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GROUND-WATER RECONNAISSANCE OF THE CENTRAL WEBER RIVER AREA, MORGAN AND SUMMIT COUNTIES, UTAH

by
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Most values in this report are given in inch-pound units followed by metric units. The conversion factors are shown to four significant figures. In the text, however, the metric equivalents are shown only to the number of significant figures consistent with the accuracy of the value in inch-pound units.

Inch-pound Unit (Multiply)	Abbreviation	(by)	Metric Unit (to obtain)	Abbreviation
Acre		0.4047	Square hectometer	hm^2
Acre-foot	acre-ft	0.001233	Cubic hectometer	hm^3
		1233	Cubic meter	m^3
Cubic foot per second	ft^3/s	0.02832	Cubic meter per second	m^3/s
Foot	ft	0.3048	Meter	m
Foot per day	ft/d	0.3048	Meter per day	m/d
Foot per mile	ft/mi	0.1894	Meter per kilometer	m/km
Foot per second	ft/s	0.3048	Meter per second	m/s
Foot squared per day	ft^2/d	0.0929	Meter squared per day	m^2/d
Gallon per minute	gal/min	0.06309	Liter per second	L/s
Gallon per minute per foot	(gal/min)/ft	0.2070	Liter per second per meter	(L/s)/m
Inch	in.	2.540	Centimeter	cm
		25.4	Millimeter	mm
Mile	mi	1.609	Kilometer	km
Square mile	mi^2	2.590	Square kilometer	km^2

Chemical concentration and water temperature are 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 (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is about the same as for concentrations in parts per million. Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: $°F=1.8(°C)+32$.

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ABSTRACT

A reconnaissance of ground water in the central Weber River area obtained data to help State administrators devise a policy for acting on applications to appropriate ground water resulting from recent and future influxes of residents.

Ground water occurs in unconsolidated alluvium and older semi-consolidated to consolidated rocks; it has been developed to a limited extent for public, industrial, and domestic use. Alluvium of Quaternary age probably is the most important aquifer, although most wells also are completed in older rocks. Alluvium is as much as 200 feet (60 meters) thick in Morgan Valley, whereas other valleys along the Weber River probably have slightly lesser thicknesses of alluvium.

In the Morgan Valley-Round Valley subarea, recharge and discharge are at least 40,000 acre-feet (49 cubic hectometers) per year. Ground water mostly moves toward the Weber River and the downstream reach of East Canyon Creek. About 170,000 acre-feet (210 cubic hectometers) of ground water, almost all of which is fresh, is stored in the alluvium of Morgan Valley and the northern valley of East Canyon Creek. Water levels in observation wells did not indicate any major changes or long-term trends in ground-water storage during 1936-80.

In the Henefer Valley subarea, recharge and discharge are at least 23,000 acre-feet (28 cubic hectometers) per year. All ground water sampled in the subarea was fresh.

In the Coalville subarea, recharge and discharge are at least 21,000 acre-feet (26 cubic hectometers) per year. Ground water sampled in the subarea was fresh, with the exception of water from one well completed in the Frontier Formation.

Surface-water resources of the study area include the Weber River and its main tributaries--Chalk, Lost, and East Canyon Creeks. Mean annual flow of the Weber River at Coalville for the 1931-60 water years was 140,000 acre-feet (170 cubic hectometers), and at Gateway (including diversions through the Gateway Tunnel during 1957-60) was 373,700 acre-feet (461 cubic hectometers). Average gain in base flow through the area for October 25-31, 1931-60, including base flow of tributaries wholly within the study area, was 109 cubic feet per second (3.1 cubic meters per second), most of which is ground-water seepage to streams. A seepage run on October 26, 1979, indicated the gain was 131 cubic feet per second (3.7 cubic meters per second).

Surface water in the area is of calcium bicarbonate or calcium magnesium bicarbonate type. In the reach of the Weber River between the Stoddard Diversion to the Gateway Canal and Gateway, where flow almost tripled during the seepage run due to ground-water inflow, analyses of samples indicated little change in dissolved-solids concentration.

Gains in long-term average base flows, seepage measurements, and water-level contours indicate that ground water seeps into the Weber River along most reaches between Coalville and Gateway and into the downstream reaches of East Canyon Creek and Lost Creek.

Present discharge from wells (average of about 2,800 acre-feet or 3.5 cubic hectometers per year during 1978-80) probably has been balanced by increases in recharge or decreases in other forms of discharge. Withdrawals from additional wells in the future ultimately will be balanced by increases in recharge or decreases in seepage to streams or evapotranspiration. Most of the changes probably will decrease streamflow; however, withdrawals from wells that are balanced by decreases in transpiration from nonirrigated phreatophytes will not affect surface-water flow.

A simplified digital-computer model of the Morgan Valley-lower East Canyon Creek area was constructed to study effects on the hydrologic system of additional ground-water withdrawals. Withdrawals from simulated wells were balanced mostly by decreases in seepage to the Weber River and the downstream reach of East Canyon Creek and by some decreases in evapotranspiration.

INTRODUCTION

Purpose and Scope of the Study

During July 1978 to June 1980, the U.S. Geological Survey conducted a reconnaissance of ground-water conditions and ground- and surface-water relationships in the central Weber River area. This reconnaissance was done in cooperation with the Utah Department of Natural Resources, Division of Water Rights.

The study area is a series of mountain valleys along the Weber River in the Wasatch Range and between the Wasatch Range and the Uinta Mountains in north-central Utah (fig. 1). As defined for this study, the area includes the Weber River drainage from Hoytsville, just south of Coalville, to the western boundary of Morgan County at the western front of the Wasatch Range (pl. 1). The East Canyon Creek tributary drainage is included from the Weber River to the Morgan County-Summit County line. The study focused on the major valleys along and tributary to the Weber River with less emphasis on the upland tributary areas.

The Division of Water Rights needs information on the ground-water system and on ground- and surface-water relationships to help determine a policy for acting on applications to appropriate ground water. Water in the Weber River and its tributaries and ground water in the Weber River drainage are considered to be fully appropriated (1981). Individuals or entities desiring ground water for domestic, public-supply, or industrial uses are permitted to lease rights to water in 1 acre-foot (1,233 m^3) per year units or

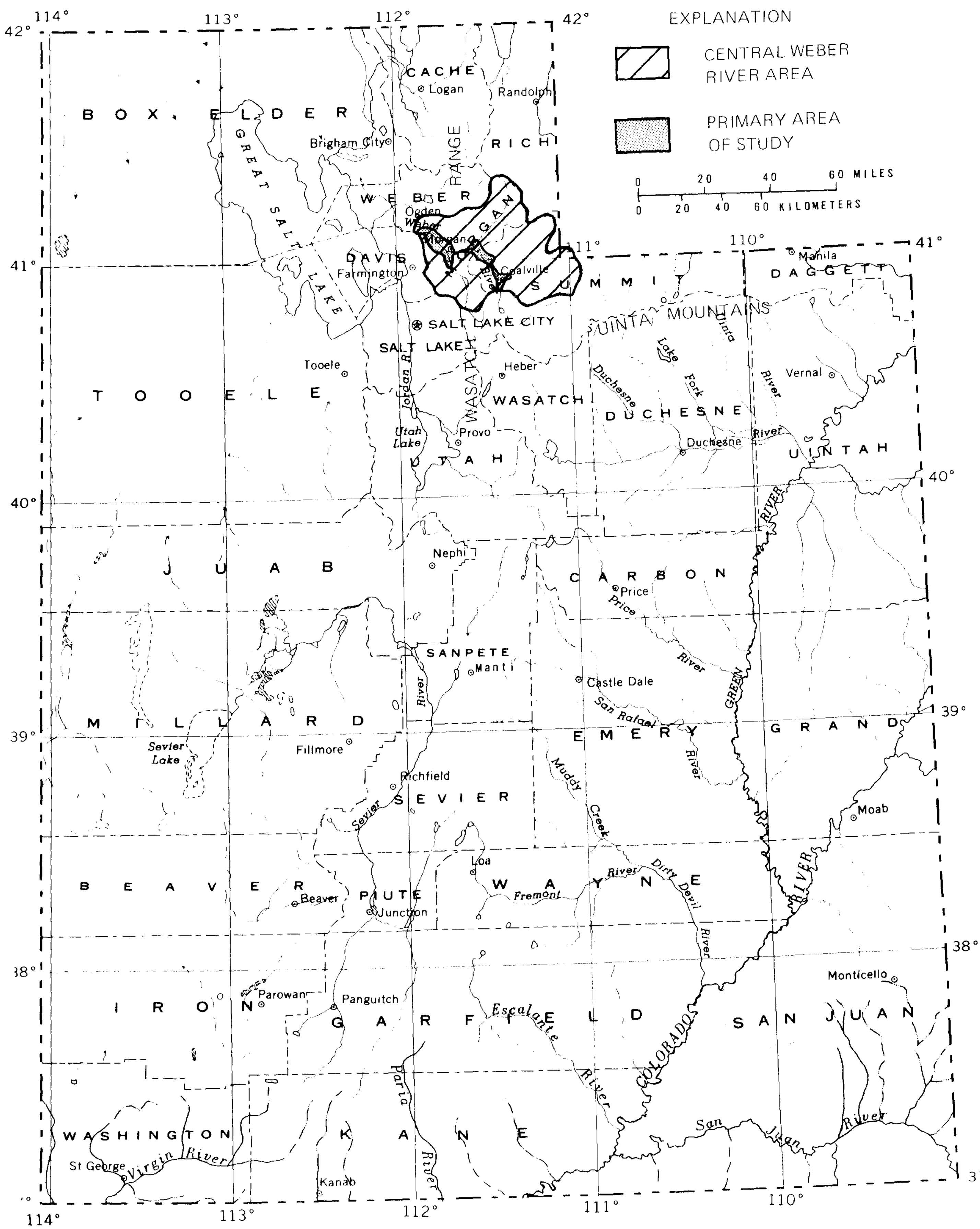

Figure 1.—Location of the central Weber River area.

in larger quantities from the Weber Basin Water Conservancy District. The District virtually has rights to all surface water in excess of primary flows (rights decreed in 1934) and holds this water in reservoirs--East Canyon, Lost Creek, and Echo Reservoirs in the study area and Rockport Lake 10 miles (16 km) south of Coalville. The District releases water annually from the reservoirs to balance use of ground water under these rights.

A major assumption in this policy of leasing surface-water rights to balance ground-water withdrawals is that the river and the ground-water reservoir have significant hydraulic connection. It is further assumed that water pumped from wells is replaced by infiltration of the released surface water. However, it is not known definitely whether or how quickly the released surface water replaces the withdrawn ground water, or whether the withdrawn ground water is taken from storage and eventually balanced by increases in recharge or decreases in another form of discharge.

The purpose of this study was to obtain information on and describe recharge, movement, and discharge of ground water, hydraulic properties of aquifers, volumes of ground water in storage, the chemical quality of ground water, and the interrelations between ground and surface water. This information can be used by the Division of Water Rights to devise a policy on ground-water appropriations that is based on actual characteristics of the physical stream-aquifer system. The main emphasis of the study was on the saturated alluvium along the Weber River and in the downstream parts of tributary drainages. Less emphasis was placed on alluvium in upstream parts of the drainages and on water in consolidated rocks.

The study consisted of an inventory (table 5, at back of report) of 6 springs and of 148 of the approximately 360 wells in the area for which ground-water claims have been made or drillers' reports filed. Springs in the study area were not inventoried unless they were in the valleys, along valley margins, or were a source of municipal supply. Drillers' logs were available for most inventoried wells and were used to estimate the base of alluvium and identify the main water-yielding unit at each well. Samples of water for chemical analysis were collected from 3 springs and 79 wells. One 8-hour aquifer test was made, and areas of ground-water discharge by evapotranspiration were located in Morgan Valley.

Base flow of the Weber River and several of its tributaries (predominantly ground-water inflow to the river system) was measured at selected sites between Coalville and the western edge of Morgan County on September 11 (17 sites) and October 26, 1979 (21 sites). These values were compared to the average of the gaged daily mean October 25-31 base flows for 1931-60. Average mean annual 1931-60 surface-water flow and 1931-60 precipitation were compiled for several subbasins to determine the variation in runoff-precipitation ratios. However, these data were not included in the report because results did not indicate anything relevant to the objectives of the study.

A simplified digital-computer model of the alluvium of Morgan Valley and lower East Canyon Creek was constructed to study ground- and surface-water relations and the effects of pumping ground water at various hypothetical levels of development.

Previous and Related Studies and Acknowledgments

A ground-water study of the Morgan Valley area was made by Saxon (1972). His report includes tables of data on wells and chemical quality of ground water, a summary of geology, and a water-resources budget for the Morgan Valley area.

Haws, Jeppson, and Huber (1970) prepared a hydrologic inventory of the entire Weber River basin, which focuses on climate, streamflow, and a water budget of the basin. This report contains tables of consumptive use of water by crops and phreatophytes and by evaporation from water bodies for subbasins of the Weber River drainage. A companion report by Haws (1970) consists of tabulated, water-related, land-use data for the Weber River drainage.

Thompson (1982) made a reconnaissance of surface-water quality in the Weber River basin. The reconnaissance focused on the chemical quality of streamflow but also touched on fluvial sediment and biological quality of the water.

We gratefully acknowledge the cooperation of individual well owners, municipalities, and industries in supplying information on wells and springs and allowing the collection of water samples for chemical analysis. E. B. Johnson, Weber River Commissioner, provided information on the Weber River, water use in the area, and ground-water inflow to the river.

Systems for Numbering Data Sites

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well or 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. 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 (4 hm^2);[1] 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 well or spring within the 10-acre (4-hm^2) tract; the letter "S" preceding the serial number denotes a spring. Thus (A-4-2)36bca-1 designates the first well constructed or visited in the NE¼SW¼NW¼ sec. 36, T 4 N., R. 2 E., and (A-2-5)9dac-S1 designates a spring in the SW¼NE¼SE¼ sec. 9, T. 2 N., R. 5. E. The numbering system is illustrated in figure 2.

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[1]Although the basic land unit, the section, is theoretically 1 square mile (2.6 km^2), many sections are irregular. Such sections are subdivided into 10-acre (4-hm^2) tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

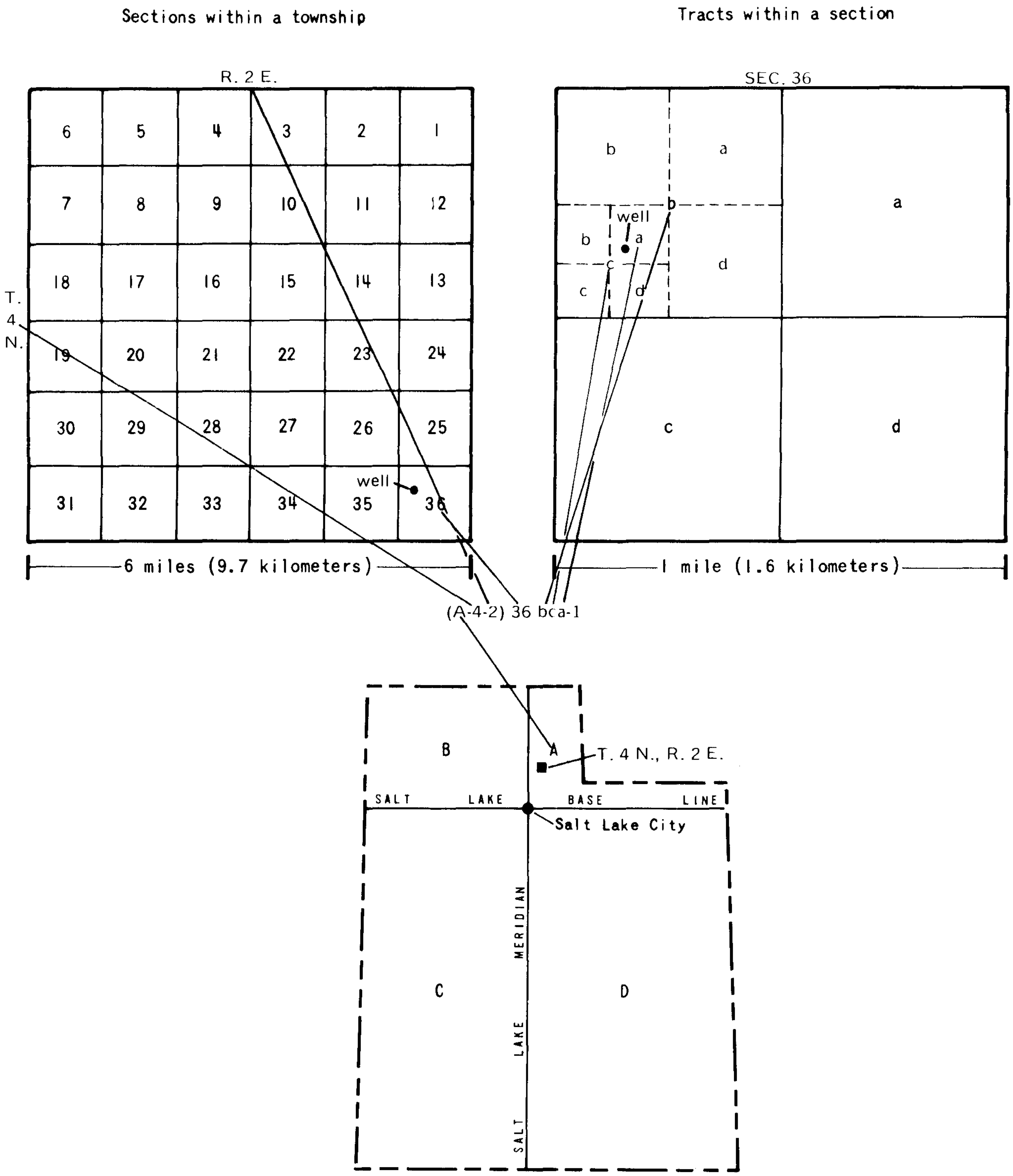

Figure 2.—Well- and spring-numbering system used in Utah.

Gaging stations, where continuous streamflow records are collected, are numbered in downstream order. For descriptions of this system, see U.S. Geological Survey (1980, p. 140). Thus, the station on the Weber River near Coalville is designated 10130500.

Physical and Cultural Characteristics

Physiography

The central Weber River area (fig. 1 and pl. 1) consists of the valleys of the Weber River and its tributaries and the Weber River drainage area between Hoytsville and the western edge of Morgan County at Gateway. Altitudes along the river range from about 4,770 feet (1,450 m) above NGVD of 1929[1] near Gateway to 5,650 feet (1,722 m) at Hoytsville. Maximum altitudes in the drainage area include Francis Peak at 9,547 feet (2,910 m) on the western edge of Morgan County to Humpy Peak at 10,870 feet (3,313 m) on the southern edge of the Chalk Creek drainage, southeast of Coalville.

Valley areas in Morgan County include: (1) Morgan Valley, bounded by Weber Canyon on the west and Upper Weber Canyon on the east; (2) the Cottonwood Creek area tributary to Morgan Valley; (3) the East Canyon Creek area tributary to Morgan Valley and extending south to East Canyon; (4) Round Valley, a small valley in Upper Weber Canyon east of Morgan; and (5) the Lost Creek area at Croydon (pl. 1). Valley areas in Summit County include: (1) Henefer Valley; (2) the Coalville area from Echo to Hoytsville, including Echo Reservoir; and (3) the Chalk Creek area just east of Coalville (pl. 1).

Climate

Normal annual precipitation on the study area for 1931-60 (pl. 1) ranged from less than 16 inches (406 mm) in the Coalville, Lost Creek, and eastern Echo Canyon areas to more than 30 inches (762 mm) in parts of the Cottonwood, Lost, and Chalk Creek drainage areas. It exceeded 40 inches (1,016 mm) along the divide in the Wasatch Range west of Morgan Valley and locally in the headwaters area of East Canyon Creek (U.S. Weather Bureau, 1963). The normal annual volume of precipitation on the entire study area for 1931-60 was estimated to be 1,330,000 acre-feet (1,640 hm^3).

Normal annual precipitation for 1941-70 at Morgan was 17.08 inches (434 mm) and at Coalville it was 14.78 inches (375 mm) (National Oceanic and Atmospheric Administration, Environmental Data Service, 1979). At Morgan, 68 percent of the precipitation falls from October through April.

Mean annual temperatures range from more than 48°F (8.9°C) in Morgan Valley to less than 34°F (1.1°C) in the southeastern corner of the Chalk Creek drainage area (Haws and others, 1970, fig. 11). Normal annual temperature for 1941-70 at Morgan was 45.4°F (7.44°C) (National Oceanic and Atmospheric Administration, Environmental Data Service, 1979).

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[1]National Geodetic Vertical Datum of 1929 (NGVD of 1929) is a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level."

Geology

The central Weber River area is underlain by rocks ranging in age from Precambrian to Quaternary. The exposed rocks have been subdivided into hydrogeologic units on the basis on water-bearing characteristics, lithology, and age (table 1).

Three units of continental, primarily alluvial, origin were defined on the basis of age and degree of consolidation, with the older units commonly more consolidated and probably less permeable. These units include alluvium and consolidated to semiconsolidated conglomerates of Cretaceous to Quaternary age. Older consolidated-rock units are defined on the basis of being either predominately clastic or carbonate and on age.

Most of the study area is underlain at the surface by conglomerates and clastic rocks of Cretaceous and Tertiary age (pl. 2). Those rocks are represented chiefly by the Wasatch Formation of Tertiary age; they also include the Echo Canyon Conglomerate of Cretaceous age, the Evanston(?) Formation of Cretaceous and Tertiary age, and the Norwood Tuff of Tertiary age (Stokes, 1964; Mullens, 1971, pl. 1; Mullens and Laraway, 1964, 1973). Clastic rocks of Cretaceous age crop out around Coalville, in the Chalk Creek drainage basin, and around Henefer Valley. Rocks older than Cretaceous age mainly crop out around and north of Upper Weber Canyon, along stream channels in the northeastern Lost Creek drainage basin, and along the drainage divide in the Wasatch Range west of Morgan Valley.

The Morgan Valley area is a structural low, in which as much as 8,000 feet (2,000 m) of Tertiary rocks--mainly volcanic-clastic rocks and conglomerates--have been preserved (Mullens and Laraway, 1973; Saxon, 1972, p. 17). Round Valley is a small anticlinal valley incised in easily erodible rocks of Paleozoic age; and the Coalville area and Henefer Valley were incised in easily erodible Tertiary sediments deposited in an ancestral drainage of the Weber River (Threet, 1959, p. 32).

Alluvial deposits of Quaternary age with thicknesses greater than about 10 feet (3 m) are confined mostly to the Weber River valley and its major tributaries--East Canyon, Lost, Chalk, and Cottonwood Creeks. Although alluvium is not widespread, it is the most important hydrogeologic unit in the area, probably containing the largest volume of water that is both fresh and can be readily developed by wells. The lithology of the alluvium is variable, consisting of interbedded clay, silt, sand, gravel, and boulders.

Data on the thickness and lithology of the alluvium are limited because few wells have been drilled through its entire thickness along the axes of the valleys. Most wells in the study area have been drilled for domestic use, and most farmhouses and wells are located along the margins of the valleys, either to minimize the danger of flooding, to avoid the shallow water table, or to avoid using valley bottom land for nonagricultural purposes. As a result,

Table 1.--General description and water-bearing characteristics of hydrogeologic units

[Information used to compile this table from Williams and Madsen (1959), Stokes (1964), Mullens and Laraway (1964, 1973), and Mullens (1971)]

Age: Era	Age: Period	Hydrogeologic unit and symbol on plate 2	Lithology and occurrence	Water-bearing characteristics
Cenozoic	Quaternary	Alluvial, lake, and glacial deposits, undivided Qu	Clay, silt, sand, and gravel under present flood plains. Alluvium in Morgan Valley is as much as 200 feet thick; alluvium in other areas probably thinner.	Very permeable and yields 2,000 gallons per minute or more to wells where coarse grained and well sorted. Less permeable with smaller yields to wells where finer grained. Most permeable material known is in the eastern end of Morgan Valley. Water in alluvium commonly is fresh (205-709 milligrams per liter of dissolved solids).
Cenozoic	Tertiary and Quaternary	Older coarse-grained deposits, some of volcanic origin QT	Partly cemented gravels and conglomerate with some tuffaceous sandstone. Occurs over lower mountain slopes on northeast side of Morgan Valley and is 0-1,000 feet thick.	Unknown, probably permeable locally and would yield water to wells if saturated.
Mesozoic and Cenozoic	Cretaceous and Tertiary	Conglomerates and other rocks, mostly coarse-grained clastics, some of volcanic origin TKcg	Boulder, cobble, and volcanic-rock conglomerate with some conglomeratic sandstone, tuffaceous sandstone, siltstone, mudstone, and limestone. Commonly reddish, brown, or gray. Includes Echo Canyon Conglomerate, Evanston(?) and Wasatch Formations and Norwood Tuff. The Echo Canyon Conglomerate is 0-3,100 feet thick and the Evanston(?) Formation is 0-1,400 feet thick in the study area. The Wasatch Formation is as much as 5,000 feet thick in the study area, and the Norwood Tuff is about 5,000 feet thick in the Morgan area. Occurs widely in the upland parts of the study area and has the largest area of outcrop of any of the hydrogeologic units.	Yields small to moderate amounts (3-560 gallons per minute) of fresh water (127-754 milligrams per liter of dissolved solids) to wells along the margins of Morgan Valley, along the downstream reach of East Canyon Creek and the upstream reach of Lost Creek, and on the edges of the Weber River flood plain near Hoytsville. Yields water to springs in upland areas and in canyons tributary to Echo Canyon.
Mesozoic	Cretaceous	Clastic rocks Ku	Marine and nonmarine sandstone, marine shale, and continental conglomerate. Includes Kelvin Formation, Bear River Formation, Aspen shale, and Frontier and Wanship Formations[1]. Frontier Formation is about 2,100 feet thick and the Wanship Formation is about 5,000 feet thick in the Coalville area. Crops out on lower mountain slopes adjacent to Henefer Valley, around Coalville and in the Chalk Creek drainage basin, and in the southern East Canyon Creek drainage.	Yields 7-300 gallons per minute of fresh to slightly saline water (235-3,000 milligrams per liter of dissolved solids) to wells around Coalville. Water is under artesian pressure locally.
Mesozoic	Triassic and Jurassic	Older clastic rocks JTRss	Sandstone, siltstone, claystone, and shale. Includes Dinwoody and Woodside Formations, Ankareh Formation, and Nugget Sandstone and equivalent units. Occurs in Upper Weber Canyon and in the northeastern part of the Lost Creek drainage.	Unknown, probably has minimal permeability except where fractured.
Mesozoic	Triassic and Jurassic	Principally limestone JTRls	Limestone, sandstone, and siltstone. Includes Thaynes and Twin Creek Limestones. Occurs in Upper Weber Canyon and in the Lost Creek drainage.	Unknown, locally may have large permeability where saturated and where fractures have been enlarged by solution.
Paleozoic	Cambrian to Pennsylvanian	Principally limestone and dolomite IPЄls	Limestone, dolomite, sandstone, siltstone, with minor conglomerate and shale. Includes all Paleozoic units except the Tintic and Weber Quartzites. Occurs in and north of Upper Weber Canyon and in southern Hardscrabble Creek drainage basin.	Do.
Paleozoic	Cambrian to Pennsylvanian	Quartzite and sandstone IPЄss	Quartzite, conglomeratic quartzite, quartzitic sandstone, and conglomerate with some siltstone, dolomite, and limestone. Includes Tintic and Weber Quartzites. Occurs in and north of southern Hardscrabble Creek drainage basin.	Unknown, probably has minimal permeability except where fractured.
Precambrian		Farmington Canyon Complex pЄf	Gneiss with some pegmatites. Forms much of the Wasatch Range west of Morgan Valley and also occurs east of Morgan Valley and in the Cottonwood Creek drainage basin.	Do.

[1]Of local usage (Stokes, 1964), not adopted by the U.S. Geological Survey. May be included in the Frontier Formation (Hintze, 1980).

domestic wells commonly penetrate and derive water from a thin section of alluvium and older underlying conglomerate and other clastic units of Cretaceous, Tertiary, and Quaternary age. Only in Morgan Valley and in the northern East Canyon Creek area have wells been drilled near the center of the valley, and these generally are far apart. In addition, in most parts of the study area the base of the alluvium is difficult to define from drillers' logs because the underlying units commonly are similar in lithology to the alluvium. Selected drillers' logs for which we have estimated the base of alluvium and the underlying rock unit are listed in table 6 (at back of report).

In Morgan Valley, it is estimated that the alluvium has a maximum thickness of about 200 feet (60 m) between Peterson and Morgan, 150 to 175 feet (46-53 m) around Mountain Green and southeast to Peterson, and about 125 feet (38 m) along northern East Canyon Creek.

Eardley (1944, p. 889) noted that Morgan Valley, in contrast to Ogden Valley 10 to 15 miles (16-24 km) to the north, was not a trap for deposition of large thicknesses of alluvium, but was an area where the alluvium was eroded by the Weber River because of uplifting by faulting.

In other parts of the study area, wells and data on the thickness of alluvium are few. The wells from which thickness of the alluvium can be estimated from drillers' logs are listed below:

Well (See also table 6)	Location	Approximate thickness of alluvium (feet)
(A-4-3)32abc-1	edge of Round Valley	85
(A-3-4) 4ddd-1	near Weber River at Henefer	76
Located in sec.25, T.3 N., R.4 E.	abandoned well at Echo	69
(A-3-5)29cdd-1	east side of Echo Reservoir	126
(A-2-5)28dcb-1	Hoytsville	130

Economy and Population

The first settlement (1854) in the central Weber River area was Echo and agricultural settlements followed in most of the area through the 1860's (Haws, Jeppsen, and Huber, 1970, fig. 9). Agriculture, primarily confined to the valley areas, has been mostly limited to small grains and forage crops, along with livestock raising and dairying. During recent years a number of mink farms have been established.

The Union Pacific Railroad was constructed down Echo Canyon from Wyoming through Morgan Valley to Ogden during the late 1860's. The railroad has long been an important part of the economy of communities such as Echo.

Industry in the study area is limited to Browning Arms Co. at Mountain Green, Ideal Cement Co. at Croydon, and several small firms at Morgan. Coal has been mined northeast of Coalville since 1859, but the mines are now inactive (1980). In 1975, a large oil and gas field was discovered in the Chalk Creek drainage area at Pineview. Exploration is continuing in the eastern part of the study area.

During recent years, Morgan Valley, and to a lesser extent the Coalville area, has had an influx of residents who work in the Ogden-Salt Lake City urban area, but prefer to live in the rural environment of the study area. Summer-home development also has occurred in several of the upland areas. Because water is considered fully appropriated, new residents or developments in areas not served by public-water supplies or water companies have had to lease surface-water rights from the Weber Basin Water Conservancy District to be able to drill domestic or public-supply wells.

Population of the study area was about 7,580 in 1980 (U.S. Bureau of the Census, 1980). Morgan County had a population of 4,914, and the part of Summit County in the study area had an estimated population of 2,700. Of the incorporated towns, Morgan had a population of 1,895; Coalville, 1,037; and Henefer, 549. Estimated 1980 population for Hoytsville was 200; Peterson, 130; Croydon, 75; Echo, 70; and Mountain Green, 600.

SURFACE-WATER HYDROLOGY

Although ground water is a locally important source of water for domestic, livestock, and public supplies, surface water is much more important in the central Weber River area in terms of investments for development (impoundment, diversion, and regulation) and annual supply. A brief discussion of the surface-water resources in the area follows.

Drainage, Diversions, and Impoundments

The Weber River enters the study area at Hoytsville and flows northwestward to Gateway where it leaves Morgan Valley through Weber Canyon. Major tributaries to the Weber River (in downstream order) are Chalk, Lost, and East Canyon Creeks. Other significant tributaries (in downstream order) are Echo Creek; streams on the southwestern side of Morgan Valley, such as Line Creek; Cottonwood Creek; and Hardscrabble Creek, which is a tributary to East Canyon Creek.

A major diversion from the Weber River is the Weber-Provo Canal near Oakley, about 12 miles (19 km) southeast of Hoytsville, where part of the river's flow is diverted to the Provo River. Another major diversion is the Gateway Canal near Stoddard in Morgan Valley (pl. 3). Part of the Weber River flow is diverted into the canal along the southwestern side of the valley to the Gateway Tunnel, which conveys water to the Wasatch Front west of Morgan Valley. That portion of water not needed for use in the Wasatch Front area is returned to the Weber River through a hydroelectric plant at the western end of Morgan Valley. Major impoundments within the study area are Echo, Lost Creek, and East Canyon Reservoirs.

Discharge of the Weber River at Gateway

The long-term flow of the Weber River is quite variable. Flow at the U.S. Geological Survey gaging station at Gateway (station 10136500) illustrates the variation in flow representative of the study area. During the 1921-80 water years, the annual flow of the Weber River at Gateway (fig. 3) ranged from minimums of 126,800 acre-feet (156 hm^3) during the 1961 water year and 133,900 acre-feet (165 hm^3) during the 1934 water year to maximums of 827,100 acre-feet (1,020 hm^3) during the 1952 water year and 864,900 acre-feet (1,066 hm^3) during the 1921 water year.

The 1931-60 average annual flow of the Weber River at Gateway, including estimated diversions through the Gateway Tunnel during 1957-60, is about 373,700 acre-feet (461 hm^3). As a comparison, the average annual 1931-60 flow of the Weber River at Coalville, at the southern end of the study area, was 140,000 acre-feet (170 hm^3).

Discharge varies greatly during the year, with peak flows coinciding with periods of maximum snowmelt. Average weekly discharge of the Weber River at Gateway for the 1944 water year, a year in which the total discharge of 371,800 acre-feet (458 hm^3) was close to the 1931-60 average, is shown in figure 4. Discharge during the 1944 water year ranged from minimums of 160 to 191 cubic feet per second (4.5-5.4 m^3/s) from January 7 to February 3, 1944, to maximums of 1,110 to 2,220 cubic feet per second (31.4-62.9 m^3/s) from May 5 to June 15, 1944. The peak daily discharge was 3,080 cubic feet per second (87.2 m^3/s) on June 3. During the late summer to early spring low-flow period, much of the discharge of the river consists of ground-water inflow.

Seepage Runs and Base Flow

To help estimate ground-water inflow to the Weber River, seepage runs were made between Coalville and Gateway on September 11 and October 26, 1979. The flow of the river on September 11 generally was too high to obtain definitive results at many places, but the October 26 data indicated several areas where ground-water inflow to the river was significant. Because the discharge of most major sources of surface inflow to the river and its major tributaries was measured during these seepage runs, the gains or losses represent mostly ground-water inflow to or outflow from the streams.

The data in table 2 show that most stream reaches in the valley areas along the Weber River and southwestern Lost and northern East Canyon Creeks were receiving ground-water inflow on October 26, 1979. However, the reach of the Weber River from south of Coalville to Echo lost 21 cubic feet per second (0.59 m^3/s). Some of this loss may be water going into bank storage, evaporation, or both from Echo Reservoir rather than ground-water outflow from the area. On September 11, this reach apparently gained water, which may have been caused by release of water from bank storage. It is possible that estimating changes in storage in Echo Reservoir introduces errors in the base-flow determinations.

The reach between Echo and Devils Slide received about 11 cubic feet per second (0.31 m^3/s), and a 1.25-mile (2.0-km) reach of Lost Creek just upstream

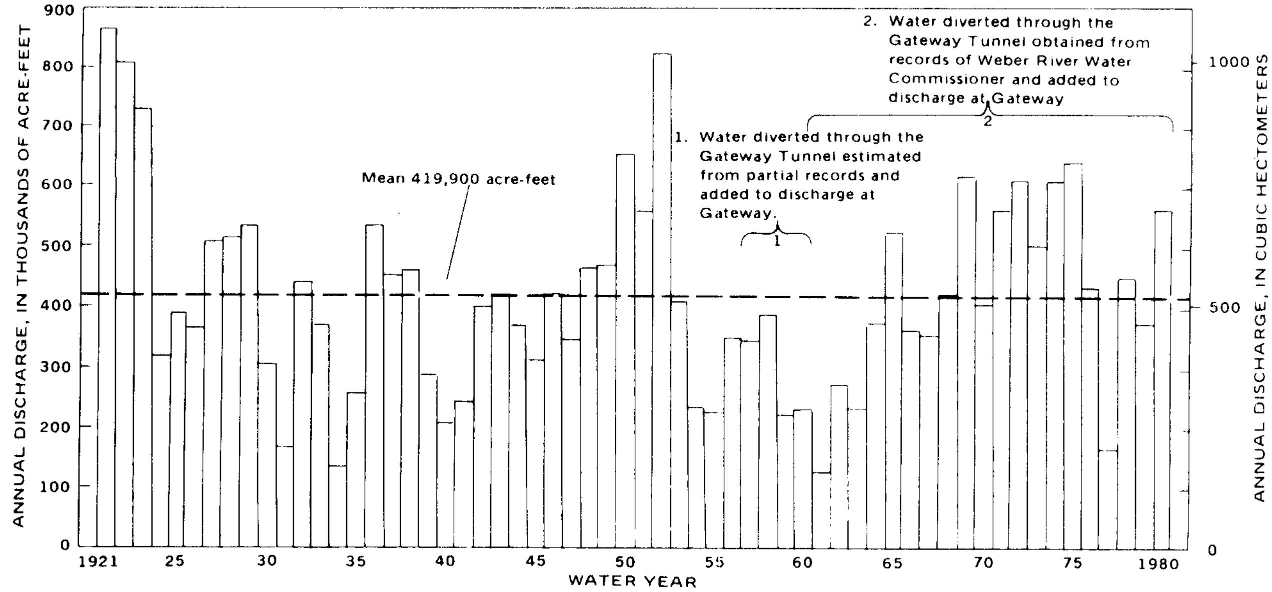

Figure 3.—Annual discharge of the Weber River at Gateway (gaging station 10136500) during the 1921-80 water years.

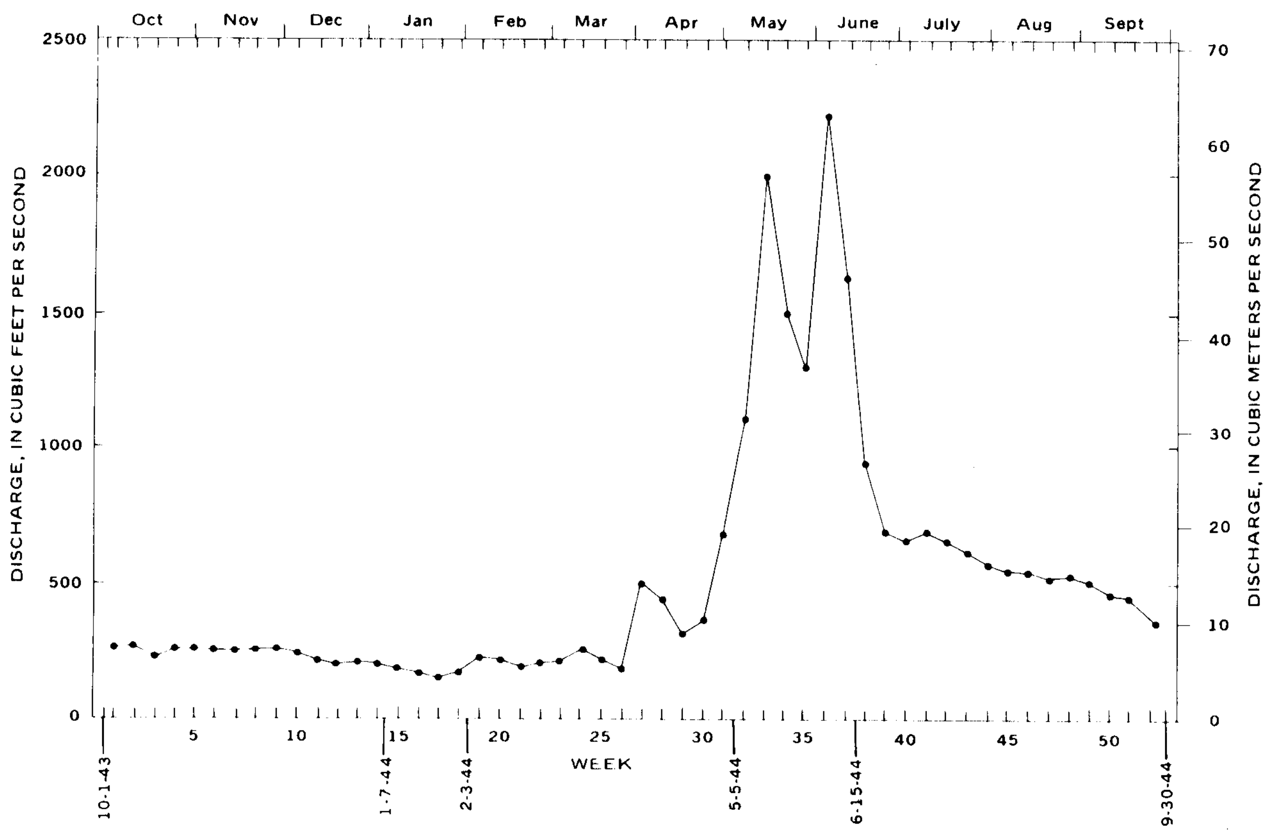

Figure 4.—Average weekly discharge of the Weber River at Gateway (gaging station 10136500) during the 1944 water year.

Table 2.--Seepage runs on the Weber River and its major tributaries, September 11 and October 26, 1979

Site no. (See pl. 1)	Stream and location	Cubic feet per second: Discharge Sept. 11, 1979	Gain (+) or loss (-), or difference not significant (NS) between sites indicated	Discharge Oct. 26, 1979	Gain (+) or loss (-), or difference not significant (NS) between sites indicated
1	Weber River above Gateway and hydroelectric plant return flow	57.7		61.1	
2	Weber River at Peterson	40.2	From site 2 to 1 +17.5	40.6	From site 2 to 1 +20.5
3	Stoddard Slough near mouth at Weber River	1.65		1.58	
4	Weber River below Stoddard diversion to Gateway Canal	[1]20.0	From site 4 to 2 +19 est.	21.4	From site 4 to 2 +17.6
5	Weber River near Milton	572.0		116.0	
6	Deep Creek at edge of Morgan Valley	--		1.93	
7	East Canyon Creek near mouth	112.0		24.4	
8	East Canyon Creek near Morgan and edge of Morgan Valley	86.8	From site 8 to 7 +25	16.9	From site 8 to 7 +7.5
9	Hardscrabble Creek near mouth at East Canyon Creek	--		3.86	
10	East Canyon Creek above Porterville	115.0		16.0	From site 10 to 8 -3
11	Weber River near Como Springs and below Como diversion	[2]480.0	From site 11 to 5 NS	59.7	From site 11 to 5 +30
12	Como diversion from the Weber River	5.64		1.74	
13	Weber River in upper Weber Canyon below Devils Slide	--		57.5	From site 13 to 11 NS
14	Weber River at Devils Slide	508.0	From site 14 to 11 NS	48.9	From site 14 to 13 +8.6
15	Lost Creek near mouth at Weber River	38.8		24.6	
16	Lost Creek near Croyden	24.5	From site 16 to 15 +14.3	13.0	From site 16 to 15 +11.6
17	Ditch in lower Henefer Valley near mouth at Weber River	--		1.64	
18	Weber River at Echo	[3]504.0	From site 18 to 14 -34.8	[4]6.01	From site 18 to 14 +11.3
19	Echo Creek near mouth at Weber River	3.84		5.36	
--	Echo Reservoir (change in storage)	[5]-333.0		[6]+126.0	
20	Chalk Creek near mouth at Weber River	9.22		16.0	
21	Weber River below Coalville	138.0	From site 21 to 18 [7]NS	137.0	From site 21 to 18 [8]-21.0

[1] Estimated from measurement of flow in Gateway Canal and flow in Weber River at Milton.
[2] About 0.5 mile downstream from the October 26, 1979 measurement site.
[3] Measurement site downstream from mouth of Echo Creek, 1.6 miles downstream from October 26, 1973 measurement site.
[4] Measurement site upstream from mouth of Echo Creek.
[5] Flowing out of reservoir storage, average for September 6-16.
[6] Flowing into reservoir storage, average for October 21-31.
[7] Small gain indicated.
[8] Not including Echo Creek.

from the Weber River received about 12 cubic feet per second (0.34 m^3/s) during the October seepage run. Even a reach largely in bedrock in Upper Weber Canyon downstream from Devils Slide received 8.6 cubic feet per second (0.24 m^3/s) of inflow, although some of this could have been in unmeasured tributaries. The Weber River and East Canyon Creek in Morgan Valley received a total of about 76 cubic feet per second (2.2 m^3/s), of which less than 10 percent is estimated to have come from unmeasured tributary inflow.

Another estimate of ground-water inflow to the Weber River was obtained from records of changes in long-term base flow between various gages on the river. October 25-31 was selected because stream discharge would be fairly representative of base-flow conditions. Most diversions for irrigation end in September (Johnson, 1980). Also, during October 25-31, transpiration from phreatophytes along the river is zero or minimal (Haws, Jeppson, and Huber, 1970, table 19), and effects of freezing and thawing are not large.

The data on mean discharge for October 25-31, 1931-60 (table 3) are similar to results of the October 26, 1979 seepage run (table 2).

	Cubic feet per second	
Stream reach	Mean gain in flow, October 25-31, 1931-60	Gain in flow, October 26, 1979
Weber River and East Canyon Creek from Devils Slide and East Canyon Reservoir to Gateway	53.4	85.2
Weber River and Lost Creek from Echo and Lost Creek Reservoir to Devils Slide	18.9	11.3
Weber River from Coalville to Echo	10.1	-

Even though all minor tributary inflow was not accounted for in the October 25-31 mean-discharge data, most of the gains in flow of the streams probably represent ground-water inflow. These data indicate, as did the seepage-run data, that most reaches of the Weber River and the downstream reaches of East Canyon and Lost Creeks are gaining reaches.

Quality of Surface Water

Evaluation of the chemical quality of surface water was not included in this study, but was the subject of a concurrent study by Thompson (1982). The following statements summarize data from his report and refer to sampling conducted July 1979 through August 1980.

Table 3.--Average of the daily mean discharge of the Weber River and its major tributaries at selected streamflow-gaging stations and changes in storage of Echo Reservoir for October 25-31, 1931 through 1960

Station name and number	Average daily mean discharge and change in reservoir storage (cubic feet per second)	Gain (+) or loss (-) between stations indicated (cubic feet per second)
Weber River at Gateway 10136500 (A)[1]	206.0	From A to C
East Canyon Creek near Morgan (just below dam) 10134500 (B)	19.6	+53.4
Weber River at Devils Slide 10133500 (C)[2]	133.0	From C to E
Lost Creek near Croyden 10132500 (D)[3]	9.7	+18.9 ([4] + 28.6)
Weber River at Echo 10132000 (E)[5]	104.4	
Echo Reservoir at Echo 10131500 (F)	[6]+21.8	From E to H
Chalk Creek at Coalville 10131000 (G)	17.1	+10.1 ([7] + 27.2)
Weber River near Coalville 10130500 (H)	99.0	

[1] Diversions through Gateway tunnel estimated and added to total for 1957-60.
[2] Estimated from 1931-54 data and from 1931-54 and 1931-60 discharge data for Weber River at Coalville, Weber River at Gateway, and Chalk Creek.
[3] Estimated from 1941-66 data and from 1941-66 and 1931-60 discharge data for Chalk Creek.
[4] Includes all of the base flow of Lost Creek.
[5] 1958-60 data collected by Weber River Water Commissioner.
[6] Volume going into storage at reservoir, not including evaporation losses of 0 to 3.5 cubic feet per second and unknown bank-storage losses.
[7] Includes all of the base flow of Chalk Creek.

The principal factors that affect the quality of water in the Weber River are tributary inflow, ground-water inflow and irrigation-return flow (which cannot be differentiated readily), and reservoir storage. Snowmelt runoff has small dissolved-solids concentrations, whereas water stored in reservoirs, ground-water inflow, and irrigation-return flow have larger dissolved-solids concentrations. The surface water in the central Weber River area is mostly of the calcium bicarbonate or calcium magnesium bicarbonate type.

The Weber River at Coalville, at the southern end of the study area, had dissolved-solids concentrations ranging from 163 to 256 mg/L (milligrams per liter); while just downstream, Chalk Creek at its mouth had dissolved-solids concentrations ranging from 237 to 446 mg/L. Echo Creek had larger dissolved-solids concentrations (273-509 mg/L) than the Weber River just upstream from Echo Creek (192-296 mg/L). Lost Creek generally had smaller dissolved-solids concentrations (169-315 mg/L) than the Weber River upstream from Lost Creek (203-396 mg/L). A 31-percent increase in dissolved solids was found in irrigation-return flow at the northern end of Henefer Valley on May 13, 1980. The return flow was sampled in a ditch tributary to the Weber River and the increase was in relation to dissolved solids in the Weber River at the northern end of Henefer Valley. East Canyon Creek had dissolved-solids concentrations ranging from 206 to 334 mg/L near its junction with the Weber River in Morgan Valley.

During the October 26 seepage run, samples of the Weber River were collected upstream from the Stoddard Diversion to the Gateway Canal and at Gateway upstream from the hydroelectric plant. The river increased in flow from 21.4 to 61.1 cubic feet per second (0.61-1.73 m^3/s) in this reach, most of which represented ground-water inflow. The dissolved solids in the river decreased from 353 to 347 mg/L in the same reach, indicating that the ground-water inflow has a dissolved-solids concentration about equal to that of the river. Dissolved solids in the Weber River at Gateway, at the western end of the study area, ranged from 173 to 367 mg/L, only a little larger than the 163 to 256 mg/L range at the southern end of the study area at Coalville.

GROUND-WATER HYDROLOGY

General Conditions of Occurrence and Development

Ground water occurs in unconsolidated alluvium and in older semi-consolidated and consolidated rocks in the central Weber River area. Ground water in the alluvium commonly is under water-table conditions. Shallow water in older units also is commonly under water-table conditions; locally (as in the Coalville subarea), water in older units is under artesian conditions. Alluvium is believed to be the most important hydrogeologic unit in the area because it is the most permeable and commmonly contains fresh water.

The principal source of recharge to the ground-water system is precipitation that falls within the area. A small quantity of water enters the area as underflow in the channel of the Weber River near Hoytsville; this is virtually balanced by subsurface outflow in the channel of the Weber River and Weber Canyon at the western end of Morgan Valley. Available data do not indicate that there is significant subsurface flow of ground water into or out of the study area through the semiconsolidated and consolidated rocks that underlie the area. The few available water-level data indicate that the ground water moves toward the Weber River and streams tributary to the river within the study area.

Ground water is less used in the area than is surface water and volumes of ground water in storage and annual recharge are not known accurately because few data are available and no detailed studies have been made. Ground water has been developed by means of small-capacity wells for domestic use at farms and individual residences and by larger capacity wells for public supply, for the Ideal Cement Co., and for the Browning Arms Co. Water from some springs is used locally for public supply.

Most wells derive water from alluvial deposits of Quaternary age, from conglomerate and other clastic rocks of Cretaceous and Tertiary age (including the Echo Canyon Conglomerate, the Evanston(?) and Wasatch Formations, and the Norwood Tuff), from clastic rocks of Cretaceous age (including the Frontier Formation and Wanship Formation [of local usage, not adopted by the U.S. Geological Survey]), and possibly from older coarser-grained deposits of Quaternary and Tertiary age.

The water-bearing characteristics of older units of Mesozoic, Paleozoic, and Precambrian age are relatively unknown. The carbonate units probably are more permeable than the clastic units and gneiss because they may include joints and fractures that have been enlarged by solution. However, clastic units that are extensively fractured may be very permeable locally. Fractures in the Weber Quartzite are the principal source of water draining into the mines of the Park City district, 20 miles (32 km) southwest of Coalville (Baker, 1970, table 1). The Weber is included in the unit in the study area defined as quartzite and sandstone of Cambrian and Pennsylvanian age, but its water-bearing characteristics in the study area are largely unknown.

Morgan Valley-Round Valley Subarea

General Availability

The Morgan Valley-Round Valley subarea includes Morgan Valley, the valley along East Canyon Creek to East Canyon, and Round Valley to a point 2 miles (3 km) west of Devils Slide (pl. 3). Ground water is known to occur in the subarea in alluvium and in older semiconsolidated to consolidated rock units, including the Norwood Tuff in northwestern Morgan Valley and in the Wasatch Formation along East Canyon Creek south of Porterville.

Wells inventoried that derive water from alluvium had an average yield of 149 gallons per minute (9.4 L/s), and those that derive water from the Norwood Tuff and Wasatch Formation had average yields of 23 and 27 gallons per minute (1.5 and 1.7 L/s) (table 4). Well (A-4-2)36bca-1, completed in alluvium for the city of Morgan in 1979, reportedly yields about 2,500 gallons per minute (160 L/s). Although the alluvium at Morgan may be more permeable than average, this well illustrates that alluvium can support large withdrawals at least locally.

Recharge

In and near the lower valley areas, recharge is from precipitation, seepage from and underflow of tributary perennial and ephemeral streams (probably occurring at the valley margins), direct seepage to alluvium from older rock units at the valley margins, from irrigation and seepage from irrigation canals located along the valley margins, and underflow into the area in alluvium of the Weber River valley. The major sources of recharge probably are seepage from and underflow of tributary streams and irrigation and canal losses. Recharge in the higher elevations of the subarea is from precipitation, and occurs mostly by infiltration of snowmelt and streamflow.

Because recharge in the study area is complex and greatly affected by the use of surface water for agriculture, and the study was a reconnaissance, detailed estimates of recharge were not made. Minimum recharge to the subarea and its tributary drainage (not including the part upstream from East Canyon Reservoir) is estimated to equal the average ground-water discharge. The estimated average discharge, discussed in a following section, is about 40,000 acre-feet (49 hm^3) per year. This is about 10 percent of the 401,400 acre-feet (495 hm^3) of normal annual precipitation on the subarea watershed--that is, the drainage area of the Weber River between gaging stations 10136500, Weber River at Gateway; 10133500, Weber River at Devils Slide; and 10134500, East Canyon Creek near Morgan.

Table 4.--Reported discharge of water from and specific capacity of wells by formation[1]

Formation	No. of wells	Range or single value of discharge (gallons per minute)	Average discharge, (gallons per minute)	No. of wells	Range or single value of specific capacity (gallons per minute per foot)	Average specific capacity (gallons per minute per foot)
			Morgan Valley-Round Valley subarea			
Alluvium	35	5-2,550	149	24	0.5-225	25
Norwood Tuff	43	1-149	23	35	0.02-50	3.0
Wasatch Formation	10	3-100	27	5	0.02-24	5.7
			Henefer Valley subarea			
Alluvium	7	3-60	32	7	.3-7.5	3.6
Wasatch Formation	4	8-60	33	2	2.7-4	3
Evanston(?) Formation	1	25	—	1	25	—
Echo Canyon Conglomerate	4	5-560	160	2	.8-28	14
Wanship Formation[2]	2	14-25	20	2	.1-1.7	.9
			Coalville subarea			
Alluvium	2	40-340	190	—	—	—
Wasatch Formation	2	15-30	23	—	—	—
Wanship Formation[2]	3	2-100	36	1	.7	—
Frontier Formation	8	7-300	80	6	.1-8	2.3

[1] Specific capacities were not computed for wells with zero drawdown reported.
[2] Of local usage.

This is a minimum estimate of recharge because: (1) Some evapotranspiration from ground water may occur during the fall base-flow period, and (2) the volume of ground water seeping to the Weber River probably is greater during the spring and early summer snowmelt-runoff period, and the summer irrigation period than it is during the fall base-flow period. The minimum estimate of recharge is estimated to be about two-thirds or more of the actual recharge.

Movement

The map of water levels in the Morgan Valley-Round Valley subarea (pl. 3) shows that ground-water movement generally is from the valley margins toward the Weber River and East Canyon Creek, and downstream. The Cottonwood Creek area is an exception in that the creek is not a ground-water drain locally; movement here is not toward the creek but down its valley toward the Weber River. In addition, the Weber River at and east of Morgan and possibly East Canyon Creek at Porterville are above the water table and may be recharging the alluvium locally.

The data on plate 3 indicate that the Weber River and East Canyon Creek are gaining streams in most of the subarea, which supports the conclusions from the seepage runs and the estimates of long-term gains in base flow between Devils Slide, East Canyon Reservoir, and Gateway.

Discharge

In the lower valley areas, ground-water discharge consists of seepage to the Weber River and East Canyon Creek, transpiration by phreatophytes and probably some from crops and pasture, discharge from wells and springs, and underflow out of the area in the alluvium of the Weber River valley. Discharge in the upland part of the subarea is largely unknown, but likely consists chiefly of local discharge by phreatophytes (probably along streams and at springs), discharge by springs (much of which probably contributes to streamflow), and local seepage to streams.

A minimum estimate of ground-water discharge from the entire subarea and its tributary drainage (not including the part upstream from East Canyon Reservoir) was made by summing the long-term gain in base flow of the Weber River and East Canyon Creek between Devils Slide, East Canyon Reservoir, and Gateway; discharge from wells; discharge from springs used for public supply; and underflow out of the basin. The sum is about 40,000 acre-feet (49 hm^3) per year, and is estimated to be at least two-thirds of the actual total annual discharge.

Discharge by transpiration from phreatophytes was not included in the minimum estimate of ground-water discharge. During the period for which average base flow was computed (October 25-31), transpiration is negligible (Haws, Jeppson, and Huber, 1970, table 19), and presumably the water that was discharged in that way during the growing season instead seeps to streams and is included in base flow. The Morgan Valley-Round Valley subarea, however, includes about 1,600 acres (650 hm^2) of phreatophytes which discharge about 3.1 feet (0.94 m) of water per year (Haws, Jeppson, and Huber, 1970, tables 19 and 26), for a total annual use of about 5,000 acre-feet (6.2 hm^3). In addition, pasture and crops discharge some ground water locally by transpiration.

The average long-term gain in base flow through the subarea is about 53 cubic feet per second (1.5 m^3/s) (table 3), or about 38,000 acre-feet (47 hm^3) per year. Use of water from wells and springs for public supply and from wells for industry was about 990 acre-feet (1.2 hm^3) during 1979. About 250 domestic wells are in the subarea and probably discharge about 250 acre-feet (0.031 hm^3) (estimated domestic use per well is about 1 acre-foot or 1,200 m^3 per year). Total ground water used from wells and springs for public supply, wells for industry, and wells for domestic supply is, therefore, about 1,200 acre-feet (1.5 hm^3) per year.

Underflow of the Weber River as it leaves the subarea in Weber Canyon probably is about 1,000 acre-feet (1.2 hm^3) per year. This was computed by assuming the cross-sectional area of saturated alluvium is about 500 feet (150 m) wide and 75 feet (23 m) deep, the hydraulic gradient is about 25 feet per mile (4.7 m/km), and the permeability is about 450 feet squared per day (42 m^2/d) (see p. 24). Using the equation Q, flow in acre-feet per year = 1.6 x 10^{-6} K (permeability) x I (hydraulic gradient) x A (cross-sectional area) gives a value of 700 acre-feet (0.9 hm^3) per year. An estimate of the underflow entering Morgan Valley in Upper Weber Canyon east of Morgan was made similarly and was about 2,000 acre-feet (2.5 hm^3) per year. An estimate of 1,000 acre-feet (1.2 hm^3) per year probably is reasonable for underflow of the Weber River throughout the central Weber River area.

Storage and Hydraulic Characteristics of the Aquifers

The volume of water stored in alluvium in most of the subarea was computed using data compiled for the digital-computer model (pl. 5). This was done by computing the volume of saturated alluvium in each model node and assuming a specific yield of 0.10. Average alluvium thickness in each node was estimated from well logs and ranged from about 100 feet (30 m) along the valley margins to about 200 feet (60 m) in the area from Morgan to Peterson. Thickness of saturated alluvium averaged 150 feet (46 m). The volume of saturated alluvium totaled about 1,700,000 acre-feet (2,100 hm^3), and the volume of theoretically recoverable ground water in storage is about 170,000 acre-feet (210 hm^3), about 50 percent of the annual flow of the Weber River at Gateway. As far as is known all this water is fresh (contains less than 1,000 mg/L of dissolved solids), as discussed in a subsequent section.

Measurements of water levels in observation wells indicate changes in storage with time. Changes in water levels in eight wells in the study area, seven of which are in the Morgan Valley-Round Valley subarea, are shown in figure 5. Actual water-level measurements are given in table 7 (at back of report). None of the hydrographs of the wells show any long-term changes which would indicate progressive decreases or increases in the volume of ground water in storage. Apparently during the past 40 to 50 years average ground-water recharge and discharge have been in equilibrium.

The hydrographs, however, show seasonal and year-to-year fluctuations which indicate short-term imbalance in recharge and discharge. Many of the hydrographs show higher levels during the late summer and fall than during the spring, indicating effects of recharge from irrigation. However, well (A-5-1)25add-1 at Mountain Green commonly has higher water levels during the spring than during the late summer and fall, indicating effects of recharge from snowmelt-runoff. Several wells (for example (A-4-3)31bcc-1 and (A-4-2)26ccd-1 near Morgan and (A-3-2)24cba-1 at Porterville) show lower average water levels during the early 1960's and higher levels during the early 1970's corresponding to periods of low and high runoff, respectively (fig. 3). This indicates that ground-water levels fluctuate with runoff, probably because both are related to changes in precipitation and snowmelt-runoff, and ground-water levels are affected by changes in volumes of surface water applied for irrigation (which likely were lower during the early 1960's).

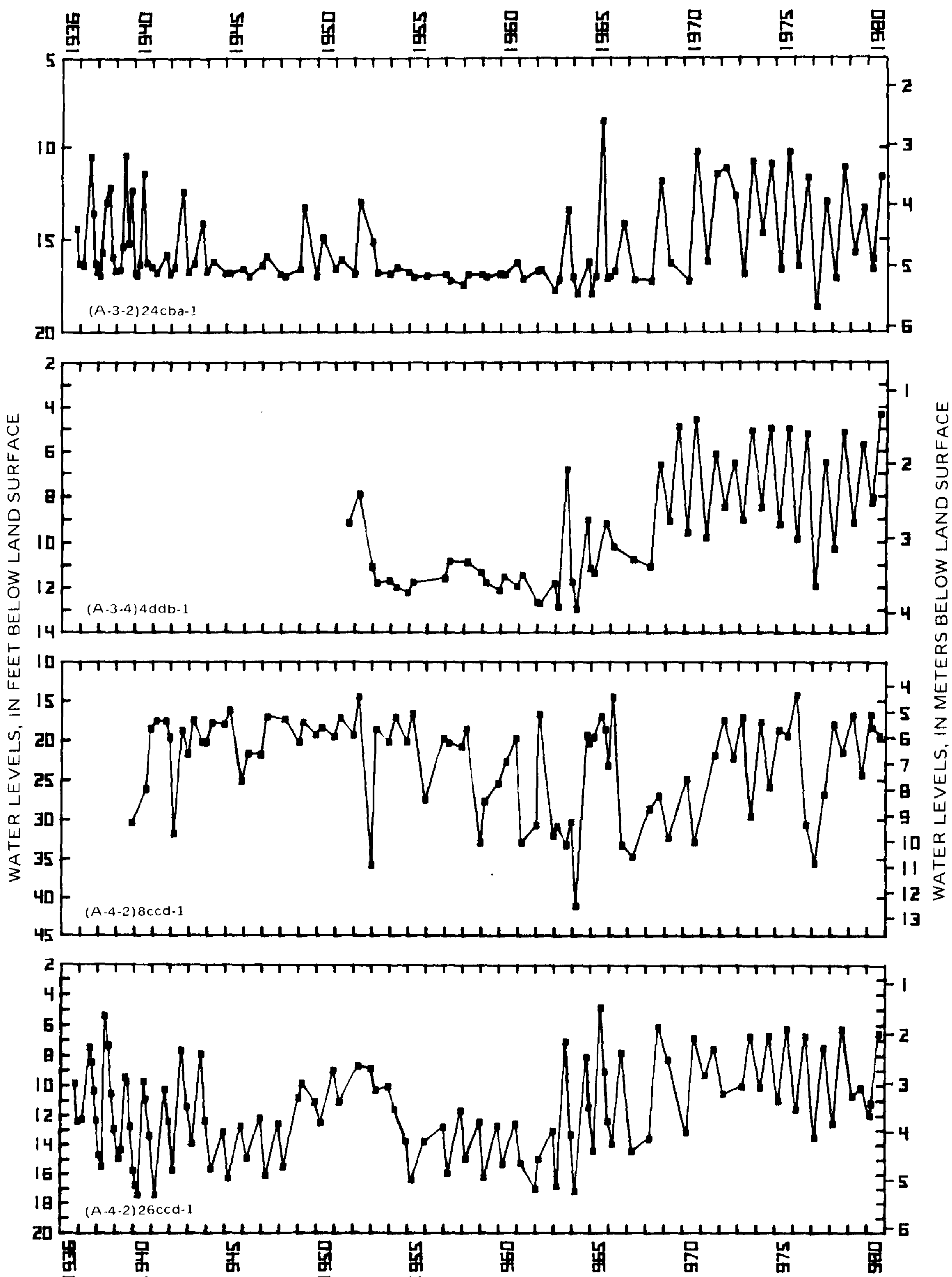

Figure 5.—Hydrographs of water levels in observation wells, 1936-80.

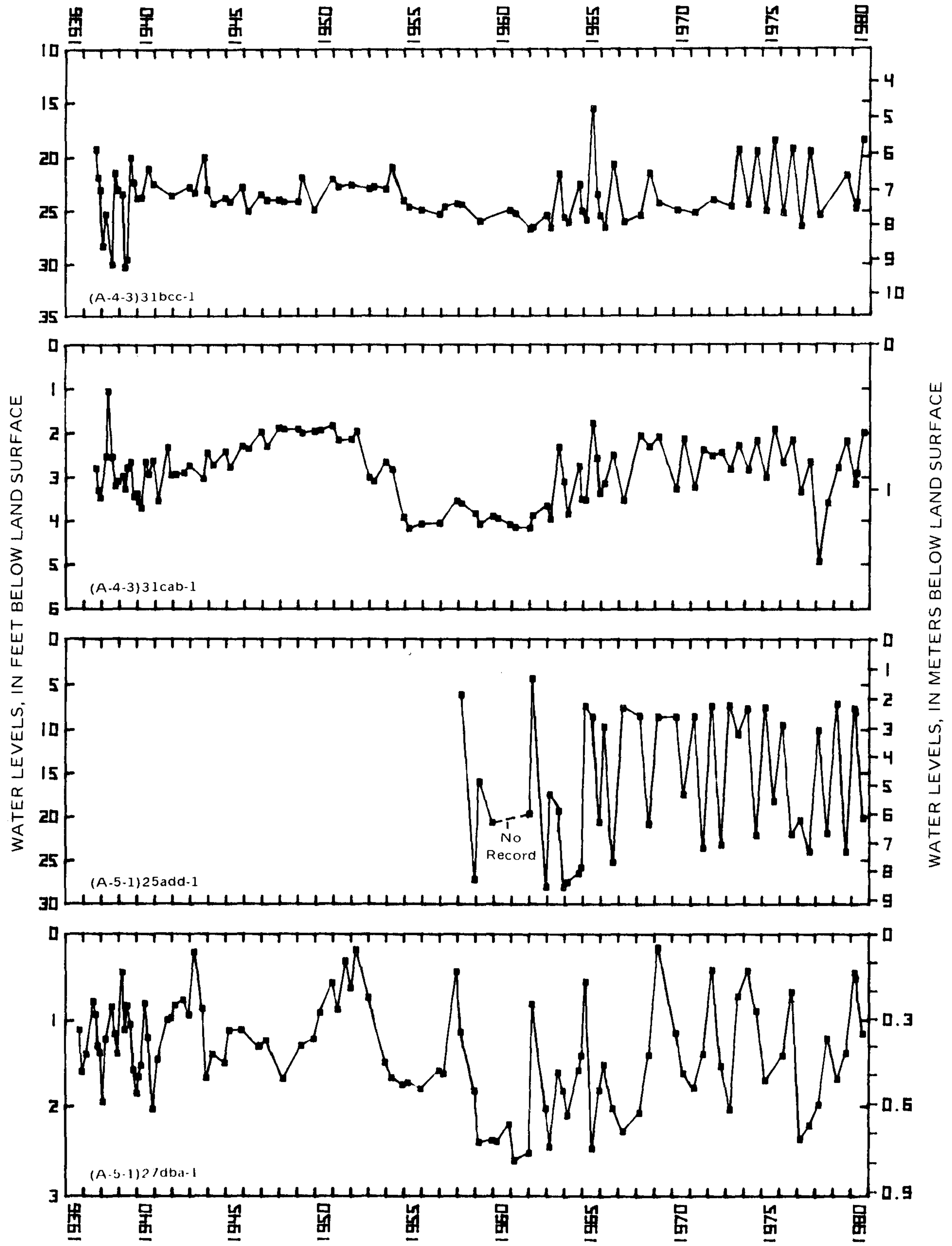

Figure 5.—Hydrographs of water levels in observation wells, 1936-80.—Continued

The water-bearing rock units in the Morgan Valley-Round Valley subarea penetrated by wells include alluvium, the Norwood Tuff, and the Wasatch Formation. Little is known of the hydraulic characteristics of these units, other than what can be inferred from specific capacities of wells.

An 8-hour aquifer test was made using Morgan city well (A-4-2)36bca-1, about 125 feet (38 m) from the Weber River, in November 1979, but the pumping apparently induced flow from the river so quickly that analysis of the data did not give an accurate estimate of transmissivity. The water level in the well stabilized within 10 minutes after pumping began and recovered within 10 minutes after the pumping stopped. Water-level measurements in these periods probably are not accurate enough and the pumpage rate is not stable enough to compute transmissivity.

According to the driller's report, the specific capacity of this well when it was completed was 196 gallons per minute per foot [41 (L/s)/m]. Using this value, transmissivity at the well was estimated to be about 40,000 to 50,000 feet squared per day (4,000-5,000 m^2/d) based on a method of Hurr (1966). The method assumed the well to be 100-percent efficient. The well probably is much less than 100-percent efficient because it is not completely open to the aquifer (it includes a steel casing perforated in place with a hydraulic knife). Therefore, the estimated transmissivity probably is conservative, and the actual transmissivity at the well could be as large as 90,000 feet squared per day (8,000 m^2/d), in which case the hydraulic conductivity of the 200-foot (61-m) section would be 450 feet per day (140 m/d).

Average specific capacities computed from data reported for wells in the subareas of the study area, subdivided by formation from which the wells derived most of their water, are listed in table 4. Wells completed in alluvium in the Morgan Valley-Round Valley subarea had an average specific capacity of 25 gallons per minute per foot [5.2 (L/s)/m], about 12 percent of the value reported for Morgan city well (A-4-2)36bca-1, indicating a transmissivity of about 11,000 feet squared per day (1,000 m^2/d). The Morgan city well probably penetrated alluvium that is more permeable than average. However, average specific capacity may be too small because it includes data from wells that are poorly constructed or penetrate thin sections of alluvium.

The average specific capacity of wells completed in the Norwood Tuff is 3.0 gallons per minute per foot [0.62 (L/s)/m] and for those completed in the Wasatch Formation it is 5.7 gallons per minute per foot [0.2 (L/s)/m]. These values are less than those for wells completed in the alluvium and indicate less transmissivity, probably because these units are partly cemented and because the Norwood contains much fine-grained tuffaceous material.

The specific yield of the alluvium is estimated to average 0.10, although locally it may be as much as 0.20. The specific yields of the Norwood Tuff and Wasatch Formation are not known, but probably average less than 0.10.

Quality of Ground Water

The ground water in the Morgan Valley-Round Valley subarea is almost all fresh. Dissolved solids in the 57 samples collected for this study and 1 sample collected previously in the subarea ranged from 127 to 754 mg/L (table 8 at back of report) and averaged 387 mg/L. Samples also were collected for analysis by Saxon (1972, table 5) from 21 wells and 5 springs. Those samples had dissolved-solids concentrations ranging from 26 to 2,568 mg/L, but values from all but four of them were within the range of values for samples collected during this study.

The overall quality of water does not show much relation to the formation from which it was withdrawn, although no attempt was made to determine the relation between specific ions and formations. Average dissolved-solids concentrations in water from the alluvium was 361 mg/L, from the Norwood Tuff 375 mg/L, and from the Wasatch Formation 478 mg/L. Apparently ground water in and near the valley areas is almost all fresh and would be suitable for most uses.

Henefer Valley Subarea

General Availability

The Henefer Valley subarea includes Henefer Valley southeast to Echo, the southwestern part of Echo Canyon, and the southwestern 7 to 8 miles (11-13 km) along Lost Creek (pl. 4). Ground water is known to occur in the subarea in alluvium and in older semiconsolidated to consolidated rock units, including the Evanston(?) and Wasatch Formations along Lost Creek, the Echo Canyon Conglomerate at Echo and Echo Canyon, and the Wanship Formation (of local usage) near Henefer.

Seven wells that derive water from alluvium had an average yield of 32 gallons per minute (2.0 L/s) and four wells deriving water from the Wasatch Formation had an average yield of 33 gallons per minute (2.1 L/s). Four wells deriving water from the Echo Canyon Formation had an average yield of 160 gallons per minute (10 L/s) (table 4).

The alluvium and possibly the underlying rocks may have small permeability in some parts of Henefer Valley. Three wells drilled in the valley did not yield enough water for domestic supply. A well drilled about 1.5 miles (2.4 km) northwest of Henefer on the edge of the valley (in the NE¼SW¼SW¼ sec. 32, T. 4 N., R. 4 E.) to a depth of 319 feet (97.2 m) was abandoned when it reportedly did not yield any water, and salt was observed in drilling cuttings from a depth of 250 feet (76 m). A 225-foot (68.6-km) well east of Henefer and the Weber River (in the SW¼SW¼SW¼ sec. 3, T. 3 N., R. 4 E.) was reported as yielding no water; and a well drilled about 1 mile (1.6 km) northwest of Henefer on the edge of the valley (in the NW¼NW¼SE¼ sec. 5, T. 3 N., R. 4 E.) to a depth of 135 feet (41.1 m) was abandoned reportedly because "salt was found." These reports indicate that the alluvium and underlying Wanship Formation (of local usage) have small permeability and that the Wanship yields saline water locally.

Recharge

The various sources of recharge to the subarea and the sources that probably contribute the most recharge are the same as those for the Morgan Valley-Round Valley subarea. A minimum estimate of recharge to the entire Henefer Valley subarea and its tributary drainage was made by assuming it equals the average ground-water discharge. This total is about 23,000 acre-feet (28 hm^3) per year, or about 5 percent of the 485,000 acre-feet (598 hm^3) of annual precipitation on the subarea watershed--that is, the drainage area of the Weber River between gaging stations 10133500 and 10132000. This is about 50 percent of the volume recharged to the Morgan Valley-Round Valley subarea, probably because there is less irrigation, and the ground-water reservoir is smaller. This is a minimum estimate of recharge for the same reasons as given for the Morgan Valley-Round Valley subarea, and is estimated to be about two-thirds or more of the actual recharge.

Movement

The map showing water levels in the Henefer Valley subarea (pl. 4) is incomplete because of a lack of data, but indicates that ground-water movement is toward the Weber River and downstream.

The data on plate 4 indicate that the Weber River (with the exception of the reach at Echo) and Lost Creek near its mouth are gaining streams, which supports the conclusions from the seepage runs and the estimates of long-term gains in flow between Echo Reservoir and Devils Slide. At Echo, the Weber River apparently is above the water table and may recharge the alluvium locally.

Discharge

Ground-water discharge in the lower valley areas and in the uplands of the subarea is from the same types of sources as in the Morgan Valley-Round Valley subarea. In the lower valley parts of the Henefer Valley subarea, discharge consists of seepage to the Weber River and the downstream reach of Lost Creek, transpiration by phreatophytes and probably some from crops and pasture, discharge from wells and springs, and underflow of the Weber River valley.

A minimum estimate of ground-water discharge from the entire subarea and its tributary drainage was made by summing the long-term gain in base flow of the Weber River between Echo Reservoir and Devils Slide, discharge from wells, discharge from springs used for public supply, and underflow of the Weber River. The sum is 23,000 acre-feet (28 hm^3) per year.

The average long-term gain in base flow through the subarea is about 29 cubic feet per second (0.82 m^3/s) (table 3), or about 21,000 acre-feet (26 hm^3) per year. Use of water from wells and springs for public supply was about 170 acre-feet (0.21 hm^3) during 1979, and from wells for the cement plant was about 810 acre-feet (1.0 hm^3) during 1980. About 18 domestic wells are in the subarea (including wells at the highway rest stop and maintenance station in Echo Canyon) and probably discharge about 20 acre-feet (0.02 hm^3) per year. Total ground water used from wells and springs for public supply, wells for industry, and wells for domestic supply is, therefore, about 1,000 acre-feet (1.2 hm^3) per year. Discharge as underflow in the alluvium of the Weber River valley is about 1,000 acre-feet (1.2 hm^3) per year.

Although transpiration from phreatophytes is not included in the minimum estimate of ground-water discharge because it probably is accounted for in base flow during the nongrowing season, it is about 2,200 acre-feet (2.7 hm^3) per year. About 820 acres (330 hm^2) of phreatophytes are in the subarea, which discharge about 2.7 feet (0.82 m) of water per year (Haws, Jeppson, and Huber, 1970, tables 19 and 26; and Haws, 1970, tables 35, 36, and 37). In addition, irrigated pasture and crops probably discharge some ground water locally by transpiration.

Storage and Hydraulic Characteristics of the Aquifers

The volume of recoverable ground water in the Henefer Valley subarea was not estimated because of insufficient data about the specific yield and volume of the saturated rocks. The volume stored in the alluvium is less than that estimated for the Morgan Valley-Round Valley subarea.

Measurements at well (A-3-4)4ddb-1 in Henefer Valley show that water levels in the well during the late summer and fall, especially since 1968, tended to be higher than levels during the spring, indicating recharge from irrigation. Levels during the early 1960's were lower than those during the early 1970's, indicating effects of periods of less-than-average precipitation and streamflow.

Specific capacities of wells give some indication of the permeability of the rock units from which water is withdrawn. In the Henefer Valley subarea, reported specific capacities are available for only a few wells (table 4). Seven wells completed in the alluvium had an average specific capacity of 3.6 gallons per minute per foot [0.75 (L/s)/m], and two wells completed in the Echo Canyon Conglomerate had an average specific capacity of 14 gallons per minute per foot [2.9 (L/s)/m]. Wells in the Wasatch Formation and Wanship Formation (of local usage) had smaller specific capacities. These data indicate that all these units have less transmissivity than the alluvium in Morgan Valley. One well in the Evanston(?) Formation had a specific capacity of 25 gallons per minute per foot [5.2 (L/s)/m].

Quality of Ground Water

The ground water sampled in the Henefer Valley subarea is all fresh. The dissolved-solids concentration in the 10 samples collected for this study (table 8) ranged from 160 to 635 mg/L and averaged 380 mg/L. The dissolved-solids concentration in samples from the alluvium ranged from 304 to 415 mg/L; from the Wasatch Formation, 160 to 348 mg/L; and from the Echo Canyon Conglomerate, 342 to 635 mg/L.

Coalville Subarea

General Availability

The Coalville subarea includes the reach of the Weber River from the downstream end of Echo Reservoir to Hoytsville and the western Chalk Creek drainage basin (pl. 4). Ground water occurs in the subarea in alluvium and in older semiconsolidated to consolidated rock units, including the Wasatch Formation east of Hoytsville, the Wanship Formation (of local usage) west and north of Coalville, and the Frontier Formation at Coalville and eastward along the downstream reach of Chalk Creek. Water in the alluvium and at shallow depths in older rock units is under water-table conditions. However, three wells, two completed in the Wanship Formation (of local usage) and one completed in the Frontier Formation, encountered water under artesian conditions. Perforated intervals in the casings of these wells range from 55 to 465 feet (17-142 m) in depth. Much of the water in rock units older than the alluvium may be under artesian conditions in the Coalville subarea.

Of the wells inventoried, two derive water from alluvium and reportedly had yields of 40 and 340 gallons per minute (2.5 and 21 L/s), and two derive water from the Wasatch Formation and had yields of 15 and 30 gallons per minute (0.95 and 1.9 L/s). Wells deriving water from the Wanship Formation (of local usage) and Frontier Formation had yields ranging from 2 to 300 gallons per minute (0.1-19 L/s) (table 4).

Recharge

The various sources of recharge to the Coalville subarea and the sources that probably contribute the most recharge are the same as those for the previously described subareas. Recharge to the entire Coalville subarea and its tributary drainage is estimated to be equal to the average annual ground-water discharge as given below--that is, about 21,000 acre-feet (26 hm^3) per year. This (a minimum estimate) is about 6 percent of the 331,500 acre-feet (409 hm^3) of normal annual precipitation on the subarea watershed (the drainage area of the Weber River between gaging stations 10132000 and 10130500).

The estimate of recharge, in addition to being a minimum (for the same reasons as given for the other two subareas), may be less accurate than the estimates for the other subareas because of the difficulties in accurately computing the changes in storage in Echo Reservoir.

Movement

The map showing water levels in the Coalville subarea (pl. 4) is incomplete because of a lack of data, but indicates that ground-water movement is toward the Weber River and downstream. The data on plate 4 indicate that the Weber River south of Coalville and Chalk Creek near its mouth are gaining streams; this supports the estimates of long-term gains in flow between the gaging station south of Coalville and the downstream end of Echo Reservoir. At one location, however, about 3 miles (4 km) east of Coalville, Chalk Creek apparently is above the water table. At this location the creek may be recharging the alluvium.

Discharge

Ground-water discharge in the lower valley parts of the Coalville subarea consists of seepage to the Weber River and probably to the downstream reach of Chalk Creek, some transpiration by crops and pasture, discharge from wells and springs, and underflow in the alluvium of the Weber River valley.

A minimum estimate of ground-water discharge from the entire subarea and its tributary drainage was made by summing the long-term gain in base flow of the Weber River between the gaging station 10130500 south of Coalville and the downstream end of Echo Reservoir, discharge from springs and wells, and underflow of the Weber River. The total is about 21,000 acre-feet (26 hm^3) per year.

The average long-term gain in base flow through the subarea is about 27 cubic feet per second (0.76 m^3/s) (table 3) or about 19,500 acre-feet (24 hm^3). This figure is only approximate, because of the difficulty in computing the changes in storage in Echo Reservoir.

Use of water from wells and springs for public supply was estimated to be about 560 acre-feet (0.69 hm^3) during 1979. About 40 to 45 domestic wells discharge about 40 acre-feet (0.05 hm^3) per year. A spring along the downstream reach of Chalk Creek probably provides another 10 acre-feet (0.01 hm^3) per year for domestic use. Total ground-water use from wells and springs for public supply and domestic use is, therefore, about 610 acre-feet (0.75 hm^3) per year. Underflow out of the subarea in the alluvium of the Weber River valley is about 1,000 acre-feet (1.2 hm^3) per year.

Although transpiration from phreatophytes in the subarea is not included in the minimum estimate of ground-water discharge because it probably is accounted for in base flow in the nongrowing season, it is about 600 acre-feet (0.74 hm^3) per year. About 250 acres (100 hm^2) of phreatophytes are in the tributary drainage to the subarea (all along Chalk Creek) and their annual use of water is 2.5 feet (0.76 m) (Haws, Jeppson, and Huber, 1970, tables 19 and 26).

Storage and Hydraulic Characteristics of the Aquifers

Well data in the Coalville subarea are insufficient to estimate the volume of ground water stored in alluvium or the hydraulic characteristics of the aquifers. However, some specific-capacity data are available which give some indication of the permeability of the Frontier Formation (table 4). From reported data from six wells, an average specific capacity of 2.3 gallons per minute per foot [0.48 (L/s)/m] was computed--much less than that for the alluvium in Morgan Valley.

Quality of Ground Water

The ground water sampled in the Coalville subarea is fresh, with the exception of water from one unused flowing well, (A-2-5)10bcb-2, that is completed in the Frontier Formation and yields water with 3,000 mg/L of dissolved solids (table 8). The dissolved-solids concentration in the 15 samples collected for this study ranged from 235 to 3,000 mg/L (235-871 mg/L without the 3,000-mg/L sample) and averaged 636 mg/L (467 mg/L without the 3,000-mg/L sample).

The dissolved solids in four water samples from alluvium ranged from 327 to 709 mg/L and averaged 407 mg/L, and in five samples from the Wanship Formation (of local usage) ranged from 235 to 871 mg/L and averaged 431 mg/L. Dissolved solids in six samples from the Frontier Formation ranged from 441 to 3,000 mg/L (441 to 551 mg/L without the 3,000-mg/L sample), and averaged 917 mg/L (500 mg/L without the 3,000-mg/L sample).

Several residents of Coalville, primarily in areas where wells are completed in the Frontier Formation, complained that the ground water was not ideally suitable for domestic use. The dissolved-solids concentration of the Frontier water does not indicate particularly mineralized water, but the dissolved-iron concentration in four of the six samples from the Frontier and three of the five samples from the Wanship Formation (of local usage) was large. The large iron concentration likely is the major cause of the complaints about the quality of ground water. The dissolved-boron concentration of one of the Frontier samples and one of the Wanship samples also was large.

Summary of Quantitative Estimates

The estimates of annual recharge and discharge for the central Weber River area are given below. These are minimum estimates but probably represent about two-thirds of the actual volumes.

Subarea	Acre-feet per year
Recharge	
Morgan Valley-Round Valley	40,000
Henefer Valley	23,000
Coalville	21,000
Total	84,000
Discharge	
Morgan Valley-Round Valley	
Seepage to streams (includes equivalent of transpiration by phreatophytes)	38,000
Discharge from wells and springs for public supply, wells for industry, and wells for domestic and stock use	1,200
Underflow in alluvium of the Weber River valley	1,000
Subtotal (rounded)	40,000
Henefer Valley	
Seepage to streams (includes equivalent of transpiration by phreatophytes)	21,000
Discharge from wells and springs for public supply, wells for industry, and wells for domestic and stock use	1,000
Underflow in alluvium of the Weber River valley	1,000
Subtotal	23,000
Coalville	
Seepage to streams (includes equivalent of transpiration by phreatophytes)	19,500
Discharge from wells and springs for public supply and wells for domestic and stock use	610
Under flow in alluvium of the Weber River Valley	1,000
Subtotal (rounded)	21,000
Total	84,000

GROUND WATER-SURFACE WATER RELATIONSHIPS

Data collected during this study indicate that most reaches of the Weber River from Coalville to Gateway drain the ground-water system; that is, ground water is tributary to the river system and the alluvial aquifer has significant hydraulic connection with the river. Evidence of ground-water flow to the river system primarily includes data on gains in the long-term average base flow from Coalville to Gateway, data on seepage runs made in 1979, and gradients inferred from water-table contours.

The base flow of streams largely is maintained by ground-water inflow. Any stream reach where a gain in base flow consistently occurs is where ground water is moving into the stream. The long-term average base flow (1931-60) for October 25-31 (table 3) shows a progressive increase throughout the area; this is especially true in the Morgan Valley-Round Valley subarea, where it gains about 53 cubic feet per second (1.5 m^3/s). The total gain in flow through the entire area is about 82 cubic feet per second (2.3 m^3/s), which does not include gains in flow of Chalk and Lost Creeks from their source to the gaging stations at the mouth of Chalk Creek and downstream from Lost Creek Reservoir. If these segments are included, the average gain in base flow through the area is about 109 cubic feet per second (3.1 m^3/s).

Some of this gain in base flow is irrigation-return flow, but it is doubtful that return flow represents all the gain. About 18,200 acres (7,370 hm^2) of land are irrigated in the area from Coalville and East Canyon Reservoir to Gateway (Haws, Jeppson, and Huber, 1970, table 26). Irrigation applications are about 3.7 feet (1.1 m) or about 70,000 acre-feet (86 hm^3) per year. Consumptive use is about 1.8 feet (0.55 m), so excess application is about 1.9 feet (0.58 m) per year (see p. 33). Even if irrigation applications exceed crop use by 2 feet (0.6 m), and all this water returns to the major streams at a constant rate, this would only account for 50 cubic feet per second (1.4 m^3/s) of the 109 cubic feet per second (3.1 m^3/s) total gain. This indicates that at least 50 percent of the gain is inflow from the ground-water system.

The 1979 seepage runs (table 2) also showed gains for most reaches of the Weber River. On October 26, 1979, the total gain from Coalville and East Canyon Reservoir to Gateway, including base flow of Lost, Chalk, and Echo Creeks, was about 131 cubic feet per second (3.7 m^3/s). This was computed by subtracting total inflows from total outflows—inflows were 137 cubic feet per second (3.9 m^3/s) in the Weber River at Coalville and 16 cubic feet per second (0.45 m^3/s) in East Canyon Creek downstream from Porterville. Outflows included 126 cubic feet per second (3.6 m^3/s) into storage in Echo Reservoir, 1.7 cubic feet per second (0.05 m^3/s) at the Como diversion from the Weber River, about 95 cubic feet per second (2.7 m^3/s) to the Gateway Canal, and 61 cubic feet per second (1.7 m^3/s) at Gateway. If base flow in tributary creeks and ditches (Chalk, Echo, northeastern Lost, Hardscrabble, and Deep Creeks, a ditch in Henefer Valley, and Stoddard Slough ditch) are not included, the gain in flow through the study area (which represents mostly direct seepage to the Weber River, East Canyon Creek, and southeastern Lost Creek) is still 87 cubic feet per second (2.5 m^3/s).

The only reach of the Weber River that showed a loss during the October 26, 1979 seepage run was from Coalville to the downstream end of Echo Reservoir. Much of the loss of 21 cubic feet per second (0.59 m^3/s) may have resulted from water going into bank storage as the reservoir was being filled, possibly some evaporation, and to inaccuracies in estimating the rate going into reservoir storage by using reservoir levels.

At most locations along the Weber River and the downstream reaches of its major tributaries of Chalk Creek, Lost Creek, and East Canyon Creek, contours of the water table (pls. 3 and 4) indicate gradients and ground-water movement toward the river from the valley sides. Water levels in wells at the sides of the Weber River valley generally are higher than the altitude of the river at its nearest location.

At a few locations, the river or stream altitude is higher than water levels in nearby wells--such as along Chalk Creek about 3 miles (5 km) east of Coalville, near Echo, between Morgan and Como Springs, and possibly along East Canyon Creek at Porterville. At these locations the river may be a source of recharge to the alluvium at least during parts of the year.

The data from the aquifer test at Morgan in well (A-4-2)36bca-1 indicate that the river is in hydraulic connection wtih the alluvium, although the water level in the well was below the river altitude in the fall of 1979.

EFFECTS OF ADDITIONAL GROUND-WATER DEVELOPMENT

During 1979-80, ground-water withdrawals from springs for public supply and from wells in the central Weber River area were relatively small--about 2,800 acre-feet (3.5 hm^3) per year. Of this quantity, about 1,500 acre-feet (1.8 hm^3) per year is from wells. The two wells at the cement plant near Devils Slide withdraw about 800 acre-feet (1.0 hm^3) per year; all other wells withdraw about 700 acre-feet (0.9 hm^3) per year.

Well withdrawals (1979-80) probably were not taking water progressively from ground-water storage, as water levels in observation wells show no long-term declines. Long-term ground-water recharge and discharge probably are in equilibrium. Withdrawals from existing wells have been balanced by increases in recharge or decreases in other forms of discharge.

If additional wells are drilled and pumped in the area, they will cause the following effects. First, a cone of depression will develop in the water table or potentiometric surface around each well. This cone induces flow toward the well to balance withdrawals, and most of the withdrawn water comes from storage within the cone. The cone will continue to deepen and expand until it intercepts sufficient water from a source of recharge or some other source of discharge to balance the rate of discharge from the well. The cone of depression will then cease growing, no more water will be taken from storage, and a new equilibrium between recharge and discharge will be established.

Possible sources of induced flow to a discharging well include streamflow in the Weber River or its tributaries, and ground water discharged naturally by seepage to the Weber River and other streams, evapotranspiration, and isolated seeps.

The current (1980) management practices along the Weber River assume that any withdrawals from wells are balanced by depletion in surface-water flow, and, therefore, that any new well must obtain water under an existing surface-water right. If withdrawal from a well is balanced by increased recharge from or decreased discharge to streams, then new wells will cause depletions in streamflow. However, if withdrawal from a well is balanced by decreases in transpiration or discharge from isolated seeps, the effects on surface water are not as easy to determine.

If withdrawal is balanced by decrease in transpiration from non-beneficial phreatophytes, then streamflow will not be depleted to any extent and the major effects will be on the phreatophytes. If withdrawal is balanced by a decrease in transpiration from crops and pasture, the plants could obtain the balance of water they need from surplus irrigation water. In the Morgan Valley-Round Valley subarea (excluding land irrigated along tributary streams above the flood plains of the Weber River, East Canyon Creek, and Hardscrabble Creek), for example, about 10,700 acres (4,330 hm^2) of land is irrigated (Haws, Jeppson, and Huber, 1970, table 26; and Haws, 1970); and the average consumptive use was computed to be about 1.8 feet (0.55 m) using data compiled by Haws, Jeppson, and Huber (1970, table 16) and Haws (1970, p. 2). The average quantity of water diverted from the Weber River and East Canyon and Hardscrabble Creeks during 1967, 1970, and 1979 was about 36,800 acre-feet (45.4 hm^3) (Johnson, 1968, 1971, and 1980).

In addition, Utah Division of Water Rights records indicate that about 2,000 acre-feet (2.5 hm^3) of water is diverted from Cottonwood Creek and two other creeks to the east to irrigate land around Mountain Green; and 1,000 acre-feet (1.2 hm^3) is diverted from Dalton, Peterson, and Deep Creeks during the peak-flow period to irrigate land in Morgan Valley. The total applied to 10,700 acres (4,330 hm^2) is therefore about 39,800 acre-feet (49.1 hm^3) per year, or about 3.7 feet (1.1 m). Therefore, about 1.9 feet (0.58 m) of water in excess of consumptive use is applied to irrigated lands. This water moves to the water table and then to the Weber River, where it provides part of the base flow in Morgan Valley. If part of the water consumed by crops and pasture comes directly from ground water, and some of this transpiration was diverted to balance water withdrawn from a well, it is probable the plants would then use more of the excess irrigation water. The excess irrigation water flowing to the river then would be decreased, and streamflow would be depleted.

If discharge from a well affected discharge from other wells, presumably owners of these wells would take steps to restore their discharge to its original rate. Ultimately the withdrawal from the new well would be balanced by diverting water from one of the other sources of recharge or discharge.

The present (1980) management policy involves releasing water from reservoirs each year to replace water withdrawn from wells. Streamflow does not move directly to a well and physically replace well pumpage unless the cone of depression created by the well actually intersects the stream. It is more likely that the well, if it affects streamflow, would decrease ground-water or surface-water flow tributary to the Weber River, and that extra surface-water releases would make up for this decreased inflow.

The decrease in streamflow caused by pumping an established well nearly constantly all year also would be nearly constant all year. Such depletion would not be balanced by a short-term release of an equivalent volume of reservoir water, except on the basis of an annual water budget. The current practice is to release some surface water from reservoirs all year to balance well withdrawals (although most of it is released during May through September) in an attempt to replace well withdrawals as realistically as possible (E. B. Johnson, oral commun., February 1981).

Another problem is that a new well obtains its water from storage until it creates a cone of depression large enough to reach a source of recharge or another source of discharge. If the well is far from sources of recharge or discharge, it might be as much as several years before its discharge affected the Weber River or evapotranspiration from phreatophytes.

The present management policy also assumes that all water discharged from wells is removed from the area's hydrologic system. Actually, part of the water withdrawn returns to the ground-water reservoir as seepage from septic tanks and irrigation in excess of consumptive use of lawns and gardens.

The limited analyses made in this study indicates that development by wells in some locations may decrease transpiration by phreatophytes, but not necessarily decrease streamflow. Haws (1970) mapped phreatophytes in the Weber River basin, although he made no determination of which were nonbeneficial as opposed to beneficial--nor is such a determination easy to make because the definition of nonbeneficial and beneficial phreatophytes is not precise. Even a phreatophyte with no economic value may have value in terms of wildlife habitat or esthetics.

Haws (1970) indicates that there are phreatophytes along the following stream reaches: the Weber River in Morgan and Henefer Valleys; the downstream reach of Cottonwood Creek; downstream reaches of Dalton and Deep Creeks; East Canyon Creek in Morgan Valley, near Porterville, and south of East Canyon Reservoir; downstream reach of Hardscrabble Creek; Lost Creek downstream from the reservoir; and the upstream reach of Chalk Creek. It is possible that wells drilled near phreatophytes in these areas would have little effect on the flow of the Weber River and its tributaries.

SIMPLIFIED DIGITAL-COMPUTER MODEL OF THE ALLUVIUM OF MORGAN VALLEY AND LOWER EAST CANYON CREEK

In order to gain insight into the alluvial aquifer-Weber River hydrologic system in the central Weber River area, a simplified digital model of Morgan Valley and the downstream part of East Canyon Creek Valley was constructed. The model was calibrated under steady-state conditions, and used to estimate effects of additional withdrawal of ground water from wells on the hydrologic system.

Design and Assumptions

The digital-computer model is a two-dimensional finite-difference model developed by Trescott, Pinder, and Larson (1976). The version of the model used in this study simulated an aquifer under water-table conditions, leakage between the aquifer and streams through a riverbed, an areal recharge function which was used to simulate recharge from irrigation, and discharge by evapotranspiration as a linear function of depth to water. The model therefore included all the major hydrologic features of the Morgan Valley area.

The area included in the model is shown on plate 5. It includes Morgan Valley from Gateway to Upper Weber Canyon, the downstream part of the Cottonwood Creek area, and the valley along East Canyon Creek to just downstream from Richville. The model includes 2,856 nodes in a 28 x 102-node grid, but only 1,095 of the nodes--an area of about 17 square miles (44 km^2)--are within the active part of the model which simulates the alluvial aquifer. All nodes are square and equal in size--0.016 square mile (0.11 km^2). The boundary of the active part of the model was located at the contact between alluvium where alluvium has a thickness greater than about 10 feet (3 m) and older rock units. This contact was inferred from geologic maps and abrupt increases in land-surface slope shown on the topographic quadrangles, and is included on plate 5.

Also shown on plate 5 are the nodes which simulate the Weber River and the downstream reach of East Canyon Creek, wells producing during 1979-80, and hypothetical wells used to simulate potential effects of additional ground-water development.

Initial estimates of water levels were made from the water-level contour map (pl. 3), and altitudes of the ground surface (used in the computation of evapotranspiration) were estimated from 7½-minute topographic quadrangles. Maximum evapotranspiration was assumed to be 3 feet (0.9 m) per year. When the depth to water declines below 10 feet (3 m), evapotranspiration is assumed to stop.

The hydraulic conductivity of the alluvium was estimated initially from specific capacities of the Morgan city wells. The average specific capacity of the three wells is about 200 gallons per minute per foot [41 (L/s)/m], which indicates a transmissivity of about 90,000 feet squared per day (8,000 m^2/d), and a hydraulic conductivity of about 450 feet per day (140 m/d) or 0.005 foot per second (0.002 m/s) (p. 24). Saxon (1972, p. 82) stated that the U.S. Bureau of Reclamation determined the hydraulic conductivity of the alluvium along East Canyon Creek at the dam to be about 480 feet per day (150 m/d) or 0.006 foot per second (0.002 m/s), close to the estimate made using data from the Morgan city wells. A hydraulic conductivity of 0.005 foot per second (0.002 m/s) corresponds to a typical value for coarse sand (sample 11 in Davis and DeWeist, 1966, table 11.1). The specific yield of the alluvium was assumed to be 0.10.

The altitude of the base of the aquifer was estimated by subtracting inferred alluvium thickness from ground-surface elevations. Average alluvium thicknesses for each model node were estimated from drillers' logs and ranged from 100 to 200 feet (30 to 60 m).

River nodes were located along the Weber River and East Canyon Creek and the downstream reach of Cottonwood Creek. Altitudes of the hydraulic heads in the river were estimated from topographic quadrangles. The vertical hydraulic conductivity of the riverbed initially was assumed to be 1/10 of the hydraulic conductivity of the aquifer, or 0.0005 foot per second (0.0002 m/s); and its thickness was assumed to be 1 foot (0.3 m).

Areal recharge was assumed to come only from irrigation--recharge from direct precipitation on the modeled area was assumed to be negligible. As discussed on p. 33, the irrigation water applied in excess of crop consumptive use is about 1.9 feet (0.58 m) per year, which is assumed to infiltrate to the water table. The area recharged by excess irrigation water was determined from the maps compiled by Haws (1970), which show areas of various irrigated crops.

It also was assumed that crops irrigated in areas where the water level is less than 10 feet (3 m) below the land surface obtain part of their water directly from the zone of saturation. In these areas, the consumptive use of irrigation water was decreased by the quantity assumed to be transpired directly from the zone of saturation (which could be a maximum of 1.8 feet [0.55 m] of water per year). As an example, if crops are grown in a node where the depth to water is 7.5 feet (2.3 m), then direct transpiration from the zone of saturation was assumed to be [(10-7.5)/10] x 3 feet (1 m) per year, or 0.75 foot (0.23 m) per year. The consumptive use of irrigation water was then decreased by 0.75 foot (0.23 m) to (1.8 - 0.75) = 1.05 feet (0.32 m) per year for that node, and recharge from irrigation was increased by 0.75 foot to (1.9 + 0.75) = 2.65 feet (0.81 m) per year.

Recharge from tributary creeks at the edge of the valley, underflow of these creeks, and seepage from rock units older than the alluvium was estimated during steady-state model simulations by making all nodes along the boundary constant hydraulic-head nodes. The model then computed the inflow at each constant hydraulic-head node that was required to maintain the local water-table gradient. During transient-state, predictive simulations of the model, these boundary inflows were simulated by wells recharging at a constant rate.

Existing wells in Morgan Valley and along the downstream reach of East Canyon Creek were located in nodes (pl. 5) and their 1979 discharge was simulated, in the case of public-supply and industrial wells. Domestic wells were assumed to discharge 1 acre-foot (1,200 m^3) each per year.

The model is more of an idealized model with the general characteristics of Morgan Valley than a detailed model of the valley. Because of a lack of data on areal variations in hydraulic conductivity of alluvium, specific yield, areal water-table configuration (most known values of hydraulic head were measured at the sides of the valley), seepage to the river, and areal distribution and rate of recharge from irrigation, the model is only an approximation of Morgan Valley's hydrologic system. Even land-surface altitudes are not sufficiently accurate because the contour intervals on available topographic maps are 20 and 40 feet (6 and 12 m). However, the model includes the major hydrologic features of the valley and was useful in approximating and evaluating the effects of future ground-water development.

Calibration

The model was calibrated only under steady-state conditions. Over the long term, recharge and discharge in Morgan Valley and along the downstream reach of East Canyon Creek are approximately in balance, or at steady state. The area's ground-water system has never been, except for short periods such as parts of a year or possibly 1 or 2 years of much above-average or much below-average precipitation and streamflow, under transient conditions.

The model was adjusted until its steady-state water levels were within about 5 to 10 feet (1.5-3 m) of the values from the maps showing water-level contours, and the seepage to streams was between 50 and 80 cubic feet per second (1.4 and 2.3 m^3/s). In many instances, differences between computed water levels and water levels from the water-table contour map were due to errors in the map, or errors in interpolating river altitudes. The seepage to the river was adjusted by changing the hydraulic conductivity of the alluvium and the riverbed. The original values of 0.005 and 0.0005 foot per second (0.0015 and 0.00015 m/s) for alluvium and river bed hydraulic conductivity, respectively, were decreased to 0.0007 and 0.00007 foot per second (0.0002 and 0.00002 m/s). These decreases seem reasonable because the original values were based on specific capacities of the Morgan city wells, which were larger than the average specific capacity of all wells completed in alluvium in Morgan Valley (table 4). Recharge from irrigation and the evapotranspiration function were not modified during calibration because there was little basis on which to do so.

The final steady-state calibration simulation had totals for the entire model of 58.7 cubic feet per second (2.00 m^3/s) for inflow from boundary nodes (recharge from the edge of the valley, excess of boundary inflows over boundary outflows), 26.1 cubic feet per second (0.74 m^3/s) for recharge from irrigation, 64.5 cubic feet per second (1.83 m^3/s) for discharge to streams, 17.6 cubic feet per second (0.50 m^3/s) for discharge by evapotranspiration, and 0.7 cubic feet per second (0.02 m^3/s) for discharge from wells (actual well discharge was 0.12 cubic foot per second (0.0034 m^3/s) larger but discharge from wells in boundary nodes was included in boundary inflow/outflow).

Simulated Effects of Future Ground-Water Development

Withdrawals from additional wells, located in areas where more residential development and domestic wells are likely (pl. 5), were simulated to see what the effects would be on discharge to streams and discharge by evapotranspiration. The following degrees of development were simulated for periods of 5 years in separate simulations of the model:

(1) 1 well, at the edge of the valley near Milton, discharging 0.0014 cubic foot per second (4.0 x 10^{-5} m^3/s);

(2) 1 well near Stoddard, in an area of evapotranspiration adjacent to a phreatophyte area, discharging 0.0014 cubic foot per second (4.0 x 10^{-5} m^3/s);

(3) 10 wells, each discharging 0.0014 cubic foot per second (4.0×10^{-5} m^3/s) (2 wells in Mountain Green, 2 in Peterson, 2 in Milton, 2 in Littleton, 1 south of Stoddard, and 1 near Morgan);

(4) 100 wells, including those in (3), each discharging 0.0014 cubic foot per second (4.0×10^{-5} m^3/s) (10 wells at Mountain Green, 10 at Peterson, 5 at Enterprise, 5 at Milton, 5 at Littleton, 20 near Morgan, 5 near Richville, 5 northeast of Richville, 5 southeast of Littleton, 10 in the Stoddard area, 10 between Milton and Peterson, and 10 southeast of Mountain Green);

(5) 1 well as in (1), discharging 100 times its original rate, or 0.14 cubic foot per second (4.0×10^{-3} m^3/s);

(6) 1 well as in (2), discharging 100 times its original rate, or 0.14 cubic foot per second (4.0×10^{-5} m^3/s); and

(7) 100 wells as in (4), each discharging 10 times its original rate, or 0.014 cubic foot per second (4.0×10^{-4} m^3/s).

Selected results of the simulations, as indicated by model inflow and outflow, are as follows:

Simulation number	Source of water diverted to the well(s), at the end of the 5-year period, in percent of the total discharge rate			Source of water discharged throughout the entire 5 years, in percent of the total volume		
	Seepage to streams	Evapotranspiration	Storage	Seepage to streams	Evapotranspiration	Storage
1	88	[1]6	[1]6	94.4	4.2	1.4
2	80	20	—	74	21	5
3	83	16	[1]1	81	16	3
4	87	13	—	86	12	2
5	96	4	—	94.5	4.2	1.3
6	Results similar to (2)			Results similar to (2)		
7	Results similar to (4)			Results similar to (4)		

[1]Quantity is so small it may not be accurate because it is of the same order of magnitude as the error in the results.

The results of the model simulations indicate that most of the simulated additional withdrawals were balanced by decreases in seepage to the Weber River and the downstream reach of East Canyon Creek and that a lesser quantity was balanced by decreases in evapotranspiration. The simulations also indicated that with new withdrawals from wells, the system would reach effective steady state within 100 to 450 days. This indicates that pumping from new wells will be balanced by decreases in other forms of discharge within one or two irrigation seasons.

SUMMARY AND CONCLUSIONS

Ground water in the central Weber River area is used much less than surface water—only 2,800 acre-feet (3.5 hm^3) was during 1979 and 1980 compared to about 70,000 acre-feet (86 hm^3) of surface water diverted annually for irrigation. Because ground water has been little developed, no detailed studies have been made of its occurrence. This reconnaissance was made to gain insight into potential effects of additional ground-water development on the hydrologic system.

Most ground water that can be developed readily by wells is in the alluvium along the Weber River and along the downstream reaches of its major tributaries, and is fresh. The alluvium is very permeable near Morgan and likely is as permeable at other locations. Older semiconsolidated to consolidated rocks commonly contain fresh water at shallow depths but have smaller permeabilities and yields to wells. The estimated volume of recoverable ground water in storage in Morgan Valley and along the downstream reach of East Canyon Creek (most of the Morgan Valley-Round Valley subarea) is about 170,000 acre-feet (210 hm^3); this is about 50 percent of the average annual flow of the Weber River at Gateway and about four times the estimated minimum annual ground-water recharge in the subarea.

Total annual recharge and discharge of ground water in the entire study area is at least 84,000 acre-feet (100 hm^3) and may be as much as one-third greater. Recharge from irrigation may be about 50 percent of the total. Long-term recharge and discharge are approximately in balance, and no long-term changes occurred in ground-water storage during 1936-80.

Along most reaches of the Weber River from Coalville to Gateway, ground water moves toward and seeps into the river. Discharge from wells (as of 1979-80) probably has been balanced by increases in recharge or decreases in other forms of discharge.

That part of withdrawal from additional wells that is not returned to the ground-water system ultimately (after some withdrawal from ground-water storage) will be balanced by increases in recharge or decreases in other forms of discharge, mostly seepage to streams or evapotranspiration. Most of these changes probably will decrease streamflow; however, withdrawal from future wells balanced by transpiration from nonirrigated phreatophytes will not affect surface-water flow. Simulation of additional wells in Morgan Valley using a simplified digital-computer model indicated that most of the withdrawals from these wells will be balanced by decreases in seepage to the Weber River and the downstream reach of East Canyon Creek, and a lesser quantity will be balanced by decreases in evapotranspiration.

The simplified digital-computer model of the Morgan Valley-lower East Canyon Creek area is adequate to give only a general assessment of the effects of additional wells. A more detailed model would be required to analyze the specific effects of additional withdrawals of ground water from particular wells on the hydrologic system. Such a model would require water-level measurements throughout the Morgan Valley area, probably requiring construction of many shallow observation holes. The altitude of the ground surface at each hole would have to be surveyed to more accurately define the water table. Data on hydraulic conductivity and specific yield would be needed and more quantitative data on seepage of ground water to the river collected. More information is needed also on the areal distribution of irrigation and quantities of water applied, as well as on the quantity that seeps to the water table. Areas and rates of transpiration of ground water by nonirrigated phreatophytes and crops and the depths to water below which evapotranspiration ceases would have to be better defined. Such a detailed model could predict the effects of well withdrawals on seepage to streams and evapotranspiration more accurately than the simplified model constructed for this study.

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Location: See text for explanation of well- and spring-numbering system.
Depth of well: Depth given is depth of hole drilled unless a part of the hole is known to be plugged or sealed; it is not known whether the interval between the bottom of casing and the bottom of hole, if any, is a source of water to the well.
Casing diameter: Diameter of smallest size casing at the land surface.
Altitude of land surface: Above NGVD of 1929, interpolated from topographic maps.
Water level: In feet below land surface, F, flowing; P, pumping; R, recently pumped; S, nearby well pumping; water levels measured by the U.S. Geological Survey given in feet and tenths of a foot.
Date water level measured: R, measurement was reported.
Type of pump: S, submersible, J, jet; T, turbine; P, piston; C, centrifugal.
Discharge: F, flowing; R, reported; B, bailer test.
Use of water: H, domestic; I, irrigation; S, stock; P, public supply; C, commercial; R, recreation; N, industrial; U, unused; Z, other.
Principal aquifer: 111ALVM, alluvial deposits; 120TRTR Tertiary System; 123NRWD, Norwood Tuff; 124WSTC, Wasatch Formation; 125EVNS, Evanston(?) Formation; 211ECCN, Echo Canyon Conglomerate; 211FRNR, Frontier Formation; 211WNSP, Wanship Formation of local usage (not adopted by the U.S. Geological Survey).
Other data available: C, chemical analysis in table 8; L, drillers' log in table 6; W, water-level measurements in table 7.

Location	Owner	Date completed	Depth of well (feet)	Casing diameter (inches)	Depth cased	Depth to first opening (feet)	Altitude of land surface (feet)	Water level (feet)
(A-2-5)4bcd-1	Coalville	6- 3-61	192	10	55	55	5,630	F
9bac-1	do.	6-18-77	500	8	320	150	5,700	21.6
9cdb-1	do.	12- 5-60	500	8	500	435	5,610	F
9dac-S1	Cluff-Ward Pipeline Co.	–	–	–	–	–	5,630	–
10aaa-1	Blonquist, Howard	9-16-61	125	6	125	125	5,800	61.9
10aaa-2	Blonquist, Alfred C.	5- 7-75	230	8	230	95	5,800	62.4
10abc-1	Willoughby, Earl	6- 2-58	185	6	185	–	5,730	74.6
10bcb-2	Moore, Doug	–	–	–	–	–	5,705	F
11aca-2	Burton, Sherman D.	7-16-70	55	6	55	51	5,730	22.7
11acb-3	Hicken, Alan	4- -74	180	6	180	–	5,740	50
15bdb-1	Mountain Fuel Supply Co.	7-17-47	150	6.6	150	66	5,900	64
17bad-1	Coalville	1963	123	6	120	82	5,580	F
18bac-S1	do.	–	–	–	–	–	5,950	–
20dbd-2	Sharp, John	1974	250	6	220	–	5,655	81.5R
20ddc-2	Hansen, G. T.	8- 5-78	56	6	56	45	5,630	3.1
21dcd-1	Coalville	9-15-79	402	8	402	159	5,690	7.6
28dcb-1	Hoytsville	8-27-74	202	8	131	80	5,675	P
(A-3-2)1cac-1	Kiddy	10- 2-71	110	6	110	100	5,100	30
2bab-1	Durrant, Ken A.	10-20-79	118	6	117	102	5,060	20.1
2dcb-1	Wiggill, Vern G.	10-14-75	120	6	110	100	5,080	14.5
4aad-1	Hansen, N. & E.	9-23-72	268	6	268	220	5,085	19.0
4acd-1	Mezenen, Bert F.	6- 5-75	160	6	160	150	5,095	2.6
4daa-1	Ecker	9-20-74	260	6	260	200	5,210	92.6
4dab-1	Anderson, Laurie	5-19-77	190	6	190	175	5,140	43.3
4dbb-1	Ukena, Dawson	11- 8-71	135	6	135	98	5,120	5.3
11caa-1	Dickson, Norris P.	1- -74	190	6	190	125	5,135	42.7R
11cdd-1	Forsey, Jack	1- 5-70	302	8	302	106	5,190	70.7
12bba-1	Lewis, James	10-10-67	160	6	157	136	5,095	7.2
12cab-1	Corpany, David R.	2- -75	310	6	300	–	5,100	–
12cac-1	Wilson, Dale	1- -72	140	6	140	102	5,120	17.3
13bba-1	Olsen, Dick	7-17-79	161	6	160	100	5,150	0.0
14dad-1	Rowser, Robert I.	3- 1-77	95	6	90	90	5,140	6.8
14dbc-1	Creager, Bud L.	7- 2-76	200	6	200	112	5,170	42.4
14dcb-1	West, Duane	4-30-55	71	6.6	71	60	5,180	45.7
23abb-1	LDS Church	8-10-78	176	6	175	123	5,190	50.4
24bab-1	Kippen, Charles	6-27-70	131	6	130	102	5,180	23.6
24bbc-1	Porter, Cole	12- -73	105	6	102	95	5,150	5.3
24bcc-1	Kilbourne, Grace	4-22-46	31	36	31	–	5,160	22.7
24caa-1	Crook, Wallace F.	12- -73	125	6	122	100	5,165	11.3
24cba-1	Adams, Hyrum	1924	19	24	–	–	5,155	13.3
24cdd-1	Leak, Gary W.	5- 3-76	125	6	125	100	5,180	23.5
25baa-1	Wingate, Clarence	4-23-48	81.5	6	70	70	5,185	18.4
25caa-1	Carter, Bud	4-15-69	112	6	111	100	5,280	25.4
25dcd-1	Carter, T. Ross	6-12-54	26	30	26	–	5,275	23.1
26aab-1	Breshears, Walter H.	8-18-76	350	6	350	300	5,300	69.0
26aac-1	Mortenson, Parley	10-26-51	87	6	81	81	5,300	65.3
26acb-1	Green, Chad	5-17-79	396	6	286	276	5,340	75.7
26acc-1	Castle, Francis M.	3-28-56	122	6	104	85	5,340	66.4
26add-1	Phillips, Marvin	4- 1-48	83	6	79	79	5,300	23.0
26bda-1	Mikesell, Darrell E.	10- 3-67	122	6	120	92	5,339	18.1
36adb-1	Mathews, Kent L.	10- 1-74	–	–	–	–	5,300	13.7
(A-3-3)31cbd-1	Iverson, D. M.	5- 3-69	30	4	30	30	5,270	8.1
(A-3-4)3add-1	Eagle Ranch Preserve	7-16-75	265	6	265	105	5,690	16.5
3cab-S1	do.	–	–	–	–	–	5,530	–
3ccc-1	Union Pacific Railroad	1-27-46	65	6	65	50	5,340	4.8
4aba-1	Anderton, Charles I.	6-15-59	38	6	38	–	5,320	14.6
4add-1	Winters, Seth	8-28-53	35	6	35	28	5,310	12.0
4ddb-1	Nichols, Allen	–	33	–	–	–	5,325	5.7
4ddd-1	Boyer, Ed	1- -72	125	6	123	105	5,325	3.2
9aaa-1	Tweed, Glen B.	7-29-48	16	2	16	14	5,325	8.4

Date water level measured	Type of pump	Discharge (gallons per minute)	Date discharge measured	Use of water	Principal aquifer	Other data available	Remarks
–	–	0.02F	8-23-79	S	211WNSP	C,L	–
8-23-79	S	300R	6-18-77	U	211FRNR	L	Gravel-packed, 115 to 320 feet.
–	S	33R	12- 5-60	P	211FRNR	C,L	–
–	–	--	–	H,I,S	111ALVM	C	–
9-27-79	–	15R,B	9-16-61	U	211FRNR	–	–
9-27-79	S	10R,B	5- 7-75	H,S	211FRNR	C,L	Drilled to 125 feet 2-2-75 and deepened to 230 feet 5-7-75.
8-24-79	–	7R,B	6- 2-58	U	211FRNR	–	Casing assumed to be 185 feet.
--	--	5F	9-27-79	U	211FRNR	C	Flow drained into adjacent gully through buried pipe.
10- 4-79	S	40R,B	7-16-70	H	211FRNR	C	–
4- -74R	S	10R,B	4- -74	H,I	211FRNR	C,L	–
7-18-47R	J	225R,B	7-18-47	N,H	211FRNR	C,L	–
–	S	100R	8-23-79	P	211WNSP	C,L	Drilled to 193 feet and cased to 191 feet 7-23-62; deepened(?) to 123 feet and cased to 120 feet in 1963(?), May represent deepening after partial caving.
–	–	–	–	P,S,	211WNSP	C	IC Springs
8-22-79	S	6R	8-22-79	H,I,S,	211WNSP	C,L	–
8-22-79	–	15R,B	8- 5-78	U	124WSTC	–	–
9-27-79	–	–	–	P	120TRTR	L	Pilot hole drilled to 515 feet 3-27-79; log available; gravel packed 149 to 365 feet.
–	T	340	8-31-79	P	111ALVM	C,L	Discharge estimated from totaling meter.
10- 2-71R	S	45R,B	10- 2-71	H,S	111ALVM	C	–
4-10-80	S	20R,B	10-20-79	H,I,S	123NRWD	–	–
6-11-79	S	40R,B	10-14-75	H	123NRWD	C,L	–
5-18-79	S	10R,B	9-23-72	H	123NRWD	C	–
8-10-79	S	10R,B	6- 5-75	H	123NRWD	C	–
8-10-79	S	10R,B	9-20-74	H	123NRWD	C	–
5-18-79	S	30R,B	5-19-77	H,I,S	124WSTC	–	–
8-10-79	S	4F,R	11- 8-71	H	123NRWD	C,L	–
10- 6-79	S	20R,B	1- -74	H	123NRWD	C,L	–
6-12-79	S	3R,B	1- 5-70	H,I,S	124WSTC	C	–
6-11-79	S	25R,B	10-10-67	H,S	111ALVM	C	–
--	S	8R,B	2- -75	H	123NRWD	L	Drilled to 105 feet 10-74; reportedly bailed 15 gallons per minute after casing perforated from 100 to 105 feet; deepened to 310 feet 2-75.
6-11-79	S	15R,B	1- -72	H,I,S	111ALVM	C	–
7-17-79	–	100R,B	7-17-79	H,I	123NRWD	C	Gravel-packed 100 to 160 feet.
6-11-79	S	25R,B	3- 1-77	H,S	123NRWD	C	–
9-21-79	S	15R,B	7- 2-76	H,I,S	123NRWD	C	–
6-12-79	S	20R	4-30-55	H	111ALVM	–	–
5- 3-79	S	20R,B	8-10-78	H	124WSTC	–	–
6-13-79	S	15R,B	6-27-70	H,I	–	–	–
6-19-79	S	12R,B	12- -73	H	111ALVM	C	–
6-13-79	–	–	–	H	111ALVM	C	Casing assumed to be 31 feet.
5- 3-79	S	40R,B	12- -73	H	123NRWD	C,L	–
9-25-79	P	–	–	H	111ALVM	C,W	–
9-21-79	S	20R,B	5- 3-76	H,I,S	111ALVM	–	–
6-20-79	S	30R,B	4-23-48	H	124WSTC	C	–
6-19-79	S	20R,B	4-15-69	H	124WSTC	C	–
6-18-79	–	12R	6-15-54	H	124WSTC	C	Casing assumed 26 feet.
6-19-79	S	15R,B	8-18-76	H,I,S	124WSTC	C,L	–
6-20-79	S	20R,B	10-26-51	H	123NRWD	C	–
6-13-79	–	6R	5-17-79	H	123NRWD	L	Gravel-packed with pea gravel, 276-396 feet.
12- 6-79	S	1R,B	3-28-56	H	123NRWD	C	–
6-18-79	S	30R,B	4- 1-48	H	123NRWD	C	–
6-13-79	S	4R,B	10- 3-67	H	123NRWD	C	–
6-20-79			--	H	111ALVM	C	–
6-18-79	S	..	..	H	111ALVM	C	..
8-15-79	–	14R	7-16-75	H,I,Z	211WNSP	L	–
--			–	P	211WNSP	–	Temperature 6.0°C; specific conductance 485 micromhos per centimeter at 25°C.
8-15-79	--	60R	1-27-46	U	111ALVM	–	Casing assumed 65 feet.
8-13-79	–	3R,B	6-15-59	S	111ALVM	–	–
8-28-53R	S	35R,B	8-28-53	H	111ALVM	C	–
9-25-79	--	--	–	U	111ALVM	W	–
10- 2-79	--	25R,B	1- 72	–	211WNSP	L	–
8-15-79	S	12R	7-30-48	U	111ALVM	–	Drilled in basement of house, top of casing 6 feet below land surface.

Location	Owner	Date completed	Depth of well (feet)	Casing diameter (inches)	Depth cased	Depth to first opening (feet)	Altitude of land surface (feet)	Water level (feet)
(A-3-4)24dbd-1	Dilree, Cora	7-10-75	130	6	76	65	5,475	45.9R
25abc-1	Echo Mutual Water Co.	9-15-53	52	8	47	46	5,442	19.1
(A-3-5)17adc-1	Utah Dept. Transportation	5- 9-69	200	8	200	124	5,630	15.5P
17cbc-S1	Echo Mutual Water Co.	—	—	—	—	—	5,760	—
17dac-2	Utah Dept. of Transportation	1974	197	8	197	—	5,750	14.7
19aaa-1	do.	9- 6-55	93	6	93	—	5,598	65.7
29cdd-1	Echo Resort	5-19-69	185	8	136	120	5,590	74.1
30bcd-1	Weber River Water Users	—	54	—	—	—	5,500	29.2
(A-3-6)25ccb-1	Staley, Claud	3-12-58	80	6	80	—	6,215	55.4
34aba-1	Jacobson, Kenneth	7- 2-64	85	6	85	42	7,000	—
34acb-1	—	—	—	—	—	—	6,050	7.1
(A-3-7)31dcb-1	Jones, Allen G.	3-16-50	58	6	58	58	6,290	9.4
(A-4-2)4cdc-1	Skeen, Blaine	8- 1-66	121	6	121	100	5,120	74.5
5bda-1	Webb	8-24-78	156	6	155	147	4,960	48.7
5bdd-1	Morgan Enterprises	8-17-68	315	8	302	175	4,965	—
6dbc-1	Peterson Pipeline Co.	6-26-67	215	12	139	—	4,910	—
8aaa-1	Morgan Enterprises	8-10-67	175	8	175	162	4,960	42.3
8bcc-1	Morris, Dana	5-10-77	137	6	137	110	4,940	32.0
8ccd-1	Betournay	1910	44	36	44		4,995	24.4
8ccd-2	Bowen, Gary	10- -74	215	6	215	100	5,005	—
8cdc-1	Cox, Robert G.	12- 1-76	160	6	160	110	4,990	67.0
9bbc-1	Wood, G. B.	9- 4-65	170	6	169	—	4,960	39.7
16dab-1	Morris, LeRoy	1972	132	6	132	—	5,020	60.2
16dab-2	O'Driscoll, Gale	8-24-65	188	6	183	154	5,040	100
17abc-1	Layton	10- 8-68	350	8	300	300	5,000	65
17abd-2	Sloan, Richard	5-21-65	63	6	63	63	4,980	34.3
17baa-1	Duncan, Kenneth A.	4-28-67	204	6	200	160	5,000	53.0
17dbb-1	Lofgren, John	9-10-68	101	6	100	80	4,990	34.7
17dca-2	Smith, Leon	10-10-74	210	6	210	150	5,010	41.3
20aba-2	Turner, Don	11- 6-75	203	6	203	160	5,005	32.3
20add-1	Nelson, W. Brent	10-29-75	100	6	100	95	5,010	33.0
21cbb-1	Nelson, Carl E.	5-16-66	160	6	160	140	5,020	25.9
21cbb-2	Christensen, Ronald	7-19-72	235	6	235	180	5,010	18
21cca-1	Jenson, Robert C.	9-22-71	118	6	118	118	5,030	31.2
21cdb-2	Mecham, Steven E.	6- 1-76	135	6	135	105	5,035	30.5
21dda-1	Dillree, Don B.	9-30-67	125	6	125	101	4,990	2.4
22bac-4	Baugh, David L.	10- 5-78	205	6	205	132	5,045	59.3
22bcd-1	Thompson, C. E.	6- 8-72	105	6	—	—	4,990	4.8
22caa-2	Heiner, C. P.	9-29-73	160	6	160	160	5,020	39.9
22cda-1	Pentz, Jay I.	6-15-76	105	6	105	85	4,990	4.0
25dbc-S1	Morgan	—	—	—	—	—	5,210	—
26abd-1	Rees, Hal	11- 2-77	162	6	162	152	5,120	115.7
26bba-1	Smith, Emma L.	11- 7-62	55	6	55	55	5,075	36.5
26ccd-1	Little, Jessie C.	1936	26	—	—	—	5,030	6.3
28acc-1	—	1980	—	6	—	—	5,020	7.4
28bad-1	Peterson, B. M.	6-15-73	215	6	215	180	5,030	20.6
28bbd-1	Oliver, Dan & Vick	2-15-77	110	6	100	100	5,080	15
28bbd-2	Argyle, Rell	1978	—	6	—	—	5,060	11.0
33aba-1	Noyes, V. M.	4- 8-77	156	6	156	126	5,030	13.4
33ada-1	Giles, Arthur	11-25-58	338	6	338	148	5,045	—
34aab-1	Webster, Francis	10-30-68	127	6	127	—	5,025	6.6
34bcc-1	Johnson, Carlyle G.	7- 2-69	83	6	83	75	5,040	18.3
34ccb-3	S. Littleton Pipeline Co.	6-23-69	200	8	100	30	5,060	8
35ccc-1	Oliver, Moyle T.	6- 5-67	130	4	130	110	5,070	4.8
36bad-1	Morgan	5-15-63	175	12	170	80	5,070	40
36bca-1	do.	6-21-79	190	12	190	110	5,060	26.0
36cbd-1	do.	6-10-36	101	8	101	61	5,070	32.2
(A-4-3)27abd-1	Taggart's Gas Station	5-25-67	84	6	84	76	5,180	11.8
28bcc-1	Rees, Joe	5-12-35	60	6	60	—	5,145	—
31bcc-1	Morgan Co.	1937	40	6	40	—	5,080	18.5
31cab-1	Como Springs Resort	1- -35	40	6	—	—	5,080	2.2
31cab-S1	do.	—	—	—	—	—	5,120	—
31cbb-1	Morgan Fur Farm	9- 4-41	15	2.5	15	12	5,075	14.5
32abc-1	Round Valley Resort	8-10-70	117	8	117	102	5,150	49
32abd-1	Ercanbrack, Weldon	4-10-35	127	8	127	103	5,180	81.7
(A-4-4)4adb-1	Pentz, Larry	5-26-76	70	8	70	70	5,480	45.7
16bca-1	Windley, Rickie D.	4-25-79	102	—	102	100	5,370	22
19dca-1	Ideal Cement Co.	1958	45	48	45	—	5,260	8.9
19dda-1	do.	1958	45	48	45	—	5,260	8.5
20bad-1	Moulding, Gloria T.	11-21-78	90	6	90	62	5,300	8.1

Date water level measured	Type of pump	Discharge (gallons per minute)	Date discharge measured	Use of water	Principal aquifer	Other data available	Remarks
9-28-79	S	30R,B	7-10-75	H,I,C	211ECCN	C,L	—
9-28-79	--	50R	9-15-53	U	111ALVM	L	—
4-28-80	--	60R	5- 9-69	H	211ECCN	—	—
--	--	3F	10- 5-79	U	211ECCN	C	One of Beckwith Springs.
10- 5-79	S	560R	74	H	211ECCN	--	--
10- 5-79	S	5R,B	9- 6-55	H	211ECCN	C	Casing assumed to be 93 feet.
9-27-79	S	40R,B	5-19-69	H,I,R	111ALVM	C,L	—
9-28-79	S		—	H	111ALVM	C	—
4-28-80	S	8R,B	3-12-58	U	124WSTC	—	—
--	S	2R,B	7- 2-64	H	211WNSP	C	—
10- 4-79	--	—	--	U	—	—	—
4-28-80	—	30R,B	3-16-50	H	124WSTC	—	—
5-17-79	S	5R,B	8- 1-66	H	123NRWD	C	—
8-29-79	S	30R,B	8-24-78	H	123NRWD	—	—
-	--	149R	8-17-68	P	123NRWD	C,L	—
-	—	—	—	U	123NRWD	L	—
5-31-79	—	75R,B	8-10-67	P	111ALVM	C,L	—
9-27-79	S	10R,B	5-10-77	H	111ALVM	C	—
9-25-79	—	—	--	U	111ALVM	W	—
--	S	30R,B	10- -74	H	123NRWD	L	—
5-10-79	S	10R,B	12- 1-76	H	123NRWD	C	—
5-17-79	S	25R,B	9- 4-65	H	111ALVM	—	—
9-27-79	S	—	—	H	—	C	—
8-24-65R	S	30R,B	8-24-65	H	111ALVM	L	—
10-10-68R	S	20R,B	10- 8-68	H	123NRWD	L	Gravel packed 295 to 350 feet.
5-10-79	S	10R,B	5-21-65	H	111ALVM	C	—
5-10-79	S	16R	4-28-67	H,I,S	123NRWD	—	—
10- 6-79	S	30R,B	9-10-68	H	111ALVM	—	—
5-11-79	S	10R,B	10-10-74	H	123NRWD	L	—
5-10-79	S	10R,B	11- 6-75	H	123NRWD	C	—
5-10-79	--	15R,B	10-29-75	H,I,S	111ALVM	—	—
9-27-79	S	10R,B	5-16-66	H	123NRWD	C	—
7-19-72R	--	10R,B	7-19-72	H	123NRWD	L	—
5-10-79	S	10R,B	9-22-71	H	123NRWD	--	—
5-11-79	S	10R,B	6- 1-76	H	123NRWD	-	—
9-20-79	S		--	H	111ALVM	C,L	—
5-16-79	S	30R,B	10- 5-78	H,S	123NRWD	C	—
6- 1-79	S	10R,B	6- 8-72	H	111ALVM	—	Probably cased to 105 feet.
5-16-79	S	10R,B	9-29-73	H	--	—	—
9-20-79	S	10R,B	6-15-76	H	111ALVM	C	—
	--	--	—	P	—	—	Robinson Spring; temperature 10°C, specific conductance 515 micromhos per centimeter at 25°C.
5-17-79	S	15R,B	11- 2-77	H,I,S,	123NRWD	C,L	—
9-21-79	S	5R,B	11- 7-62	H	111ALVM	C	—
9- 7-78	—	—	—	I	111ALVM	C,W	—
4- 8-80	—	—	—	H	—	—	—
5-11-79	S	10R,B	6-15-73	H	123NRWD	C	—
2-15-77R	S	20R,B	2-15-77	H	123NRWD	C	Drilled to 42 feet 10-5-75 and deepened to 110 feet 2-15-77.
5-11-79	—	—	—	—	—	--	—
9- 7-79	S	10R,B	4- 8-77	H	123NRWD	—	—
--	--	30R,B	11-25-58	H	123NRWD	L	Dug to 22 feet in 1900; deepened to 164 feet 9-6-46 and perforated 148 to 158 feet; deepened to 338 feet 11-25-58, casing assumed 338 feet.
5-17-79	S	40R,B	10-30-68	H,I,S	111ALVM	C	—
10- 6-79	S	35R,B	7- 2-69	H,S	111ALVM	C	—
6-23-69R	T	40R,B	6-23-69	P	111ALVM	C,L	—
9- 6-79	S	20R	6- 5-67	H	123NRWD	C	—
5-16-63R	T	450R	5-16-63	P	111ALVM	C	—
4-11-80	T	2,550R	6-21-79	P	111ALVM	C,L	—
4-11-80	T	315R	6-10-36	P	111ALVM	C	--
8-13-79	S	45R,B	5-25-67	C	111ALVM	C	—
--	S	40R	5-12-35	H	111ALVM	C	Casing assumed 60 feet.
9- 3-80	—	36R	9-22-37	I	111ALVM	W	—
9-25-79				U	111ALVM	W	—
				R	--	C	Como Springs.
6-20-79	S	10R	9- 6-41	U	111ALVM		Casing assumed 15 feet.
8- -70R	S	100R	8-10-70	I,P	124WSTC	L	
11-19-79	S	35R	4-10-35	H	124WSTC	C	
10- 2-79	S	60R,B	5-26-76	H	124WSTC	C	
4- -79R		25R,B	4-25-79	H,I	125EVNS	L	
12- 4-79	T			N,P	111ALVM		
12- 4-79	T			N,P	111ALVM	C	
8-13-79	S	50R	11-21-78	H	111ALVM	C	Casing assumed 90 feet.

Location	Owner	Date completed	Depth of well (feet)	Casing diameter (inches)	Depth cased	Depth to first opening (feet)	Altitude of land surface (feet)	Water level (feet)
(A-4-4)33dcc-1	Anderton, Charles I.	4- 4-58	45	6	45	25	5,316	9.3
(A-5-1)23bcc-1	Nelson, C. S.	11- 72	126	6	125	105	5,065	35
25add-1	Nance, Russell	1915	30	-	-	-	4,900	24.0
25add-2	do.	10-10-68	128	6	128	92	4,900	18.0
25bca-1	Love, Hugh W.	10- -74	113	6	113	102	4,870	13.1
25bca-2	Warner, Paul F.	12- 3-66	507	6	142	142	4,875	-
25bda-1	Warner, Lloyd R.	12- 8-46	121	6	121	58	4,870	14.0
25cbc-1	Utah Dept. of Transportation	9-30-65	175	8	175	130	4,870	10.2
26aca-1	Associated Steel Foundries Co.	8-30-72	200	10	194	118	4,860	7.5
26bcd-1	Poll, Verland	7-28-65	120	6	118	73	4,825	2.6
27bcd-1	Adams, Brent W.	7-31-75	190	6	190	100	4,960	70.8
27cdb-1	U.S. Bureau of Reclamation	6-22-57	142	6	142	132	4,835	22.5
27dba-1	France, E. R.	1933	150	6	–	–	4,835	1.4
(A-5-2)19cda-1	Browning Arms Co.	4- 4-63	170	12	166	63	4,965	9.2
19dbd-1	do.	1- -73	187	8	187	105	4,990	6.0
30cab-1	Wilkinson, Harry	6- 5-71	145	10	145	76	4,920	54.9P
30cbc-1	LDS Church, Peterson	6- 8-62	144	8	144	122	4,920	45.1
30ccd-1	Wilkinson, Harry	8-29-78	180	8	180	180	4,900	56.7P
31bad-1	Wilkinson, Max	11-13-64	176	6.5	176	140	4,925	47.4
31bba-1	Lang	11- 9-46	129	6	129	123	4,865	11.2
31dca-1	Union Pacific Railroad	3-28-46	69	5	69	49	4,890	11.2
31dcc-1	Olsen, Reinhardt	1934	20	72	20	–	4,885	6.6
(A-5-4)26dba-1	Lost Creek Ranch	10- 3-77	84	6	81	75	5,645	19.5
35abc-1	do.	8- 1-72	84	8	84	76	5,610	16

Date water level measured	Type of pump	Discharge (gallons per minute)	Date discharge measured	Use of water	Principal aquifer	Other data available	Remarks
8-13-79	S	12R,B	4- 4-58	H,S	111ALVM	C	–
11- -72R	S	25R,B	11- -72	H	123NRWD	C,L	–
9-25-79	–	–	–	U	111ALVM	W	–
5-25-79	S	20R,B	10-10-68	H,I	111ALVM	–	–
4-10-80	S	30R,B	10- -74	H	123NRWD	C	–
	–	–	–	U	123NRWD	L	Drilled 174 feet 11-2-66; deepened to 507 feet 12-3-66, not completed, insufficient water.
5-25-79	–	24R	12- 8-46	S	123NRWD	–	Deepened from 37 feet 12-8-46; casing assumed 121 feet.
5-31-79	S	250R	9-13-64	P,I	111ALVM	C,L	–
5-31-79	S	22R	8-30-72	I	123NRWD	L	–
4-10-80	–	35R,B	7-28-65	P	123NRWD	C	–
5-24-79	S	4R,B	7-31-75	H,I	124WSTC	C,L	–
5-24-79	S	50R	1957	H	111ALVM	–	–
9-25-79	–	–	–	U	–	W	–
5-25-79	T	350R	4- 4-63	H	111ALVM	C,L	–
5-25-79	S	60R	1- -73	N	123NRWD	–	–
5-25-79	–	40R	6- 5-71	H	111ALVM	L	–
4-10-80	S	150R,B	6- 8-62	H	111ALVM	C	–
5-25-79	–	400R	8-29-78	P	111ALVM	–	–
6- 1-79	–	15R,B	11-13-64	H	123NRWD	L	–
6- 1-79	S	22R	11- 9-46	H	111ALVM	C	–
6- 1-79	–	15R	3-28-46	H	111ALVM	–	–
4-10-79	C	–	–	I	111ALVM	C	–
8-30-79	–	24R,B	10- 3-77	H,I,S	124WSTC	C,L	–
8- 1-72R	–	40R,B	8- 1-72	H	124WSTC	C	–

Table 6.--Drillers' logs of selected wells

Well number: See text for explanation of well-numbering system.
Altitudes: Given in feet above NGVD of 1929 and interpolated from topographic maps.
Thickness: Given in feet.
Depth: Given in feet below the land surface. Depths to base of alluvium were estimated from logs; estimated designation of rock units below the alluvium was from logs and geologic maps.

Material	Thickness	Depth
(A-2-5)4bcd-1. Log by M. Church Drilling Co. Altitude 5,630. Depth to the base of alluvium 7 feet. Rock below alluvium is Wanship Formation of local usage (not adopted by the U.S. Geological Survey).		
Clay	4	4
Conglomerate	3	7
Shale, gray	13	20
Shale, sandy, tan	14	34
Sandstone	2	36
Shale, gray	13	49
Shale, dark-gray	34	83
Shale, gray	6	89
Sandstone	2	91
Soapstone	20	111
Shale, sandy, gray	3	114
Soapstone	14	128
Shale, tan	8	136
Soapstone	8	144
Sandstone	3	147
Shale, tan	6	153
Soapstone	14	167
Sandstone	8	175
Soapstone	8	183
Sandstone	5	188
Soapstone	4	192
(A-2-5)9bac-1. Log by Uintah Basin Drilling Co. Altitude 5,700. Depth to base of alluvium 95 feet. Rock unit below alluvium is Frontier Formation.		
Clay	95	95
Coal	5	100
Bedrock	100	200
Shale	20	220
Bedrock	180	400
Shale	100	500
(A-2-5)9cdb-1. Log by M. Church Drilling Co. Altitude 5,610. Depth to base of alluvium 28 feet. Rock unit below alluvium is Frontier Formation.		
Boulders	8	8
Boulders; water seepage	4	12
Clay and boulders	16	28
Shale, red	10	38
Chips; water seepage	1	39
Shale, multi-colored	21	60
Sand, dry	3	63
Shale, red, colored streaks.	9	72
Sandstone, brown	8	80
Shale, gray	5	85
Shale, green	2	87
Shale, red	21	108
Shale, light-gray	50	158
Shale, tan	9	167
Limestone, brown	24	191
Shale, red	162	353
Siltstone	5	358
Shale, red	37	395
Soapstone	19	414
Shale, gray	44	458
Soapstone	19	477
Siltstone	13	490
Shale, tan	10	500
(A-2-5)10aaa-2. Log by Wasatch Drilling (0-125 feet) and Petersen Bros. Drilling Co. (125-230 feet). Altitude 5,800. Depth to base of alluvium 23 feet. Rock unit below alluvium is Frontier Formation.		
Clay and gravel	23	23
Clay, red	7	30
Clay	20	50
Limestone, black	5	55
Clay	35	90
Sandstone	5	95
Clay, red; some water	10	105
Sandstone	10	115
Clay, red	10	125
Limestone	7	132
Clay and gravel, red	83	215
Gravel	15	230
(A-2-5)11acb-3. Log by Petersen Bros. Drilling Co. Altitude 5,740. Depth to base of alluvium 55 feet. Rock unit below alluvium is Frontier Formation.		
Topsoil	2	2
Gravel and clay, brown	33	35
Clay, red, brown	20	55
Clay, blue	8	63
Conglomerate and clay; some water	32	95
Clay, brown	7	102
Conglomerate and clay; water	33	135
Clay, brown	5	140
Conglomerate and clay	23	163
Clay	2	165
Conglomerate and clay, blue.	15	180
(A-2-5)15bdb-1. Log by Livingston and Wilson. Altitude 5,900. Depth to base of alluvium 65 feet. Rock unit below alluvium is Frontier Formation.		
Clay, soft, gray	65	65
Sandstone, hard	5	70
Sand, loose; water	25	95
Clay, soft, gray	4	99
Coal	12	111
Clay bentonitic	6	117
Coal	4	121
Clay, yellow	1.5	122.5
Sandstone, conglomeratic	2.5	125
Clay, soft, gray	7	132
Sandstone, hard	3	135
Sandstone interbedded with gray streaks	15	150
(A-2-5)17bad-1. Log by M. Church Drilling Co. Deepening log by Hubbard Drilling Co. Altitude 5,580. Depth to base of alluvium 24 feet. Rock unit below alluvium is Wanship Formation (of local usage).		
Fill, manmade	8	8
Topsoil	3	11
Clay and boulders	13	24
Shale, gray	38	62
Sandstone	6	68
Shale, blue	13	81
Shale, gray-green	8	89
Shale, gray	4	93
Sandstone	12	105
Shale, blue	10	115
Shale, gray	8	123
Sandstone	8	131
Shale, gray	7	138
Shale, blue	47	185
Sandstone	9	194
Deepening (may represent redrilling of a caved well)		
Shale, gray, dense	9	109
Shale, blue	3	112
Sandstone, gray	4	116
Sandstone, gray with shale particles	7	123
(A-2-5)20dbd-2. Log by Petersen Bros. Drilling Co. Altitude 5,655. Depth to base of alluvium 55 feet. Rock unit below alluvium is Wanship Formation (of local usage).		
Topsoil	2	2
Sand and gravel, brown	12	14
Clay, brown	21	35
Gravel, small, and sand, brown	20	55
Clay, blue	10	65
Clay, light-gray, dusty	7	72
Clay, blue; some water	15	87
Clay, blue, dense	48	135
Clay, light-blue	13	148
Clay, gray, hard, dusty	92	240
Hardpan and limestone; small amount of water	10	250
(A-2-5)21dcd-1. Log by Wright Drilling Co. Altitude 5,690. Depth to base of alluvium 33 feet. Rock unit below alluvium is of the Tertiary System (Wasatch or Evanston(?) Formations).		
Clay	8	8
Gravel and water	25	33
Bedrock, red shale	4	37
Conglomerate	5	42
Sandy shale	12	54
Sandstone and shale layers	11	65
Gray shale	15	80
Red shale	35	115
Sandstone and shale layers	21	136
Red shale	6	142
Sandstone	12	154
Conglomerate; water	29	183
Gravel and red shale	18	201
Shale, red, sandy	54	255
Conglomerate; water	20	275
Shale, red, sandy	22	297
Conglomerate; water	8	305
Shale, red, sandy	9	314
Conglomerate; water	47	361
Shale, red	-	361
(A-2-5)28dcb-1. Log by Cec Stephenson Drilling. Altitude 5,675. Depth to base of alluvium 130 feet. Rock unit below alluvium is Wasatch Formation.		
Topsoil	12	12
Clay, sand, and sandy clay	8	20
Cobbles	10	30
Clay and sandstone blocks	20	50
Sandstone	2	52
Clay, sand, and sandy clay	6	58
Sand, gravel, cobbles, and cemented gravel	17	75
Gravel and cobbles	25	100
Sand and gravel	30	130
Limestone, solid	27	157
Shale, red	45	202
(A-3-2)2dcb-1. Log by Petersen Bros. Drilling Co. Altitude 5,080. Depth to base of alluvium 60 feet. Rock unit below alluvium is Norwood Tuff.		
Clay, silt, and topsoil	2	2
Clay, silt, cobbles, and fill dirt	13	15
Gravel, cobbles, and boulders; some surface water	25	40
Clay, red	4	44
Sand, gravel, and cobbles; some water	16	60
Shale, red	10	70
Shale, brownish-red	25	95
Conglomerate	25	120
(A-3-2)4dbb-1. Log by Petersen Bros. Drilling Co. Altitude 5,120. Depth to base of alluvium 43 feet. Rock unit below alluvium is Norwood Tuff.		
Topsoil	3	3
Gravel, cobbles, and topsoil	8	11
Clay and cobbles, gray	12	23
Cobbles	1	24
Clay and gravel, gray	6	30
Clay and gravel, brown; water	13	43
Gravel and reddish-brown shale; water	7	50
Shale, reddish brown	24	74
Gravel and reddish-brown shale	2	76
Gravel and shale; water	5	81
Gravel and reddish-brown shale; water	15	96
Sand and reddish-brown shale	14	110
Clay, brown	16	126
Hardpan	9	135

Table 6.--Drillers' logs of selected wells--Continued

Material	Thickness	Depth
(A-3-2)11caa-1. Log by Petersen Bros. Drilling Co. Altitude 5,135. Depth to base of alluvium 60 feet. Rock unit below alluvium is Norwood Tuff.		
Silt	4	4
Clay	21	25
Clay, gravel, and cobbles	7	32
Clay, dense	9	41
Clay, gravel, and cobbles	19	60
Bedrock hardpan	130	190
(A-3-2)12cab-1. Log by Petersen Bros. Drilling Co. Altitude 5,100. Depth to base of alluvium 90 feet. Rock unit below alluvium is Norwood Tuff.		
Clay	4	4
Clay, gravel, and cobbles	42	46
Clay, red	17	63
Cobbles and boulders	27	90
Conglomerate, red; water 15 gallons per minute	15	105
Shale, red	24	129
Conglomerate, red; water at 160 feet	31	160
Sandstone, red	80	240
Limestone, broken; water	20	260
Sandstone, red, hard	40	300
Sandstone, red, broken; water	10	310
(A-3-2)24caa-1. Log by Petersen Bros. Drilling Co. Altitude 5,165. Depth to base of alluvium 66 feet. Rock unit below alluvium is Norwood Tuff.		
Clay, silt, and surface soil	4	4
Clay, sand, and gravel; water	18	22
Clay, dense, tight	25	47
Clay, gravel, and cobbles	19	66
Hardpan and conglomerate	32	98
Conglomerate; water	22	120
(A-3-2)26aab-1. Log by Petersen Bros. Drilling Co. Altitude 5,300. Depth to base of alluvium 10 feet. Rock unit below alluvium is Norwood Tuff to 308 feet; below 308 feet rock unit is Wasatch Formation.		
Clay, brown	10	10
Clay, white	30	40
Clay and sand, no water	12	52
Clay, white	28	80
Shale, white	5	85
Clay, red, and shale	56	141
Clay, blue, and sand; no water	19	160
Clay, red	23	183
Clay, blue, and sand; no water	13	196
Clay, red	9	205
Clay, brown	15	220
Shale, different color; some water	28	248
Clay, red	17	265
Shale and clay	43	308
Sandstone, fractured; water at 15-20 gallons per minute	42	350
(A-3-2)26acb-1. Log by Billings Drilling Co. Altitude 5,340. Depth to base of alluvium 74 feet. Rock unit below alluvium is Norwood Tuff.		
Topsoil	3	3
Clay, sand, gravel, cobbles, red, and thin clay streaks	42	45
Boulders, very hard	1	46
Sand, gravel, cobbles, and boulders	28	74
Clay, red, and thin rock layers	37	111
Clay, blue speckled	13	124
Clay, white, sandy, soft	10	134
Clay, blue, white	12	146
Clay, brown	63	209
Clay, white, blue streaks	6	215
Clay, brown, hard streaks	36	251
Clay, blue	36	287
Clay, rock streaks	1	288
Clay	1	289
Shale	1	290
(A-3-2)26acb-1.--Continued		
Clay, brown, hard thin rock streaks	65	355
Clay and gravel	9	364
Clay	10	374
Clay and gravel	2	376
Clay, brown	3	379
Clay and gravel	1	380
Clay and streaks of shale	16	396
(A-3-4)3add-1. Log by Petersen Bros. Drilling Co. Altitude 5,690. Depth to base of alluvium 45 feet. Rock unit below alluvium is Wanship Formation (of local usage).		
Silt and topsoil	4	4
Gravel, cobbles, and boulders, hard drilling	21	25
Gravel; water at approximately 40 gallons per minute	20	45
Conglomerate, broken	45	90
Conglomerate, hard	105	195
Bedrock, sandstone, hard	25	220
Sandstone, soft; water	45	265
(A-3-4)4ddd-1. Log by Petersen Bros. Drilling Co. Altitude 5,325. Depth to base of alluvium 76 feet. Rock unit below alluvium is Wanship Formation (of local usage).		
Topsoil	1	1
Clay, gravel, cobbles, and boulders	6	7
Clay and sand, soft; with some water	2	9
Clay, gravel, and hardpan, very hard and tight	31	40
Gravel; water	25	65
Clay and gravel, hard and tight	3	68
Clay and gravel, softer; water	8	76
Shale, extremely hard; water	6	82
Shale, softer	41	123
Shale	2	125
(A-3-4)24dbd-1. Log by Petersen Bros. Drilling Co. Altitude 5,475. Depth to base of alluvium 60 feet. Rock unit below alluvium is Echo Canyon Conglomerate.		
Topsoil	4	4
Gravel and cobbles	6	10
Gravel and clay	20	30
Clay, brownish-red	30	60
Water at 30 gallons per minute	18	78
Conglomerate	52	130
(A-3-4)25abc-1. Log by J. V. Stoddard Drillers Inc. Altitude 5,442. Depth to base of alluvium is greater than 52 feet.		
Clay	20	20
Clay and gravel	15	35
Gravel	11	46
Gravel with little clay and rock	4	50
Gravel	2	52
(A-3-5)29cdd-1. Log by Ben B. Gardner Drilling Co. Altitude 5,590. Depth to base of alluvium 126 feet. Rock unit below alluvium is Wanship Formation (of local usage).		
Clay, gravel, and boulders	54	54
Gravel and boulders; water	14	68
Clay, gravel, and boulders	32	100
Gravel and boulders; water	9	109
Clay, gravel, and boulders	13	122
Gravel and boulders; water	4	126
Conglomerate	35	161
Shale, red	5	166
Shale, blue	19	185
(A-4-2)5bbd-1. Log by J. S. Lee and Sons. Altitude 4,965. Depth to base of alluvium 59 feet. Rock unit below alluvium is Norwood Tuff.		
Topsoil	3	3
Gravel and boulders	4	7
(A-4-2)5bbd-1.--Continued		
Clay and boulders, brown	18	25
Gravel and boulders	34	59
Clay, blue	41	100
Clay, sand, and gravel	75	175
Gravel; water	5	180
Clay, brown	70	250
Clay and gravel	18	268
Clay and gravel; little water	9	277
Clay and gravel, sandy	12	289
Clay, sand, and gravel	16	305
Bedrock, gray shale	10	315
(A-4-2)6dbc-1. Log by J. S. Lee and Sons. Altitude 4,910. Depth to base of alluvium 138 feet. Rock unit below alluvium is Norwood Tuff.		
Sand, gravel, and boulders	24	24
Clay, gray	34	58
Clay, sandy	41	99
Conglomerate	20	119
Clay, sticky	3	122
Clay and gravel, hard	16	138
Bedrock, pummy stone	44	182
Gray shale	33	215
(A-4-2)8aaa-1. Log by L. S. Lee and Sons. Altitude 4,960. Depth to base of alluvium is greater than 175 feet.		
Topsoil	2	2
Clay and gravel, hard	6	8
Clay, brown	11	19
Gravel, dry	36	55
Clay, brown	23	78
Sand, brown	76	154
Gravel; water	18	172
Clay and gravel, sandy-brown	3	175
(A-4-2)8ccd-2. Log by Petersen Bros. Drilling Co. Altitude 5,005. Depth to base of alluvium 42 feet. Rock unit below alluvium is Norwood Tuff.		
Clay and surface soil	6	6
Clay, sand, gravel, and cobbles	36	42
Bedrock conglomerate	48	90
Shale, red; water at 2 gallons per minute	50	140
Shale, red; water at 3 gallons per minute	55	195
Shale, red; water at 20 gallons per minute	20	215
(A-4-2)16dab-2. Log by J. Petersen and Sons. Altitude 5,040. Depth to base of alluvium 176 feet. Rock unit below alluvium is Norwood Tuff.		
Topsoil	2	2
Clay, yellow	23	25
Gravel	5	30
Clay, yellow	5	35
Clay and gravel	6	41
Clay and sand	45	86
Clay	4	90
Clay, sand, and gravel	22	112
Gravel; no water	8	120
Sand and gravel	8	128
Clay with streaks of gravel; water	32	160
Sand and gravel	11	171
Clay, yellow and gravel	5	176
Clay, blue	12	188
(A-4-2)17abc-1. Log by Ben B. Gardner. Altitude 5,000. Depth to base of alluvium 92 feet. Rock unit below alluvium is Norwood Tuff.		
Silt	1	1
Silt and boulders	19	20
Boulders; small quantity of water	2	22
Clay, gravel, and boulders	48	70
Clay, sand, gravel	22	92
Clay, white	7	99
Clay and sand; small quantity of water	56	155
Clay and gravel; small quantity of water	12	167
Clay, white	21	188
Sand; water	25	213
Clay and sandy	44	257
Sand; water	4	261

Material	Thickness	Depth
(A-4-2)17abc-1.--Continued		
Sand and gravel; water	39	300
Sand and gravel, streaks; small quantity of water ..	50	350
(A-4-2)17dca-2. Log by George C. Morris. Altitude 5,010. Depth to base of alluvium 150 feet. Rock unit below alluvium is Norwood Tuff.		
Clay, hard	28	28
Boulders, large	6	34
Clay and sand, soft	36	70
Clay, hard	60	130
Clay and gravel	10	140
Clay, soft	10	150
Clay and sandstone	40	190
Clay, sand, gravel, and fine sand	20	210
(A-4-2)21cbb-2. Log by George C. Morris. Altitude 5,010. Depth to base of alluvium 40 feet. Rock unit below alluvium is Norwood Tuff.		
Topsoil	12	12
Clay and gravel, gray	28	40
Clay, gray	40	80
Clay and coarse gravel	80	160
Sandstone	68	228
Shale	7	235
(A-4-2)21dda-.1 Log by J. G. Lee Drilling Co. Altitude 4,990. Depth to base of alluvium greater than 120 feet.		
Topsoil and gravel	3	3
Sand	4	7
Gravel and boulders	12	19
Sand	63	82
Gravel	38	120
(A-4-2)26adb-1. Log by J. Gary Petersen and Sons. Altitude 5,120. Depth to base of alluvium 16 feet. Rock unit below alluvium is Tertiary and Quaternary conglomerate (to 97 feet?) and Norwood Tuff(?).		
Clay, light-brown	16	16
Clay, cobbles, and boulders.	11	27
Clay and boulders	39	66
Clay, gravel, cobbles, and boulders	18	84
Clay, dark-brown	13	97
Clay, gravel, and cobbles, light-red	7	104
Clay, red	15	119
Clay, gravel, cobbles, and boulders, red	23	142
Clay, gravel, and cobbles ..	10	152
Gravel; water at 15 gallons per minute	-	152
Clay, gravel, and cobbles ..	8	160
Gravel; water at 10 gallons per minute	2	162
(A-4-2)33ada-1. Log by J. G. Turner (22 to 162 feet) and Larry W. Dalton (162 to 338 feet), interpreted by J. I. Steiger. Altitude 5,045 feet. Depth to base of alluvium 62 feet. Rock unit below alluvium is Norwood Tuff.		
Dug, no record	22	22
Sand	15	37
Clay, reddish, and sand	25	62
Sandstone, brownish	20	82
Sandstone, gray	63	145
Sand	2	147
Gravel	15	162
Shale, sticky	61	223
Boulders	6	229
Shale, gumbo	109	338
(A-4-2)34ccb-3. Log by Ben B. Gardner Drilling Co. Altitude 5,060. Depth to base of alluvium 59 or 151 feet. Rock unit below alluvium is Norwood Tuff.		
Silt and topsoil	4	4
Clay and sand	20	24
Clay, gravel, and boulders; water	35	59
Clay, sand, and gravel	84	143
Clay, brown, and sand	8	151
Clay, white and sand	25	176
Shale, white	24	200
(A-4-2)36bca-1. Log by J. S. Lee and Sons. Altitude 5,060. Depth to base of alluvium greater than 189 feet.		
Sand, gravel, and boulders .	25	25
Sand, dry	16	41
(A-4-2)36bca-1.--Continued		
Gravel; water	64	105
Sand	3	108
Sand, gravel, and boulders; water	78	186
Clay, gravel, and boulders .	3	189
(A-4-3)32abc-1. Log by Charles W. Stoddard. Altitude 5,150. Depth to base of alluvium 85 feet. Rock unit below alluvium is Wasatch Formation.		
Clay	25	25
Gravel, pea	2	27
Clay	17	44
Gravel	8	52
Clay	33	85
Boulders and shale	7	92
Gravel	12	104
Shale	4	108
Boulders	9	117
(A-4-4)16bca-1. Log by Gary Petersen and Sons. Altitude 5,370. Depth to base of alluvium 45 feet. Rock unit below alluvium is Evanston(?) Formation.		
Clay, silt, and topsoil	2	2
Clay, red	20	22
Clay, sand, and gravel, light-brown	23	45
Conglomerate, broken	5	50
Conglomerate, hard	30	80
Conglomerate, broken	18	98
Conglomerate, soft; water ..	4	102
(A-5-1)23bcc-1. Log by Petersen Bros. Drilling Co. Altitude 5,065. Depth to base of alluvium 21 feet. Rock unit below alluvium is Norwood Tuff.		
Silt and surface soil	1	1
Cobbles and boulders	11	12
Clay and gravel, brown	9	21
Clay and sand, dense	11	32
Clay, green	4	36
Clay and sand, brown	5	41
Clay and shale, blue	17	58
Clay and shale, gray	12	70
Clay and shale, blue	19	89
Clay, bedrock, fractured shale, gray; with water ..	37	126
(A-5-1)25bca-2. Log by J. S. Lee and Sons (0 to 174 feet) and Charles W. Stoddard (177 to 507 feet). Altitude 4,875. Depth to base of alluvium 83 feet. Rock unit below alluvium is Norwood Tuff.		
Gravel and boulders	18	18
Sand, brown	65	83
Clay, blue, sandy	64	147
Bedrock, blue shale	27	174
No record	3	177
Shale, brown, white	58	235
Clay, brown	3	238
Shale, brown	6	244
Clay, brown, sticky	19	263
Sand	3	266
Clay, brown, sticky	12	278
Clay, blue	5	283
Clay, brown, sticky	32	315
Shale, brown	47	362
Shale, blue	28	390
Clay, blue and white shale .	32	422
Clay, blue and light-blue shale	16	438
Shale, brown, white	69	507
(A-5-1)25cbc-1. Log by Petersen Bros. Drilling Co. Altitude 4,870. Depth to base of alluvium 175 feet. Rock unit below alluvium Norwood Tuff(?).		
Clay, sand, and cobbles	18	18
Sand	55	73
Sand and gravel	46	119
Gravel; much water	34	153
Clay and gravel; water	5	158
Gravel, clean; water	8	166
Gravel, hard, tight	3	169
Gravel, clean; water	6	175
Clay, yellow	-	175
(A-5-1)26aca-1. Log by Petersen Bros. Drilling Co. Altitude 4,860. Depth to base of alluvium 49 feet. Rock unit below alluvium is Norwood Tuff.		
Silt and surface soil	2	2
Clay, silt, gravel, and cobbles; small amount surface water	15	17
Clay	3	20
Gravel and cobbles	8	28
(A-5-1)26aca-1.--Continued		
Cobbles	13	41
Clay, dense	6	47
Sand	2	49
Clay and white shale	38	87
Gravel and cobbles, cemented	13	100
Clay and blue shale	18	118
Gravel, cemented; water	13	131
Clay and blue shale	4	135
Clay, gravel, and conglomerate; water	20	155
Clay, white	9	164
Gravel; water	1	165
Clay, gravel, and white, hard shale	13	178
Clay and white, soft shale .	22	200
(A-5-1)27bcd-1. Log by Petersen Bros. Drilling Co. Altitude 4,960. Depth to base of alluvium 80 feet. Rock unit below alluvium is Wasatch Formation.		
Clay, silt, and topsoil	2	2
Gravel, cobbles, and boulders	28	30
Gravel; water at 2 gallons per minute	1	31
Gravel, cobbles, and boulders; water at 4-5 gallons per minute	29	60
Clay, cobbles, and some red shale	20	80
Conglomerate, broken	10	90
Conglomerate, hard, red	33	123
Conglomerate, hard, broken; water at 3-4 gallons per minute	67	190
(A-5-2)19cda-1. Log by J. S. Lee and Sons. Altitude 4,965. Depth to base of alluvium 153 feet. Rock unit below alluvium is Norwood Tuff.		
Topsoil and boulders	6	6
Boulders	12	18
Gravel and boulders	43	61
Gravel, clean; water	22	83
Clay and gravel	70	153
Bedrock, blue shale	17	170
(A-5-2)30cab-1. Log by Petersen Bros. Drilling Co. Altitude 4,920. Depth to base of alluvium 116 feet. Rock unit below alluvium is Norwood Tuff.		
Silt and topsoil	2	2
Clay and silt	5	7
Cobbles	9	16
Clay, tight, dense	11	27
Cobbles	13	40
Gravel and cobbles, dark-brown; water	29	69
Cobbles, light-brown; no water	7	76
Gravel and dark-brown cobbles; water	11	87
Clay	5	92
Gravel and cobbles; water ..	24	116
Clay, red	29	145
(A-5-2)31bad-1. Log by John A. Nak Drilling Co. Altitude 4,925. Depth to base of alluvium 113 feet. Rock unit below alluvium is Norwood Tuff.		
Topsoil	15	15
Gravel	5	20
Clay, red	10	30
Clay, sandy	33	63
Clay and sand	50	113
Sand and sandstone; some water	22	135
Gravel and sandstone	41	176
(A-5-4)26dba-1. Log by J. Gary Petersen and Sons. Altitude 5,645. Depth to base of alluvium 81 feet. Rock unit below alluvium is Wasatch Formation.		
Clay, hard, dense, light-brown	10	10
Clay and silt	26	36
Gravel; water at 5 gallons per minute	-	36
Clay, hard, dense, red	29	65
Clay, gravel, cobbles, and boulders	4	69
Clay, dense, red	3	72
Clay, light-brown	3	75
Gravel; water at 25 gallons per minute	6	81
Bedrock, limestone	3	84

Table 7.--Water levels in observation wells, 1936-80

Well number: See text for explanation of well-numbering system.
Altitude of land surface: Above National Geodetic Vertical Datum of 1929, interpolated from topographic maps.
Water levels: In feet below land surface. P, pumping; R, recently pumped.

(A- 3- 2)24CBA- 1 ALT. 5155

OCT 16, 1936	14.39	AUG 24, 1942	12.44	DEC 12, 1955	16.90	SEP 16, 1968	11.84
DEC 11	16.25	DEC 13	16.69	DEC 20, 1956	16.83	MAR 24, 1969	16.24
MAR 11, 1937	16.35	MAR 31, 1943	16.25	MAR 25, 1957	17.18	MAR 19, 1970	17.19
AUG 03	10.53	SEP 18	14.14	DEC 09	17.39	AUG 21	10.22
SEP 22	13.60	DEC 10	16.65	MAR 17, 1958	16.85	MAR 25, 1971	16.16
NOV 04	16.25	APR 14, 1944	16.15	DEC 18	16.84	SEP 21	11.45
DEC 14	16.67	DEC 13	16.77	MAR 20, 1959	16.97	MAR 23, 1972	11.12
FEB 07, 1938	16.90	MAR 23, 1945	16.76	DEC 09	16.82	SEP 29	12.65
MAR 15	15.65	NOV 22	16.55	MAR 22, 1960	16.84	MAR 20, 1973	16.82
MAY 31	13.02	MAR 30, 1946	16.94	NOV 30	16.21	SEP 10	10.77
AUG 20	12.20	DEC 12	16.37	MAR 21, 1961	17.08	MAR 21, 1974	14.68
OCT 16	15.90	MAR 12, 1947	15.84	JAN 12, 1962	16.63	SEP 13	10.89
DEC 11	16.62	DEC 15	16.81	MAR 08	16.57	MAR 19, 1975	16.55
MAR 14, 1939	16.60	MAR 26, 1948	16.94	DEC 18	17.68	SEP 09	10.24
MAY 01	15.35	JAN 12, 1949	16.56	MAR 06, 1963	17.15	MAR 04, 1976	16.40
JUN 22	10.47	MAR 29	13.25	AUG 30	13.40	SEP 13	11.65
AUG 29	15.19	DEC 06	16.94	DEC 09	16.98	MAR 04, 1977	18.60
OCT 30	12.40	APR 06, 1950	14.89	MAR 04, 1964	17.91	SEP 08	12.94
JAN 09, 1940	16.75	DEC 12	16.53	OCT 20	16.16	MAR 14, 1978	17.05
FEB 14	16.86	APR 04, 1951	16.04	DEC 10	17.88	SEP 07	11.05
APR 04	16.30	DEC 27	16.80	MAR 08, 1965	16.96	MAR 28, 1979	15.67
JUN 26	11.45	APR 17, 1952	12.98	JUL 27	8.48	SEP 25	13.30
AUG 30	16.20	DEC 29	15.10	OCT 18	17.06	MAR 19, 1980	16.55
NOV 30	16.42	APR 03, 1953	16.75	DEC 13	16.98	APR 08	16.01
MAR 14, 1941	16.75	DEC 09	16.81	MAR 16, 1966	16.66	SEP 03	11.59
SEP 27	15.78	APR 19, 1954	16.47	SEP 12	14.12		
DEC 12	16.81	DEC 08	16.70	APR 12, 1967	17.15		
MAR 09, 1942	16.45	MAR 31, 1955	16.99	MAR 14, 1968	17.20		

(A- 3- 4) 4DDB- 1 ALT. 5325

SEP 13, 1951	9.16	NOV 30, 1960	11.95	MAR 12, 1968	11.07	SEP 09, 1975	4.99
APR 17, 1952	7.91	MAR 21, 1961	11.44	SEP 16	6.61	MAR 04, 1976	9.89
DEC 29	11.09	JAN 12, 1962	12.66	MAR 24, 1969	9.11	SEP 08	5.23
APR 03, 1953	11.80	MAR 08	12.72	SEP 18	4.89	MAR 04, 1977	11.94
DEC 09	11.71	DEC 18	11.81	MAR 19, 1970	9.60	SEP 08	6.51
APR 19, 1954	11.99	MAR 06, 1963	12.85	AUG 21	4.59	MAR 14, 1978	10.31
DEC 08	12.22	AUG 30	6.83	MAR 25, 1971	9.83	SEP 07	5.14
MAR 31, 1955	11.77	DEC 09	11.76	SEP 21	6.13	MAR 28, 1979	9.18
DEC 20, 1956	11.60	MAR 04, 1964	12.96	MAR 24, 1972	8.49	SEP 25	5.74
MAR 25, 1957	10.84	OCT 20	9.04	SEP 29	6.55	MAR 19, 1980	8.32
MAR 17, 1958	10.87	DEC 10	11.15	MAR 20, 1973	9.06	APR 11	8.09
DEC 18	11.33	MAR 08, 1965	11.36	SEP 10	5.08	SEP 05	4.34
MAR 20, 1959	11.79	OCT 18	9.23	MAR 21, 1974	8.52		
DEC 09	12.12	MAR 16, 1966	10.19	SEP 13	4.98		
MAR 21, 1960	11.53	APR 12, 1967	10.77	MAR 19, 1975	9.25		

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NOV 24, 1939	30.40	DEC 06, 1949	19.32	MAR 21, 1961	32.89	SEP 21, 1971	21.90
AUG 30, 1940	26.09	APR 06, 1950	18.45	JAN 12, 1962	30.73	MAR 23, 1972	17.45
NOV 24	18.57	DEC 12	19.52	MAR 08	16.73	SEP 29	22.27
MAR 14, 1941	17.56	APR 04, 1951	17.17	DEC 18	32.04	MAR 30, 1973	17.09
SEP 27	17.57	DEC 27	19.37	MAR 06, 1963	30.83	SEP 10	29.56
DEC 12	19.61	APR 17, 1952	14.49	AUG 30	33.20	MAR 21, 1974	17.70
MAR 09, 1942	31.75	DEC 29	35.79	DEC 09	30.28	SEP 13	25.91
AUG 24	18.77	APR 03, 1953	18.65	MAR 11, 1964	41.09	MAR 19, 1975	18.73
DEC 13	21.66	DEC 09	20.25	OCT 20	19.37	SEP 09	19.48
MAR 31, 1943	17.43	APR 19, 1954	17.08	DEC 10	20.40	MAR 04, 1976	14.24
SEP 18	20.20	DEC 08	20.18	MAR 08, 1965	19.61	SEP 13	30.64
DEC 10	20.21	MAR 31, 1955	16.64	JUL 27	16.95	MAR 04, 1977	35.50
APR 14, 1944	17.80	DEC 12	27.40	OCT 18	18.67	SEP 08	26.80
DEC 13	17.97	DEC 20, 1956	19.79	DEC 13	23.17	MAR 14, 1978	18.03
MAR 23, 1945	16.14	MAR 25, 1957	20.36	MAR 16, 1966	14.47	SEP 07	21.56
NOV 22	25.12	DEC 09	20.81	SEP 12	33.21	MAR 28, 1979	16.87
MAR 30, 1946	21.65	MAR 17, 1958	18.60	APR 12, 1967	34.75	SEP 25	24.39
DEC 12	21.81	DEC 18	32.88	MAR 14, 1968	28.59	MAR 19, 1980	16.72
APR 12, 1947	17.00	MAR 20, 1959	27.65	SEP 16	26.97	APR 10	18.42
MAR 26, 1948	17.36	DEC 09	25.40	MAR 24, 1969	32.37	SEP 03	19.43
JAN 12, 1949	20.17	MAY 22, 1960	22.68	MAR 19, 1970	24.89		
MAR 29	17.71	NOV 30	19.76	AUG 21	32.86		

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OCT 16, 1936	9.85	MAR 09, 1942	15.70	MAR 31, 1955	16.39	APR 12, 1967	14.39
DEC 11	12.39	AUG 24	7.65	DEC 12	13.74	MAR 14, 1968	13.55
MAR 11, 1937	12.26	DEC 13	11.37	DEC 20, 1956	12.78	SEP 16	6.13
AUG 03	7.47	MAR 31, 1943	13.89	MAR 25, 1957	15.94	MAR 24, 1969	8.24
SEP 22	8.47	SEP 18	7.90	DEC 09	11.65	MAR 19, 1970	13.12
NOV 04	10.35	DEC 10	12.33	MAR 17, 1958	14.92	AUG 21	6.85
DEC 14	12.35	APR 14, 1944	15.63	DEC 18	12.43	MAR 25, 1971	9.31
FEB 07, 1938	14.70	DEC 13	13.15	MAR 20, 1959	16.22	SEP 21	7.55
APR 15	15.50	MAR 23, 1945	16.30	DEC 09	12.69	MAR 23, 1972	10.54
MAY 31	5.40	NOV 22	12.71	MAR 22, 1960	15.30	MAR 30, 1973	10.05
AUG 20	7.30	MAR 30, 1946	14.88	NOV 30	12.54	SEP 10	6.74
OCT 16	10.52	DEC 12	12.19	MAR 21, 1961	15.23	MAR 21, 1974	10.08
DEC 11	12.90	APR 12, 1947	16.07	JAN 12, 1962	17.02	SEP 13	6.71
MAR 14, 1939	14.92	DEC 15	12.55	MAR 08	14.97	MAR 19, 1975	10.98
MAY 01	14.35	MAR 26, 1948	15.49	DEC 18	13.04	SEP 09	6.25
JUN 22	9.47	JAN 12, 1949	10.80	MAR 06, 1963	16.82	MAR 04, 1976	11.56
AUG 29	9.76	MAR 29	9.84	AUG 30	7.10	SEP 13	6.72
OCT 30	12.73	DEC 06	11.07	DEC 09	13.30	MAR 04, 1977	13.48
JAN 09, 1940	15.75	APR 06, 1950	12.46	MAR 04, 1964	17.18	SEP 08	7.49
FEB 14	16.78	DEC 12	8.96	OCT 20	8.09	MAR 14, 1978	12.55
APR 04	17.44	APR 04, 1951	11.05	DEC 10	11.42	SEP 07	6.25
JUN 26	9.73	APR 17, 1952	8.66	MAR 08, 1965	14.39	MAR 28, 1979	10.69
AUG 30	10.89	DEC 29	8.85	JUL 27	4.88	SEP 25	10.18 P
NOV 30	13.36	APR 03, 1953	10.28	OCT 18	9.05	MAR 19, 1980	11.98
MAR 14, 1941	17.46	DEC 09	10.07	DEC 13	12.37	APR 08	11.18
SEP 27	10.26	APR 19, 1954	11.57	MAR 16, 1966	13.91	SEP 03	6.55
DEC 12	12.38	DEC 08	13.72	SEP 12	7.80		

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SEP 22, 1937	19.25	APR 14, 1944	24.29	DEC 20, 1956	25.27	APR 12, 1967	25.98
NOV 04	21.85	DEC 13	23.75	MAR 25, 1957	24.61	MAR 14, 1968	25.39
DEC 14	23.00	MAR 23, 1945	24.11	DEC 09	24.27	SEP 16	21.47
FEB 07, 1938	28.25	NOV 22	22.76	MAR 17, 1958	24.37	MAR 24, 1969	24.25
APR 15	25.28	MAR 30, 1946	25.00	MAR 20, 1959	25.92	APR 01, 1970	24.88
AUG 20	30.00 P	DEC 12	23.41	NOV 30, 1960	24.92	MAR 25, 1971	25.14
OCT 16	21.46	APR 12, 1947	23.93	MAR 21, 1961	25.19	APR 03, 1972	23.92
DEC 11	22.98	DEC 15	23.89	JAN 12, 1962	26.65	APR 07, 1973	24.52
MAR 14, 1939	23.41	MAR 26, 1948	24.10	MAR 08	26.49	SEP 10	19.39
MAY 01	30.27 P	JAN 12, 1949	24.10	DEC 18	25.38	MAR 21, 1974	24.40
JUN 22	29.55 P	MAR 29	21.85	MAR 06, 1963	26.54	SEP 13	19.50
AUG 29	20.02 R	DEC 06	24.84	AUG 30	21.52	MAR 19, 1975	24.95
OCT 30	22.32	DEC 12, 1950	22.01	DEC 09	25.58	SEP 09	18.52
JAN 08, 1940	23.76	APR 04, 1951	22.70	MAR 04, 1964	26.06	MAR 04, 1976	25.18
APR 04	23.72	DEC 27	22.53	OCT 20	22.53	SEP 13	19.28
AUG 30	21.05	DEC 29, 1952	22.87	DEC 10	25.01	MAR 04, 1977	26.38
NOV 30	22.45	APR 03, 1953	22.70	MAR 08, 1965	25.82	SEP 08	19.48
DEC 12, 1941	23.52	DEC 09	22.89	JUL 27	15.63	MAR 14, 1978	25.36
DEC 13, 1942	22.75	APR 19, 1954	20.94	OCT 18	23.39	SEP 24, 1979	21.68 R
MAR 31, 1943	23.28	DEC 08	23.97	DEC 13	25.43	MAR 19, 1980	24.72
OCT 18	19.98	MAR 31, 1955	24.62	MAR 16, 1966	26.50	APR 11	24.18
DEC 10	22.98	DEC 12	24.90	SEP 12	20.71	SEP 03	18.51

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SEP 22, 1937	2.80	DEC 10, 1943	2.45	DEC 09, 1957	3.54	MAR 24, 1969	2.08
NOV 04	3.30	APR 14, 1944	2.72	MAR 17, 1958	3.60	MAR 19, 1970	3.26
DEC 14	3.47	DEC 13	2.42	DEC 18	3.83	AUG 21	2.12
APR 15, 1938	2.53	MAR 23, 1945	2.77	MAR 20, 1959	4.07	MAR 25, 1971	3.23
MAY 31	1.05	NOV 22	2.30	DEC 09	3.89	SEP 21	2.38
AUG 20	2.54	MAR 28, 1946	2.35	MAR 22, 1960	3.94	MAR 23, 1972	2.51
OCT 16	3.20	DEC 12	1.97	NOV 30	4.08	SEP 29	2.43
DEC 11	3.09	APR 12, 1947	2.30	MAR 21, 1961	4.14	MAR 20, 1973	2.81
MAR 14, 1939	2.98	DEC 15	1.88	JAN 12, 1962	4.16	SEP 10	2.28
MAY 01	3.27	MAR 26, 1948	1.91	MAR 08	3.88	MAR 21, 1974	2.83
JUN 22	2.79	JAN 12, 1949	1.91	DEC 18	3.65	SEP 13	2.16
AUG 29	2.66	MAR 29	1.99	MAR 06, 1963	3.96	MAR 19, 1975	2.99
OCT 30	3.44	DEC 06	1.95	AUG 30	2.31	SEP 09	1.90
JAN 08, 1940	3.37	APR 06, 1950	1.93	DEC 09	3.09	MAR 04, 1976	2.66
FEB 14	3.56	DEC 12	1.83	MAR 04, 1964	3.84	SEP 13	2.15
APR 04	3.70	APR 04, 1951	2.15	OCT 20	2.74	MAR 04, 1977	3.33
JUN 26	2.65	DEC 27	2.13	DEC 10	3.50	SEP 08	2.64
AUG 30	2.92	APR 17, 1952	1.95	MAR 08, 1965	3.52	MAR 14, 1978	4.93
NOV 30	2.62	DEC 29	3.00	JUL 27	1.77	SEP 07	3.59
MAR 14, 1941	3.54	APR 03, 1953	3.09	OCT 18	2.56	MAR 28, 1979	2.78
SEP 27	2.32	DEC 09	2.65	DEC 13	3.36	SEP 25	2.17
DEC 02	2.94	APR 19, 1954	2.82	MAR 16, 1966	3.13	MAR 19, 1980	3.15
MAR 09, 1942	2.93	DEC 08	3.92	SEP 12	2.49	APR 11	2.90
AUG 24	2.89	MAR 31, 1955	4.17	APR 12, 1967	3.53	SEP 05	1.99
DEC 13	2.73	DEC 12	4.07	MAR 14, 1968	2.05		
SEP 18, 1943	3.03	DEC 20, 1956	4.05	SEP 16	2.30		

Table 7.--Water levels in observation wells, 1936-80--Continued

(A- 5- 1)25ADD- 1 ALT. 4900

MAR 17, 1958	6.10	DEC 10, 1964	25.83	MAR 25, 1971	8.53	MAR 04, 1977	20.39
DEC 18	27.20	MAR 08, 1965	7.37	SEP 21	23.56	SEP 08	23.89
MAR 20, 1959	15.96	JUL 27	8.53	MAR 23, 1972	7.38	MAR 14, 1978	10.05
DEC 09	20.62	DEC 13	20.59	SEP 29	23.17	SEP 07	21.84
JAN 12, 1962	19.64	MAR 16, 1966	9.63	MAR 20, 1973	7.26	MAR 28, 1979	7.10
MAR 08	4.33	SEP 12	25.18	SEP 10	10.50	SEP 25	23.95
DEC 18	28.03	APR 12, 1967	7.57	MAR 21, 1974	7.65	MAR 19, 1980	7.64
MAR 06, 1963	17.44	MAR 14, 1968	8.40	SEP 13	22.08	APR 10	7.95
AUG 30	19.32	SEP 16	20.78	MAR 19, 1975	7.50	SEP 04	20.15
DEC 09	28.06	MAR 24, 1969	8.55	SEP 09	18.21		
MAR 04, 1964	27.52	MAR 19, 1970	8.52	MAR 04, 1976	9.49		
OCT 20	26.51	AUG 21	17.42	SEP 13	21.94		

(A- 5- 1)27DBA- 1 ALT. 4835

OCT 16, 1936	1.11	MAR 09, 1942	0.82	MAR 31, 1955	1.73	APR 12, 1967	2.28
DEC 11	1.60	AUG 24	0.76	DEC 12	1.80	MAR 14, 1968	2.07
MAR 11, 1937	1.40	DEC 13	0.93	DEC 20, 1956	1.59	SEP 16	1.41
AUG 03	0.78	MAR 31, 1943	0.21	MAR 25, 1957	1.63	MAR 24, 1969	0.16
SEP 22	0.93	SEP 18	0.86	DEC 09	0.43	MAR 19, 1970	1.15
NOV 04	1.30	DEC 10	1.67	MAR 17, 1958	1.14	AUG 21	1.62
DEC 14	1.38	APR 14, 1944	1.40	DEC 18	1.82	MAR 25, 1971	1.79
FEB 07, 1938	1.95	DEC 13	1.50	MAR 20, 1959	2.40	SEP 21	1.40
APR 15	1.22	MAR 23, 1945	1.12	DEC 09	2.38	MAR 23, 1972	0.41
AUG 20	0.84	NOV 22	1.11	MAR 22, 1960	2.39	SEP 29	1.54
OCT 16	1.16	NOV 13, 1946	1.31	NOV 30	2.20	MAR 30, 1973	2.03
DEC 11	1.39	DEC 12	1.30	MAR 21, 1961	2.60	SEP 10	0.72
MAR 14, 1939	0.44	APR 12, 1947	1.24	JAN 12, 1962	2.52	MAR 21, 1974	0.42
MAY 01	1.11	MAR 26, 1948	1.68	MAR 08	0.81	SEP 13	0.89
JUN 22	0.83	MAR 29, 1949	1.30	DEC 18	2.02	MAR 19, 1975	1.70
AUG 29	1.05	DEC 06	1.22	MAR 06, 1963	2.45	MAR 04, 1976	1.42
OCT 30	1.58	APR 06, 1950	0.91	AUG 30	1.61	SEP 13	0.67
JAN 09, 1940	1.85	DEC 12	0.56	DEC 09	1.82	MAR 04, 1977	2.36
FEB 14	1.66	APR 04, 1951	0.87	MAR 11, 1964	2.10	SEP 08	2.21
APR 04	1.53	SEP 13	0.31	OCT 20	1.59	MAR 14, 1978	1.98
JUN 26	0.80	DEC 27	0.62	DEC 10	1.42	SEP 07	1.22
AUG 30	1.20	APR 17, 1952	0.18	MAR 08, 1965	0.55	MAR 28, 1979	1.69
NOV 30	2.03	DEC 29	0.73	JUL 27	2.47	SEP 25	1.39
MAR 14, 1941	1.46	DEC 09, 1953	1.49	DEC 13	1.82	MAR 19, 1980	0.44
SEP 27	0.99	APR 19, 1954	1.67	MAR 16, 1966	1.52	APR 15	0.51
DEC 12	0.97	DEC 08	1.75	SEP 12	2.02	SEP 04	1.16

Table 8.--Chemical

[Abbreviations used in table headings are: ft, feet; °C, micromhos per centimeter at 25° Celsius; mg/L, milligrams

Well or spring number: See text for explanation of well- and spring-numbering system.
Date of sample: Year-month-date.
Geologic unit: 111ALVM, alluvial deposits; 123NRWD, Norwood Tuff; 124WSTC, Wasatch Formation; 211WNSP, Wanship Formation of local usage (not adopted by the U.S. Geological Survey); 211ECCN, Echo Canyon Conglomerate; 211FRNR, Frontier Formation. All samples were collected and analyzed by the U.S. Geological Survey except where noted.

Location (well or spring number)	Date of sample	Geo-logic unit	Depth of well (ft)	Temper-ature, water (°C)	Dis-charge (gpm)	Spe-cific con-duct-ance (μmhos/cm at 25°C)	pH field (units)	Bicar-bonate (mg/L as HCO_3)	Car-bonate (mg/L as CO_3)	Hard-ness (mg/L as $CaCO_3$)	Hard-ness, noncar-bonate (mg/L as $CaCO_3$)	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)
(A- 2- 5) 4BCD- 1	79-08-23	211WNSP	192	20.0	.02	710	6.3	--	--	290	99	73	26
(A- 2- 5) 9CDB- 1	79-08-23	211FRNR	500	11.0	--	880	6.6	--	--	350	0	85	33
(A- 2- 5) 9DAC-S1	79-10-04	111ALVM	--	--	--	800	--	--	--	380	140	100	32
(A- 2- 5)10AAA- 2	79-09-28	211FRNR	230	11.5	--	900	--	--	--	180	0	46	17
(A- 2- 5)10BCB- 2	79-09-27	211FRNR	--	12.5	5.0	3,200	--	--	--	2,300	2,000	640	180
(A- 2- 5)11ACA- 2	79-10-04	211FRNR	55	--	--	910	--	--	--	180	0	46	17
(A- 2- 5)11ACB- 3	79-09-27	211FRNR	180	--	--	740	--	--	--	230	0	56	21
(A- 2- 5)15BDB- 1	79-08-31	211FRNR	150	10.0	--	855	6.7	--	--	300	45	77	25
(A- 2- 5)17BAD- 1	79-08-24	211WNSP	123	13.0	--	440	6.4	--	--	180	0	44	17
(A- 2- 5)18BAC-S1	79-08-24	211WNSP	--	--	--	680	6.5	--	--	310	42	100	15
(A- 2- 5)20DBD- 2	79-08-22	211WNSP	250	--	6.0	500	6.6	--	--	61	0	14	6.3
(A- 2- 5)28DCB- 1	79-08-31	111ALVM	131	11.0	340	600	6.1	--	--	280	7	78	20
(A- 3- 2) 1CAC- 1	79-10-06	111ALVM	110	--	--	680	6.4	--	--	320	47	76	31
(A- 3- 2) 2DCB- 1	79-09-07	123NRWD	120	--	--	650	5.4	--	--	300	34	84	23
(A- 3- 2) 4AAD- 1	79-09-06	123NRWD	268	--	--	640	6.1	--	--	260	45	61	25
(A- 3- 2) 4ACD- 1	79-09-06	123NRWD	160	--	--	450	6.4	--	--	190	0	53	13
(A- 3- 2) 4DAA- 1	79-09-06	123NRWD	260	--	--	750	6.4	--	--	310	85	86	22
(A- 3- 2) 4DBB- 1	79-12-04	123NRWD	135	--	--	560	--	--	--	200	0	49	19
(A- 3- 2)11CAA- 1	79-10-06	123NRWD	190	--	--	580	6.7	--	--	220	18	51	22
(A- 3- 2)11CDD- 1	79-09-07	124WSTC	302	--	--	600	5.2	--	--	230	0	64	18
(A- 3- 2)12BBA- 1	79-09-07	111ALVM	160	--	--	630	5.0	--	--	300	32	83	23
(A- 3- 2)12CAC- 1	79-09-07	111ALVM	140	--	--	680	5.2	--	--	310	28	82	25
(A- 3- 2)13BBA- 1	79-12-04	123NRWD	161	12.0	--	560	6.6	--	--	250	18	73	16
(A- 3- 2)14DAD- 1	79-09-07	123NRWD	95.0	--	--	730	5.0	--	--	360	66	93	30
(A- 3- 2)14DBC- 1	79-09-21	123NRWD	200	--	--	520	6.1	--	--	250	10	84	9.7
(A- 3- 2)24BBC- 1	79-09-27	111ALVM	105	--	--	610	6.5	--	--	290	42	89	17
(A- 3- 2)24BCC- 1	79-09-07	111ALVM	31.0	--	--	340	5.1	--	--	160	0	48	9.8
(A- 3- 2)24CAA- 1	79-09-07	123NRWD	125	--	--	600	5.1	--	--	280	42	85	17
(A- 3- 2)24CBA- 1	79-09-27	111ALVM	19.0	--	--	560	6.4	--	--	280	8	85	16
(A- 3- 2)25BAA- 1	79-09-24	124WSTC	81.5	--	--	640	6.4	--	--	300	0	86	20
(A- 3- 2)25CAA- 1	79-09-24	124WSTC	112	--	--	1,180	6.0	--	--	500	200	150	31
(A- 3- 2)25DCD- 1	79-09-24	124WSTC	26.0	--	--	900	6.6	--	--	400	0	110	31
(A- 3- 2)26AAB- 1	79-09-24	124WSTC	350	--	--	570	6.5	--	--	260	16	58	27
(A- 3- 2)26AAC- 1	79-09-24	123NRWD	87.0	--	--	830	6.8	--	--	350	52	98	26
(A- 3- 2)26ACC- 1	79-12-06	123NRWD	122	--	--	750	6.2	--	--	370	110	99	30
(A- 3- 2)26ADD- 1	79-09-24	123NRWD	83.0	--	--	750	6.0	--	--	320	71	94	21
(A- 3- 2)26BDA- 1[1]	71-06-02	123NRWD	122	--	--	--	8.4	--	--	1,073	--	284	113
(A- 3- 2)36ADB- 1	79-09-24	111ALVM	--	--	--	750	6.0	--	--	330	56	76	33
(A- 3- 3)31CBD- 1	79-09-24	111ALVM	30.0	13.0	--	560	6.6	--	--	270	44	75	21
(A- 3- 4) 3CAB-S1	81-01-23	211WNSP	--	6.0	--	485	--	--	--	--	--	--	--
(A- 3- 4) 4ADD- 1	79-10-02	111ALVM	35.0	--	--	660	6.5	--	--	300	40	87	20
(A- 3- 4)24DBD- 1	79-09-28	211ECCN	130	--	--	940	--	--	--	410	70	90	45
(A- 3- 5)17CBC-S1	79-10-05	211ECCN	--	11.5	3.0	570	--	--	--	260	16	68	21
(A- 3- 5)19AAA- 1	79-10-05	211ECCN	93.0	--	--	1,000	--	--	--	--	--	--	--
(A- 3- 5)29CDD- 1	79-09-27	111ALVM	185	--	--	1,220	--	--	--	490	230	120	45
(A- 3- 5)30BCD- 1	79-09-28	111ALVM	54.0	--	--	725	--	--	--	320	45	75	31
(A- 3- 6)34ABA- 1	79-10-04	211WNSP	85.0	--	--	1.320	--	--	--	580	320	140	57
(A- 4- 2) 4CDC- 1	79-08-29	123NRWD	121	--	--	660	6.4	--	--	260	41	60	27
(A- 4- 2) 5BDD- 1	79-08-29	123NRWD	315	--	--	480	6.3	--	--	220	28	61	16
(A- 4- 2) 8AAA- 1	79-08-29	111ALVM	175	--	--	600	6.4	--	--	210	0	51	21
(A- 4- 2) 8BCC- 1	79-08-28	111ALVM	137	--	--	400	6.4	--	--	190	9	56	12
(A- 4- 2) 8CDC- 1	79-08-30	123NRWD	160	--	--	420	5.3	--	--	170	0	49	12
(A- 4- 2)16DAB- 1	79-09-28	--	132	--	--	800	6.7	--	--	340	15	88	28
(A- 4- 2)17ABD- 2	79-09-06	111ALVM	63.0	--	--	340	5.2	--	--	130	0	41	7.8
(A- 4- 2)20ABA- 2	79-09-06	123NRWD	203	--	--	520	5.1	--	--	210	21	69	9.4
(A- 4- 2)21CBB- 1	79-09-27	123NRWD	160	--	--	450	6.6	--	--	190	0	61	9.9
(A- 4- 2)21DDA- 1	79-09-20	111ALVM	125	--	--	600	6.0	--	--	290	36	83	19
(A- 4- 2)22BAC- 4	79-08-29	123NRWD	205	--	--	560	6.2	--	--	280	36	66	27
(A- 4- 2)22CDA- 1	79-09-21	111ALVM	105	--	--	650	5.9	--	--	320	48	86	25
(A- 4- 2)26ABD- 1	79-08-28	123NRWD	162	--	--	440	6.6	--	--	190	13	56	13
(A- 4- 2)26BBA- 1	79-09-28	111ALVM	55.0	--	--	540	7.0	--	--	280	34	61	32
(A- 4- 2)26CCD- 1	79-09-25	111ALVM	26.0	15.0	--	610	6.6	--	--	300	31	89	19
(A- 4- 2)28BAD- 1	79-10-06	123NRWD	215	--	--	340	6.4	--	--	150	0	48	6.3
(A- 4- 2)28BBD- 1	79-09-06	123NRWD	110	--	--	520	6.4	--	--	220	16	52	21
(A- 4- 2)34AAB- 1	79-08-29	111ALVM	127	--	--	570	6.4	--	--	290	31	87	18

analyses of ground water

degrees Celsius; gpm, gallons per minute; μmhos/cm at 25°C, per liter; μg/L, micrograms per liter; ac-ft, acre-foot.]

Sodium, dis-solved (mg/L as Na)	Sodium ad-sorp-tion ratio	Sodium percent	Sodium + potas-sium, dis-solved (mg/L as Na)	Potas-sium, dis-solved (mg/L as K)	Chlo-ride, dis-solved (mg/L as Cl)	Sulfate, dis-solved (mg/L as SO_4)	Fluo-ride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)	Boron, dis-solved (μg/L as B)	Iron, dis-solved (μg/L as Fe)	Solids, residue at 180°C, dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Solids, dis-solved (tons per ac-ft)
42	1.1	24	46	4.0	110	27	.3	7.6	60	2,100	--	406	.55
53	1.2	25	55	2.3	50	25	.5	28	90	100	--	499	.68
38	.8	18	--	2.3	63	27	.3	13	70	10	397	420	.54
130	4.2	60	--	5.0	130	72	1.0	6.1	100	550	529	522	.72
62	.6	5	--	9.8	65	1,800	.2	5.4	680	29,000	1,620	3,000	2.20
130	4.2	60	--	2.0	110	24	1.0	6.1	50	550	551	517	.75
76	2.2	42	--	3.1	38	41	.5	8.6	40	<10	441	425	.60
57	1.4	39	57	.3	86	62	.6	22	70	20	--	480	.65
14	.5	14	20	6.2	14	18	.5	13	30	400	--	235	.32
16	.4	10	17	.8	21	48	.3	11	30	<10	--	374	.51
82	4.6	73	86	3.5	43	1.4	1.2	7.6	1,600	300	--	269	.37
15	.4	10	17	1.7	16	18	.2	16	50	40	--	327	.44
34	.8	27	39	4.5	61	26	.2	38	60	<10	477	433	.65
33	.8	19	41	8.2	45	47	.3	26	70	<10	--	429	.58
36	1.0	23	43	6.6	80	23	.3	36	60	<10	--	394	.54
21	.7	19	29	7.6	30	13	.3	49	40	<10	--	301	.41
32	.8	18	39	7.2	110	21	.2	51	70	<10	--	462	.63
44	1.4	40	59	15	50	41	.4	75	90	20	400	426	.54
39	1.2	27	46	6.7	67	20	.3	25	50	<10	360	351	.49
50	1.4	31	57	7.0	36	23	.2	30	80	<10	--	391	.53
23	.6	14	27	3.5	33	54	.2	20	50	20	--	402	.55
29	.7	16	39	10	44	49	.2	55	70	<10	--	463	.63
29	.8	25	38	8.9	49	14	.2	65	60	10	406	393	.55
29	.7	15	33	3.5	44	65	.2	21	60	20	--	460	.63
17	.5	13	22	4.5	27	12	.2	46	30	<10	--	345	.47
20	.5	13	23	3.3	29	53	.1	14	30	<10	--	376	.51
7.3	.3	9	11	4.1	7.3	11	.2	15	30	<10	--	205	.28
21	.5	14	27	5.6	31	55	.2	13	30	<10	--	372	.51
17	.4	12	19	1.5	23	17	.3	19	30	<10	--	341	.46
34	.9	20	39	5.0	27	17	.2	43	60	<10	--	419	.57
62	1.2	21	67	5.4	230	50	.3	45	70	20	--	754	1.03
55	1.2	23	60	4.8	69	39	.3	26	100	<10	--	582	.79
24	.7	16	35	11	50	10	.2	64	40	<10	--	389	.53
50	1.2	23	56	5.5	90	38	.3	37	70	20	--	525	.71
37	.8	24	41	3.9	40	120	.2	12	70	20	529	499	.72
38	.9	20	43	4.8	92	23	.2	55	50	20	--	478	.65
--	--	--	230	--	673	327	--	13	--	0	2,568	--	--
36	.9	19	38	2.1	82	21	.4	23	50	<10	--	436	.59
21	.6	14	23	2.0	35	43	.2	11	30	80	--	347	.47
--	--	--	--	--	--	--	--	--	--	--	--	--	--
31	.8	23	36	4.7	50	35	.2	11	160	10	400	395	.54
49	1.1	20	--	6.2	74	65	.4	12	230	<10	587	546	.80
27	.7	18	--	2.4	41	12	.1	14	60	<10	342	330	.47
--	--	--	--	5.2	80	87	1.0	--	200	--	635	--	.86
78	1.5	26	--	1.8	130	140	.3	14	110	<10	709	686	.96
40	1.0	21	--	2.8	37	67	.4	11	100	160	445	427	.61
84	1.5	24	--	4.3	110	270	.3	14	100	10	871	836	1.18
29	.8	28	38	8.9	70	49	.2	56	50	<10	--	432	.59
21	.6	23	25	3.5	35	14	.1	28	50	<10	--	293	.40
29	.9	22	33	4.3	45	27	.2	36	40	<10	--	358	.49
19	.6	22	22	2.6	19	14	.1	28	30	<10	--	259	.35
19	.6	25	22	2.6	19	14	.2	40	30	<10	--	270	.37
25	.6	14	28	3.1	33	42	.2	26	60	<10	--	438	.60
22	.8	26	25	2.7	15	16	.1	19	50	<10	--	208	.28
28	.8	22	34	5.9	50	17	.4	47	50	<10	--	341	.46
24	.8	21	29	5.1	29	13	.3	52	40	50	--	315	.43
17	.4	11	20	2.6	26	36	.2	16	30	30	--	350	.48
21	.6	14	25	3.9	27	43	.2	37	40	<10	--	369	.50
22	.5	13	26	3.6	30	62	.3	13	60	<10	--	404	.55
24	.8	21	25	1.3	30	13	.2	19	40	<10	--	265	.36
16	.4	11	17	1.4	20	30	.1	11	30	<10	--	322	.44
19	.5	12	26	6.8	26	33	.2	13	50	<10	--	368	.50
15	.5	21	18	2.9	18	3.5	.1	51	10	350	242	241	.33
22	.7	17	34	12	43	22	.3	59	50	<10	--	352	.48
20	.5	13	22	2.0	25	46	.1	15	30	<10	--	369	.50

Table 8.--Chemical analyses

Location (well or spring number)	Date of sample	Geo-logic unit	Depth of well (ft)	Temper-ature, water (°C)	Dis-charge (gpm)	Spe-cific con-duct-ance (µmhos/cm at 25°C)	pH field (units)	Bicar-bonate (mg/L as HCO_3)	Car-bonate (mg/L as CO_3)	Hard-ness (mg/L as $CaCO_3$)	Hard-ness, noncar-bonate (mg/L as $CaCO_3$)	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)
(A- 4- 2)34BCC- 1	79-10-06	111ALVM	83.0	--	--	460	6.1	--	--	210	33	64	13
(A- 4- 2)34CCB- 3	79-12-04	111ALVM	200	10.0	--	640	6.4	--	--	330	10	99	20
(A- 4- 2)35CCC- 1	79-09-06	123NRWD	130	--	--	610	5.9	--	--	290	44	88	18
(A- 4- 2)36BAD- 1[1]	71-06-03	111ALVM	175	--	--	--	8.1	--	--	296	--	79	24
(A- 4- 2)36BCA- 1	79-11-21	111ALVM	190	11.0	--	720	6.7	--	--	360	65	95	31
(A- 4- 2)36CBD- 1[2]	69-06-12	111ALVM	101	--	--	645	7.8	327	--	298	30	88	19
(A- 4- 3)27ABD- 1	79-10-02	111ALVM	84.0	--	--	810	6.6	--	--	400	200	110	30
(A- 4- 3)28BCC- 1	79-09-28	111ALVM	60.0	--	--	510	6.4	--	--	250	20	72	17
(A- 4- 3)31CAB-S1	66-05-18	--	--	25.0	--	896	7.4	250	0	398	193	109	31
(A- 4- 3)32ABD- 1	79-11-19	124WSTC	127	10.0	--	925	6.5	--	--	490	190	120	45
(A- 4- 4) 4ADB- 1	79-10-02	124WSTC	70.0	--	--	270	6.4	--	--	130	10	39	7.8
(A- 4- 4)19DDA- 1	79-12-04	111ALVM	45.0	10.0	--	655	6.5	--	--	270	41	82	16
(A- 4- 4)20BAD- 1	79-10-02	111ALVM	90.0	--	--	490	6.4	--	--	230	22	70	14
(A- 4- 4)33DCC- 1	79-10-02	111ALVM	45.0	--	--	540	6.6	--	--	260	27	75	17
(A- 5- 1)23BCC- 1	79-08-30	123NRWD	126	--	--	520	5.7	--	--	150	0	37	13
(A- 5- 1)25BCA- 1	79-08-29	123NRWD	113	--	--	600	6.2	--	--	200	0	50	19
(A- 5- 1)25CBC- 1[2]	65-09-23	111ALVM	175	--	--	430	8.1	193	--	195	37	56	13
(A- 5- 1)26BCD- 1[1]	71-05-21	123NRWD	120	--	--	--	8.1	--	--	306	--	88	21
(A- 5- 1)27BCD- 1	79-08-28	124WSTC	190	--	--	220	5.9	--	--	86	17	28	4.0
(A- 5- 2)19CDA- 1[1]	71-05-21	111ALVM	170	--	--	--	8.1	--	--	213	--	59	16
(A- 5- 2)30CBC- 1	79-08-30	111ALVM	144	10.0	--	470	5.4	--	--	210	38	65	11
(A- 5- 2)31BBA- 1	79-12-06	111ALVM	129	--	--	460	6.2	--	--	250	27	74	15
(A- 5- 2)31DCC- 1	79-10-06	111ALVM	20.0	11.0	--	560	6.2	--	--	260	41	75	18
(A- 5- 4)26DBA- 1	79-08-30	124WSTC	84.0	--	--	550	6.1	--	--	300	40	79	25
(A- 5- 4)35ABC- 1	79-08-30	124WSTC	84.0	--	--	440	5.8	--	--	230	35	66	17

[1] Sample collected by Saxon (1972), analyzed by Utah Department of Agriculture.
[2] Sample collected by Saxon (1972), analyzed by Utah Department of Health.

of ground water--Continued

Sodium, dis- solved (mg/L as Na)	Sodium ad- sorp- tion ratio	Sodium percent	Sodium + potas- sium, dis- solved (mg/L as Na)	Potas- sium, dis- solved (mg/L as K)	Chlo- ride, dis- solved (mg/L as Cl)	Sulfate, dis- solved (mg/L as SO_4)	Fluo- ride, dis- solved (mg/L as F)	Silica, dis- solved (mg/L as SiO_2)	Boron, dis- solved (µg/L as B)	Iron, dis- solved (µg/L as Fe)	Solids, residue at 180°C, dis- solved (mg/L)	Solids, sum of consti- tuents, dis- solved (mg/L)	Solids, dis- solved (tons per ac-ft)
15	.4	16	20	4.9	27	38	.1	23	30	<10	307	293	.42
25	.6	17	33	7.8	29	19	.2	40	70	20	431	432	.59
22	.6	14	28	6.0	33	53	.2	23	50	<10	--	394	.54
--	--	--	32	--	22	90	--	6.0	--	0	--	424	--
27	.6	19	32	5.1	35	61	.4	21	60	20	470	456	.64
--	--	--	17	--	31	37	.1	13	--	--	--	380	--
40	.9	24	43	3.1	62	190	.2	11	70	<10	597	567	.81
16	.4	12	18	2.3	20	26	.2	9.8	30	<10	--	302	.41
34	.7	--	--	8.4	28	231	2.0	19	10	--	622	586	--
50	1.0	26	54	4.1	55	190	.6	21	50	20	687	666	.93
6.9	.3	10	8.0	1.1	9.2	8.5	.1	8.1	20	20	165	153	.22
47	1.2	27	50	3.2	68	50	.2	10	30	10	346	415	.47
18	.5	18	21	2.5	24	40	.1	8.9	30	10	310	304	.42
17	.5	16	20	3.3	27	27	.1	12	50	<10	333	317	.45
66	2.4	49	68	1.9	50	15	.3	15	50	1,800	--	320	.44
55	1.7	48	59	3.6	25	50	.4	34	60	1,300	--	401	.55
--	--	--	20	--	25	33	.3	15	--	7	--	268	--
--	--	--	--	--	6.0	37	--	1.0	--	0	--	363	--
11	.5	22	12	.8	17	14	.2	10	<20	<10	--	127	.17
--	--	--	7.0	--	--	70	6.0	1.0	--	0	--	329	--
19	.6	16	23	3.8	25	57	.2	26	30	<10	--	309	.42
14	.4	14	17	2.7	15	24	.2	24	40	20	306	301	.42
19	.5	18	22	3.3	34	31	.2	14	60	190	344	327	.47
16	.4	15	18	1.7	15	43	.2	12	50	<10	--	348	.47
14	.3	15	16	1.6	16	30	.2	9.3	30	<10	--	274	.37

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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Prepared in cooperation with the
STATE OF UTAH
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TECHNICAL PUBLICATION NO. 77
1984
PLATE 1

EXPLANATION

—20— LINE OF EQUAL NORMAL ANNUAL PRECIPITATION, 1931-60 – Interval 4, 5 and 10 inches (100, 125, and 250 millimeters)

•L,C WELL – L, drillers log in table 6; C, chemical analysis in table 8

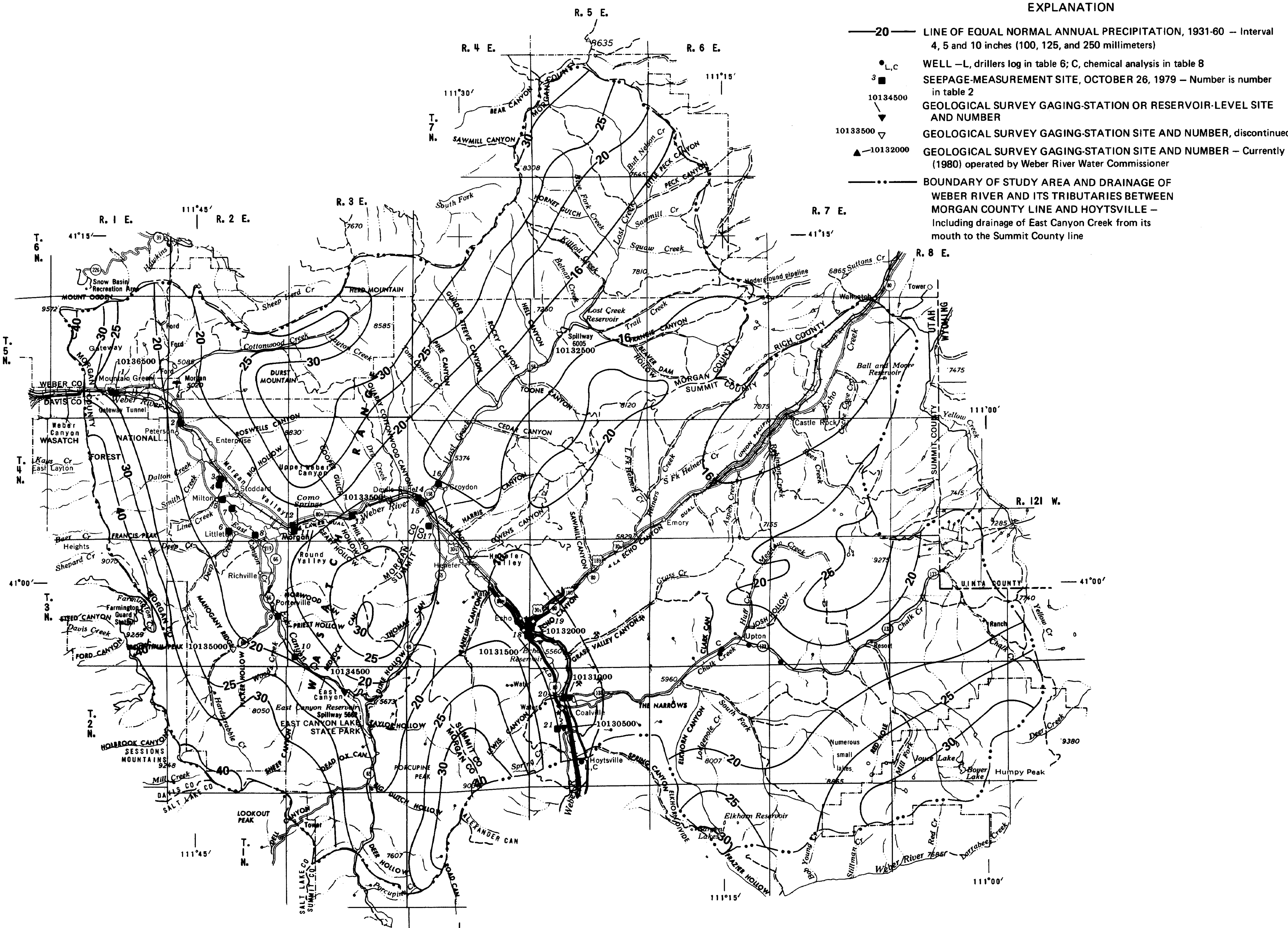
3 ■ SEEPAGE-MEASUREMENT SITE, OCTOBER 26, 1979 – Number is number in table 2

10134500 ▼ GEOLOGICAL SURVEY GAGING-STATION OR RESERVOIR-LEVEL SITE AND NUMBER

10133500 ▽ GEOLOGICAL SURVEY GAGING-STATION SITE AND NUMBER, discontinued

▲ 10132000 GEOLOGICAL SURVEY GAGING-STATION SITE AND NUMBER – Currently (1980) operated by Weber River Water Commissioner

—••— BOUNDARY OF STUDY AREA AND DRAINAGE OF WEBER RIVER AND ITS TRIBUTARIES BETWEEN MORGAN COUNTY LINE AND HOYTSVILLE – Including drainage of East Canyon Creek from its mouth to the Summit County line



Base from U.S. Geological Survey 1:250,000 quadrangles,
Salt Lake City, Utah, Wyoming, 1954, revised 1970;
Ogden, Utah, Wyoming, 1954, limited revision, 1966

5 0 5 10 MILES
5 0 5 10 KILOMETERS

Precipitation data from U. S. Weather Bureau (1963)

Compiled by J. I. Steiger, 1980

MAP SHOWING SELECTED HYDROLOGIC-DATA SITES AND NORMAL ANNUAL PRECIPITATION FOR 1931-60
IN THE CENTRAL WEBER RIVER AREA, MORGAN AND SUMMIT COUNTIES, UTAH.

Prepared in cooperation with the
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CORRELATION OF MAP UNITS

Unit	Era	Period
Qu	Cenozoic	QUATERNARY
QT	Cenozoic	TERTIARY AND QUATERNARY
TKcg	Cenozoic / Mesozoic	CRETACEOUS AND TERTIARY
Ku	Mesozoic	CRETACEOUS
JŦRss	Mesozoic	TRIASSIC AND JURASSIC
JŦRls	Mesozoic	TRIASSIC AND JURASSIC
IP€ls	Paleozoic	CAMBRIAN TO PENNSYLVANIAN
IP€ss	Paleozoic	CAMBRIAN AND PENNSYLVANIAN
p€f		PRECAMBRIAN

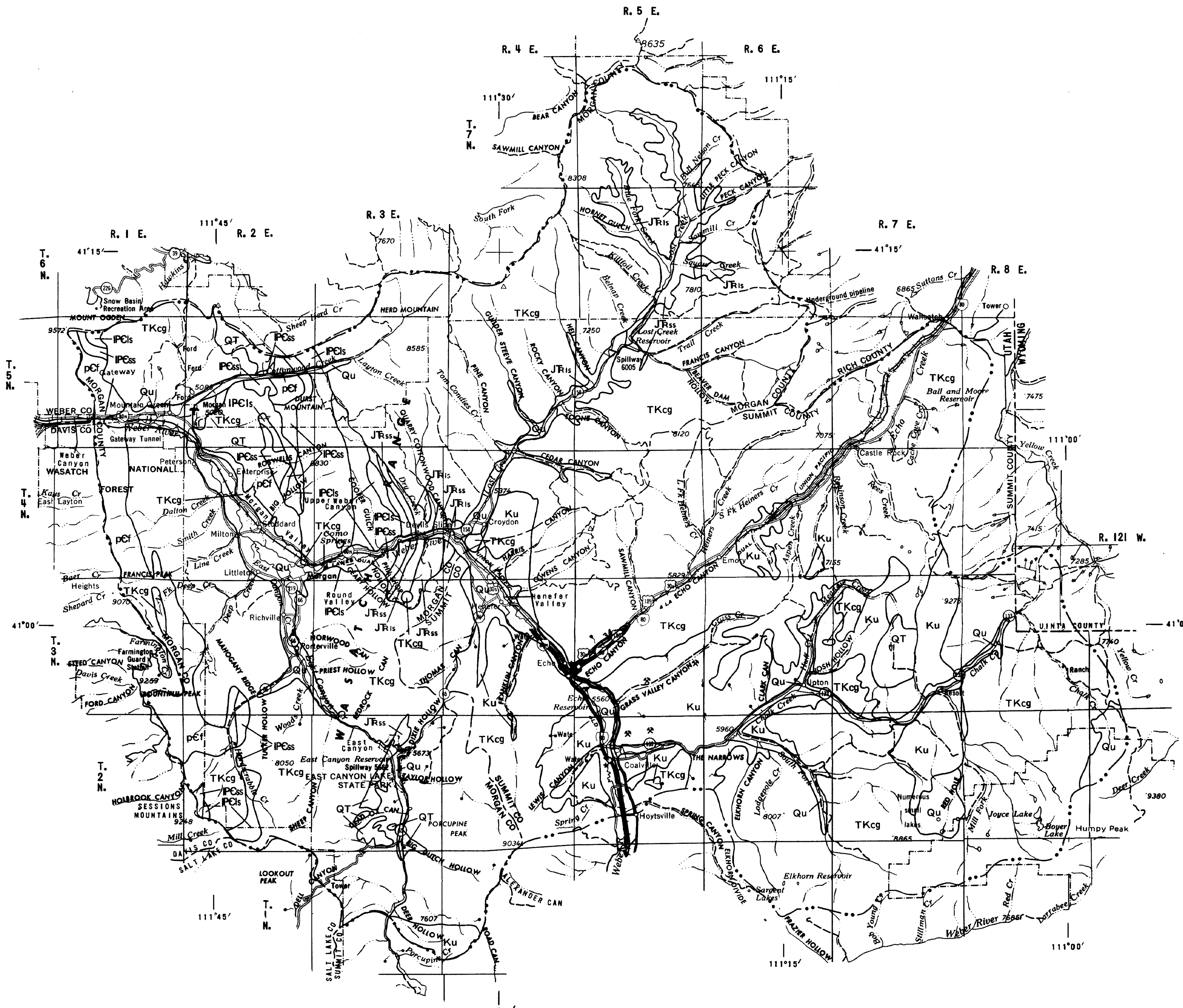
DESCRIPTION OF MAP UNITS

Unit	Description
Qu	Alluvial, lake, and glacial deposits
QT	Older coarse-grained deposits, some of volcanic origin
TKcg	Conglomerates and other rocks, mostly coarse-grained clastics, some of volcanic origin
Ku	Clastic rocks
JŦRss	Older clastic rocks
JŦRls	Principally limestone
IP€ls	Principally limestone and dolomite
IP€ss	Quartzite and sandstone
p€f	Farmington Canyon complex

——— CONTACT

EXPLANATION

—••— BOUNDARY OF STUDY AREA AND DRAINAGE OF WEBER RIVER AND ITS TRIBUTARIES BETWEEN MORGAN COUNTY LINE AND HOYTSVILLE – Including drainage of East Canyon Creek from its mouth to the Summit County line



5 0 5 10 MILES
5 0 5 10 KILOMETERS

Base from U.S. Geological Survey 1:250,000 quadrangles, Salt Lake City, Utah, Wyoming, 1954 revised 1970; Ogden, Utah, Wyoming, 1954, limited revision, 1966

Generalized by R.T. Green and J. S. Gates, 1981, from Stokes (1964); Mullens and Laraway (1964 and 1973); and Mullens (1971)

GEOLOGIC MAP OF THE CENTRAL WEBER RIVER AREA, MORGAN AND SUMMIT COUNTIES, UTAH.

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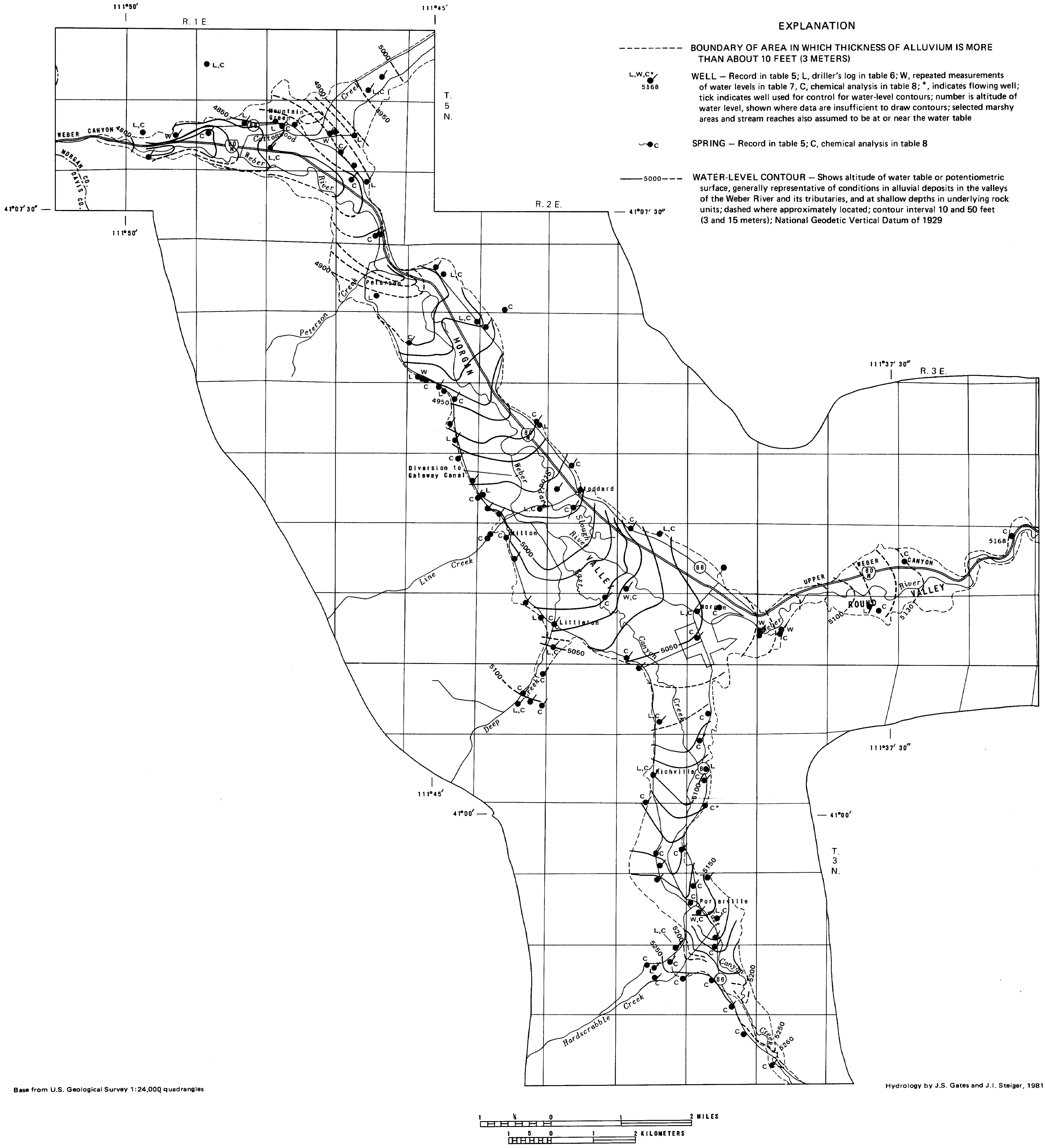
PLATE 3



MAP SHOWING THE LOCATION OF INVENTORIED WELLS AND SPRINGS AND WATER-LEVEL CONTOURS, FALL 1980, IN THE MORGAN VALLEY-ROUND VALLEY SUBAREA, MORGAN COUNTY, UTAH.

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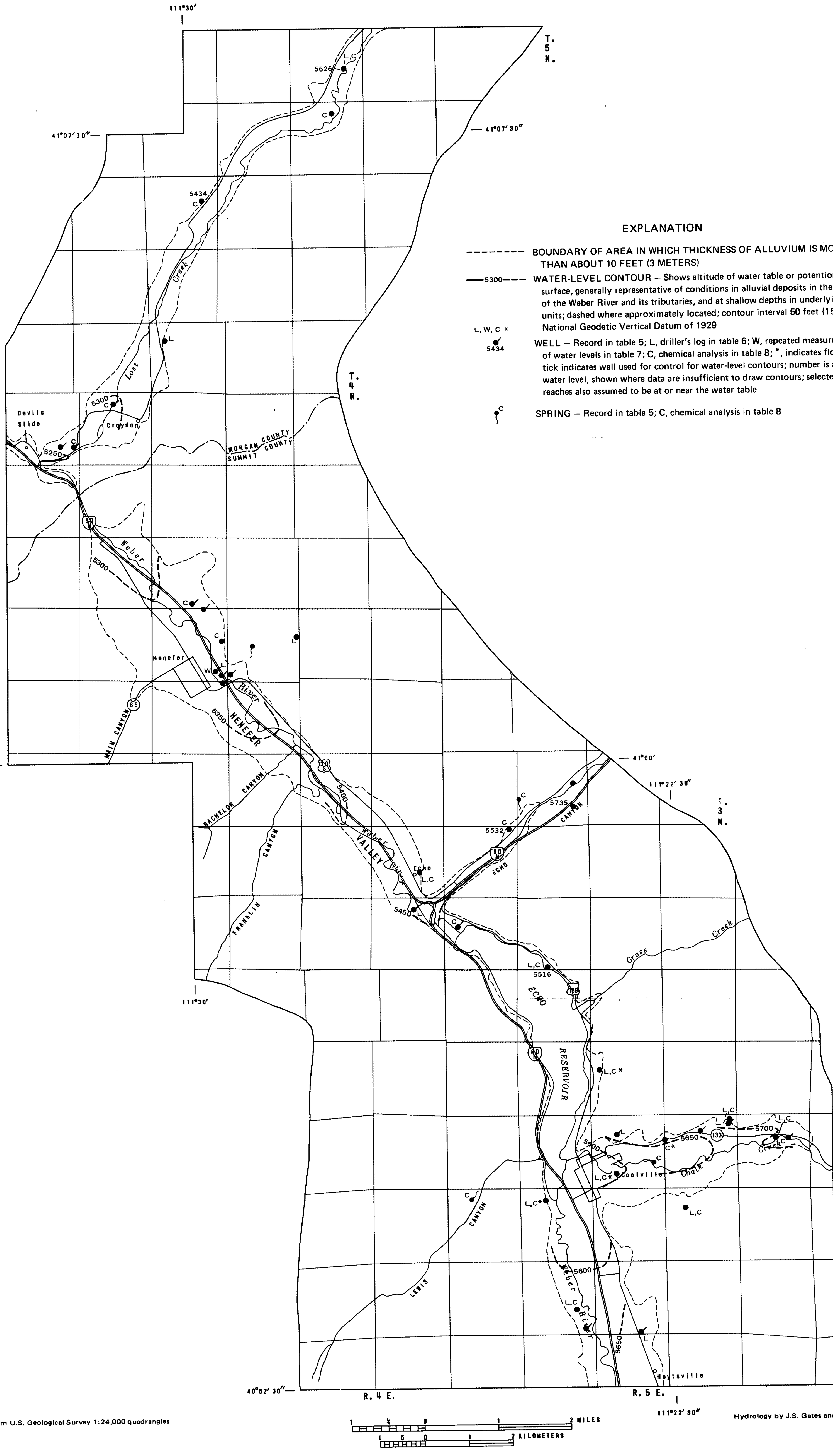
TECHNICAL PUBLICATION NO. 77
1984 PLATE 4



EXPLANATION

BOUNDARY OF AREA IN WHICH THICKNESS OF ALLUVIUM IS MORE THAN ABOUT 10 FEET (3 METERS)

5300 WATER-LEVEL CONTOUR – Shows altitude of water table or potentiometric surface, generally representative of conditions in alluvial deposits in the valleys of the Weber River and its tributaries, and at shallow depths in underlying rock units; dashed where approximately located; contour interval 50 feet (15 meters); National Geodetic Vertical Datum of 1929

L, W, C * 5434 WELL – Record in table 5; L, driller's log in table 6; W, repeated measurements of water levels in table 7; C, chemical analysis in table 8; *, indicates flowing well; tick indicates well used for control for water-level contours; number is altitude of water level, shown where data are insufficient to draw contours; selected stream reaches also assumed to be at or near the water table

C SPRING – Record in table 5; C, chemical analysis in table 8

Base from U.S. Geological Survey 1:24,000 quadrangles

Hydrology by J.S. Gates and J.I. Steiger, 1981

MAP SHOWING THE LOCATION OF INVENTORIED WELLS AND SPRINGS AND WATER-LEVEL CONTOURS, 1979-80, IN THE HENEFER VALLEY AND COALVILLE SUBAREAS, MORGAN AND SUMMIT COUNTIES, UTAH.

UNITED STATES DEPARTMENT OF THE INTERIOR
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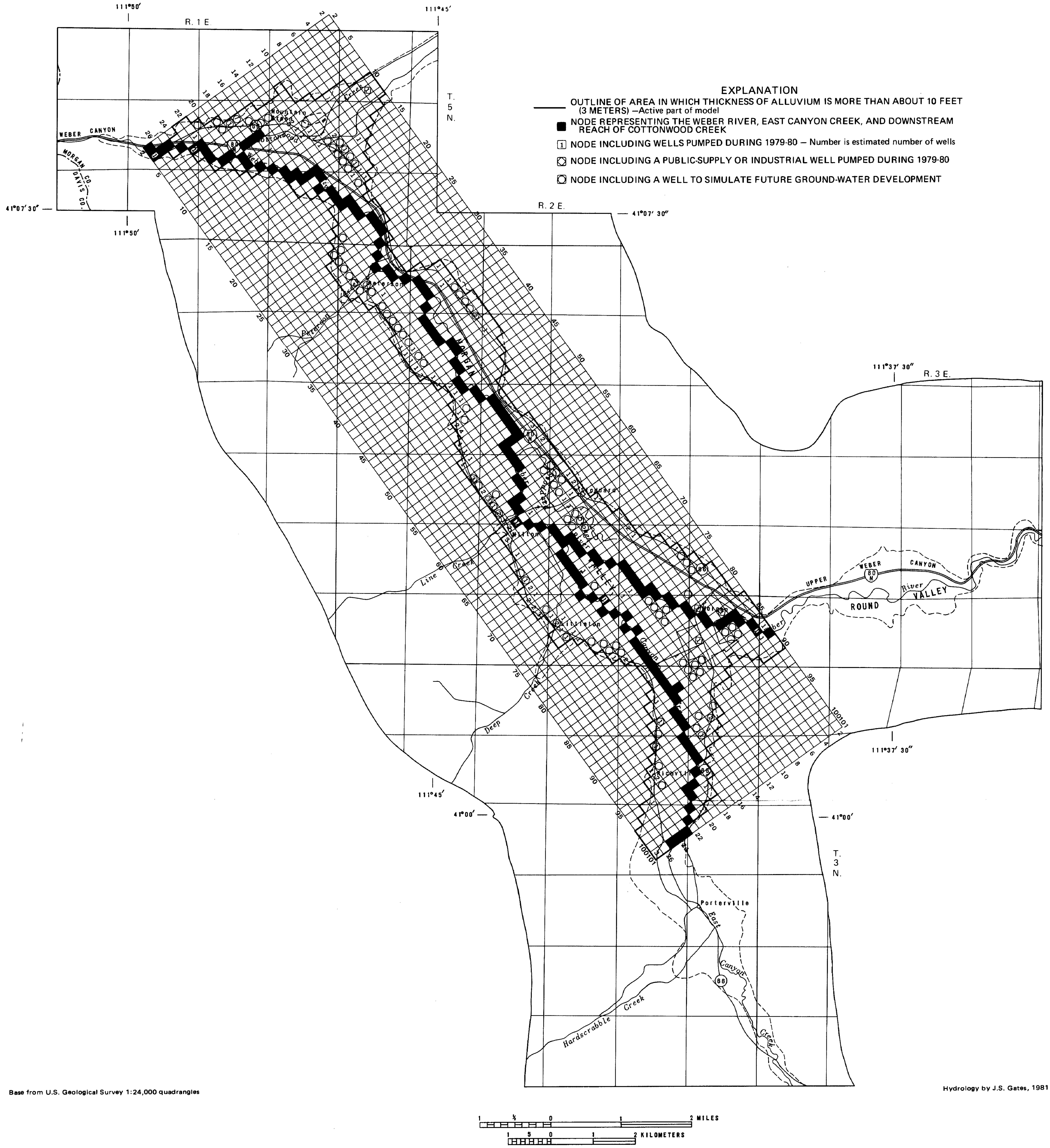
TECHNICAL PUBLICATION NO. 77
1984 PLATE 5



MAP SHOWING THE GRID USED FOR THE DIGITAL-COMPUTER MODEL OF THE MORGAN VALLEY-EAST CANYON CREEK AREA, MORGAN COUNTY, UTA