 microsiemens per centimeter at 25 °Celsius, and the predominant ions are calcium and bicarbonate.

Seventeen of the 18 mountain springs that discharge from the extrusive geohydrologic units are in the East and West Tintic Mountains. Only one spring, (C-13-19)25bab-S1, is not within the contiguous Tintic Mountain area and its water chemistry has a slight compositional variation from other extrusive-unit springs on the Piper diagram (fig. 11).

The springs that discharge from the metamorphic, intrusive, and carbonate geohydrologic units are in the West Tintic and Sheeprock Mountains, and the Deep Creek Range at altitudes ranging from 6,630 feet at (C-11-5)8dcc-S1 to more than 8,900 feet at (C-12-19)27dcd-S1. Based on hardness and dissolved solids (sum of constituents), the least mineralized spring waters sampled in the study area discharge from quartzite in the Deep Creek Range and Sheeprock Mountains (fig. 12).

The chemical quality of springs discharging from the carbonate and clastic geohydrologic unit in the Swasey Mountain area varies areally. It appears that springflow becomes more mineralized downgradient from the recharge area near Swasey Peak. The increased concentrations of chemical constituents probably indicate complex flow paths and longer residence times in the local carbonate ground-water system. According to figure 13, the predominant compositions range from calcium bicarbonate at (C-16-13)23cdb-S1 (Red Cedar Spring), to sodium chloride at (C-15-13)32baa-S1 (Lost Spring), (fig. 13).

Non-thermal Valley Springs

The non-thermal valley springs occur in local valley ground-water systems of limited extent, chiefly near the valley margins. The Piper diagram (fig. 14) shows a considerable variety of water composition and indicates dissimilar ground-water flow paths through diverse lithologies. These springs range from fresh to moderately saline and reflect seasonal variations in temperature and discharge. The probable source units for the non-thermal valley springs include unconsolidated, extrusive, intrusive, and carbonate geohydrologic units. Although the water composition seems quite variable (fig. 14), a more complete sampling of the intermediate spring locations within the study area might better clarify the local ground-water conditions.

Thermal Valley Springs

The thermal valley springs are near the topographic low areas of the basins several to many miles from apparent recharge areas. Some thermal valley springs are thought to be discharge points for a regional artesian aquifer system because their temperatures and discharges have little seasonal variation, and the altitudes of their discharge points are congruent with regional ground-water levels as determined by Bedinger and others (1984). At most spring locations, the discharge point is in unconsolidated Quaternary deposits but the probable source is from solution-enlarged fracture openings in Paleozoic carbonate geohydrologic units (Gates and Kruer, 1981, p. 33).

There are two distinct water compositions of the thermal valley springs located in Snake Valley and the Tule Valley-Fish Springs Flat area (fig. 15). The compositions of the thermal valley springs range from predominantly calcium magnesium bicarbonate water from springs in Snake Valley to predominantly sodium sulfate chloride water from springs in Tule Valley and

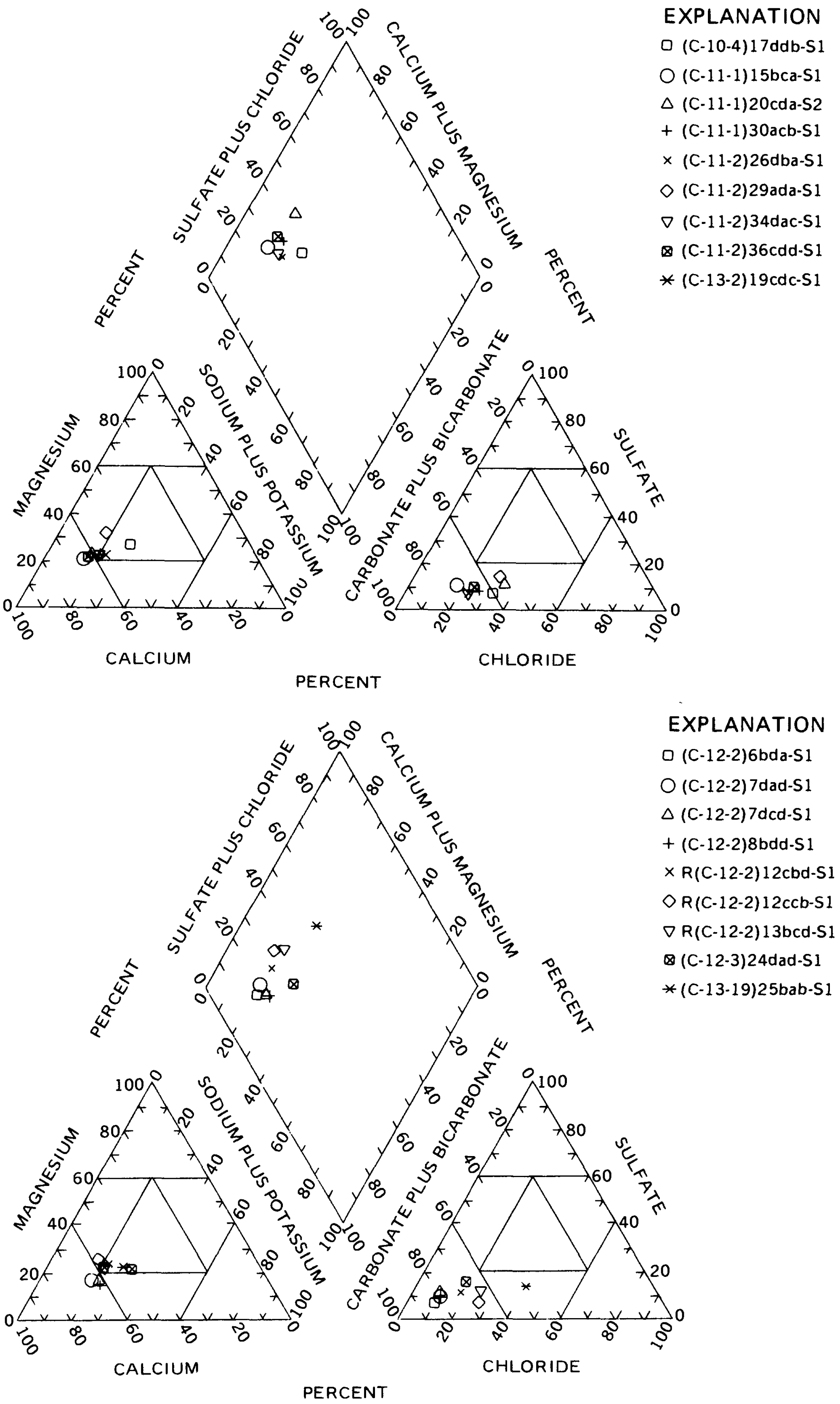


Figure 11.—Chemical composition of mountain springs discharging from the extrusive geohydrologic unit.

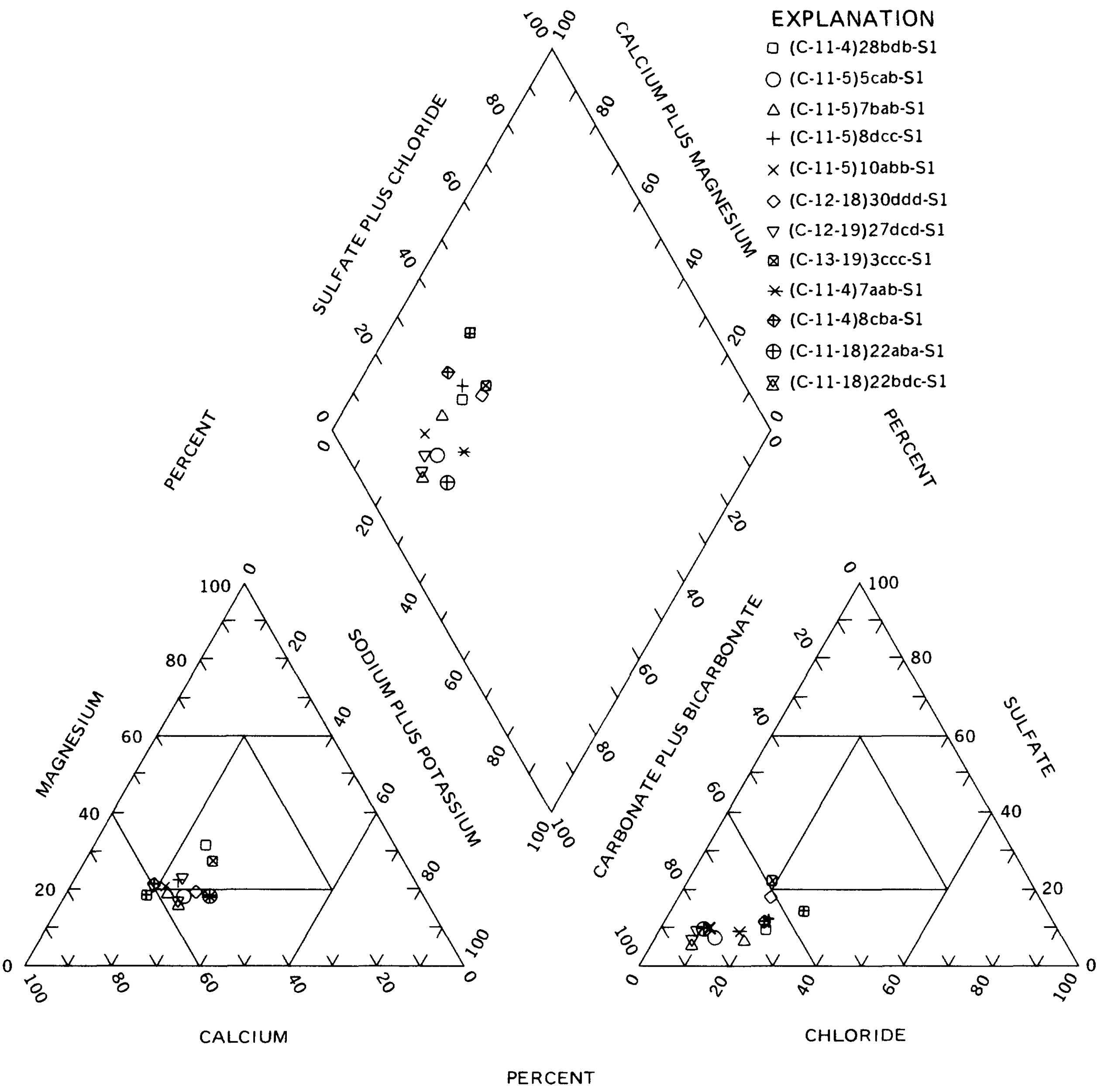


Figure 12.—Chemical composition of mountain springs discharging from metamorphic, intrusive, and carbonate geohydrologic units.

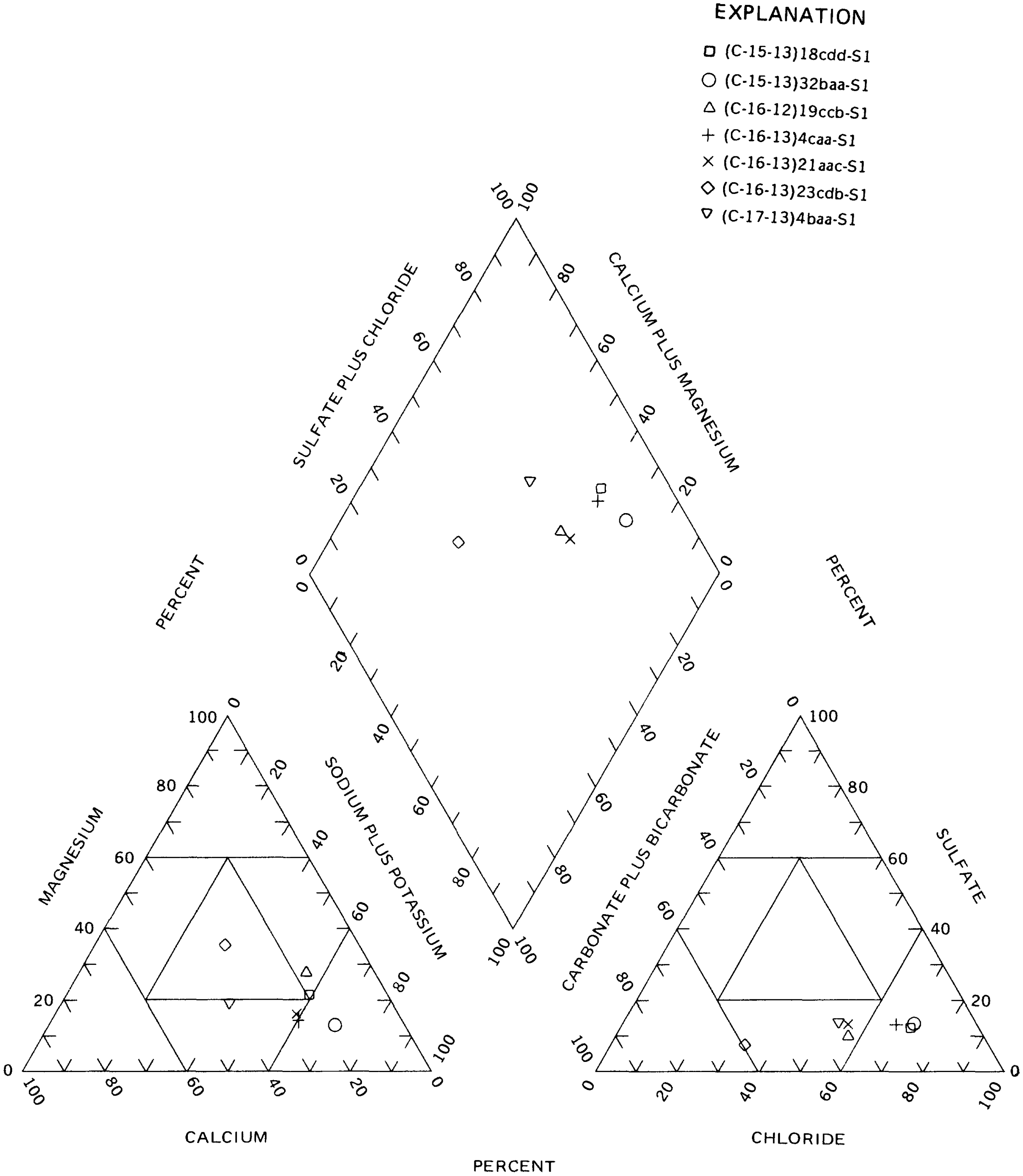


Figure 13.—Chemical composition of mountain springs discharging from the carbonate geohydrologic unit in the Swasey Mountain area.

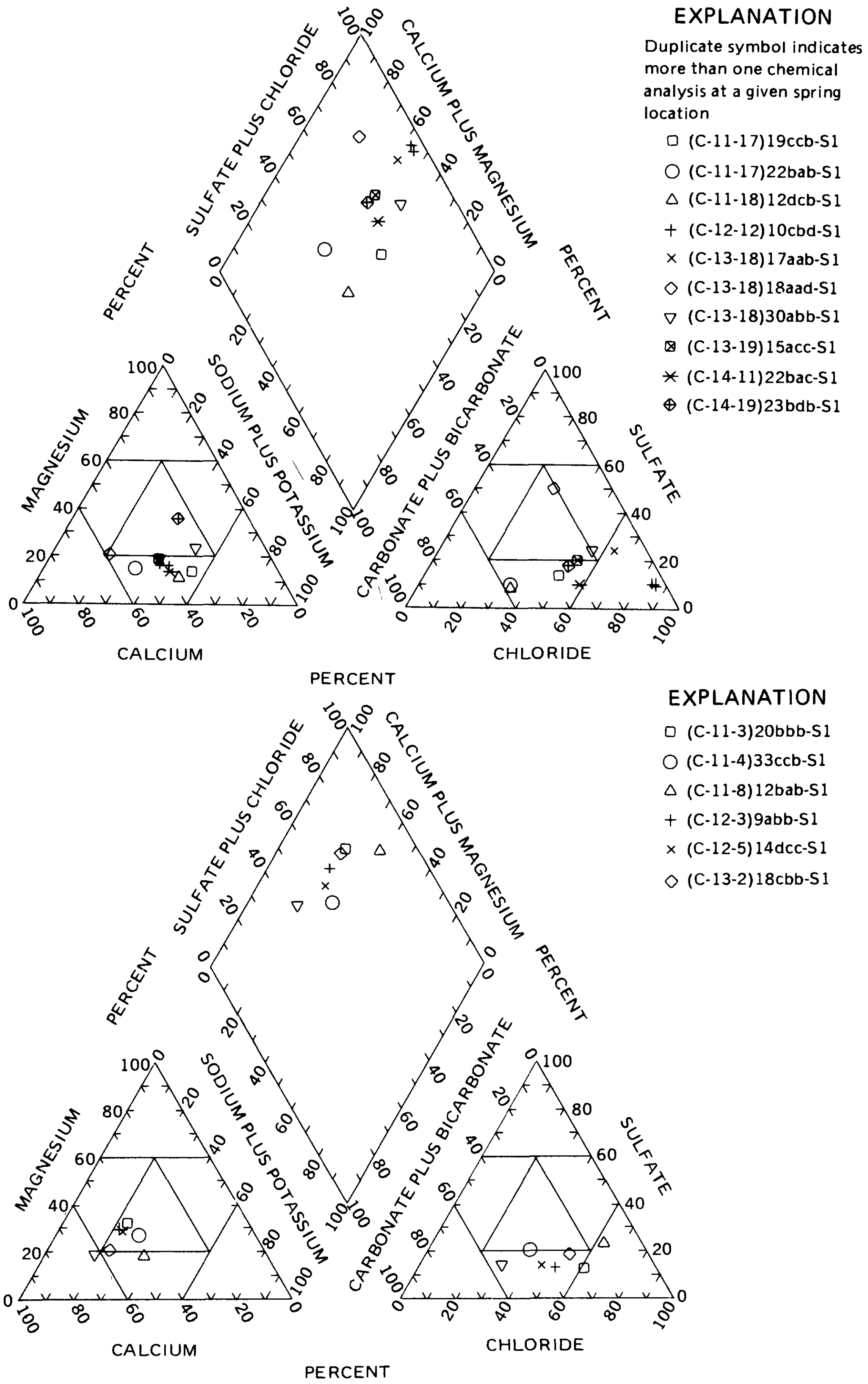


Figure 14.—Chemical composition of non-thermal valley springs discharging from unconsolidated, extrusive, intrusive, and carbonate geohydrologic units.

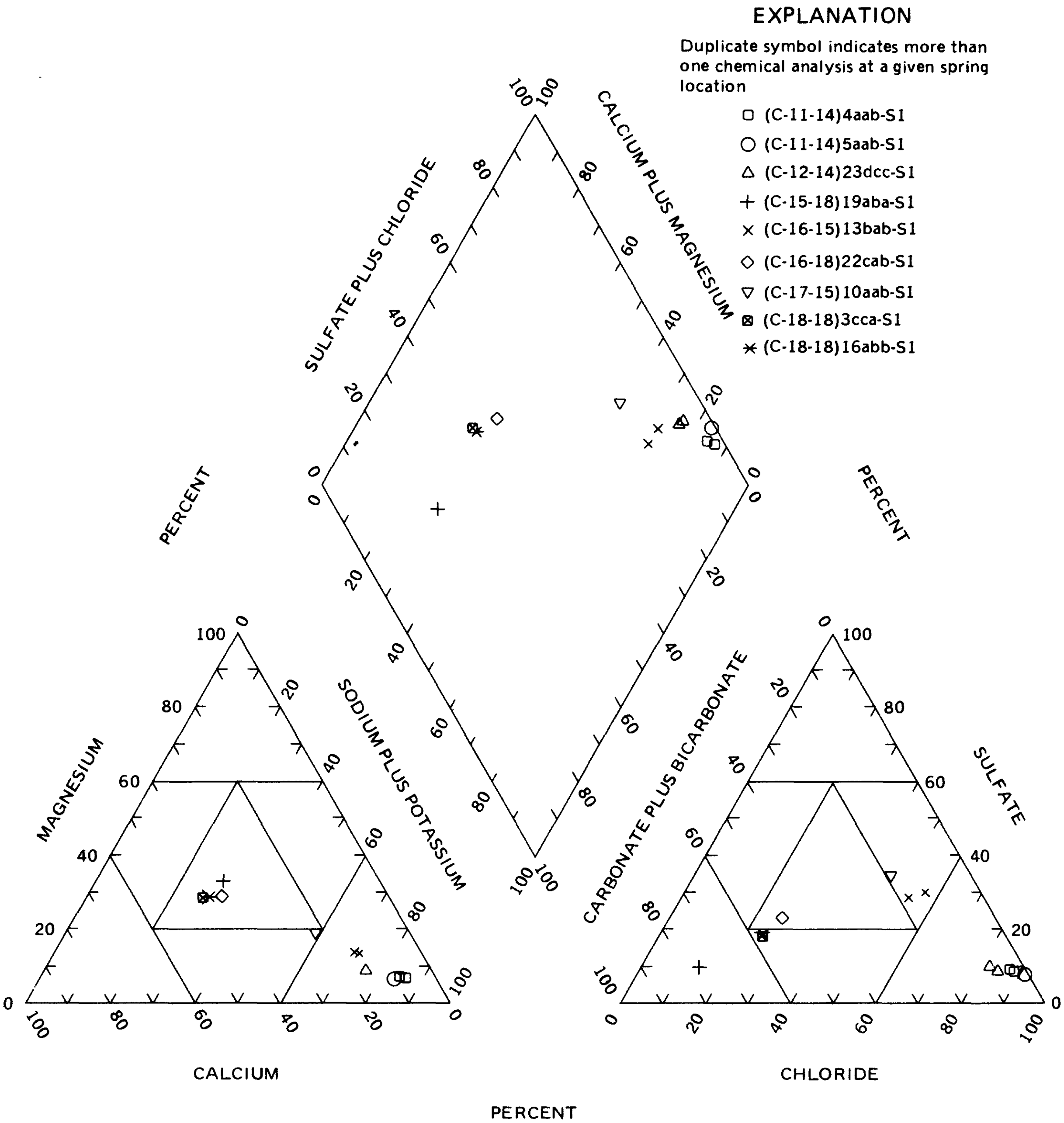


Figure 15.—Chemical composition of thermal valley springs discharging from the carbonate geohydrologic unit.

Fish Springs Flat. Specific conductances indicate a similar variation ranging from less than 800 microsiemens per centimeter at 25° Celsius for springs in Snake Valley to more than 9,500 microsiemens for springs in Fish Springs Flat. Springs in Tule Valley have intermediate specific conductances which range from 1,500 to 2,500 microsiemens. The fresh springflow that discharges in Snake Valley may indicate short flow paths, short residence times, and shallow circulation of the ground water. Conversely, the slightly saline to very saline springs in Tule Valley and Fish Springs Flat reflect an increase in mineralization that may be due to lengthy residence times in long flow paths of a regional ground-water flow system.

SUMMARY

Several regional geologic processes resulted in the complex basin and range physiographic and geologic setting of west-central Utah. Erosion and deposition has partly filled the basins (some topographically closed) with thick unconsolidated erosional deposits. The existence of isolated mountain ranges and vast alluvial slopes and basins affects the distribution of climatic zones and vegetative communities. The mountain ranges are barriers to advancing storm systems and result in increased precipitation with altitude. Thus, in the higher altitudes, precipitation exceeds evaporation. This results in sufficient soil moisture to support diverse plant communities, recharge of the local ground-water systems, and some overland runoff.

Springs in the study area are classified on the basis of physical characteristics and chemical composition as mountain springs, non-thermal valley springs, and thermal valley springs.

Mountain springs are in mountainous areas where precipitation exceeds evaporation. The seasonal flucuation of temperature and discharge of the mountain springs indicates that those springs are part of local ground-water systems. The mountain springs in the East and West Tintic Mountains, the Sheeprock Mountains, and the Deep Creek Range are fresh with small dissolved-solid concentrations. This is due chiefly to the proximity of those springs to the area of ground-water recharge and the nature of the rock (quartzite) from which the springs discharge. The mountain springs in the Swasey Mountain area represent a ground-water flow system in carbonate rock units and have a progressive increase in mineralization down gradient from the recharge area near Swasey Peak.

Non-thermal valley springs are on alluvial slopes adjacent to recharge areas and mineralization of springflow increases down gradient. The quality of the inventoried non-thermal valley springs ranges from fresh to moderately saline. The increasing mineralization may occur because of the longer flow paths of the ground-water system that increase the water's contact time with a variety of geohydrologic units including those containing easily dissolved minerals.

Thermal valley springs are near the topographic low areas of the basins and at long distances from recharge areas. They are thought to be discharge points for a regional artesian aquifer system chiefly because: (1) their discharge and temperature have little or no seasonal variation, (2) their thermal nature indicates deep circulation of the water over great distances, and (3) the altitudes of their discharge points are congruent with the altitudes of the regional ground-water levels.

The springflow from the thermal valley springs shows an increase in mineralization from fresh at the inventoried springs in Snake Valley to very saline at the inventoried springs in Tule Valley and Fish Springs Flat.

The scope of this project did not allow for a comprehensive analysis of the data collected; however, these data can be used in a later study of broader scope to more precisely define the geohydrologic system in the study area and in the immediate area of each spring inventoried. Continued sampling of certain springs on a regular basis, perhaps annually or bi-annually, is needed to better define the relationship between climatic flucuations and discharge variability.

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Table 3.--Records of selected springs

Number: See text for explanation of numbering system for hydrologic-data sites.
Altitude: Interpolated from U.S. Geological Survey 7 1/2- and 15-minute topographic maps.
Geohydrologic unit: Probable source of spring discharge: 1, unconsolidated sedimentary deposits include Quaternary alluvial, colluvial, eolian, glacial, and lacustrine deposits and semiconsolidated mudstone, sandstone, and pyroclastic and ash fall deposits of the Tertiary Salt Lake Formation; 2, extrusive igneous rocks include Quaternary and Tertiary rhyolite, basalt, and tuffaceous flows; 3, intrusive igneous rocks include the granatoid bodies in the Sheeprock Mountains, House Range, Deep Creek Range, and Desert Mountains; 4, carbonate sedimentary rocks include limestone and dolomite primarily deposited during the Paleozoic Era with minor deposition during the Mesozoic and Cenozoic Eras; 5, clastic sedimentary rocks include conglomerate, quartzite, sandstone, and shale deposited during the Paleozoic, Mesozoic, and Cenozoic Eras; 6, metamorphic rocks include Precambrian rocks, principally quartzite and argillite, in the Sheeprock Mountains, Canyon Mountains, Simpson Mountains, and Deep Creek Range.
Topographic setting: Topographic setting in which the spring is located and geomorphic features in the vicinity of the spring; A, alluvial fan; C, stream channel; D, depression; F, flat; G, floodplain; H, hilltop; L, swamp; S, hillside; T, terrace; V, valley flat; W, upland draw.
Class and type of spring: Classification of springs with chemical analyses is based on similarities between physical characteristics and chemical constituents; M, mountain spring; N, non-thermal valley spring; T, thermal valley spring. Type of spring indicates the factors that control the springs occurrence; A, artesian; C, contact; D, depression; F, fracture; P, perched; Q, perched, fracture; R, perched, seepage; S, seepage, filtration.
Date: Month, day, and year that data were collected.
Discharge: Spring discharge in gallons per minute. Springs listed with zero discharge have no discernible flow from collection box.
Specific conductance: Electrical conductivity of spring water in microsiemens per centimeter at 25° Celsius.
Remarks: C, chemical analysis available in table 4; number indicates U.S. Bureau of Land Management's spring numbering sequence shown on plate 1.

Number	Name	Altitude of land surface (feet)	Geo-hydrologic unit (see plate 2)	Topo-graphic setting	Class and type of spring	Date	Discharge (gallons per minute)	Water temperature (degrees Celsius)	Specific conductance	pH (units)	Remarks
(C-10-4)17ddb-S1	West Brush	6,970	2	W	M;C	6-12-84	13	10.5	670	7.5	C,44
						9-13-84	11	10.5	630	7.9	
(C-11-1)15bca-S1	Spring Canyon	5,760	2	C	M;--	7-26-84	10	13.0	620	7.6	C,69
						10-10-84	7.5	13.0	580	7.7	
20cda-S1	Slate Jack	6,055	2	C	-;F	5-23-84	3.9	14.0	760	7.9	11
	do.					8-31-84	0.8	12.5	680	7.6	
20cda-S2	do.	6,050	2	C	M;--	8-31-84	2.4	13.0	550	8.0	C,
30acb-S1	Cottonwood	5,740	2	G	M;F	5-16-84	2.3	14.0	530	7.0	C, 2
						9-11-84	1.6	15.0	600	7.1	
(C-11-2)26dba-S1	Kimball	5,435	2	C	M;F	4-13-84	22	10.0	490	6.8	C, 9
						9-10-84	10	11.0	530	7.0	
29ada-S1	Copperopolis	6,850	2	C	-;S	5-20-63	1.0	--	680	--	
					M;--	5-14-84	6.3	7.0	900	7.0	C, 1
						8-27-84	3.8	10.5	1,220	7.3	
34dab-S1	Keystone	6,435	2	W	-;--	5-22-84	2.0	19.0	430	7.7	
						9-10-84	3.0e	12.5	410	7.3	
34dac-S1	do.	6,360	2	C	M;--	5-22-84	6.3	13.5	355	7.5	C, 8
						9-10-84	12	13.0	375	7.6	
36cdd-S1	Young	6,240	2	S	M;F	5-30-84	8.0	13.0	680	7.0	C,14
						8-28-84	9.0	14.0	640	7.3	
(C-11-3)20bbb-S1	Death Creek	5,605	1	C,G	N;S	7-18-84	2.0e	11.0	1,900	7.2	C, 3
						9-13-84	6.0	11.5	1,940	7.4	
(C-11-4)7aab-S1	Keg	6,770	4	C	-;F	5-22-63	3.5	9.0	640	--	
					M;--	6- 1-84	52	9.0	495	6.9	C,67
						9-13-84	25	11.5	550	7.0	
8cba-S1	Maple	7,000	4	W	M;F	6- 1-84	25	10.5	590	6.8	C,66
						9-13-84	12	11.0	590	6.8	
28bdb-S1		6,470	6	S	M;C,F,P	4- 5-84	26	10.0	730	6.9	C,
33ccb-S1	South Maple Peak	6,190	2	S,W	N;--	8- 9-84	3.9	12.0	1,420	7.8	C,15
						10-10-84	3.1	13.0	1,440	7.6	
(C-11-5)5cab-S1		6,990	6	C	M;F	5-31-84	120	14.0	345	7.6	C,24
						9-14-84	19	16.5	420	8.2	
7bab-S1		6,635	6	S	-;--	5-28-63	9.2	14.0	330	--	
					M;--	5-31-84	9.7	14.5	310	6.8	C,25
						9-14-84	8.4	14.0	320	7.6	
8dcc-S1		6,630	6	S,W	M;C,F	5-31-84	51	12.5	350	6.8	C,
						9-14-84	43	12.5	360	7.3	
8dcd-S1	Indian	6,600	6	S	-;C,F	5-22-63	30	12.0	380	--	
						9-14-84	45	13.0	350	7.2	7
10abb-S1	Dave Egar	7,360	6	S,W	M;F	6-11-84	13	8.5	105	6.1	C,23
						8- 9-84	1.0	7.5	170	7.0	
(C-11-8)12bab-S1	Antelope	5,540	6	S	N;F	12-13-83	2.0e	13.0	2,450	7.5	C,34
						7-30-84	.2	16.0	2,650	7.1	
12bab-S2	do.	5,500	6	S	-;F	12-13-83	1.2	4.0	2,400	7.6	35
						7-30-84	2.0	17.0	2,730	7.4	
(C-11-14)4aab-S1	Cold	4,305	4	V	T;A,F	6- 7-74	--	--	11,700	7.5	C,
					T;--	8-24-76	--	17.5	11,400	7.4	C,
					T;--	12-14-83	150	17.5	11,100	7.5	C,51
						7-30-84	77	17.5	11,700	7.5	
4bbb-S1		4,300	4	V	-;A,F	8-24-76	20	18.0	9,000	--	
						12-14-83	20	17.0	9,200	7.5	52
						7-30-84	28	17.0	9,700	7.5	
5aab-S1		4,287	4	V	T;A,F	12-14-83	3.0e	22.5	34,800	7.4	C,53
						7-30-84	3.0e	26.5	34,800	7.3	
(C-11-17)19ccb-S1		5,595	3	W	N;F	3-16-84	4.7	11.0	1,420	8.1	C,64
						9-27-84	5.3	13.5	1,580	8.0	
22bab-S1		4,640	1	V	N;D,S	3-15-84	6.0e	11.5	520	8.4	C,65
						9-28-84	dry	--	--	--	
(C-11-18)12dcb-S1		6,260	3	W	N;F	3-13-84	.7	11.0	750	8.3	C,38
						9-27-84	.7	15.0	780	8.0	
22aba-S1		7,750	3	C,W	M;S	7-13-84	6.3	10.5	350	7.3	C,62
						9-27-84	4.0	10.5	390	7.4	
22bdc-S1		8,080	3	S,W	M;S	7-13-84	11	9.5	230	7.9	C,63
						9-27-84	8.3	10.0	260	7.9	

Table 3.--Records of selected springs--Continued

Number	Name	Altitude of land surface (feet)	Geo-hydrologic unit (see plate 2)	Topo-graphic setting	Class and type of spring	Date	Discharge (gallons per minute)	Water temperature (degrees Celsius)	Specific conductance	pH (units)	Remarks
(C-12-2)6bda-S1		6,690	2	C	-;S	5-20-63	1.0	--	410	--	
					M;--	5-12-84	.5	9.0	460	7.1	C,74
						8-27-84	1.5	10.0	445	7.7	
7dad-S1	Mud	7,010	2	S	M;F,S	5-30-84	11	11.0	420	7.3	C,72
						8-28-84	4.0	11.5	440	7.0	
7dad-S2	do.	7,020	2	C	-;F,S	5-30-84	2.0e	10.5	430	7.7	
						8-28-84	9.4	10.5	570	7.0	
7dcd-S1		6,965	2	S	M;F,S	5-29-84	4.5	--	350	6.9	C,71
						8-28-84	4.7	10.5	375	6.7	
7dcd-S2		6,960	2	S	-;F,S	5-29-84	1.3	--	405	7.5	
						8-28-84	.8	17.5	420	7.4	
8bdd-S1	Maple	6,865	2	W	M;F	5-30-84	18	9.5	440	6.8	C,73
						8-28-84	5.8	11.0	450	7.0	
R(C-12-2)12cbd-S1	Hop Creek	6,500	2	C	M;F	5-12-84	92	8.0	540	6.8	C, 4
						8-27-84	36	11.0	485	7.1	
12ccb-S1	do.	6,530	2	W	M;R	5-12-84	1.6	11.0	520	7.8	C, 5
						8-27-84	2.6	13.0	485	8.2	
13bcd-S1	Riley	6,570	2	C	-;F	6-12-63	--	--	680	--	
					M;--	5- 9-84	2.2	11.5	510	7.2	C,54
						8-29-84	2.5	12.5	520	7.2	
13cbb-S1	Riley	6,480	2	C	-;F	5- 9-84	1.0e	8.5	590	7.4	55
						8-29-84	.2e	12.5	620	7.0	
(C-12-3)9abb-S1	Railroad	5,490	1	W	-;S	6-12-63	5.9	12.0	690	--	
					N;--	12-13-83	9.3	12.0	840	7.7	C,22
						8- 9-84	9.6	11.5	900	7.6	
9abc-S1	do.	5,480	1	W	-;S	12-16-83	.7	5.5	2,050	8.1	
						8- 9-84	.6	16.0	2,480	7.8	
9abc-S2	do.	5,480	1	W	-;S	12-16-83	.8	7.0	1,900	7.9	
						8- 9-84	.8	13.0	3,660	7.8	
9acb-S1	do.	5,490	1	W	-;S	12-13-83	2.5	7.0	3,900	7.4	57
						8- 9-84	1.0	13.0	3,670	7.6	
9dac-S1	do.	5,520	1	W	-;S	12-16-83	dry	--	--	--	58
						9-11-84	.3	13.0	1,460	8.0	
9dbd-S1	do.	5,520	1	W	-;S	12-16-83	2.5	11.5	1,700	7.4	59
						9-11-84	.5e	11.0	2,010	7.2	
9dbd-S2	do.	5,520	1	W	-;S	12-16-83	2.5	12.5	1,290	--	60
						9-11-84	.5e	10.5	1,400	7.1	
24dad-S1	Riley	6,340	2	C	M;S	5- 9-84	4.7	10.5	690	7.0	C,10
						8-29-84	1.1	14.0	590	7.3	
24dad-S2	do.	6,330	2	S	-;--	8-29-84	2.0	12.5	710	7.1	
24ddb-S1	do.	6,240	2	C,G	-;--	6-12-63	1.0	--	700	--	
						5- 9-84	0.0	10.5	670	6.8	56
						8-29-84	0.0	14.0	700	7.1	
(C-12-5)14dbd-S1		5,560	1	H	-;--	12-13-83	2.0	4.0	1,100	7.4	16
						7-30-84	.8	23.0	1,580	7.7	
14dcb-S1		5,560	1	H	-;--	12-13-83	.7	4.0	1,900	7.5	18
						7-30-84	.7	21.0	3,800	7.6	
14dcc-S1		5,530	1	H	-;--	7- 8-63	--	--	770	--	
					N;--	12-13-83	1.1	9.5	1,500	7.5	C,17
						7-30-84	1.5	21.0	1,920	7.5	
(C-12-12)10cbd-S1	Wildhorse	5,280	2	S	N;F	8-23-76	1.0e	22.0	8,400	7.3	C,
					N;--	12-14-83	.5	13.5	7,200	7.1	C,45
						7-31-84	.6	19.0	7,100	7.0	
(C-12-14)23dbc-S1	Cane	4,327	4	V	-;A,F	12-15-83	5.0e	--	--	--	
						7-31-84	5.0e	22.0	10,000	--	
23dcc-S1	do.	4,333	4	V	T;A,F	8-24-76	--	20.0	10,000	7.3	C,
					T;--	12-15-83	47	22.0	9,700	7.6	C,43
						7-31-84	41	26.0	9,500	7.2	
26abb-S1	do.	4,336	4	V	-;A,F	12-15-83	13	--	--	--	
						7-31-84	9.0	24.0	--	--	
(C-12-18)30ddd-S1		7,450	6	W	M;F,S	3-14-84	8.0e	0.5	83	7.8	C,77
						8- 2-84	21	5.5	60	7.7	
(C-12-19)27dcd-S1	Blue	8,910	6	S,W	M;F	7-20-84	50e	8.5	70	7.3	C,79
						9-21-84	26	7.5	80	7.0	
(C-13-2)18cbb-S1		5,955	2	W	N;Q	4-11-84	.5	10.5	1,500	7.0	C,13
						8-28-84	.6	14.5	1,580	7.3	
19cdc-S1	Tidwell	5,380	2	S	M;C,F,P	12-16-83	3.2	12.0	1,110	8.1	C,12
						7-26-84	5.8	11.0	1,080	6.9	
(C-13-18)17aad-S1	Partoun	5,280	1	A	N;S	2-11-84	1.3	10.0	2,100	7.9	C,47
						9-26-84	1.3	15.5	2,000	7.2	
18aad-S1	Trough	5,780	1	A	N;S	2-11-84	19	15.0	680	7.7	C,30
						9-26-84	22	15.0	810	7.5	
30abb-S1	Lime	5,280	4	A	N;Q	2-10-84	2.6	13.0	1,540	8.0	C,31
						8- 1-84	.5	15.5	1,200	7.7	
(C-13-19)3ccc-S1		8,460	6	S,W	M;F,S	2- 8-84	5.0	8.0	160	8.0	C,78
						8- 3-84	10	11.5	190	7.7	
12cad-S1		6,640	6	S	-;F	2-10-84	.8	6.5	930	--	33
						9-26-84	.2	16.0	980	8.3	
15acc-S1	Red Cedar	6,560	4	S	N;F	2- 9-84	2.5	11.0	1,450	7.6	C,76
						9-25-84	1.5	13.5	1,410	7.2	
25bab-S1		5,580	2	A	M;F	2- 9-84	3.0e	6.0	600	7.5	C,75
						9-26-84	2.0e	13.5	680	7.5	
(C-14-11)22bac-S1	Schoenburger	5,765	1	A,S	-;D	6-24-63	--	--	1,620	--	
						4-11-84	0.0	8.0	1,870	6.8	41
					N;--	7-19-84	0.0	14.0	1,640	7.3	C,
(C-14-19)23bdb-S1	Coyote	5,085	2	C	N;C	2- 7-84	84	14.0	1,840	7.8	C,32
						8- 1-84	49	13.5	1,900	7.7	
(C-15-13)18cdd-S1	Tuck	5,710	5	S	M;F	4-10-84	5.5	11.0	3,120	7.2	C,68
						9-21-84	.8	14.5	2,070	7.6	
32baa-S1	Lost	7,060	4	C	M;F	6-15-84	15	11.0	5,420	8.0	C,70
						9-20-84	.6	14.5	5,380	7.8	
(C-15-18)19aba-S1		4,795	1	D,V	T;A,F	2- 7-84	15	7.0	485	8.0	C, 6

Table 3.—Records of selected springs—Continued

Number	Name	Altitude of land surface (feet)	Geo-hydrologic unit (see plate 2)	Topo-graphic setting	Class and type of spring	Date	Discharge (gallons per minute)	Water temperature (degrees Celsius)	Specific conductance	pH (units)	Remarks
(C-16-12)19ccb-S1	Mud	6,070	4	A	M;A,F	4-10-84	5.0	11.0	1,480	8.4	C,49
						9-19-84	6.0	12.0	2,050	7.6	
(C-16-13)4caa-S1	Robbers Roost	7,010	4	C	M;F	6-14-84	11	8.0	4,050	7.4	C,36
						9-20-84	1.5	11.5	3,930	7.9	
21aac-S1	lower Sawmill Basin	7,555	4	C	M;F	6-14-84	2.3	9.5	2,360	7.7	C,
						9-19-84	1.2	12.5	1,290	8.0	
21dac-S1	Sawmill Basin	7,710	4	S	-;F	9-19-84	2.0	7.5	660	7.6	27
23cdb-S1	Red Cedar	7,130	4	W	M;F	6-14-84	54	10.5	690	7.2	C,48
						9-19-84	36	10.5	720	7.7	
(C-16-15)13bab-S1	Coyote	4,420	4	D,L,V	T;A,F	9-19-74	10e	28.0	2,400	--	C,
						1-15-76	100e	28.0	2,000	--	
					T;--	8-25-81	--	28.0	2,380	7.3	C,
					T;--	12-14-83	320	29.0	2,500	8.2	C,42
						7-31-84	400	28.0	2,450	7.3	
						11-17-84	380e	28.5	2,430	7.4	
34dac-S1		4,420	4	D,L,V	-;A,F	9-19-74	--	19.5	1,900	--	
						7-31-84	100e	21.5	1,600	7.1	
(C-16-18)22cab-S1	Twin	4,812	4	V	-;A,F	3-25-81	1,220	18.5	750	--	
					T;--	8-26-81	--	20.0	750	7.3	C,
					T;--	12-15-83	1,050	19.0	780	7.7	C,61
						7-31-84	1,370	20.0	790	7.4	
						1-15-76	--	27.5	1,500	--	
					T;--	12-14-83	198	28.5	1,620	7.7	C,40
						7-31-84	176	28.5	1,550	7.4	
10aba-S1		4,420	4	D,L,V	-;A,F	9-19-74	--	28.0	--	--	
						12-14-83	13	29.0	1,630	7.8	
						7-31-84	62	29.0	1,570	7.4	
15abc-S1	South Tule	4,427	4	D,L,V	-;A,F	9-19-74	--	25.0	1,750	--	
						11-17-84	100e	28.5	1,530	7.6	
(C-17-13)4baa-S1	Wildhorse	7,350	4	W	M;F	6-13-84	.9	10.5	1,450	7.1	C,50
						9-18-84	.4	13.0	1,660	7.6	
(C-17-15)3aba-S1	Willow	4,415	4	D,L,V	-;A,F	12-14-83	11	27.0	1,670	7.	26
						7-31-84	21	26.5	1,610	7.4	
3abc-S1		4,418	4	D,L,V	-;A,F	12-14-83	3.0	28.0	1,650	7.9	20
						7-31-84	1.5	28.0	1,640	7.5	
3dba-S1		4,420	4	D,L,V	-;A,F	12-14-83	20	22.0	1,580	7.6	19
						7-31-84	30	22.0	1,570	7.5	
10aab-S1	Tule	4,420	4	D,L,V	-;A,F	9-19-74	--	27.5	1,600	--	
(C-18-18)3cca-S1	North Knoll	4,871	4	V	T;A,F	12-15-83	15e	17.0	740	7.6	C,39
						8- 1-84	15e	21.5	750	8.0	
16abb-S1	Knoll	4,878	4	V	T;A,F	12-15-83	20e	19.0	750	7.7	C,46

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Table 4.--Chemical analyses of water

Location: See text for explanation of numbering system for hydrologic-data sites.
Constituents: The symbol * indicates value exceeds the minimum recommended limit for human consumption given in table 5, the symbol < indicates
Units: µS/cm, microsiemens per centimeter at 25° Celsius; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter.

Location	Date of sample	Specific conductance (µS/cm)	pH (units)	Temperature (°C)	Hardness (mg/L as $CaCO_3$)	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity field (mg/L as $CaCO_3$)	Sulfate dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)
(C-10- 4)17ddb-S1	84-06-12	670	7.5	10.5	240	59	22	44	1.0	200	24	77	0.3
(C-11- 1)15bca-S1	84-07-26	620	7.6	13.0	260	78	16	19	4.6	240	34	40	.3
20cda-S1	84-05-23	760	7.9	14.0	310	90	21	29	4.2	210	43	94	.4
30acb-S1	84-05-16	530	7.0	14.0	230	67	16	21	9.7	190	22	56	.3
(C-11- 2)26dba-S1	84-04-13	490	6.8	10.0	200	57	14	23	4.8	190	23	42	.3
29ada-S1	84-05-14	900	7.0	7.0	400	99	38	40	2.5	270	68	110	.4
34dac-S1	84-05-22	355	7.5	13.5	160	46	11	16	4.4	140	15	33	.2
36cdd-S1	84-05-30	680	7.0	13.0	290	86	19	23	6.5	230	33	59	.2
(C-11- 3)20bbb-S1	84-07-18	1,900	7.2	11.0	690	160	71	99	3.6	250	120	410	.4
(C-11- 4) 7aab-S1	84-06-01	495	6.9	9.0	170	50	11	38	.7	190	22	34	.3
8cba-S1	84-06-01	590	6.8	10.5	250	73	16	26	1.0	210	35	51	.3
28bdb-S1	84-04-05	730	6.9	10.0	290	67	30	45	2.2	280	40	71	.2
33ccb-S1	84-08-09	1,420	7.8	12.0	490	120	47	100	1.7	320	150	200	.4
(C-11- 5) 5cab-S1	84-05-31	345	7.6	14.0	140	41	8.4	23	.8	160	14	18	.2
7bab-S1	84-05-31	310	6.8	14.5	130	38	7.9	17	1.0	120	12	24	.2
8dcc-S1	84-05-31	350	6.8	12.5	140	40	10	20	.9	120	21	30	.2
10abb-S1	84-06-11	105	6.1	8.5	44	13	2.9	5.2	.8	45	5.2	4.3	<.1
(C-11- 8)12bab-S1	83-12-13	2,450	7.5	13.0	750	210	54	200	2.7	150	260 *	500 *	1.1
(C-11-14) 4aab-S1	74-06-07	11,700	7.5	--	850	180	98	2,100	70	200	480 *	3,500 *	1.0
	76-08-24	11,400	7.4	17.5	890	190	100	2,200	73	200	540 *	3,700 *	1.0
	83-12-14	11,100	7.5	17.5	800	170	91	2,300	62	140	520 *	3,600 *	1.0
5aab-S1	83-12-14	34,800	7.4	22.5	2,700	650	270	6,400	170	120	1,400 *	12,000 *	1.6
(C-11-17)19ccb-S1	84-03-16	1,420	8.1	11.0	320	90	24	180	1.9	260	92	240	2.9 *
22bab-S1	84-03-15	520	8.4	11.5	170	54	9.7	39	1.9	140	24	58	.7
(C-11-18)12dcb-S1	84-03-13	750	8.3	11.0	190	56	11	88	.9	210	32	84	1.4
22aba-S1	84-07-13	350	7.3	10.5	130	37	8.5	28	1.7	160	18	12	.6
22bdc-S1	84-07-13	230	7.9	9.5	94	29	5.2	15	1.2	110	7.1	6.8	.5
(C-12- 2) 6bda-S1	84-05-12	460	7.1	9.0	210	60	14	22	4.0	210	22	16	.2
7dad-S1	84-05-30	420	7.3	11.0	190	60	9.5	20	2.6	190	22	17	.2
7dcd-S1	84-05-29	350	6.9	20.5	150	46	8.1	19	.3	150	23	12	.2
8bdd-S1	84-05-30	440	6.8	9.5	180	59	8.6	24	3.3	190	26	17	.2
R(C-12- 2)12cbd-S1	84-05-12	540	6.8	8.0	220	63	16	22	6.8	200	31	34	.2
12ccb-S1	84-05-12	520	7.8	11.0	220	62	16	17	7.5	180	18	48	.2
13bcd-S1	84-05-09	510	7.2	11.5	220	62	15	22	6.0	170	31	47	.2
(C-12- 3) 9abb-S1	83-12-13	840	7.7	12.0	320	79	29	38	7.8	130	46	130	.3
24dad-S1	84-05-09	690	7.0	10.5	270	74	20	49	12	270	59	48	.4
(C-12- 5)14dcc-S1	83-12-13	1,500	7.5	9.5	560	140	52	82	3.2	360	120	280 *	.2
(C-12-12)10cbd-S1	76-08-23	8,400	7.3	22.0	2,400	690	170	870	18	180	380 *	2,500 *	2.9 *
	83-12-14	7,200	7.1	13.5	2,100	600	140	680	8.3	130	330 *	2,200 *	2.7 *
(C-12-14)23dcc-S1	76-08-24	10,000	7.3	20.0	1,200	300	120	1,700	100	400	540 *	3,100 *	.9
	83-12-15	9,700	7.6	22.0	1,200	280	110	1,600	110	280	410 *	2,700 *	.8
(C-12-18)30ddd-S1	84-03-14	83	7.8	.5	27	7.7	1.8	4.6	.9	19	5.3	4.4	<.1
(C-12-19)27dcd-S1	84-07-20	70	7.3	8.5	27	7.7	2.0	3.7	.8	32	3.2	2.2	<.1
(C-13- 2)18cbb-S1	84-04-11	1,500	7.0	10.5	580	170	38	77	5.5	220	140	290	.1
19cdc-S1	83-12-16	1,110	8.1	12.0	490	150	27	48	5.8	260	63	100	.3
(C-13-18)17aad-S1	84-02-11	2,100	7.9	10.0	650	180	48	200	4.1	130	250 *	490 *	.2
18aad-S1	84-02-11	680	7.7	15.0	300	87	19	35	2.7	75	170	71	.2
30abb-S1	84-02-10	1,540	8.0	13.0	380	80	44	180	7.0	160	180	310 *	.9

from selected springs

less than value shown.

Silica, dissolved (mg/L as SiO_2)	Solids, Sum of constituents, dissolved (mg/L)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Nitrogen, Ammonia dissolved (mg/L as N)	Phosphorus, Ortho, dissolved (mg/L as P)	Arsenic dissolved (µg/L as As)	Boron, dissolved (µg/L as B)	Cadmium dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Mercury dissolved (µg/L as Hg)	Selenium, dissolved (µg/L as Se)	Cyanide dissolved (mg/L as CN)
240	589	0.54	0.01	0.03	5	50	<1	<10	8	60	<10	27	<0.1	<1	<0.01
54	387	.13	.11	.02	3	70	<1	<10	<1	3	<10	14	<.1	<1	<.01
47	452	.69	.02	.04	4	80	<1	<10	<1	6	<10	5	<.1	1	<.01
58	364	1.0	.02	.16	6	70	<1	<10	1	8	<10	<1	<.1	<1	<.01
51	327	.46	.02	.03	4	50	<1	<10	<1	<3	<10	<1	.1	<1	<.01
25	542	.87	<.01	.02	<1	50	<1	<10	<1	10	<10	2	<.1	<1	<.01
49	261	.47	.03	.05	2	50	<1	<10	1	200	<10	14	<.1	<1	<.01
55	418	1.6	<.01	.06	2	60	<1	<10	<1	9	<10	5	< .1	<1	<.01
43	1,050	.58	.03	.05	7	140	<1	<10	<1	7	10	4	<.1	7	<.01
14	286	.3	.01	.01	<1	60	1	<10	<1	20	<10	2	<.1	<1	<.01
11	341	.3	<.01	.01	<1	40	<1	<10	3	20	<10	4	<.1	<1	<.01
16	441	.5	.02	.02	<1	70	<1	<10	<1	<3	<10	<1	<.1	1	<.01
24	833	<.1	.01	<.01	<1	170	<1	<10	1	<3	<10	2	<.1	<1	<.01
15	214	<.1	.02	.01	<1	50	<1	<10	2	20	<10	9	1.2	<1	<.01
15	190	.4	<.01	.02	2	30	<1	<10	<1	30	<10	<1	<.1	<1	<.01
12	205	.4	.04	.01	<1	30	<1	<10	1	7	<10	<1	<.1	<1	<.01
8.3	67	.12	<.01	.03	1	10	<1	<10	<1	40	<10	2	<.1	<1	<.01
15	1,330	<.1	.01	<.01	1	120	<1	<10	<1	30	100 *	10	<.1	1	<.01
--	6,550 *	--	--	--	--	--	--	--	--	90	--	<10	--	--	--
1	6,950 *	.34	--	.01	--	1,200	--	--	--	40	--	<10	--	--	--
19	6,850 *	.34	.02	<.01	5	1,300	<1	10	<1	40	100 *	10	--	1	<.01
25	21,000 *	<.1	4.50	.01	19	2,800	<1	30	4	230	200 *	270 *	.5	<1	<.01
25	813	1.4	.06	.02	1	330	<1	<10	1	<3	<10	<1	<.1	<1	<.01
23	296	<.1	.09	.02	2	60	<1	<10	1	30	<10	11	<.1	<1	<.01
18	415	.83	.06	.02	1	200	<1	<10	1	6	<10	4	<.1	1	<.01
20	220	.32	.03	.01	<1	90	<1	<10	<1	6	<10	<1	<.1	<1	<.01
30	159	<.1	.03	<.01	<1	60	<1	<10	2	20	<10	15	<.1	<1	<.01
45	311	.44	<.01	.04	2	60	<1	<10	<1	10	<10	<1	<.1	<1	<.01
32	280	.2	.02	.10	3	40	<1	<10	<1	20	<10	38	<.1	<1	<.01
34	235	<.1	.02	.02	2	40	<1	<10	<1	20	<10	3	<.1	<1	<.01
32	284	.4	.02	.25	6	50	<1	<10	<1	<3	<10	1	<.1	2	<.01
46	340	.98	<.01	.06	2	60	2	<10	<1	5	<10	<1	<.1	<1	<.01
54	328	.89	.01	.03	2	60	<1	<10	<1	9	<10	10	<.1	<1	<.01
52	339	1.2	<.01	.04	2	70	2	<10	<1	<3	<10	<1	<.1	<1	<.01
53	461	.99	<.01	<.01	3	80	<1	<10	1	4	<10	<1	<.1	1	<.01
61	483	.33	.01	.02	11	170	<1	<10	1	10	<10	<1	<.1	1	<.01
24	917	<.1	.03	<.01	3	80	<1	<10	1	8	<10	3	.3	1	<.01
31	4,770 *	1.9	--	.03	--	490	-	--	--	120	--	100 *	--	--	--
32	4,070 *	1.8	.04	<.01	<1	330	2	10	<1	40	<100	10	3.9 *	4	<.01
21	6,120 *	.06	--	.03	--	1,500	-	--	--	60	--	240 *	--	--	--
22	5,400 *	<.1	.02	.01	6	1,500	<1	10	1	50	100	30	.1	<1	<.01
10	46	.82	.07	.03	<1	20	<1	<10	2	40	<10	2	<.1	<1	<.01
13	52	<.1	.11	.01	1	10	<1	<10	<1	70	<10	3	<.1	<1	<.01
50	903	6.1	.05	.03	4	170	1	<10	3	<3	<10	<1	.1	3	<.01
51	601	2.2	<.01	<.01	2	110	<1	<10	<1	10	<10	<1	<.1	1	<.01
21	1,270	.39	.01	<.01	<1	190	<1	<10	7	40	<100	<10	<.1	2	<.01
19	449	.28	.17	.02	<1	--	<1	<10	5	--	<10	<1	--	<1	<.01
14	910	.12	.01	.01	<1	270	<1	<10	1	3	<10	<1	<.1	3	<.01

Table 4.--Chemical analyses of water

Location	Date of sample	Specific conductance (µS/cm)	pH (units)	Temperature (°C)	Hardness (mg/L as $CaCO_3$)	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity field (mg/L as $CaCO_3$)	Sulfate dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)
(C-13-19) 3ccc-S1	84-02-08	160	8.0	8.0	61	15	5.7	11	0.9	45	16	10	0.2
15acc-S1	84-02-09	1,450	7.6	11.0	440	120	34	130	7.2	200	140	270 *	1.1
25bab-S1	84-02-09	600	7.5	6.0	230	63	17	39	2.5	130	39	83	.3
(C-14-11)22bac-S1	84-07-19	1,640	7.3	14.0	410	120	26	160	6.7	260	78	340 *	.3
(C-14-19)23bdb-S1	84-02-07	1,840	7.8	14.0	600	100	86	170	5.6	310	170	350 *	.5
(C-15-13)18cdd-S1	84-04-10	3,120	7.2	11.0	640	120	82	420	4.9	270	190	810 *	.3
32baa-S1	84-06-15	5,420	8.0	11.0	850	190	90	890	9.6	420	370 *	1,400 *	.7
(C-15-18)19aba-S1	84-02-07	485	8.0	7.0	210	44	24	39	5.7	210	26	25	1.1
(C-16-12)19ccb-S1	84-04-10	1,480	8.4	11.0	340	50	52	190	2.0	250	79	310 *	.2
(C-16-13) 4caa-S1	84-06-14	4,050	7.4	8.0	830	210	73	570	5.6	410	270 *	1,000 *	.5
21aac-S1	84-06-14	2,360	7.7	9.5	490	120	47	320	3.4	390	160	480 *	.6
23cdb-S1	84-06-14	690	7.2	1 .5	260	50	33	55	1.3	220	28	86	.2
(C-16-15)13bab-S1	74-09-19	2,400	--	28.0	330	71	38	350	37	210	330 *	450 *	1.1
	81-08-25	2,380	7.3	28.0	350	72	42	380	30	--	310 *	460 *	1.0
	83-12-14	2,500	8.2	29.0	350	71	41	380	34	160	340 *	470 *	1.1
(C-16-18)22cab-S1	81-08-26	750	7.3	20.0	290	66	30	54	5.1	--	66	71	.6
	83-12-15	780	7.7	19.0	280	64	29	57	5.6	180	80	66	.8
(C-17-13) 4baa-S1	84-06-13	1,450	7.1	10.5	440	120	34	140	1.6	250	99	280 *	.3
(C-17-15)10aab-S1	83-12-14	1,620	7.7	28.5	320	69	35	200	18	140	240	240	1.1
(C-18-18) 3cca-S1	83-12-15	740	7.6	17.0	280	68	27	46	5.4	180	56	53	.5
16abb-S1	83-12-15	750	7.7	19.0	270	65	27	49	5.1	180	58	54	.6

from selected springs--Continued

Silica, dis- solved (mg/L as SiO_2)	Solids, Sum of consti- tuents, dis- solved (mg/L)	Nitro- gen, NO_2+NO_3 dis- solved (mg/L as N)	Nitro- gen, Ammonia dis- solved (mg/L as N)	Phos- phorus, ortho, dis- solved (mg/L as P)	Arsenic dis- solved (µg/L as As)	Boron, dis- solved (µg/L as B)	Cadmium dis- solved (µg/L as Cd)	Chro- mium, dis- solved (µg/L as Cr)	Copper, dis- solved (µg/L as Cu)	Iron, dis- solved (µg/L as Fe)	Lead, dis- solved (µg/L as Pb)	Manga- nese, dis- solved (µg/L as Mn)	Mercury dis- solved (µg/L as Hg)	Sele- nium, dis- solved (µg/L as Se)	Cyanide dis- solved (mg/L as CN)
18	104	0.78	0.04	0.01	<1	30	<1	<10	2	<3	<10	3	<0.1	<1	<0.01
18	840	<.1	.01	.01	<1	160	<1	<10	4	<3	<10	<1	<.1	2	<.01
30	354	<.1	<.01	<.01	3	70	<1	<10	4	<3	<10	<1	<.1	<1	<.01
53	942	<.1	1.60	.16	3	220	<1	<10	1	80	<10	110 *	.1	<1	<.01
42	1,110	<.1	.02	.04	6	400	<1	<10	<1	<3	<10	<1	<.1	1	<.01
17	1,810	1.6	.06	.02	<1	270	1	<10	<1	60	<100	<10	.2	9	<.01
37	3,240 *	.12	.01	.02	3	710	<1	<10	<1	50	<100	20	<.1	2	<.01
42	332	.16	.12	.02	5	110	<1	<10	2	10	<10	9	<.1	<1	<.01
13	848	.35	<.01	.02	<1	170	<1	<10	<1	5	<10	<1	.1	1	<.01
27	2,400 *	.51	.01	.02	1	430	<1	<10	1	60	<100	10	<.1	2	<.01
23	1,390	.99	<.01	.02	2	420	<1	<10	2	50	--	10	<.1	2	<.01
11	397	.59	<.01	.03	<1	50	<1	<10	<1	9	<10	2	<.1	<1	<.01
23	1,430	.12	--	.04	--	610	--	--	--	30	--	<10	--	--	--
23	1,450	--	--	--	--	--	<2	--	<20	<20	<20	3	--	--	--
23	1,460	<.1	<.01	<.01	16	590	2	<10	<1	30	<100	<10	<.1	<1	<.01
18	454	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	429	.1	<.01	<.01	5	110	<1	<10	<1	4	<10	<1	<.1	1	<.01
15	842	1.1	<.01	.02	<1	150	<1	<10	<1	20	<10	5	<.1	1	<.01
22	910	.24	<.01	<.01	17	370	<1	<10	<1	<3	<10	<1	<.1	<1	<.01
19	383	<.1	.01	<.01	9	80	<1	<10	1	5	<10	<1	.2	<1	<.01
19	386	.12	<.01	<.01	6	90	<1	<10	<1	10	<10	<1	<.1	1	<.01

Table 5.—Allowable recommended limits of physical properties and chemical constituents for human and livestock consumption and possible sources of these properties and constituents

Allowable recommended limits of chemical constituents for human and livestock consumption: (E), U.S. Enviromental Protection Agency (1972, p. 54, 59, 68, 73, 88); (F), U.S. Enviromental Protection Agency (1976, p. 98, 107); (G), U.S. Enviromental Protection Agency (1979, p. 42198); (H), U.S. Environmental Protection Agency, 1980, p. 79331); (I), U.S. Enviromental Protection Agency (1983, p. 45511); (U), State of Utah, Department of Health, Division of Enviromental Health, Bureau of Public Water Supplies (1984, p. 3-1, 3-6).

Livestock watering: (P), U.S. Enviromental Protection Agency (1972, p. 310-314, 316); (Q), State of Utah, Department of Social Services (1978, p. 8)(amended 1983).

Property or constituent	Recommended maximum allowable limit for human consumption	Recommended maximum allowable limit for livestock watering	Possible source of property or constituent
Specific conductance (microsiemens per centimeter at 25° Celsius)	- -	- -	The presence of charged ionic species in a solution enables a solution to conduct electrical charge (Hem, 1970, p. 96). Greater specific conductance greater concentrations of dissolved ions.
pH (units)	from 6.5 to 8.5 (G) from 6.5 to 8.5 (U)	- -	pH is a logrithmic measurement of the hydrogen-ion concentration in a solution. A pH of 7 indicates the hydrogen-ion concentration equals 1 x 10^{-7} moles per liter of solvent; pH of 4 indicates 1 x 10^{-4} moles per liter of solvent.
Hardness (milligrams per liter as calcium carbonate)	Based on consumer preference (E)	- -	Hardness of water is the property attributable to the presence of alkaline earthe (principally calcium and magnesium) and results from the solution of alkaline-earth minerals from rocks and soils (Rainwater and Thatcher, 1960, p. 173).
Calcium dissolved as Ca (milligrams per liter)	- -	- -	Calcium is the principal cation in most natural waters. Although calcium is present in most igneous, metamorphic and sedimentary rocks (Hem, 1970, p. 131), most dissolved calcium in the study area is assumed to come from limestone, dolomite, and gypsum of the carbonate geohydrologic unit.
Magnesium dissolved as Mg (milligrams per liter)	- -	- -	Magnesium typically is a constituent of dark colored igneous rocks and sedimentary carbonate rocks such as dolomite. Magnesium is released during weathering of these rocks (Hem, 1970, p. 141.)
Sodium dissolved as Na (milligrams per liter)	no recommendation made (E)	- -	Sodium principally is derived from weathering of sodium feldspars in igneous materials and from precipitation of sodium salts from solution during evaporation of water. Sodium is very soluble and tends to remain in solution once liberated from silicate minerals. The largest concentration of sodium is found at the inventoried springs in Fish Springs Flat.
Potassium dissolved as K (milligrams per liter)	- -	- -	Potassium principally is derived from potassium feldspars or evaporite beds of potassium salt. Potassiuum does not dissolve from silicate minerals as readily as sodium and shows a strong tendency to be reincorporated into solid weathering products such as clay minerals. Thus, in most natural waters, potassium concentrations are much smaller than sodium concentrations (Hem, 1970, p. 150).
Alkalinity (milligrams per liter as calcium carbonate)	no recommendation made (E)	- -	Alkalinity is defined as the ability of a solution to neutralize acid. Alkalinity of natural waters results from the neutralizing ability of carbonate and bicarbonate (Hem, 1970 p. 152), and is reported as an equivalent quantity of $CaCO_3$. The weathering of carbonate rock is the main source of carbonate and bicarbonate.
Sulfate dissolved as SO_4 (milligrams per liter)	250 (G) 1000 (U)	- -	Sulfate, the oxidized form of sulfur, occurs in certain ingeous rocks but the most common occurrence is in evaporite sedimentary deposits such as gypsum and anhydrite (Hem, 1970, p. 164).
Chloride dissolved as Cl (milligrams per liter)	250 (G) 250 (U)	- -	Chloride sources include evaporite beds, some types of igneous rocks, and waters incorporated in ocean sediment during deposition. In all rock types, chloride commonly is present as either sodium chloride crystals or as sodium and chloride ions in solution (Hem, 1970, p. 171).
Fluoride dissolved as F (milligrams per liter)	1.4 to 2.4 (I) depending on climete 1.6 to 2.0 (U) depending on climate	- -	Most fluoride bearing minerals are only slightly soluable, which generally results in small fluoride concentrations in natural waters (Hem, 1970, p. 177). The elemsnt usually is characteristic of water from deep strata and in water from areas of recent vulcanism (Rainwater and Thatcher, 1960, p. 163).

Table 5.--Allowable recommended limits of physical properties and chemical constituents for human and livestock consumption and possible sources of these properties and constituents--Continued

Property or constituent	Recommended maximum allowable limit for human consumption	Recommended maximum allowable limit for livestock watering	Possible source of property of constituent
Silica dissolved as SiO_2 (milligrams per liter)	- -	- -	Silicon is the second most common element of the Earth's crust. Silica in water probably is derived from the decomposition of rocks with a large content of silicate minerals, particularly feldspars, in metamorphic, igneous, and sedimentary terrains.
Solids, sum of constituents (milligrams per liter)	2000 (U)	1200 (Q)	
Nitrogen (NO_2 + NO_3) dissolved as N (milligrams per liter)	NO_3 - 10 as N (F) NO_3 - 10 as N (E) NO_2 - 10 as N (U)	NO_3 - 100 as N (P)	Nitrate (NO_3) and nitrite (NO_2) ions are concentrated by certain species of bacteria that metabolize and oxidize elementary nitrogen from the atmosphere and from decay of organic matter (Hem, 1970, p. 181).
Phosphorus (PO_4) dissolved as P (milligrams per liter)	- -	- -	The most common natural source of phosphate ions is the rock forming the mineral apatite[$Ca_5F(PO_4)_3$]. Apatite is found in many igneous rocks and marine sediments (Hem, 1970, p. 184).
Arsenic dissolved as As (micrograms per liter)	50 (I) 50 (U)	200 (P) 100 (Q)	Arsenic may occur in reduced form in mineral veins and metallic ores in intrusive and extrusive rocks (Hem, 1970, p. 206).
Boron dissolved as B (micrograms per liter)	- -	5000 (P) 750 (Q)	Water in volcanic areas and the water from thermal springs can contain large concentrations of boron (Hem, 1970, p. 187) Certain evaporite deposits in closed depositional basins also may contain boron salt accumulations.
Cadmium dissolved as Cd (micrograms per liter)	10 (I) 10 (U)	50 (P) 10 (Q)	- -
Chromium dissolved as Cr (micrograms per liter)	50 (I) 50 (U)	1000 (P) 100 (Q)	The occurrence of chromium in water usually results from pollution related to industrial processes.
Copper dissolved as Cu (micrograms per liter)	1000 (H) 1000 (V)	5000 (P) 2000 (Q)	Large concentrations of copper in water may result from leaching of mineralized areas and mine debris.
Iron dissolved as Fe (micrograms per liter)	300 (G) 300 (U)	No upper limit set (P)	Iron is one of the most abundant elements in the Earth's crust and is found in dark colored igneous rocks (both intrusive and extrusive), as iron oxide cements in sandstone, and as iron sulfides in anaerobicly deposited shales.
Lead dissolved as Pb (micrograms per liter)	50 (I) 50 (U)	100 (P) 100 (Q)	The lead carbonate mineral cerussite($PbCO_3$) and the lead sulfide mineral galena (PbS) are two natural sources of lead (Hem, 1970, p. 205). Most lead compounds are relatively insoluble, thus lead concentrations in natural water usually are small.
Manganese dissolved as Mn (micrograms per liter)	50 (G) 50 (U)	No recommendation made (P)	Manganese is concentrated in natural water through weathering of igneous rocks, decomposition of organic material, or dissolved manganese oxide deposits. Dark colored minerals such as biotite and amphiboles contain manganese. Plant metabolism also can affect manganese concentrations in natural waters (Hem, 1970, p. 126).
Mercury dissolved as Hg (micrograms per liter)	2.0 (F) 2.0 (U)	10 (P)	Mercury found in natural waters is introduced through man's activities or associated with circulation within intrusive and extrusive rocks. The volatility of mercury allows it be transported more readily in hot water.
Selenium dissolved as Se (micrograms per liter)	10 (I) 10 (U)	50 (P) 50 (Q)	Selenium typically shows large concentrations in sedimentary limestone and shale (Drever, 1982, p. 298-299) and in the soils derived from limestone and shale parental material. Springflow from two of the inventoried springs, Death Creek and Tuck, have concentrations of selenium approaching the recommended limit.
Cyanide dissolved as CN (milligrams per liter)	0.2 (H)	- -	Cyanide is a by-product of specific types of industrial and mining processes (Shelley, 1979, p. D-201).

Hardness Classification[2]

Hardness range (milligrams per liter as calcuim carbonate)	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
More than 180	Very hard

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[2] From Hem (1970, p. 225)

CONVERSION FACTORS

Values in this report are given in both inch-pound units and metric units. The conversion factors from inch-pound to metric units are listed below:

Multiply	By	To obtain
Acre	4047.	Square meter
Cubic foot per second	0.02832	Cubic meter per second
Foot	0.3048	Meter
Gallon	3.785	Liter
Gallon per minute	3.78	Liter per minute
Inch	2.54	Centimeter
Mile	1.609	Kilometer
Square mile	2.590	Square kilometer

Chemical concentration is given only in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (μg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligram) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 mg/L. For concentrations less than 7,000 mg/L, the numerical value is about the same as for concentrations in the inch-pound unit, parts per million.

Water temperatures are given in degrees Celsius (°C), and air temperatures are given in degrees Fahrenheit (°F). The temperature conversion formulae are:

$$^{\circ}F = 1.8(^{\circ}C) + 32$$

$$^{\circ}C = 0.56(^{\circ}F - 32)$$

Classification of Natural Water[1]

Class	Dissolved solids (milligrams per liter)	Specific conductance (microsiemens per centimeter at 25° Celsius)
Fresh	0 to 1,000	0 to 1,400
Slightly saline	1,000 to 3,000	1,400 to 4,000
Moderately saline	3,000 to 10,000	4,000 to 14,000
Very saline	10,000 to 35,000	14,000 to 50,000
Briny	More than 35,000	More than 50,000

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[1] From Feltis (1966, p. 8) and Robinove and others (1958, p. 3).