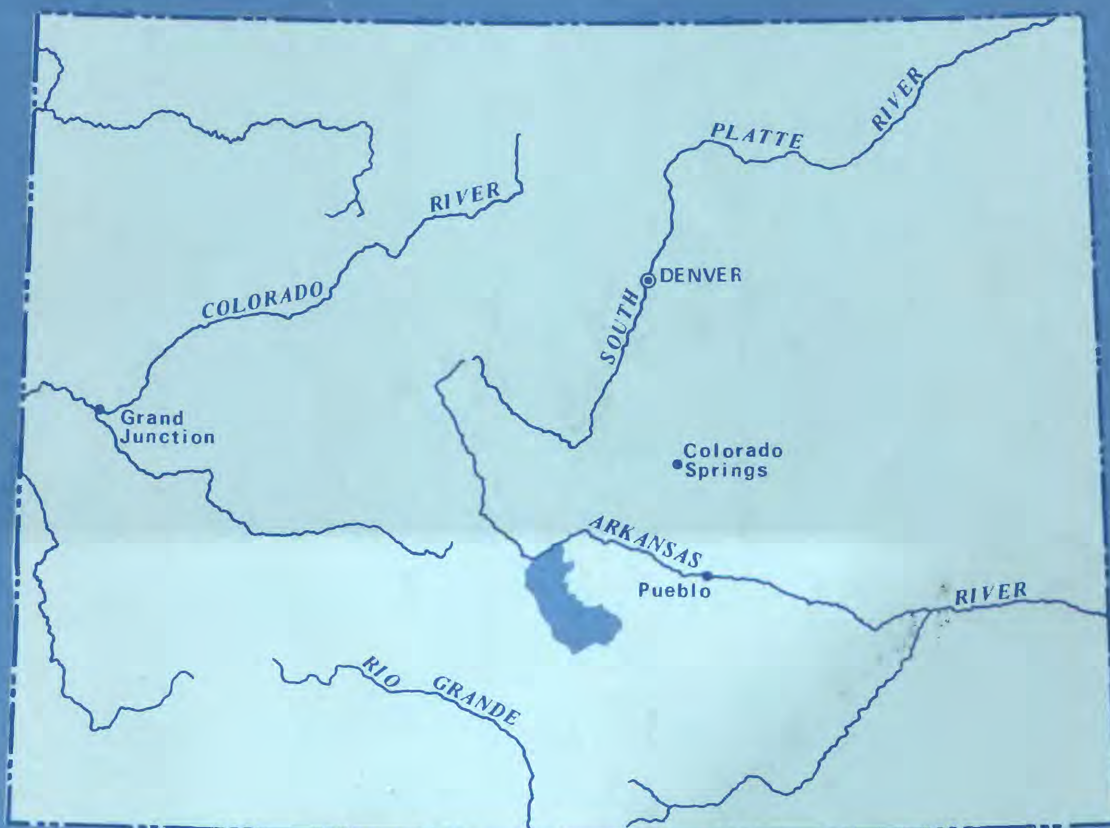
WATER-RESOURCES APPRAISAL OF THE WET MOUNTAIN VALLEY, IN PARTS OF CUSTER AND FREMONT COUNTIES, COLORADO

U. S. GEOLOGICAL SURVEY



Water-Resources Investigations 78-1

Prepared in cooperation with the Southeastern Colorado Water Conservancy District

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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By Clark J. Londquist and Russell K. Livingston

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Open-File Report

February 1978

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

W. A. Radlinski, Acting Director

Open-File Report

For additional information write to:

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Box 25046, Mail Stop 415
Denver Federal Center
Denver, Colo. 80225

CONTENTS

ILLUSTRATIONS

CONTENTS

TABLES

METRIC CONVERSION

Customary units used in this report may be expressed as metric units by use of the following conversion factors:

Multiply customary units	*By*	*To obtain metric units*
inch (in.)	25.40	millimeters
foot (ft)	.3048	meter
foot per mile (ft/mi)	.1894	meter per kilometer
mile (mi)	1.609	kilometers
square mile (mi^2)	2.590	square kilometers
acre	.4047	hectare
acre-foot (acre-ft)	1.233×10^{-3}	cubic hectometers
gallon per minute (gal/min)	.06309	liter per second
cubic foot per second (ft^3/s)	.02832	cubic meter per second
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	.01093	cubic meter per second per square kilometer

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ABSTRACT

The Wet Mountain Valley is an intermontane trough filled to a depth of at least 6,700 feet with unconsolidated deposits. Ground water occurs under both artesian and water-table conditions within the basin-fill aquifer and ground-water movement is toward Grape and Texas Creeks. The depth to the water table is less than 10 feet in an area of about 40 square miles along the central part of the valley and is less than 100 feet in most of the remainder of the valley. Ground water stored in the upper 100 feet of saturated basin-fill sediments is estimated to total 1.5 million acre-feet.

Yields greater than 50 gallons per minute generally can be expected from wells in the central part of the basin-fill aquifer, and yields less than 50 gallons per minute are generally reported from wells around the edge of the basin-fill aquifer. Yields of wells in the mountainous areas are generally less than 10 gallons per minute.

The 540-square-mile study area is drained by two principal streams, Grape Creek and Texas Creek. Most streamflow occurs as a result of snowmelt runoff during June and July. In addition to a stream-gaging station on Grape Creek near Westcliffe, which has operated since 1924, there are two continuous-record and four partial-record stations in the study area that were established in 1974. The long-term annual runoff at these seven stations ranges from an estimated 0.02 cubic foot per second per square mile to an estimated 1.17 cubic feet per second per square mile, generally increasing with station altitude.

DeWeese Reservoir, just outside of the study area, has a design storage capacity of 1,772 acre-feet. All other reservoirs in the area have a combined design storage capacity of about 215 acre-feet.

Generalized annual water budgets for two areas in the Wet Mountain Valley indicate that surface-water outflow is only 7 to 11 percent of the total water supply from precipitation and other sources. The remaining water is lost to the atmosphere by evapotranspiration. Ground-water underflow and changes in ground-water storage are considered insignificant in both water budgets.

The quality of both the surface and ground water is generally within the recommended limits for drinking water set by the U.S. Public Health Service. The hardness, as calcium carbonate, of the ground water is generally greater than 100 milligrams per liter.

INTRODUCTION

The Southeastern Colorado Water Conservancy District entered into a cooperative agreement with the U.S. Geological Survey in 1970 to conduct a water-resources investigation of the Wet Mountain Valley (fig. 1). The purpose of this investigation was to determine the quantity and quality of both the surface and the ground water within the valley. This information will be used in the management of the water resources of the area.

Westcliffe and Silver Cliff are the only towns with centralized populations in the area, each with a population of less than 400 people. The economy of the region is based primarily on agriculture. Irrigation plays a major role in crop production throughout the valley, particularly in the valley floor north and south of Westcliffe.

The scope of this investigation included the determination of the quality of water in the area, the amount of recoverable water stored in the first 100 ft of saturated alluvial material, expected yields from properly constructed wells, depths to water in the alluvial aquifer, estimates of surface-water flow from small ungaged drainage basins, and a water budget for the Grape Creek drainage area. Streamflow was measured at 7 sites, water samples for chemical analysis were collected from 20 wells and at 2 surface-water sites, and a network of 31 wells was measured bimonthly during 1970-75 (pl. 1).

The authors wish to acknowledge the cooperation and assistance provided by the many landowners in the area, particularly those who permitted access to their wells and property for the many measurements and tests necessary for the successful completion of this investigation.

GEOHYDROLOGIC SETTING

The Wet Mountain Valley is an intermontane trough filled with unconsolidated deposits of Cenozoic age, bordered by mountain ranges composed of volcanic rocks of Tertiary age and igneous, metamorphic, and sedimentary rocks of pre-Tertiary age (MacNish, 1966). The approximate location and extent of the various geologic units within the study area are shown on figure 2.

The study area includes about 540 mi^2 and is primarily drained by two north-flowing tributaries of the Arkansas River. Grape Creek, the principal stream, drains the southern 320 mi^2 of the study area. Texas Creek, the other large stream in the study area, drains an area of 144 mi^2. The remainder of the area is drained by several small streams that flow directly into the Arkansas River west of Texas Creek.

Precipitation generally increases with land-surface altitude in the Wet Mountain Valley. Based on the areal distribution of the average annual precipitation from 1931 to 1940 (fig. 3) (U.S. Weather Bureau, 1967),

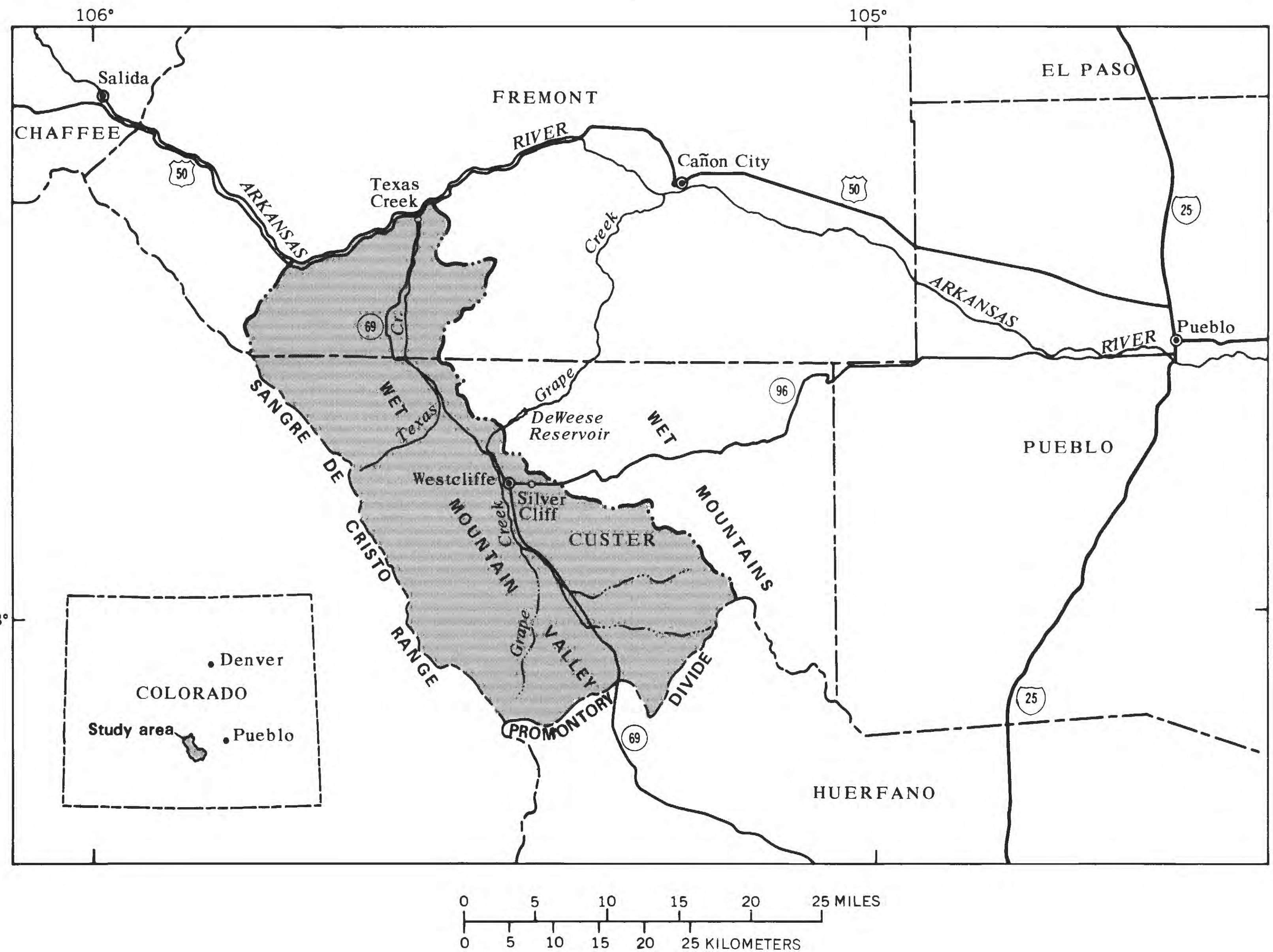

Figure 1.--Location of study area.

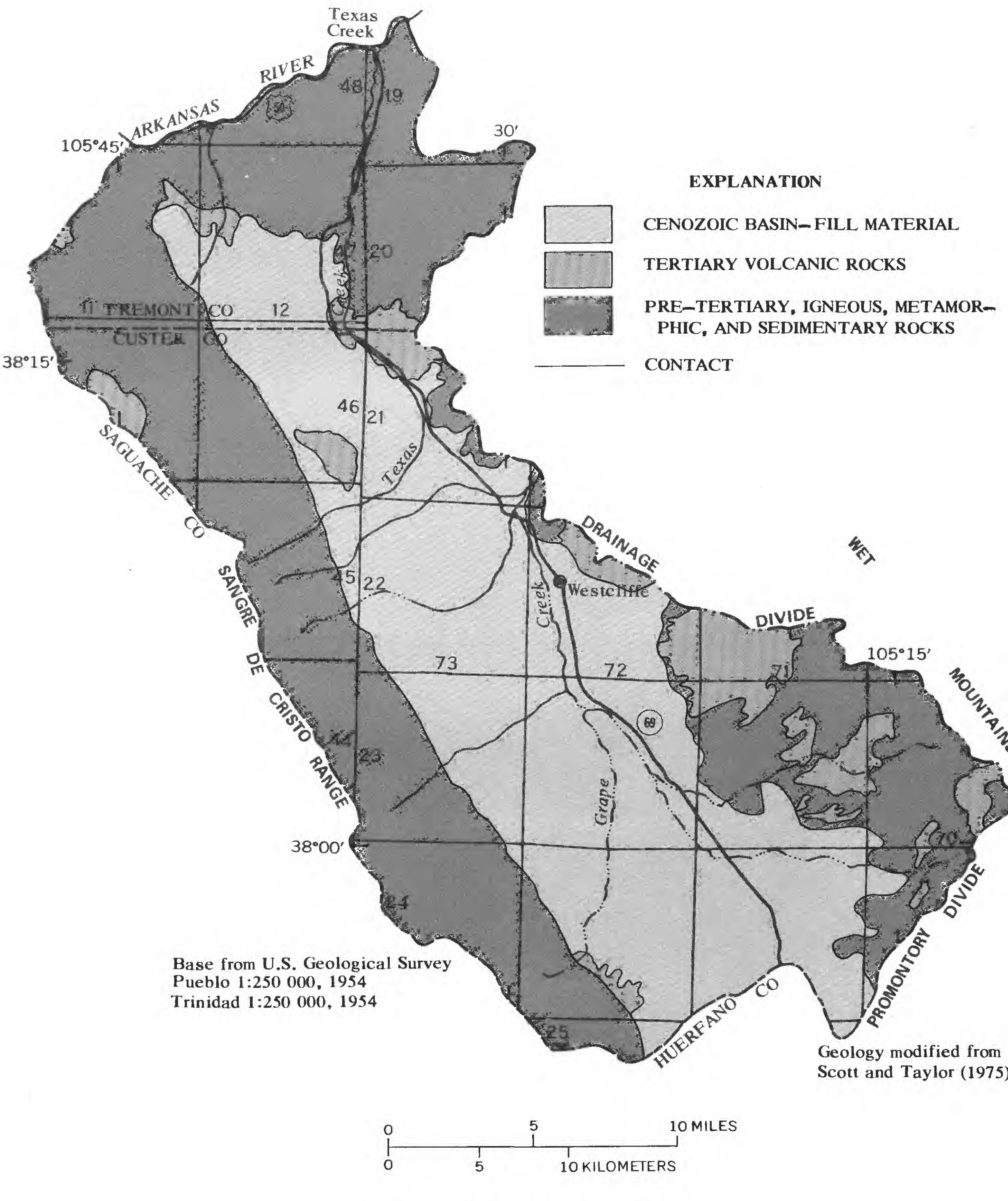

Figure 2.--Generalized geologic map.

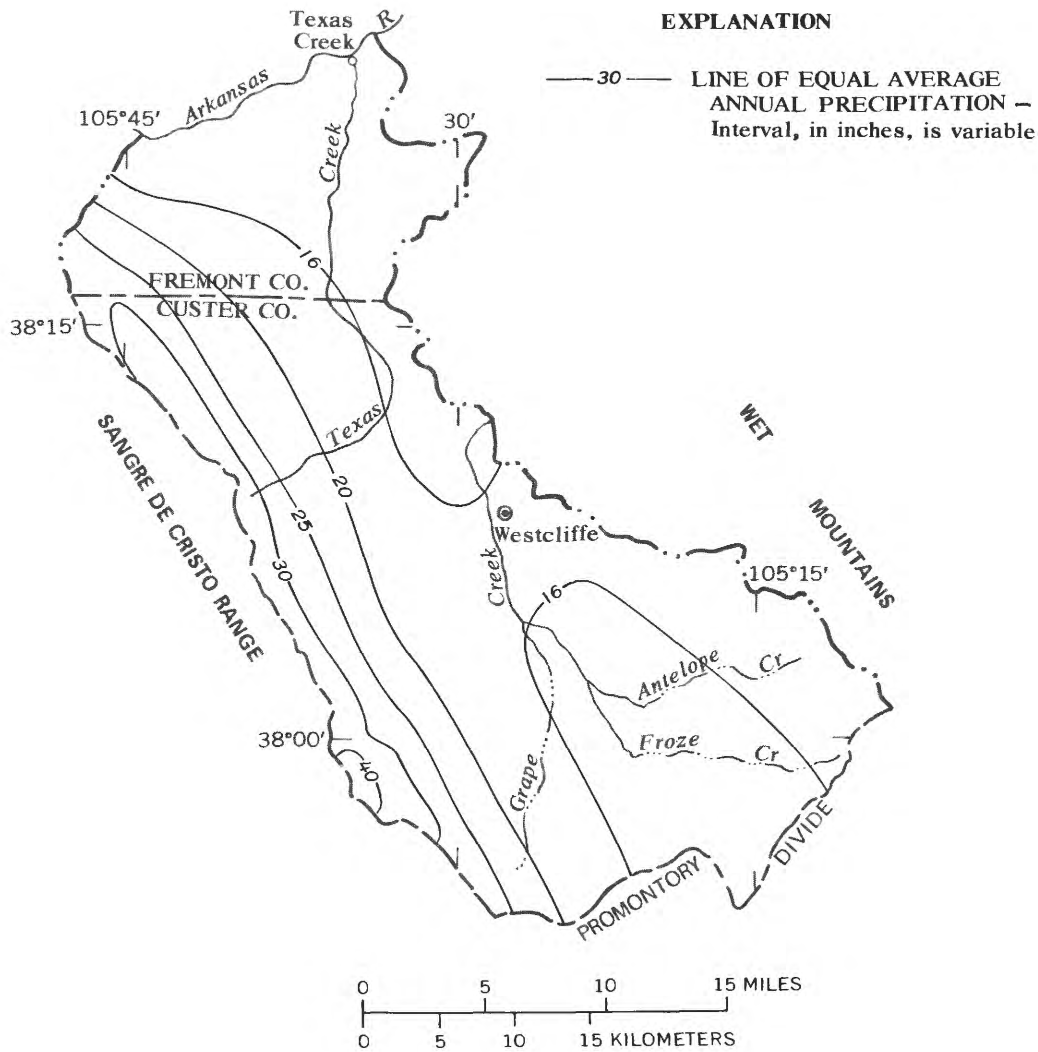

Figure 3.--Distribution of average annual precipitation 1931–60 (from U.S. Weather Bureau, 1967).

precipitation ranges from less than 16 in. per year on the valley floor (altitude about 8,000 ft) to more than 40 in. per year (altitude about 13,000 ft) along the Sangre de Cristo Range. About 37 percent of the total annual precipitation in the area occurs in the form of snow.

GROUND-WATER OCCURRENCE

Ground water occurs in two different hydrologic environments within the study area--the mountainous area, which is composed chiefly of consolidated rocks, and the valley-floor area, which is underlain by unconsolidated basin-fill material. The availability of ground water in the Wet Mountain Valley is summarized in figure 4.

Mountainous Area

The Sangre de Cristo Range, on the west side of the valley, consists of igneous, metamorphic, and complexly folded and faulted sedimentary rocks of pre-Tertiary age. The Wet Mountains, on the east side of the valley, are composed of igneous and metamorphic rocks of pre-Tertiary age which are overlain by Tertiary volcanic rocks at some localities.

In the mountainous area, ground water is chiefly contained in the fractured and weathered zones of the consolidated rocks or in minor, isolated pockets of overlying glacial and alluvial material. The weathered zones of the consolidated rocks are generally limited to the upper few tens-of-feet of the rock and the fractures generally become tighter and, hence, contain less water with depth. Yields from wells completed in consolidated rock are unpredictable due to the uncertain distribution of fractures and thickness of the weathered zones but, generally, are less than 10 gal/min (fig. 4). Yields greater than 10 gal/min might be obtained where the fractures or weathered zones are in direct hydraulic connection with the water in nearby streams.

The glacial and alluvial material in the mountainous area is generally restricted to the canyons and is not widespread. Where these materials occur above the water level of nearby streams, they are generally well drained and can be expected to yield less than 10 gal/min. In areas where the unconsolidated materials are in direct hydraulic connection with the water in nearby streams, well yields greater than 10 gal/min may be obtained.

In the volcanic rocks along the eastern margin of the valley, reported well yields vary considerably. In areas where the volcanic rocks are tuffaceous and of low permeability, the reported well yields are relatively small. Several wells have reportedly been drilled to depths ranging from 200 to 300 ft and have yields of less than 2 gal/min . Locally, where rhyolitic rock is encountered, well yields of as much as 30 gal/min have been reported from wells of less than 50 ft deep.

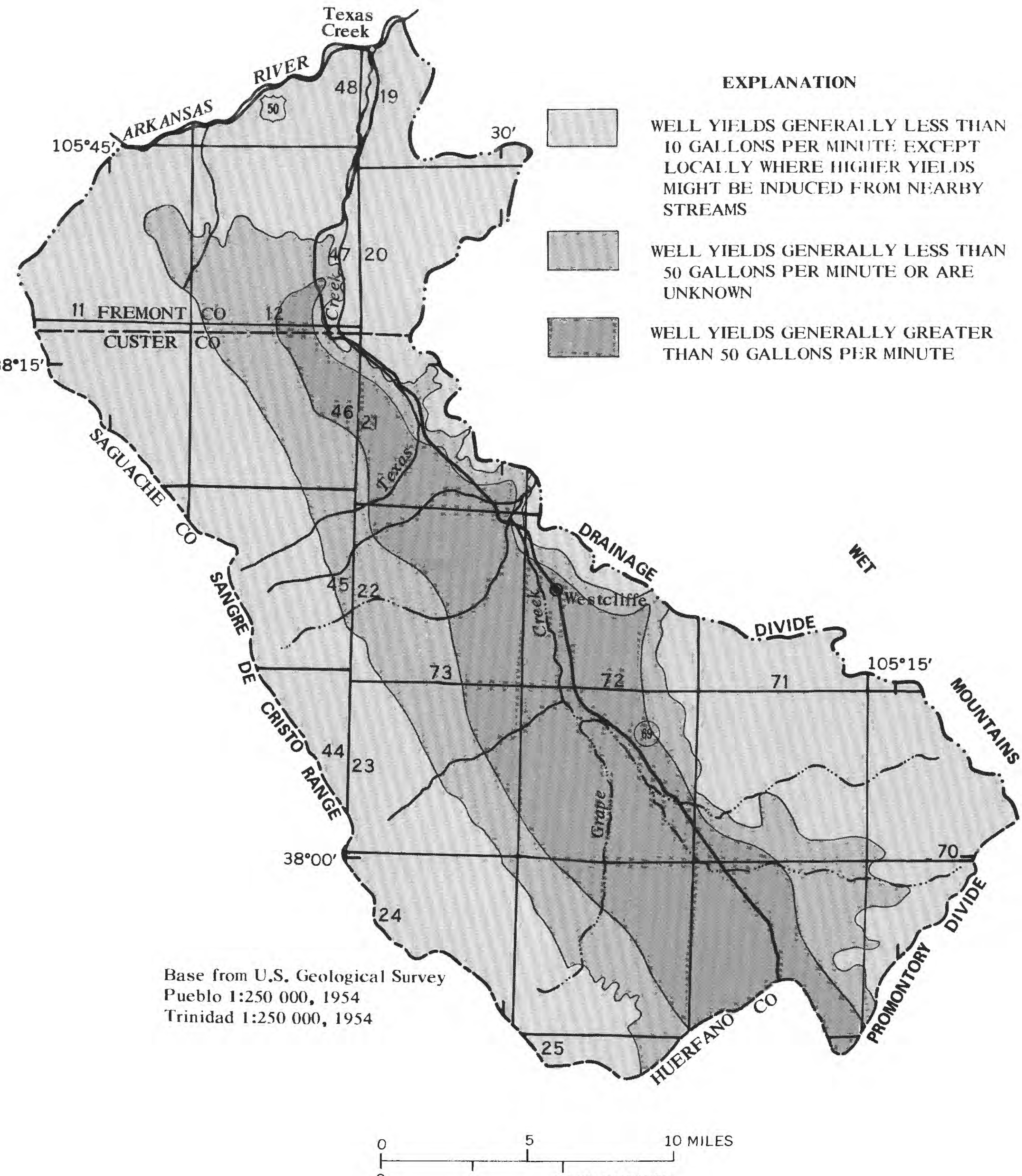

Figure 4.--Availability of ground water.

Valley-Floor Area

The basin-fill deposits in the valley-floor area cover an area of approximately 233 mi^2 and are the principal source of ground water in the study area. The basin-fill material is composed primarily of alluvial material derived during Tertiary time from the mountains surrounding the valley. Glaciation of the Sangre de Cristo Range has formed glacial moraine and outwash deposits which are superimposed on the Tertiary basin-fill material in some localities. Since the disappearance of the glaciers from the area, the trough has continued to slowly fill with alluvial material derived from the surrounding mountains.

An electrical resistivity survey was made from west to east across the valley about 3 mi south of Westcliffe (pl. 1). The resistivity section (fig. 5) indicates that the thickness of the basin-fill material ranges from about 1,000 ft at the east end of the section to about 6,700 ft at the west end (Zohdy and others, 1971). A test hole, SC 23-72- 6AAB1 (the system of numbering wells is explained in the Supplemental Information section of this report), was drilled along the line of the section, about 0.5 mi west of Grape Creek, to a depth of 1,200 ft. The geologic log of this test hole is included as Supplemental Information in this report. The log indicates that the upper 1,200 ft of the basin-fill material, in this area, is composed primarily of sand and gravel with interbedded and intergranular clay. The resistivity section indicates that the basin-fill material contains increasing amounts of clay with depth, or that the water in the basin-fill material contains increasing amounts of dissolved solids with depth.

Ground water occurs under both artesian and water-table conditions within the basin-fill aquifer. Artesian conditions are created by interbedded and intergranular clays confining the water beneath them. These confining layers probably are not continuous or completely impermeable and there is most likely a considerable amount of leakage between the confined and unconfined parts of the aquifer. The artesian conditions exist, to some extent, throughout most of the area of the basin fill. Along the central part of the valley, there are several flowing wells (pl. 1).

The depth to the water table is less than 10 ft in an area of about 46 mi^2 along the central part of the valley, as shown on figure 6. The depth to the water table is less than 100 ft in most of the remainder of the valley except for the extreme southern and southeastern parts of the valley, where it is generally greater than 100 ft.

There is an estimated 1.5 million acre-ft of recoverable ground water stored in the upper 100 ft of saturated basin-fill material. Hydrographs from selected wells are shown in figure 7. The hydrographs indicate that for the observed period of record, 1970-75, the water levels are undergoing only seasonal fluctuations and that no changes in the amount of ground water in storage are taking place.

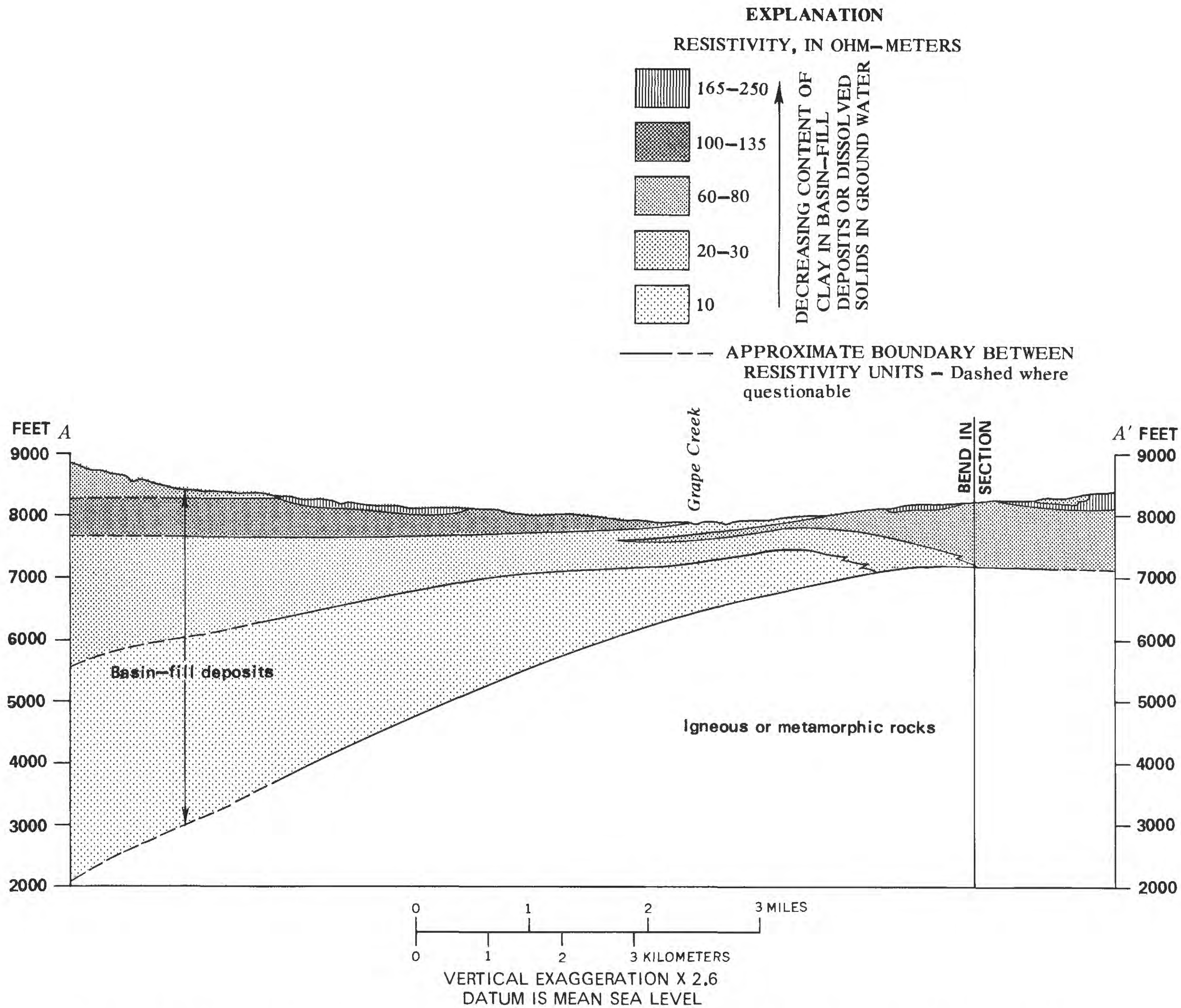

Figure 5.--Electrical resistivity section near Westcliffe. Modified from Zohdy and others, (1971).

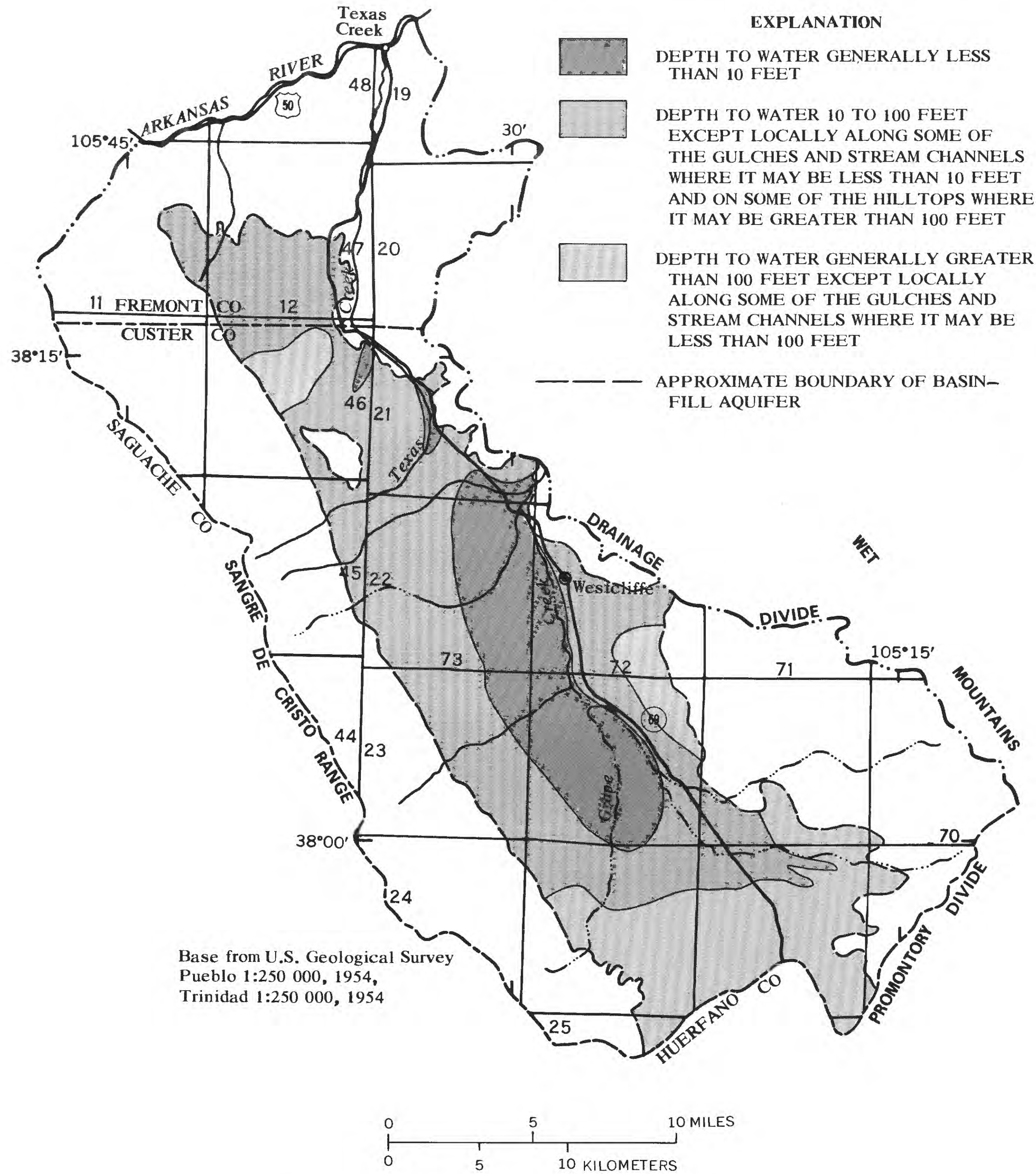

Figure 6.--Depth to water in the basin-fill aquifer.

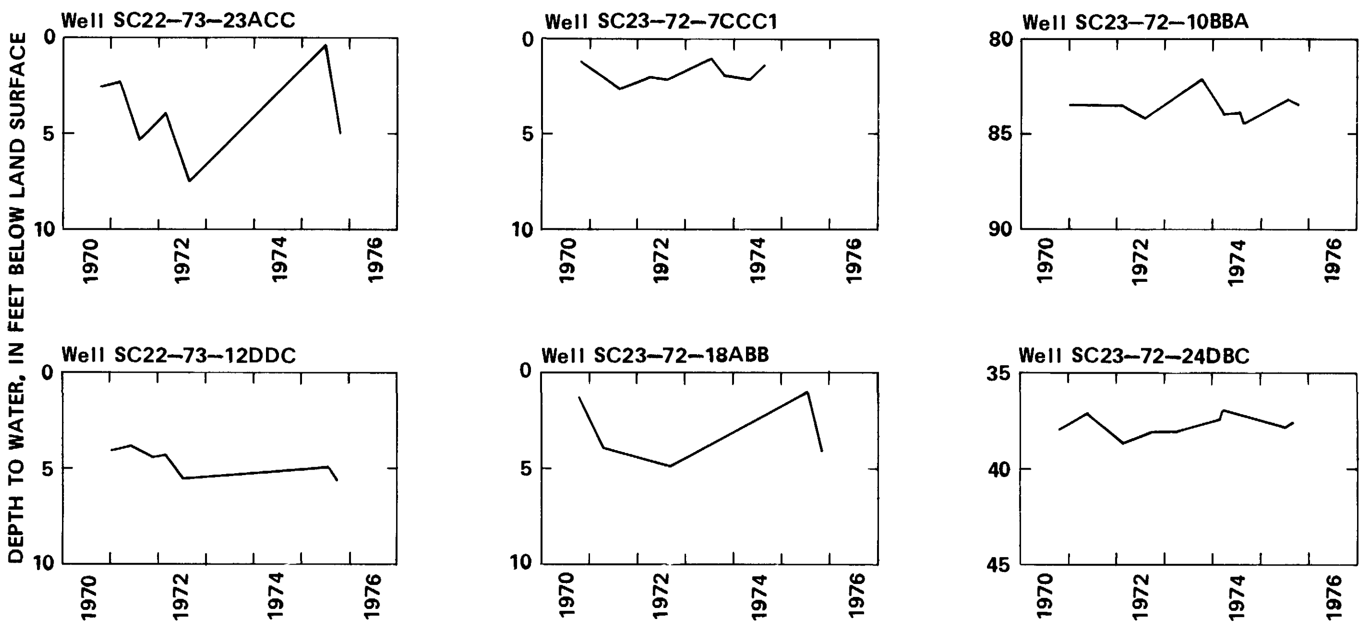

Figure 7.--Hydrographs from selected wells in the basin–fill aquifer.

The basin-fill area has been divided into two areas on the basis of reported well yields (fig. 4). In the central part of the valley, wells of adequate depth, diameter, and screen length can be expected to have sustained yields of at least 50 gal/min. Several wells in this area have reported yields greater than 300 gal/min. (See Records of Selected Wells in the Supplemental Information section of this report.)

GROUND-WATER MOVEMENT

Water enters the aquifers in the mountainous area as infiltration from precipitation or streams. The water then moves downgradient where it is discharged by springs to the numerous small streams, lost to evapotranspiration, or discharged into the basin-fill aquifer as underflow.

Extensive faults have been mapped along both the east and west sides of the basin between the basin-fill material and the consolidated rock (Scott and Taylor, 1975). The low permeability fault gouge associated with these faults probably serves as at least a partial barrier to water movement between the consolidated rock and the basin-fill material. This barrier and the general low permeability of the consolidated rock limit the direct discharge of water from the consolidated rock to the basin-fill material to very small amounts. Water enters the basin-fill aquifer as infiltration from precipitation falling directly on the aquifer or as rim inflow from the surrounding mountainous area.

The basin-fill material is surrounded, except for the southern end, by bedrock of low permeability. The volcanic rocks in the basin (fig. 2) are not continuous and do not serve as a conduit for transporting water out of the basin. Once the water enters the basin-fill aquifer, it moves toward the center of the basin and does not flow out of the basin to the south under Promontory Divide. Very little, if any, water leaves the basin-fill aquifer as underflow. The direction of ground-water flow in the basin-fill aquifer is shown on plate 1. Ground water moves from higher to lower potentiometric levels. As illustrated by the potentiometric map (pl. 1), ground water moves from the boundaries of the basin-fill aquifer toward Grape and Texas Creeks.

Water leaves the aquifer in several ways. Direct evapotranspiration from the water table occurs in the area where the depth to water is less than 10 ft (fig. 6). Water is discharged from the aquifer into Grape Creek along the reach from just south of Westcliffe to the edge of the basin fill and to Texas Creek in the reach just before it leaves the basin-fill material. Some water also is lost to small streams that cross the northern end of the valley-fill material and then discharge directly into the Arkansas River. Water is discharged through wells either by pumping or by artesian flow. Part of the water discharged from wells infiltrates the land surface and percolates back down to the water-table aquifer, while the remainder is consumed, lost to evapotranspiration, or runs off into the streams.

SURFACE WATER

The surface-water resources of the Wet Mountain Valley are vital to the agricultural economy of the area. Most of the water for irrigation is obtained by diversion of surface water rather than pumping of ground water. A tabulation of water rights on Grape Creek and Texas Creek is presented in table 1.

Observed streamflow consists of runoff from precipitation, return flow from irrigation, seepage from ground water, and (or) water released from reservoir storage. A hydrograph of mean monthly discharges (1925-75) of Grape Creek near Westcliffe (station 07095000; the station numbering system is explained in the Supplemental Information section of this report) is shown in figure 8. Runoff from melting snow dominates the hydrograph during May, June, and July. Streamflow during the low-flow or base-flow period in fall and winter is due largely to irrigation return flows and ground-water discharge.

The streamflow hydrograph shown in figure 8 does not indicate the effects of significant surface-water storage in the watershed. A tabulation of lakes and reservoirs in the study area and their location, design surface area, and design storage capacity is given in table 2. DeWeese Reservoir, the largest reservoir in the vicinity of the study area, is located about 0.5 mi downstream from station 07095000. The water-storage capacity of this reservoir is 1,772 acre-ft. The remaining five reservoirs in the study area have a combined water-storage capacity of about 215 acre-ft.

Streamflow

The Wet Mountain Valley has large year-to-year variations in streamflow. A hydrograph of annual runoff recorded by the Grape Creek near Westcliffe gage (07095000) is shown in figure 9. From 1924 to 1975, annual recorded runoff ranged between 5,120 acre-ft in 1963 and 78,850 acre-ft in 1942. As previously stated, the study area has only about 215 acre-ft of available water storage in surface-water reservoirs.

Other than at the Grape Creek near Westcliffe (07095000) gaging station that was established in 1924, very few records of streamflow have been collected in the study area. The streamflow-gaging station on Grape Creek near Canon City (07095500) was operated during 1907-09 and the station on Texas Creek at Texas Creek (07094000) was operated during 1923. Unpublished records of streamflow exist for Dry Creek near Westcliffe during the late 1960's and for Texas Creek at Texas Creek since September 1970.

In order to improve areal coverage of streamflow information, two continuous-record and four partial-record gaging stations were installed in August 1974 as part of this study. These stations are listed in table 3 and located on plate 1. Data obtained from these six additional stations were useful in evaluating the streamflow characteristics of the many smaller streams draining the perimeter of the study area.

Table 1.--*Surface-water diversion rights prior to 1880 along Grape and Texas Creeks*[1]

Name of diversion	Location[2] Township	Range	Section	Amount of decree, in cubic feet per second	Date of decree
GRAPE CREEK					
Aldrich No. 2	22S	072W	32	0.34	04-15-1870
Voris Bros. No. 1	21S	073W	25	2.34	07-31-1871
DeWeese Dye Main	19S	070W	06	2.34	07-31-1871
Voris Bros. No. 1	21S	073W	25	2.34	07-31-1871
Pinto	23S	072W	21	.50	05-01-1872
Southern	23S	072W	27	1.38	06-12-1873
Voris Bros. No. 1	21S	072W	25	.95	10-31-1873
DeWeese Dye Main	19S	070W	06	.95	10-31-1873
Voris Bros. No. 1	21S	072W	25	.95	10-31-1873
Difz	23S	072W	27	.83	06-15-1874
Rifster No. 2	23S	072W	34	.88	10-10-1874
C B H	23S	072W	34	.50	10-10-1874
Pinto	23S	072W	21	2.50	03-03-1875
Gordon W. Smith No. 1	22S	072W	19	3.00	05-15-1875
Elze No. 3	24S	072W	04	.69	05-31-1875
Elze No. 5	24S	072W	03	.16	05-31-1875
Voris Jarvis No. 1	22S	073W	01	2.61	05-31-1875
Risser and Locke	23S	072W	05	5.11	06-01-1875
Hulmuth	23S	072W	16	2.50	10-05-1875
R B	23S	072W	20	.89	05-05-1876
Chetelate No. 2	23S	072W	20	.33	06-01-1876
Schulz No. 3	24S	072W	03	.66	06-01-1876
C B H	46N	012E	13	1.30	06-05-1876
Colfax	23S	072W	04	2.33	06-10-1876
Voris Bros. No. 2	22S	073W	01	1.33	06-30-1877
DeWeese Dye Main	19S	070W	06	1.33	06-30-1877
Voris Bros. No. 2	22S	073W	01	1.33	06-30-1877
Schoolfield No. 4	22S	072W	05	.56	04-01-1878
Schulz No. 5	24S	072W	03	.33	05-15-1878
Voris Bros. No. 1, 2d Enl	21S	073W	25	1.09	10-31-1879
DeWeese Dye Main	19S	070W	06	1.09	10-31-1879
Voris Bros. No. 1, 2d Enl	21S	073W	25	1.09	10-31-1879
Total				44.53	

Table 1.--*Surface-water diversion rights prior to 1880 along Grape and Texas Creeks*[1]--Continued

Name of diversion	Location[2]			Amount of decree, in cubic feet per second	Date of decree
	Township	Range	Section		
TEXAS CREEK					
Hill No. 1------------------	47N	012E	12	1.05	08-31-1869
Hill No. 2------------------	47N	012E	12	1.05	08-31-1869
Pitter No. 1----------------	21S	073W	29	1.00	04-30-1871
Likely & McCormick----------	47N	012E	14	1.32	06-01-1871
McCormick-------------------	47N	012E	13	1.00	06-01-1871
Mill------------------------	---	----	--	1.00	09-01-1871
Ritter No. 2----------------	21S	073W	29	1.00	05-01-1872
Duckett No. 1---------------	47N	012E	26	1.00	05-10-1872
Belknap & Hendrickson--------	47N	012E	35	1.00	05-10-1872
Duckett No. 1---------------	47N	012E	26	1.00	05-10-1872
Belknap & Howard-------------	46N	012E	--	2.76	05-31-1872
Dissmore No. 2 McClurkens----	21S	073W	31	1.00	07-24-1872
McClurken No. 1-------------	21S	073W	31	1.00	07-30-1872
Hugg No. 3------------------	21S	073W	32	1.06	11-30-1872
Hugg No. 4------------------	21S	073W	32	1.00	11-30-1872
Duckett No. 2---------------	47N	012E	26	1.32	05-15-1873
Hill Ditch No. 2------------	47N	012E	12	1.05	01-17-1874
Myers-----------------------	21S	073W	16	1.00	05-01-1874
J. M. Duckett---------------	47N	012E	34	3.50	05-31-1874
Burgman No. 2---------------	47N	012E	33	1.00	04-30-1875
Hill No. 1------------------	47N	012E	12	1.05	04-14-1876
Likely----------------------	47N	012E	12	1.60	03-06-1877
Belknap & Hendrickson--------	47N	012E	35	1.58	05-31-1878
Total-------------------------------------				29.34	

[1]Source: Colorado Division of Water Resources, Office of the State Engineer.

[2]Refers to location of point of diversion.

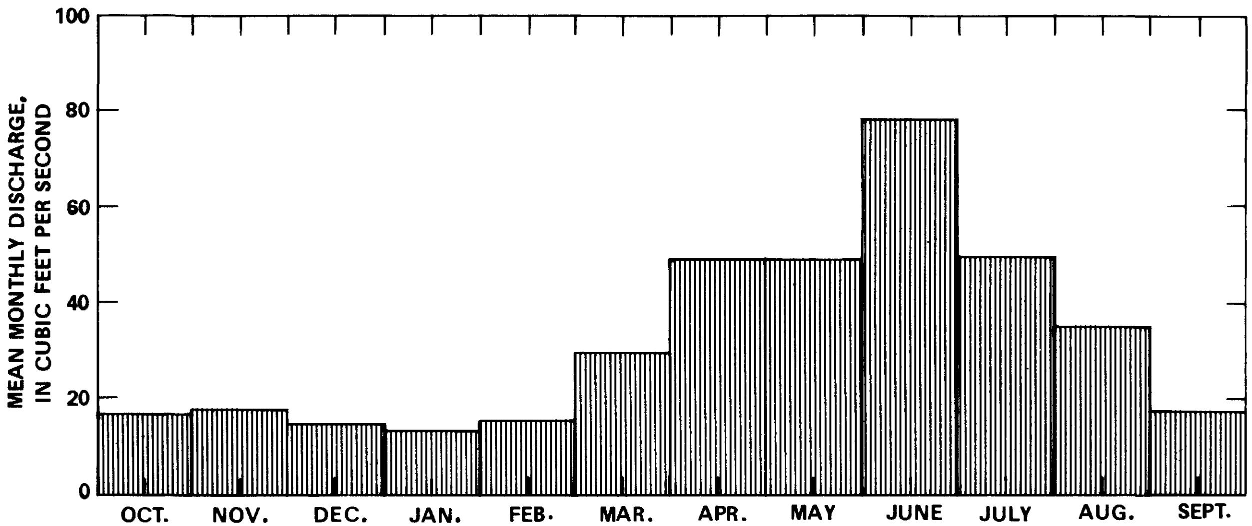

Figure 8.--Mean monthly discharge of Grape Creek near Westcliffe (station number 07095000), 1927 to 1975 water years.

Table 2.--*Principal lakes and reservoirs in the Wet Mountain Valley and vicinity*[1]

Name	Location[2]			Owner	Design surface area, in acres	Design capacity, in acre-feet
	Town-ship	Range	Section			
Balman Reservoir--	46N	12E	6	U.S. Forest Service	3.6	50.9
Hook Reservoir----	46N	12E	2	Thomas Hook	2.0	35.0
DeWeese Reservoir-	21S	72W	20	DeWeese Dye Ditch and Reservoir Co.	148	1,772
Lake of the Clouds Reservoir No. 1-	45N	12E	(21)	U.S. Forest Service	15.0	48.0
Lake of the Clouds Reservoir No. 2-	45N	12E	(21)	-----do------------	15.0	36.0
Lake of the Clouds Reservoir No. 3-	45N	12E	(21)	-----do------------	(15)	(45)

[1]Source: Colorado Division of Water Resources, Office of the State Engineer.

[2]Refers to location of dam or outlet.

Table 3.--*Stream-gaging stations in*

Stream site number[1]	U.S. Geological Survey station number	Station name	Operating agency	Location	
				Latitude	Longitude
1	07093980	Lake Creek near Hillside, Colo-	U.S. Geological Survey	38°15'49"	105°39'41"
2	07094000	Texas Creek at Texas Creek (near Cotapaxi), Colo----	Office of the Colorado State Engineer	38°24'30"	105°35'00"
3	07094530	Grape Creek near Bradford, Colo-	U.S. Geological Survey	37°57'03"	105°27'03"
4	07094600	South Colony Creek near Westcliffe, Colo-----------	-----do---------	37°59'57"	105°29'25"
5	07094700	Antelope Creek near Rosita, Colo-----------	-----do---------	38°01'18"	105°21'43"
6	07094800	Venable Creek near Westcliffe, Colo---	-----do---------	38°05'02"	105°33'52"
7	07094900	Middle Taylor Creek near Westcliffe, Colo-----------	-----do---------	38°06'30"	105°36'03"
8	07095000	Grape Creek near Westcliffe, Colo-----------	Office of the Colorado State Engineer	38°11'10"	105°28'59"

[1]Refers to sites shown on figure 2.
[2]Refers to available record from which flow characteristics were

the Wet Mountain Valley and vicinity

Drainage area (mi²)	Period of record[2]	Mean annual discharge (ft³/s)	Maximum observed discharge (ft³/s)	Minimum observed discharge (ft³/s)	Remarks
9.07	June 1974-September 1976	-----	20	1.6	Partial-record station, discharge measurements only.
144	April-November 1923	-----	2,800	----	Records only for 1923 are published.
6.72	June 1974-September 1976	-----	19	.3	Partial-record station, discharge measurements only.
6.03	October 1974-September 1976	6.65	47	.20	
35.3	June 1974-September 1976	-----	9.4	0	Do.
2.55	June 1974-September 1976	-----	17	.04	Do.
3.19	October 1974-September 1976	4.10	38	.40	
320	October 1924-September 1961; October 1962-September 1976	32.3	7,460	.01	

determined; records may exist for other periods.

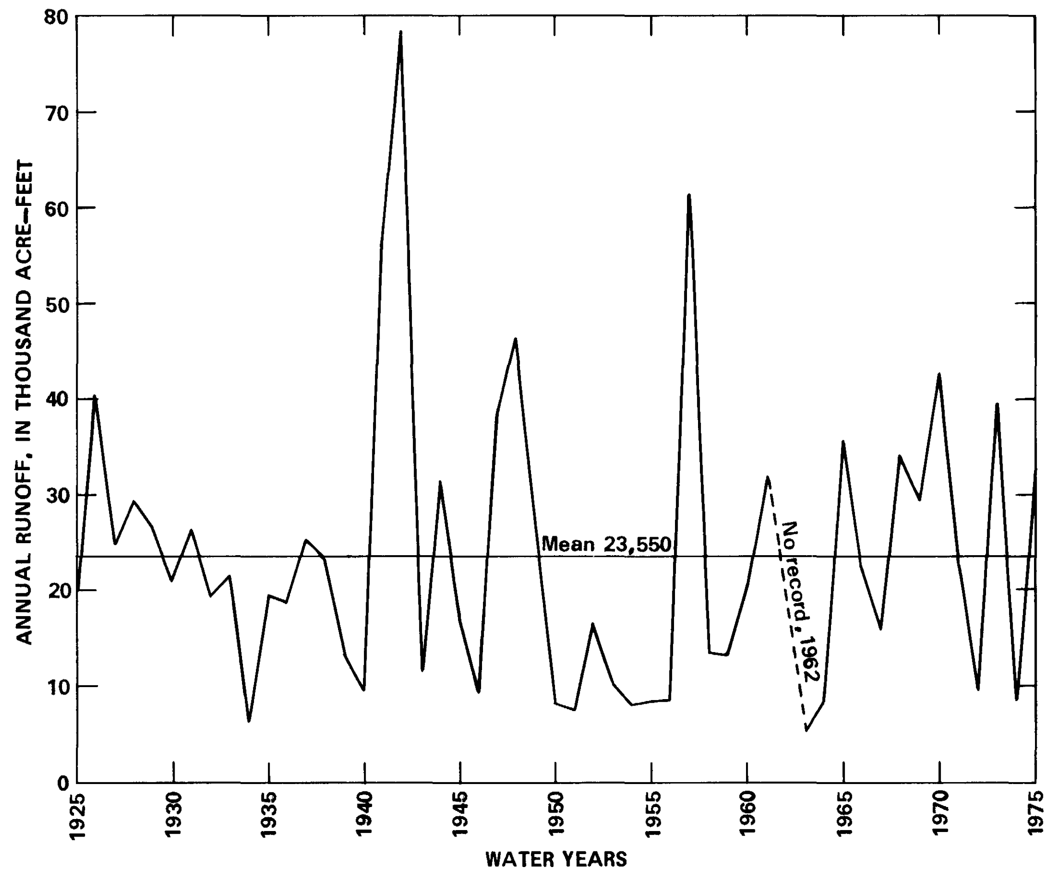

Figure 9.--Annual runoff of Grape Creek near Westcliffe (station number 07095000), 1925 to 1975 water years.

Runoff Analysis

The results of an analysis of runoff in the study area are summarized in table 4. The 1975-76 annual runoff for the four partial-record stations was determined by correlation techniques using the two continuous-record stations and is expected to be within 10 percent of the actual runoff (Riggs, 1969). Observed annual runoff in the study area was generally greatest during the 1975 water year.

Long-term annual runoff (1931-60), also given in table 4, was estimated for the six short-term gaging stations based on the 1975-76 average annual runoff, channel-geometry techniques (Hedman and others, 1972), and regression analysis of basin characteristics (Livingston, 1970). Equations for predicting the long-term mean annual runoff using channel-geometry measurements have a standard error of estimate of 19 percent; those for basin characteristics, 47 percent. (The standard error of estimate is the percentage above or below calculated values within which about two-thirds of the actual values are expected to fall.) The recorded 1975-76 average annual runoff for Grape Creek near Westcliffe is in close agreement with the long-term (1931-60) runoff. Consequently, the 1975-76 average annual runoff for the six short-term gaging stations, along with the determinations made using channel-geometry and regression methods, were averaged to estimate the long-term (1931-60) mean annual runoff at these stations. These data were used in the water-budget analysis which is discussed in a later section of this report.

Annual runoff expressed as a function of drainage area, in cubic feet per second per square mile, generally increases with altitude in the Wet Mountain Valley, as shown in table 4. Values of estimated mean annual runoff for 1931 through 1960 range from about 0.02 $(ft^3/s)/mi^2$ for Antelope Creek (altitude 8,290 ft) to about 1.17 $ft^3/s)/mi^2$ for Middle Taylor Creek(altitude 9,960 ft). Such data can be used to give an estimate of annual runoff at ungaged sites in the study area. For example, the data shown in table 4 indicate that the annual runoff for a stream with a 5-mi^2 drainage area at an altitude of 9,000 ft is about 5 ft^3/s or 1.0 $(ft^3/s)/mi^2$.

Magnitude and Frequency of Floods

Occasional flooding in the Wet Mountain Valley results from either intensive rainstoms or unusual snowmelt-runoff conditions. Information on the magnitude and frequency of floods can be used by planners and designers to minimize damages and hazards in areas subject to flooding.

Where adequate records of flood discharge are available, a relation can be developed between flood magnitude and frequency of occurrence. The log-Pearson Type III distribution has been established as the method for uniform flood-frequency analyses by all Federal agencies (U.S. Water Resources Council, 1976). In order to reduce the effects of possible time-sampling errors associated with such analyses, a weighting procedure can be used (Sauer, 1974; McCain and Jarrett, 1976). For example, the 100-year flood discharge for Grape Creek at Westcliffe (07095000) is 4,900 ft^3/s by log-

Table 4.--*Annual runoff in the*

Station name (station number)	Drainage area, in square miles	Altitude, in feet	Observed annual runoff, in acre-feet		
			1975 Water year	1976 Water year	1975-76 Average
Lake Creek near Hillside (07093980)[4]--	9.07	8,300	3,590	3,610	3,600
Grape Creek near Bradford (07094530)[4]--	6.72	8,690	3,330	2,960	3,140
South Colony Creek near Westcliffe (07094600)-	6.03	8,940	5,060	4,570	4,820
Antelope Creek near Rosita (07094700)[4]----	35.3	8,290	780	50	420
Venable Creek near Westcliffe (07094800)[4]	2.55	9,020	2,160	1,510	1,840
Middle Taylor Creek near Westcliffe (07094900)-	3.19	9,960	3,700	2,240	2,970
Grape Creek near Westcliffe (07095000)-	320	7,790	33,710	14,780	24,240

[1]Hedman, Moore, and Livingston, 1970.
[2]Livingston, 1970.
[3]Figures in parentheses were determined as the mean of the observed regression methods (see text).
[4]Partial-record station.
[5]Value not used in determining mean annual runoff.

Pearson Type III analysis and 9,370 ft^3/s by the weighting procedure. A complete summary of the flood characteristics for Grape Creek at Westcliffe (07095000), including the equations and parameter values used in their determination, is given in table 5.

For natural-flow streams where adequate records of flood discharge are not available, the flood characteristics can be estimated using regional relations given in a manual developed by McCain and Jarrett (1976). The method presented in the manual involves the use of basin characteristics and regionalized regression equations. A summary showing the use of this method to determine the flood characteristics at two partial-record stations, Antelope Creek near Rosita (07094700) and Venable Creek near Westcliffe (07094500) is given in table 5.

Estimated annual runoff, in acre-feet		Mean annual runoff (1931-60 calendar years)[3]	
Channel-geometry method[1]	Regression method[2]	Acre-feet	Cubic feet per second per square mile
3,560	[5]5,170	(3,600)	(0.55)
[5]1,120	2,880	(3,000)	(.62)
2,920	5,930	(4,500)	(1.03)
380	-----	(400)	(.02)
1,830	1,930	(1,900)	(1.03)
2,260	2,850	(2,700)	(1.17)
-----	-----	22,460	.10

1975-76 average runoff and the estimated runoff by channel-geometry and

GENERALIZED WATER BUDGET

The movement of water in a particular area may be expressed as a water budget in which an accounting is made of all water entering or leaving the area. The water budget can be expressed in equation form as:

$$\text{Water in} = \text{Water out} \pm \text{change in storage},$$

where "water in" includes precipitation and surface- and ground-water inflow, "water out" includes evapotranspiration and surface- and ground-water outflow, and "change in storage" includes both surface- and ground-water storage and is positive for a net increase in storage.

Table 5.--*Flood characteristics for selected*

Station name and number	Basin type	Required parameters
Antelope Creek near Rosita (07094700)-----	Ungaged site--mixed population (plains/mountain) region	Q_T=discharge for recurrence interval, T, D_T=depth for recurrence interval, T, A= 35.3 mi^2 (drainage area) (9.45 mi^2, plains region; 25.8 mi^2, mountain region), P=18 in. =mean annual precipitation (mountain region only), S_B=114 ft/mi (basin slope) S_S= 64 ft/mi (streambed slope) R=0.70 (reduction factor for site elevation).
Venable Creek near Westcliffe (07094900)-----	Ungaged site--mountain region	A=2.55 mi^2 (drainage area), P=28 in. (mean annual precipitation).
Grape Creek near Westcliffe (07095000)-----	Gaged site--mixed population (plains/mountain) region	$Q_{T(W)}$=weighted discharge for recurrence interval, T, $Q_{T(S)}$=station value of the flood for recurrence interval, T[1], $Q_{T(R)}$=regression value of the flood for recurrence interval, T, N=46 (number of years of station data used to compute $Q_{T(S)}$), E=10 (equivalent years of record for $Q_{T(R)}$), A= 320 mi^2 (drainage area) (220 mi^2, plains region; 100 mi^2, mountain region), P=19 in., S_B=47 ft/mi, S_S=29 ft/mi.

[1]Method of determination as described by McCain and Jarrett, 1976.
[2]Standard error of estimate is the percentage above or below calculated
[3]Highest flood characteristic obtained by the two methods used; in this

gaging stations in the Wet Mountain Valley[1]

Regression equation	Standard error of estimate[2] (percent)	Resultant flood characteristic
Plains region:		
$Q_{10} = 144\ A^{0.528}\ S_B^{0.336}$	31	[3]$Q_{10} = 1,620\ ft^3/s.$
$Q_{50} = 891\ A^{0.482}\ S_B^{0.154}$	24	[3]$Q_{50} = 3,820\ ft^3/s.$
$Q_{100}=1,770\ A^{0.463}\ S_B^{0.086}$	28	[3]$Q_{100}= 5,270\ ft^3/s.$
$Q_{500}=5,770\ A^{0.432}$	45	[3]$Q_{500}=10,660\ ft^3/s.$
$D_{100}=59.3\ S_S^{-0.517}$	21	[3]$D_{100}=6.9$ ft.
Mountain region:		
$Q_{10} =0.12\ A^{0.815}\ P^{1.592}$	39	
$Q_{50} =0.91\ A^{0.795}\ P^{1.110}$	37	
$Q_{100}=1.88\ A^{0.787}\ P^{0.932}$	38	
$Q_{500}=8.70\ A^{0.766}\ P^{0.560}$	45	
$D_{100}=1.44\ A^{0.187}\ P^{0.059}$	28	
(Equations given above)		$Q_{10} = 52\ ft^3/s.$
		$Q_{50} = 77\ ft^3/s.$
		$Q_{100}= 88\ ft^3/s.$
		$Q_{500}=115\ ft^3/s.$
		$D_{100}=2.1$ ft.
$Q_{T(W)}=\dfrac{(Q_{T(S)}\times N)+(Q_{T(R)}\times E)}{N+E}$		[3]$Q_{10(W)} = 2,780\ ft^3/s.$
(Equations for $Q_{T(R)}$ and D_{100} given above)		[3]$Q_{50(W)} = 6,740\ ft^3/s.$
		[3]$Q_{100(W)}= 9,370\ ft^3/s.$
		[3]$Q_{500(W)}=18,800\ ft^3/s.$
		[3]$D_{100(W)}=10.4$ ft.

values within which about two-thirds of the actual values are expected to fall.
instance, the characteristics from the plains-region determination are used.

Generalized annual water budgets are given in table 6 for the Grape Creek drainage basin above the Grape Creek near Westcliffe gaging station (07095000), and for that part of this drainage basin consisting of basin-fill material (fig. 10). The area of basin-fill drained by Grape Creek represents 167 mi^2 of the 320-mi^2 drainage basin. The budgets are based on calendar years 1931 through 1960.

Precipitation

The average annual precipitation falling on the water-budget areas was determined by use of the distribution of mean annual precipitation for 1931-60 shown on figure 3. The isohyetal method of analysis resulted in a 331,000-acre-ft average for the entire drainage area and a 151,000-acre-ft average for the basin-fill area.

Surface-Water Inflow and Outflow

There is no surface-water inflow across the Grape Creek drainage divide, such as transmountain diversions. Surface-water inflow to the basin-fill area consists of runoff from the mountainous regions along the perimeter of the area. For purposes of the water budget, the 153 mi^2 that contribute inflow were separated into the two tributary areas shown on figure 10. Tributary area A (72 mi^2), which extends from the Sangre de Cristo Range divide to the basin-fill boundary, receives the most precipitation within the study area (fig. 3) and is consequently heavily vegetated. Tributary area B (81 mi^2), on the other hand, generally extends from the Wet Mountain divide to the basin-fill boundary and is characteristically dry and sparsely vegetated except at higher altitudes. Runoff from the two tributary areas was determined using the estimated 1931-60 mean annual runoff for the six gaging stations (table 4), with consideration given to the relative characteristics of these basins and the ungaged area. Runoff data from several other hydrologically similar gaged basins outside the Wet Mountain Valley also were considered. The average annual yield during 1931-60 was estimated to be 50,000 acre-ft from tributary area A and 4,000 acre-ft from tributary area B.

Surface-water outflow from both the entire drainage basin and the basin-fill part of the basin was measured by the Grape Creek near Westcliffe gaging station (07095000). During the 1931 through 1960 calendar years, the flow past this gage averaged about 22,000 acre-ft annually.

Ground-Water Underflow

Ground-water underflows into or out of both water-budget areas are assumed negligible because low-permeable pre-Tertiary rocks are located along most of the perimeter of the basin. The potentiometric map (pl. 1) indicates that ground-water does not flow across the Grape Creek-Texas Creek drainage divide or the Promontory Divide (Custer-Huerfano County line). Consequently, there are no significant ground-water underflows out of the water-budget areas.

Table 6.--*Generalized annual water budgets for two areas in the Wet Mountain Valley, calendar years 1931 through 1960*

Grape Creek budget area	Water in				Water out			
	Source	Acre-feet	Inches	Percentage	Source	Acre-feet	Inches	Percentage
Entire drainage area[1]	Precipitation[2]	331,000	19.4	100	Evapotranspiration[3]	309,000	18.1	93
	Surface water		0	0	Surface water[2]	22,000	1.3	7
	Ground-water underflow[4]	0	0	0	Ground-water underflow[4]	0	0	0
					Change in storage[4]	0	0	0
	Totals	331,000	19.4	100	Totals	331,000	19.4	100
Basin-fill area[5]	Precipitation[2]	151,000	17.0	74	Evapotranspiration[3]	183,000	20.5	89
	Surface water (tributary area A)[6]	50,000	5.6	24	Surface water[2]	22,000	2.5	11
	Surface-water (tributary area B)[6]	4,000	0.4	2	Ground-water underflow[4]	0	0	0
	Ground-water underflow[4]	0	0	0	Change in storage[4]	0	0	0
	Totals	205,000	23.0	100	Totals	205,000	23.0	100

[1]Drainage basin above Grape Creek near Westcliffe (07095000), location shown on figure 11. This is an area of 320 mi^2.

[2]Based on recorded data.

[3]Estimated as all water otherwise unaccounted for in the budget.

[4]Assumed negligible.

[5]That part of the Grape Creek near Westcliffe (07095000) drainage composed of basin-fill material (see figure 11). This is an area of 167 mi^2.

[6]Estimated (see text).

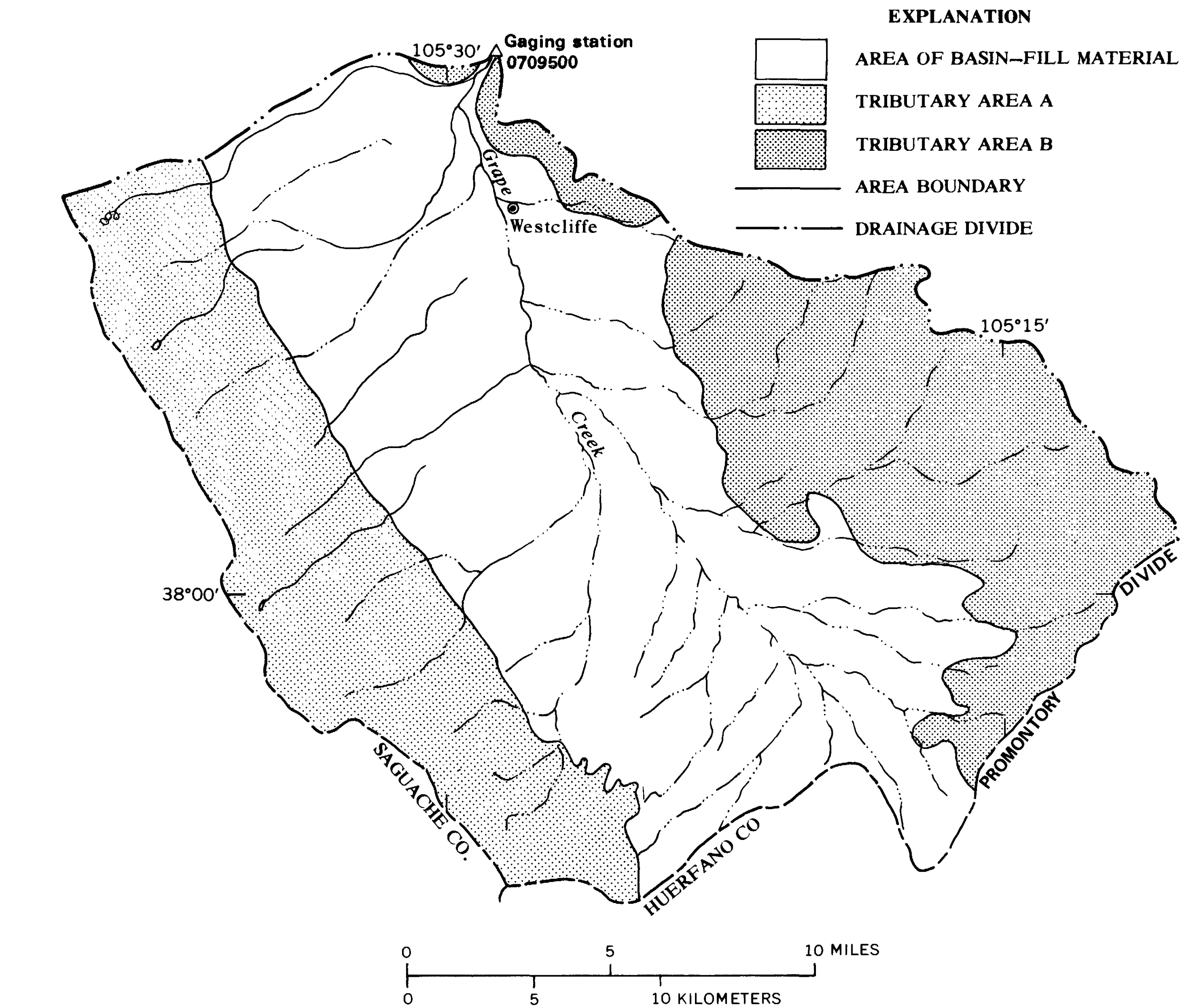

Figure 10.--Locations of water-budget tributary areas and area of basin-fill material in the Grape Creek basin.

Evapotranspiration

The evapotranspiration component of the water budgets was estimated to be all water unaccounted for in the budget. The result of this determination is 309,000 acre-ft or 18.1 in. for the entire drainage basin, and 183,000 acre-ft or 20.5 in. for the basin-fill area. These estimates are in close agreement with the results of several detailed studies conducted elsewhere in Colorado. Wymore (1974) estimated that the average annual evapotranspiration from the 142-mi^2 upper Piceance Creek basin is 18.47 in. Kruse and Haise (1974) measured 23.2 to 24.5 in. of evpotranspiration from high mountain meadows in the South Park area, and 23.5 to 27.8 in. in the Gunnison area.

Change in Storage

Because there are no large surface-water reservoirs in the water-budget area and ground-water levels measured in wells during the 24-month period were relatively stable, this component of the budgets was assumed to be zero.

WATER QUALITY

Ground Water

Water samples were collected and analyzed from 20 wells within the basin (pl. 1). The results of these analyses are shown in table 7. (The system of numbering water-quality sampling sites is explained in the Supplemental Information section of this report.) The analyses indicate that, except for four wells discussed below, the constituents found in ground water in the basin are within the recommended limits for drinking water (table 8) set by the U.S. Public Health Service (1962) and the U.S. Environmental Protection Agency (1972).

The concentrations of dissolved solids, 703 mg/L (milligrams per liter), and dissolved nitrite plus nitrate, 16 mg/L, exceeded the recommended limits of 10 mg/L in water from well SC 22-72-31ADB. As this well is a 15-ft deep stock well, located in a feed lot, the water chemistry is not typical of the water from the major part of the valley. Dissolved solids greater than 500 mg/L may impart a bitter taste to the water. Dissolved nitrite plus nitrate greater than 10 mg/L is generally indicative of pollution of the water from animal wastes and (or) fertilizers and may cause methemoglobinemia (blue-baby disease) in infants (less than 6 months of age) who drink the water or who are breast-fed by mothers who drink the water.

The main significance of the above sampled well shows the relative ease with which surface and near-surface sources may pollute a normally potable domestic water supply. Therefore, it is important that proper consideration be given in the future to waste-disposal practices and their consequent effects upon the ground-water supply, especially in the 46-mi^2 area in which the depth to water is less than 10 ft.

Table 7.--*Chemical analyses of water from selected wells*

[Major aquifer codes: 02, Basin fill; E7, Dry Union Formation; E8, Santa Fe Formation or Group; E9, Tertiary igneous, undivided]

Site number[1]	Local well number	Station number	Date of sample	Depth of well (ft)	Major aquifer	Dissolved silica (SiO_2) (mg/L)	Dissolved aluminum (Al) (µg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)
1	SC 21-73- 8BDD	381438105335900	72-08-22	66	E8	24	10	30	40	82
10	SC 21-73-28BDC	381155105330500	72-08-18	117	E8	18	0	110	10	34
16	SC 21-73-34DBB	381059105314600	72-08-18	202	E8	17	10	40	0	27
19	SC 21-73-35CDB	381042105305800	72-08-22	124	E8	20	10	20	0	34
22	SC 22-72-14CDA	380752105241500	72-08-16	50	02	29	10	20	0	60
26	SC 22-72-17CAC	380805105273800	72-08-16	120	E9	29	10	120	10	43
32	SC 22-72-31ADB	380608105282300	72-08-18	15	02	21	20	160	20	47
34	SC 22-72-32AAB	380605105271000	72-08-16	89	E8	27	10	6,000	3	77
37	SC 22-73- 6ACB	381017105350800	72-08-22	46	02	15	10	60	30	32
46	SC 22-73-12DDC	380847105292500	72-08-18	45	02	22	10	100	20	31
66	SC 22-73-36DCC	380519105294600	72-08-16	103	E8	11	0	240	40	22
74	SC 23-72- 6AAB	380513105281400	72-08-18	1,200	E8	25	10	40	0	26
101	SC 23-72-20CBC	380201105280600	72-08-16	23	02	14	0	20	0	46
108	SC 23-72-23DDD	380142105235000	72-08-16	180	02	31	0	80	10	55
112	SC 23-72-24DBC	380155105231500	72-08-16	96	02	29	10	20	0	44
114	SC 23-72-26CBB	380114105245800	72-08-16	60	02	22	0	60	0	30
118	SC 23-73- 4CAC	380443105332200	72-08-18	95	02	15	10	50	0	41
127	SC 24-71- 6BAA	385947105222500	72-08-16	29	E7	41	10	70	10	100
144	NA 45-12- 2DAA	381039105362400	72-08-22	110	--	19	0	4,200	230	43
153	NA 46-12-12DBC	381548105355800	72-08-22	184	E8	17	10	20	0	26

Table 7.--*Chemical analyses of water from selected wells*--Continued

Site number[1]	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrite plus nitrate (N) (mg/L)	Dissolved orthophosphorus (P) (mg/L)
1	14	21	2.1	263	0	220	82	7.1	0.5	0.51	0.02
10	7.2	7.5	1.4	151	0	124	9.5	2.3	.2	.52	.01
16	7.9	5.6	1.1	113	0	93	22	1.0	.2	.43	.01
19	10	8.0	.9	149	0	122	21	.9	.2	.16	.01
22	17	12	2.8	192	0	157	48	25	.6	3.6	.02
26	8.6	17	2.6	183	0	150	21	8.2	.6	1.1	.03
32	14	39	200	359	0	294	63	69	.5	16	.55
34	13	16	4.8	333	0	273	13	6.8	.4	.00	.01
37	5.2	7.9	.4	136	0	112	8.5	.9	.2	.12	.00
46	7.3	9.4	1.4	145	0	119	11	1.2	.2	.11	.01
66	4.7	3.8	1.0	85	0	70	8.5	.9	.1	.06	.00
74	2.5	15	1.1	125	0	103	4.3	1.6	.2	.09	.01
101	8.6	9.0	1.4	198	0	163	7.2	1.2	.2	.75	.02
108	8.3	12	3.7	225	0	185	12	3.6	.3	.38	.02
112	6.5	13	3.5	191	0	157	11	3.8	.6	.29	.07
114	4.9	6.5	1.2	123	0	101	7.4	3.3	.3	.42	.03
118	5.8	4.7	.9	170	0	139	4.7	.9	.1	.07	.02
127	12	14	6.1	261	0	214	35	31	.3	14	.35
144	17	14	2.3	226	0	185	23	2.0	1.8	.01	.01
153	2.9	4.6	.7	106	0	87	2.6	.9	.1	.02	.01

Table 7.--*Chemical analyses of water from selected wells*--Continued

Site number[1]	Dissolved orthophosphate (PO_4) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Dissolved solids (tons per acre-ft)	Hardness as $CaCO_3$ (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium-adsorption ratio (SAR)	Specific conductance (µmhos/cm at 25°C)	pH	Temperature (degrees Celsius)	Carbon dioxide (CO_2) (mg/L)
1	0.06	367	0.50	260	43	15	0.6	590	7.4	15.0	17
10	.03	157	.21	110	0	12	.3	262	7.5	9.5	7.6
16	.03	139	.19	100	7	11	.2	226	7.7	10.5	3.6
19	.03	169	.23	130	4	12	.3	273	7.5	12.5	7.5
22	.06	305	.41	220	62	10	.4	493	7.6	15.5	7.7
26	.09	225	.31	140	0	20	.6	357	7.6	15.0	7.4
32	1.7	703	.96	170	0	16	1.3	1,110	7.5	12.0	18
34	.03	328	.45	250	0	12	.4	543	7.4	10.0	21
37	.00	138	.19	100	0	14	.3	230	7.2	9.0	14
46	.03	155	.21	110	0	16	.4	247	7.6	11.5	5.8
66	.00	94	.13	74	5	10	.2	154	7.4	10.0	5.4
74	.03	138	.19	75	0	30	.8	206	7.7	17.0	4.0
101	.06	188	.26	150	0	11	.3	324	7.6	10.0	8.0
108	.06	238	.32	170	0	13	.4	382	7.7	9.5	7.2
112	.21	207	.28	140	0	17	.5	329	7.6	15.0	7.7
114	.09	138	.19	95	0	13	.3	217	7.9	10.5	2.5
118	.06	157	.21	130	0	7	.2	266	7.7	9.0	5.4
127	1.1	431	.59	300	85	9	.4	678	7.4	8.0	17
144	.03	238	.32	180	0	14	.5	397	7.7	11.0	7.2
153	.03	107	.15	77	0	11	.2	170	7.9	10.5	2.1

[1]See figure 2.

Table 8.--*Recommended limits of selected substances in water supplies*

[Adapted from U.S. Public Health Service, 1962. The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgment of the reporting agency and the certifying authority, other more suitable supplies are or can be made available]

Substance	Concentration, in	
	Milligrams per liter	Micrograms per liter
Chloride (Cl)-------------------------	250	
Dissolved solids----------------------	500	
Fluoride (F)[1]------------------------	1.3	
Iron (Fe)-----------------------------	.30	300
Manganese (Mn)------------------------	.05	50
Nitrite-plus-nitrate as elemental nitrogen (N)[2]----------------------	10	
Sulfate (SO_4)------------------------	250	

[1]The recommended control limit for fluoride concentrations is variable and dependent upon the annual average of maximum daily air temperature.

[2]In areas in which the nitrate concentration of water is known to be in excess of the listed concentration, the public should be warned of the potential danger of using the water for infant feeding.

The concentration of dissolved iron, 6,000 μg/L (micrograms per liter), exceeded the recommended limit in water from well SC 22-72-32AAB. Dissolved iron greater than 300 μg/L imparts a bitter taste to beverages, such as coffee and tea made using the water, and stains laundry and porcelain fixtures.

The concentration of dissolved nitrite plus nitrate of 14 mg/L exceeds the recommended limit in water from well SC 24-71-06BAA,a 29-ft deep windmill.

The concentrations of dissolved iron, 4,200 μg/L; manganese, 230 μg/L; and fluoride, 1.8 mg/L, exceeded recommended limits in water from well NA 45-12-02DAA. Dissolved manganese greater than 50 μg/L causes the same effects as dissolved iron greater than 300 μg/L. Dissolved fluoride greater than 1.3 mg/L can cause mottling of children's teeth.

Ground water in the basin is generally hard (as defined by Hem, 1970, p. 225). The hardness, expressed as calcium carbonate (table 7), in the samples analyzed ranged from 74 to 300 mg/L. All but four of the samples have a hardness of 100 mg/L or greater. According to Hem (1970), the hardness of water to be used for domestic purposes becomes objectionable when the concentration is about 100 mg/L.

According to J. M. Klein, P. A. Emery, L. A. Hershey, and R. D. Penley (written commun., 1977), there are two different water-quality zones in the basin-fill aquifer. Generally, east of the axis of the valley the concentration of dissolved silica is greater than 25 mg/L and the concentrations of dissolved solids are greater than 200 mg/L, while in the western part of the basin these constituents are generally less than these concentrations. The difference in water quality between these two zones is probably due to the different sources of the sediments in the two areas. The source of the sediments in the western one-half of the valley is the Sangre de Cristo Range and the source for the east side of the basin is the Wet Mountains.

Dissolved silica in ground water originates from dissolution of various silicate minerals or volcanic glass which the ground water contacts. Large areas of the Wet Mountains are covered with layers of volcanic rocks (fig. 2) that contain substantial proportions of readily dissolved silica. Sediments derived from these volcanic rocks are the probable source of the larger silica concentrations on the east side of the valley.

Surface Water

Two surface-water samples were collected for water-quality analyses from a site along lower Grape Creek (pl. 1). The results of these analyses are listed in table 9 and indicate that, at the time the samples were collected, the substances analyzed for were within the recommended limits for drinking water set by the U.S. Public Health Service (1962) (table 8). Wentz (1974) lists temperature, pH, and specific-conductance data for several surface-water sites in the study area.

Suitability of Water for Irrigation

The suitability of water for irrigation is dependent on several variables, the most important of which are the quality of the water, the type of soil and crops to be irrigated, and the irrigation practices used. A concentration of dissolved solids greater than 1,000 mg/L (Robinove and others, 1958) may affect crop growth indirectly through the effect on the physical condition of the soil, and directly by increasing the osmotic pressure of the soil solution and by an accumulation of toxic quantities of various ions within the plant. Thus, the ability of a plant to use water is diminished and a reduced crop yield results (Reeve, 1957, p. 175). Sodium buildup in the soil may reduce soil permeability, which limits air penetration to the root zone, leads to waterlogging, and reduces plant growth (Klein and Bingham, 1975).

A diagram used for classification of irrigation water, based on the sodium-adsorption ratio (SAR) and the specific conductance, is shown on figure 11. This diagram is a useful tool in predicting potential sodium and salinity hazards involved in the use of water for irrigation. The diagram has 16 different categories for classifying irrigation water. These categories range from low salinity (C1), low sodium (S1), which is water that can be

Table 9.--*Chemical analyses of water from selected surface-water sites*

Site number[1]	Station name	Station number	Date of sample	Discharge (ft^3/s)	Dissolved silica (SiO_2) (mg/L)	Dissolved aluminum (Al) (μg/L)	Dissolved iron (Fe) (μg/L)	Dissolved manganese (Mn) (μg/L)	Dissolved calcium (Ca) (mg/L)
1	Grape Creek at Hermit Lake Road---------	380752105262000	72-08-18	4.0	22	--	20	20	41
1	Grape Creek at Hermit Lake Road---------	380751105262000	72-11-30	10	21	--	50	10	42

Site number[1]	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Carbonate (CO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Dissolved nitrite plus nitrate (N) (mg/L)	Dissolved orthophosphorus (P) (mg/L)
1	7.7	10	2.2	176	0	144	8.0	3.3	0.4	0.09	0.01
1	8.0	9.5	1.6	182	0	149	12	3.1	.3	.16	.02

Site number[1]	Dissolved orthophosphate (PO_4) (mg/L)	Dissolved solids (sum of constituents) (mg/L)	Dissolved solids (tons per acre-ft)	Hardness as $CaCO_3$ (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium-adsorption ratio (SAR)	Specific conductance (μmhos/cm at 25°C)	pH	Temperature (degrees Celsius)	Carbon dioxide (CO_2) (mg/L)
1	0.01	182	0.25	130	0	14	0.4	291	7.9	22.0	--
1	.06	187	.25	140	0	13	.4	286	7.1	.5	--

[1]See figure 2.

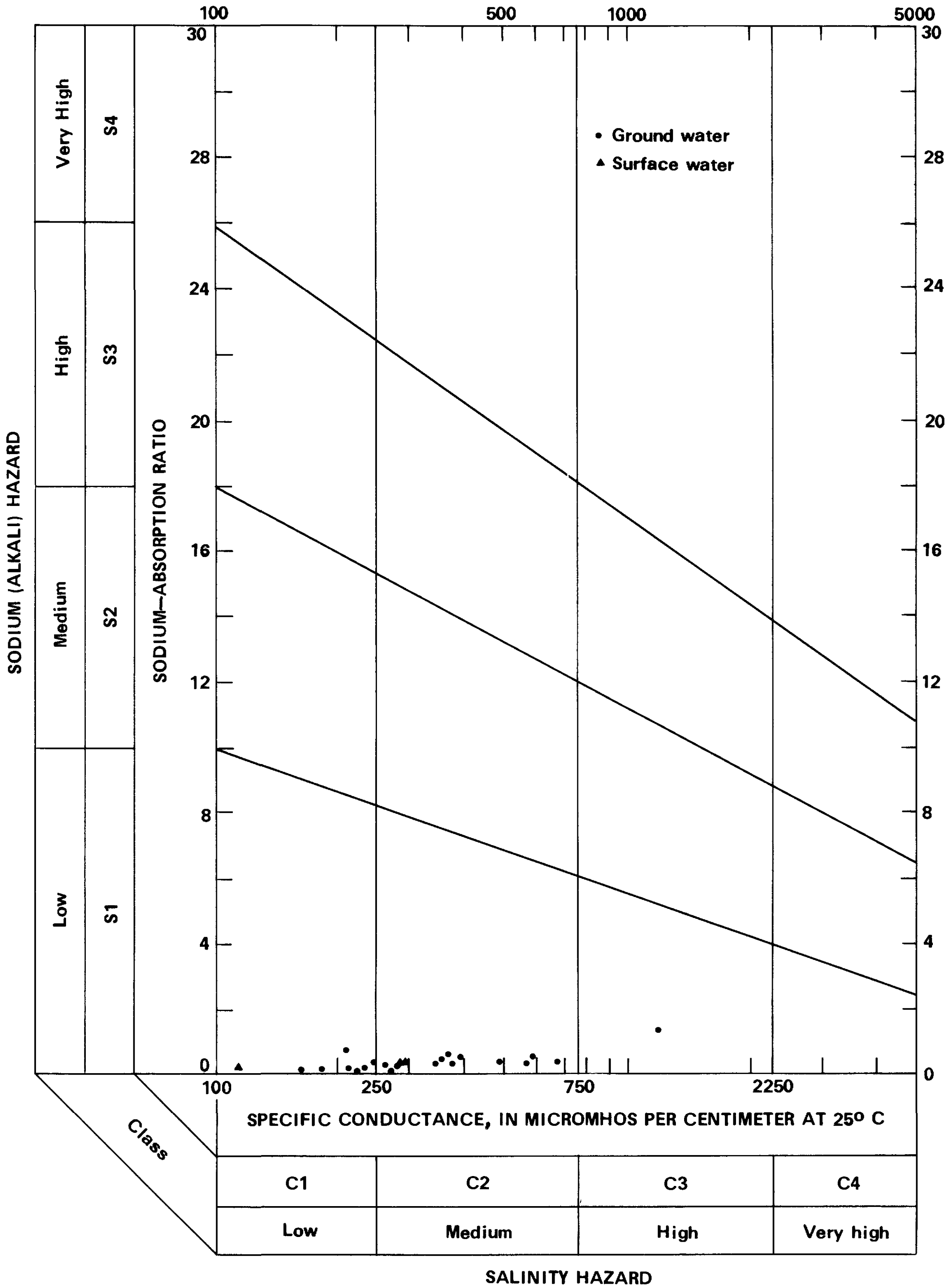

Figure 11.--Classification of irrigation water.

applied to nearly all types of soils and crops with little danger of harmful effects, to very high salinity (C4), very high sodium (S4), which is water suitable for irrigation use only under very limited conditions (table 10).

All of the water samples analyzed during the course of this study plot within the S1 sodium-hazard category and all but one plot within either the C1 or C2 salinity-hazard categories (fig. 11). This would indicate that both the surface and ground water have low-sodium hazard and low- to medium-salinity hazard. Within the study area, surface and ground water are generally safe to use for irrigation under most conditions.

SUMMARY

The Wet Mountain Valley is an intermontane trough filled with unconsolidated deposits of Cenozoic age, and bordered by mountain ranges composed of volcanic rocks of Tertiary age and igneous, metamorphic, and sedimentary rocks of pre-Tertiary age. The valley includes an area of 540 mi^2 and is primarily drained by Grape Creek and Texas Creek. Average annual precipitation ranges from less than 16 in. to more than 40 in., generally increasing with land-surface altitude.

Ground water occurs in two different hydrologic areas within the study area--the mountainous area, which is composed chiefly of consolidated rock; and the valley-floor area, which is underlain by unconsolidated basin-fill sediments. In the mountainous area, well yields are highly unpredictable but are generally less than 10 gal/min. In the basin-fill aquifer, yields of greater than 50 gal/min can generally be expected from wells located near the central part of the valley. In areas around the edge of the basin-fill aquifer, well yields of less than 50 gal/min are generally reported.

The basin-fill deposits cover an area of about 233 mi^2 and are the principal source of ground water in the study area. South of Westcliffe, this material is at least 6,700 ft thick and the upper 1,200 ft is composed of sand and gravel with interbedded and intergranular clay. There is an estimated 1.5 million acre-ft of ground water stored in the upper 100 ft of saturated basin-fill sediments although considerably less than this amount could be developed from wells. Hydrographs of selected wells indicate that the volume of water stored in the basin-fill material is not changing.

Ground water occurs under both artesian and water-table conditions within the basin-fill aquifer. Artesian conditions exist, to some extent, throughout most of the basin-fill area and there are several flowing wells. The depth to the water table is less than 10 ft in an area of about 46 mi^2 along the central part of the valley and is less than 100 ft in most of the remainder of the valley.

Ground-water movement in the basin-fill aquifer is generally toward Grape and Texas Creeks. Ground water leaves the aquifer either by discharge to streams, discharge by wells, or as direct evapotranspiration from the water table. Underflow out of the basin is considered negligible.

Table 10.--*Salinity and sodium classification for irrigation water*

[Adapted from U.S. Salinity Laboratory Staff (1954)]

SALINITY		
Class	Specific conductance, in micromhos per centimeter at 25°C	Comments
C1 (low)-------	Less than 250	May be used for any crop on nearly all soils.
C2 (medium)----	250-750	May be used if a moderate amount of leaching occurs.
C3 (high)------	750-2,250	Should be used only on soils with better than adequate drainage and for plants with good salt tolerance.
C4 (very high)-	Greater than 2,250	Not suitable for irrigation under ordinary conditions, but may be used on permeable soil with adequate drainage if water is applied in excess to provide considerable leaching. Very salt-tolerant plants should be selected.

SODIUM	
Class	Comments
S1 (low)-------	May be used for any crop on nearly all soils.
S2 (medium)----	May be used on coarse-textured (sandy) soils with good permeability; may present a moderate sodium problem in fine-textured (clay) soils unless gypsum is present.
S3 (high)------	May present sodium problems in most soil types.
S4 (very high)-	Not suitable for irrigation of any crops in any soil, except under special conditions.
	Sodium-adsorption-ratio range for each class is dependent on specific conductance.

Streamflow in the area is typical of a high mountain valley with most runoff occurring in June and July as the result of snowmelt. Observed streamflow consists of runoff from precipitation, return flow from irrigation, discharge of ground water, and water released from reservoir storage. Continuous records of streamflow have been collected since 1924 at the Grape Creek near Westcliffe gaging station. Additionally, two continuous-record and four partial-record stations have been operated in the study area since August 1974. Analysis of the streamflow data for water years 1975 and 1976 shows that the average annual runoff for 1975-76 at the seven stations ranged from about 420 to 24,240 acre-ft per year. Long-term annual runoff (1931-60) at these stations ranges from an estimated 0.02 $(ft^3/s)/mi^2$ to an estimated 1.17 $(ft^3/s)/mi^2$, generally increasing with station altitude. Using the data at two partial-record stations where natural-flow conditions prevailed, the magnitude, frequency, and depth of floods were estimated using basin characteristics and regionalized regression equations.

DeWeese Reservoir, located near the study area, has a storage capacity of 1,772 acre-ft. All of the other reservoirs within the study area have a combined storage capacity of about 215 acre-ft.

Generalized annual water budgets for two areas in the Wet Mountain Valley indicate that surface-water outflow is only 7 to 11 percent of the total water supply from precipitation and other sources. The remaining water is lost to the atmosphere by evapotranspiration. Ground-water underflow and changes in ground-water storage are considered insignificant in both water budgets.

The quality of both the surface and ground water is generally within the recommended limits for drinking water set by the U.S. Public Health Service (1962). The hardness of the ground water is generally greater than 100 mg/L as calcium carbonate. There are two different water-quality zones in the basin-fill aquifer. East of the axis of the valley, the concentration of dissolved silica is greater than 25 mg/L and the concentration of dissolved solids is greater than 200 mg/L. In the western part of the valley, these constituents are generally less than these concentrations.

Both the surface and ground water are generally safe to use for irrigation. None of the samples analyzed indicated a potential sodium hazard and most indicated only a low- to medium-potential salinity hazard.

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SUPPLEMENTAL INFORMATION

System of Numbering Water-Quality Sampling Sites

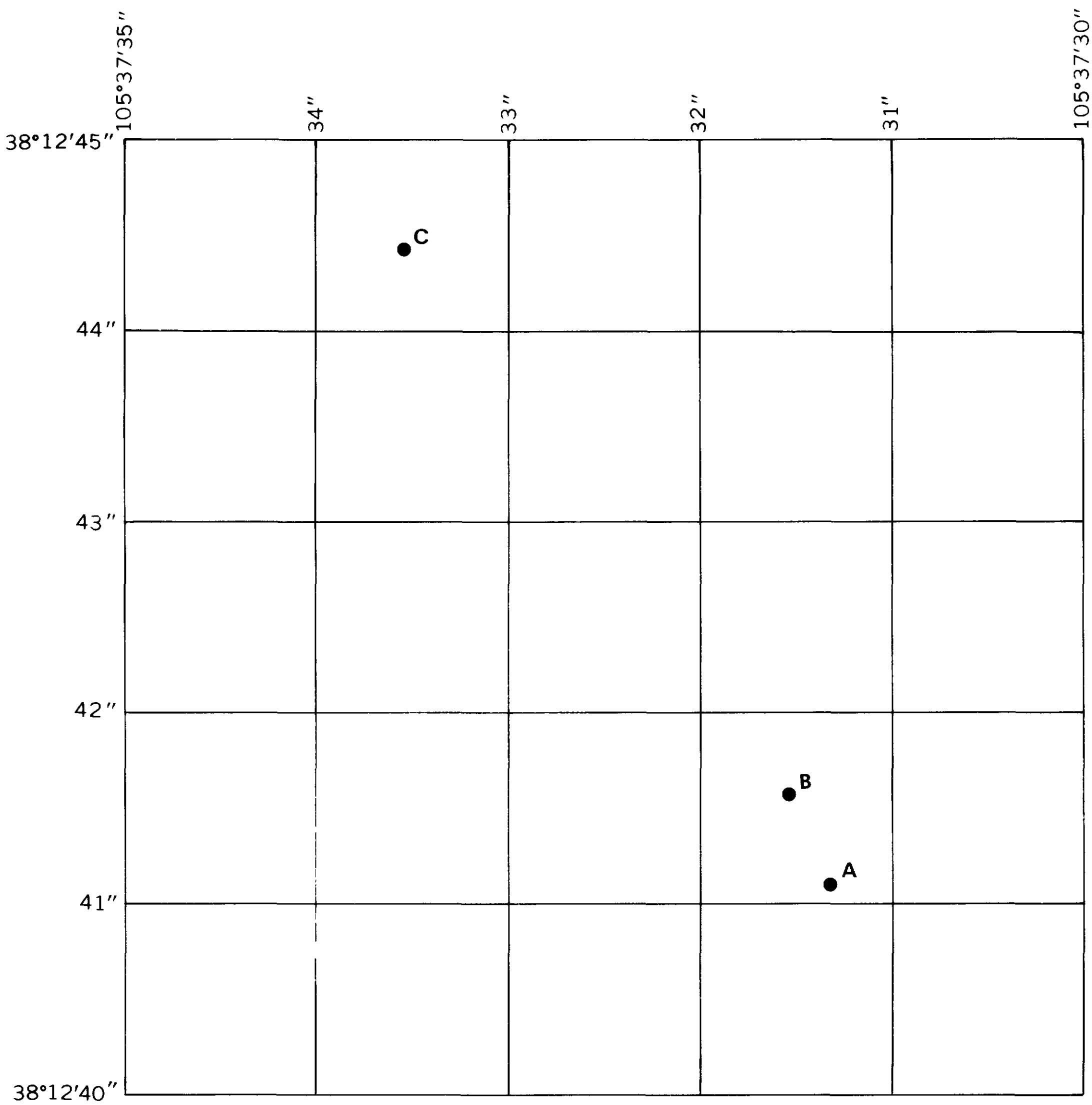
The system of numbering water-quality sampling sites is based on the grid system of latitude and longitude. The system provides the geographic location of the site and a unique number for each site. The number consists of 15 digits. The first six digits denote the degrees, minutes, and seconds of latitude; the next seven digits denote degrees, minutes, and seconds of longitude; and the last two digits are a sequential number for sites within a 1-second grid. (In the event that the latitude-longitude coordinates for two or more sites are the same, sequential numbers "01," "02," and so forth are assigned. See figure 12.)

System of Numbering Wells

The well locations in this report are given numbers based on the U.S. Bureau of Land Management system of land subdivision, and show the location of the wells by quadrant, township, range, section, and position within the section. A graphic illustration of this method of well location is shown in figure 13. The first letter of the location number indicates which principal meridian governs the area in which the well is located; S indicates the sixth principal meridian and N indicates the New Mexico principal meridian. The second letter indicates the quadrant in which the well is located. Four quadrants are formed by the intersection of the base line and the principal meridian; A indicates the northeast quadrant, B the northwest, C the southwest, and D the southeast. The first number indicates the township; the second, the range; and the third, the section in which the well is located. The letters following the section number indicate the location of the well within the section. The first letter denotes the quarter section; the second, the quarter-quarter section; and the third, the quarter-quarter-quarter section. The letters are assigned within the section in a counterclockwise direction, beginning with A in the northeast quarter. Letters are assigned within each quarter section and within each quarter-quarter section in the same manner. Where two or more locations are within the smallest subdivision, consecutive numbers, beginning with 1, are added in the order in which the wells are inventoried. For example, SC23-72-15DAA indicates a well in the NE¼NE¼SE¼ sec. 15, T. 23 S., R. 72 W.

System of Numbering Surface-Water Stations

Surface-water station numbers are assigned in downstream direction along the main stream. Station numbers on tributaries are assigned between station numbers on the main stream in the order in which those tributaries enter the main stream. Downstream-order station numbers are not assigned to miscellaneous sites where water-quality samples are collected or discharge measurements are made intermittently.



Coordinates for site A 381241105373101
B 381241105373102
C 381244105373301

Figure 12.--U.S. Geological Survey's system of numbering water–quality sampling sites.

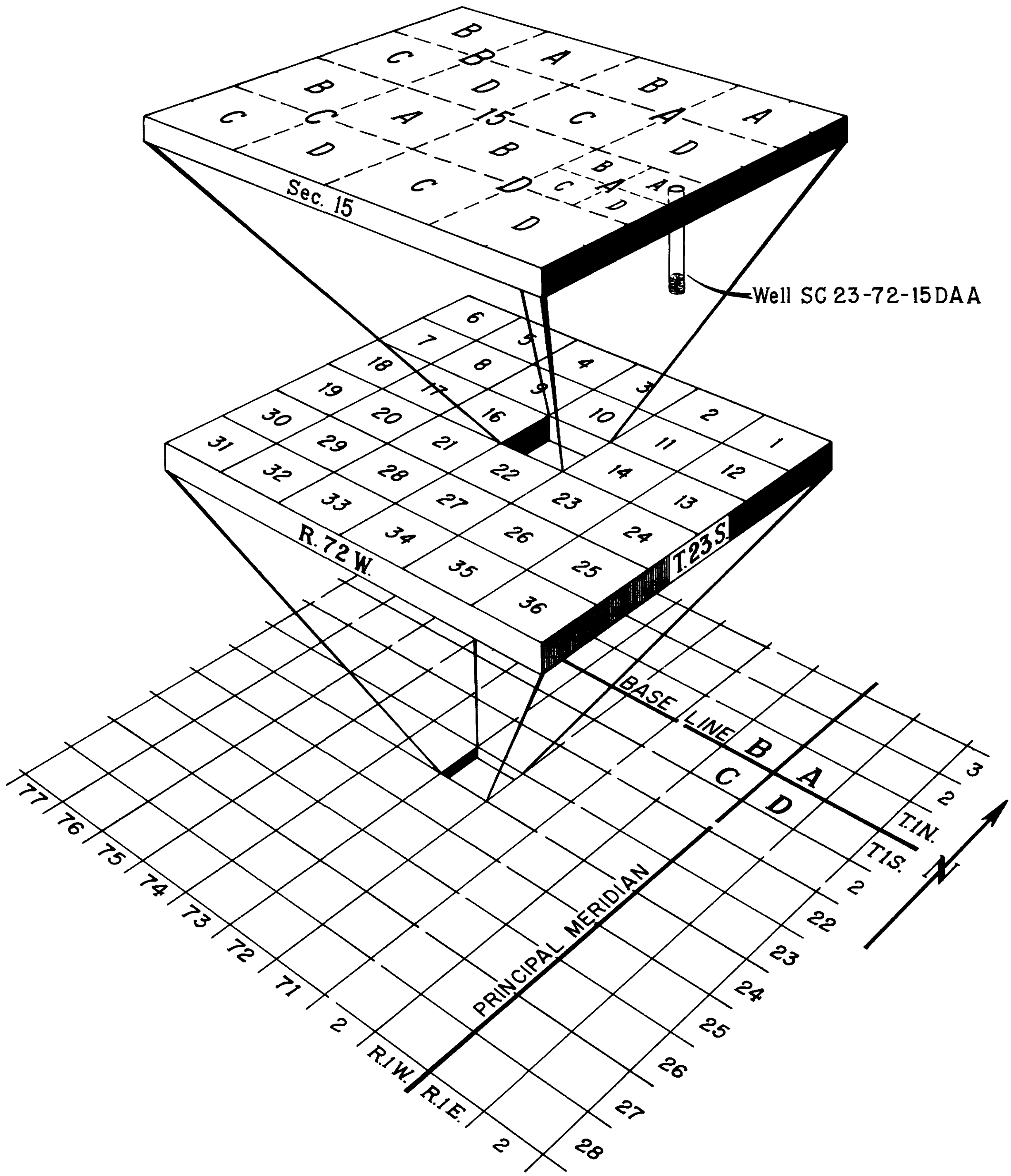


Figure 13.--System of numbering wells.

Geologic Log of Test Hole SC 23-72- 6AAB1

SC 23-72- 6AAB1 (Altitude 7,930 feet above mean sea level)	Thickness, in feet	Depth below land surface, in feet
Soil, brown; contains scattered 1-inch rounded gravel	3	3
Gravel, clayey; contains rounded cobbles as large as 6 inches	3	6
Gravel, very fine, to very coarse sand; contains some medium gravel	4	10
Sand, very coarse, silty; contains some medium gravel	10	20
Sand, very coarse, arkosic; contains some reddish-brown clay	10	30
Clay, reddish-brown	5	35
Gravel, fine to very fine, clayey	10	45
Clay, reddish-brown	5	50
Gravel, fine to very fine, clayey	5	55
Gravel, fine, well-sorted, clayey	5	60
Sand, very coarse, clayey, grading to well-sorted fine gravel	10	70
Clay, reddish-brown, sandy, grading to clay; contains thin yellowish-gray, hard, platy bentonite(?) stringers	10	80
Gravel, very fine, to coarse sand, clayey; contains cemented beds in bottom 10 feet	25	105
Gravel, very fine, to sand, very coarse, clayey	15	120
Gravel, very fine to fine, clayey	40	160
Gravel, grading from coarse to very coarse sand; contains clay streaks and some intergranular clay	20	180
Gravel, very fine to fine, and sand, clayey; contains some clean beds	30	210
Clay, grayish-yellow, and interbedded sand and gravel	20	230
Sand and very fine gravel, some clayey	20	250
Sand, very coarse, to gravel, very fine, clayey; contains cemented zone from 255 to 260 feet	20	270
Sand, very coarse to coarse, grading to fine gravel	10	280
Gravel, very fine to fine, and sand grading to very fine, silty gravel	20	300
Sand, silty, poorly sorted	25	325
Gravel and sand, clayey	10	335

Geologic Log of Test Hole SC 23-72- 6AAB1--Continued

SC 23-72- 6AAB1 (Altitude 7,930 feet above mean sea level)	Thickness, in feet	Depth below land surface, in feet
Sand, coarse to medium, clayey; contains cemented(?) sand and gravel	40	375
Sand, medium, to very fine gravel, clayey; clean(?) from 375 to 380 feet	20	395
Sand, very clayey, grading to clay, sandy	20	415
Sand and interbedded clay	20	435
Clay, sandy; contains some very fine gravel	20	455
Sand, coarse, clayey, grading to clay, containing very fine gravel	20	475
Sand, very coarse, grading to sandy clay	20	495
Sand, medium, to very fine gravel, grading to sandy clay	20	515
Sand, medium to coarse, grading to sandy clay	20	535
Clay, sandy, and interbedded clay	20	555
Sand, medium to coarse; contains clay streaks	20	575
Sand, poorly sorted, some clayey and reddish-brown clay streaks; some caliche bottom 5 feet	40	615
Sand, medium to very coarse, and very fine gravel; contains clay streaks	20	635
Sand, medium to coarse, clayey; contains beds of yellowish-gray bentonitic(?) clay	20	655
Sand, very coarse, clean, grading to poorly sorted clayey sand	20	675
Sand, coarse, to very fine gravel, clayey	50	725
Sand, silty to clayey, cemented(?); small amount of reddish-brown clay and yellowish-gray, bentonitic(?) clay	10	735
Sand, silty to clayey, loosely cemented, grading to reddish-brown clay	15	750
Clay, reddish-brown to greenish-yellow	10	760
Clay, sandy, greenish-yellow to pink; contains some caliche	15	775
Clay, reddish-brown, sandy, grading to varicolored clays	20	795
Sand and very fine gravel, clay-filled	20	815
Sand, medium to coarse, clayey, grading to sandy clay	20	835

Geologic Log of Test Hole SC 23-72- 6AAB1--Continued

SC 23-72- 6AAB1 (Altitude 7,930 feet above mean sea level)	Thickness, in feet	Depth below land surface, in feet
Sand, fine to medium; contains some clay grading to very fine gravel and coarse sand	20	855
Sand, fine, clayey, grading to clean coarse sand	20	875
Sand, medium to coarse, grading to clayey sand and some tightly cemented conglomerate	20	895
Sand and gravel, conglomeratic; some interbedded clay	20	915
Sand to very fine gravel; contains loosely cemented stringers	20	935
Sand, clayey; contains some tightly cemented sand and gravel beds	20	955
Sand, poorly sorted to clayey	20	975
Sand, medium to very coarse, less clayey than above	20	995
Sand, very coarse, grading to very fine, clayey gravel	20	1,015
Sand and fine gravel grading to sand and medium gravel; contains clay stringers	20	1,035
Sand and very fine gravel grading to tightly cemented gravel	20	1,055
Sand, fine to very coarse; contains some reddish-brown clay and cemented beds	20	1,075
Gravel, very fine to medium; contains cemented beds and sandy clay	40	1,115
Gravel, fine to very fine, and sand, and interbedded caliche, brown clay, and sandstone	20	1,135
Sand, fine to very coarse, silty and clayey	20	1,155
Sand and interbedded reddish-brown clay	25	1,180
Sand, silty to clayey	20	1,200

Records of Selected Wells

[Depth to water: F, Flowing.
Major aquifer codes: 02, Basin fill; E7, Dry Union Formation; E8, Santa Fe Formation or Group; E9, Tertiary, igneous, undivided; F1, Precambrian, undifferentiated.
Type lift: C, Centrifugal; J, Jet; N, None; P, Piston; S, Submersible; T, Turbine.
Power: E, Electric; G, Gas, diesel, natural or LP gas engine; H, Hand; N, None; W, Wind.
Use of water: H, Domestic; I, Irrigation; P, Public supply; S, Stock; U, Unused]

Site number on figure 2	Local well number	Year drilled	Altitude of land surface (ft)	Well depth (ft)	Depth to water (ft)	Date water level measured (M-Y)	Major aquifer	Yield (gal/min)	Drawdown (ft)	Casing diameter (in.)	Type lift	Power	Use of water
1	SC 21-73- 8BDD	1971	7,615	66	---	-----	E8	-------	---	5	J	E	H
2	SC 21-73-18DBC	----	7,960	183	87	5-71	02	-------	---	6	P	G	S
3	SC 21-73-21CDC	1955	7,820	120	9	10-70	E8	350	---	8	T	E	I
4	SC 21-73-21CDD	----	7,880	174	52	10-70	E8	350	---	--	T	E	I
5	SC 21-73-26CCC	----	7,841	25	12	4-71	E8	-------	---	12	P	W	S
6	SC 21-73-27CBC	----	7,882	110	24	8-72	02	-------	---	6	P	W	S
7	SC 21-73-27CDC	----	7,891	62	17	10-70	E8	-------	---	8	T	G	I
8	SC 21-73-27DCC	----	7,880	70	19	10-70	E8	-------	---	8	T	G	I
9	SC 21-73-27DDD	1953	7,850	30	7	10-70	E8	-------	---	--	T	E	H
10	SC 21-73-28BDC	----	7,928	117	72	10-70	E8	-------	---	6	P	W	S
11	SC 21-73-28DAA	----	7,896	110	19	10-70	E8	-------	---	7	P	W	S
12	SC 21-73-34AAA	----	7,840	202	F	10-70	E8	-------	---	12	N	N	I
13	SC 21-73-34BAA	1947	7,878	128	9	10-70	E8	602	---	12	T	G	I
14	SC 21-73-34BBB	1947	7,890	220	14	10-70	E8	1,203	---	12	T	G	I
15	SC 21-73-34BBC	1974	7,885	92	16	5-75	02	-------	---	3	N	N	U
16	SC 21-73-34DBB	1947	7,868	202	F	10-70	E8	-------	---	24	N	N	I
17	SC 21-73-34DBD	----	7,859	284	F	10-70	E8	-------	---	12	N	N	I
18	SC 21-73-35CCB	1947	7,821	197	F	10-70	E8	-------	---	8	N	N	I
19	SC 21-73-35CDB	1946	7,805	124	F	10-70	E8	-------	---	--	N	N	I
20	SC 22-72- 7CCA	----	7,775	11	8	7-71	02	-------	---	30	C	E	H
21	SC 22-72-14BCD	----	8,195	43	25	8-71	F1	-------	---	6	P	W	S
22	SC 22-72-14CDA	----	8,260	50	35	11-70	02	-------	---	6	P	W	S
23	SC 22-72-16BDD	----	7,980	119	5	11-70	E9	-------	---	--	T	E	P
24	SC 22-72-17CAC1	1920	7,890	120	69	10-70	E9	300	---	8	T	E	P
25	SC 22-72-17CAC2	----	7,890	120	---	-----	E9	350	---	8	T	E	P

26	SC 22-72-17CAC3	1920	7,890	120	---	-----	E9	300	---	8	T	E	P
27	SC 22-72-22DAD	1916	8,210	38	28	11-70	E8	-------	---	60	P	W	S
28	SC 22-72-29ADD	----	7,972	130	93	11-70	E8	-------	---	--	P	W	S
29	SC 22-72-29BCB	----	7,850	19	14	12-70	02	-------	---	36	J	E	H
30	SC 22-72-29CCA	----	7,870	13	4	11-70	02	-------	---	40	P	E	S
31	SC 22-72-30BBC	1966	7,866	81	5	8-71	E8	24	14	7	S	E	H
32	SC 22-72-31ADB	----	7,895	15	9	11-70	02	-------	---	36	J	E	S
33	SC 22-72-31DDA	----	7,905	10	7	11-70	02	-------	---	48	-	-	S
34	SC 22-72-32AAB	1960	7,950	89	62	10-70	E8	-------	---	6	P	W	S
35	SC 22-72-32DDA	1960	7,955	60	52	10-70	E8	-------	---	--	P	W	S
36	SC 22-72-35CBD	----	8,196	204	Dry	4-71	--	-------	---	6	P	N	-
37	SC 22-73- 6ACB	----	8,430	46	15	10-70	02	-------	---	6	S	E	H
38	SC 22-73- 8DCA	----	8,301	75	8	10-70	02	-------	---	6	P	W	S
39	SC 22-73- 9AAC	----	8,032	49	3	11-70	02	-------	---	8	P	W	S
40	SC 22-73-10ACC	----	7,915	70	3	11-70	02	-------	---	12	-	-	I
41	SC 22-73-10ACD	----	7,908	160	8	11-70	02	-------	---	16	S	E	H
42	SC 22-73-11CDD	1947	7,850	93	9	10-70	02	-------	---	6	J	E	S
43	SC 22-73-12BCA	1946	7,785	350	9	11-70	02	-------	---	--	J	E	H
44	SC 22-73-12CBA	----	7,800	50	5	11-70	02	-------	---	6	C	E	H
45	SC 22-73-12CDC	----	7,790	63	1	11-70	02	-------	---	12	N	N	I
46	SC 22-73-12DDC	----	7,778	45	5	11-70	02	-------	---	12	N	N	I
47	SC 22-73-13CDC	----	7,830	94	5	4-71	02	-------	---	7	S	E	S
48	SC 22-73-14BDD	1946	7,870	100	8	10-70	02	-------	---	6	J	E	H
49	SC 22-73-15BCB	1963	8,060	95	9	10-70	02	5	83	6	P	W	S
50	SC 22-73-21BDC	----	8,240	72	6	11-70	02	-------	---	6	C	E	H
51	SC 22-73-21DAB	----	8,120	99	6	11-70	02	-------	---	8	J	E	H
52	SC 22-73-23ACB	1959	7,883	39	4	10-70	02	10	---	6	J	E	H
53	SC 22-73-23ACC	1963	7,900	403	3	10-70	E8	-------	---	16	T	N	I
54	SC 22-73-23BBC	1963	7,920	217	1	10-71	02	160	---	16	N	N	I
55	SC 22-73-25ABD	----	7,880	14	2	10-70	02	-------	---	40	J	-	H
56	SC 22-73-25BDD	----	7,910	65	F	10-70	02	-------	---	10	P	W	S
57	SC 22-73-25CDD	----	7,920	38	2	11-70	--	-------	---	6	P	W	S
58	SC 22-73-26ABB	----	7,940	50	2	11-70	02	-------	---	6	P	E	S
59	SC 22-73-26BBA	1934	7,990	74	3	11-70	02	-------	---	6	J	-	S
60	SC 22-73-26BCC	----	8,015	141	F	11-70	02	8	---	12	N	N	S

Records of Selected Wells--Continued

Site number on figure 2	Local well number	Year drilled	Altitude of land surface (ft)	Well depth (ft)	Depth to water (ft)	Date water level measured (M-Y)	Major aquifer	Yield (gal/min)	Drawdown (ft)	Casing diameter (in.)	Type lift	Power	Use of water
61	SC 22-73-27BAD	1964	8,040	128	12	12-64	02	30	---	7	-	E	H
62	SC 22-73-28BBC	1953	8,238	89	--	-----	02	-------	---	6	C	-	H
63	SC 22-73-28BDD	----	8,240	82	12	8-71	02	-------	---	8	J	E	H
64	SC 22-73-35CDB	----	8,182	13	4	4-71	02	-------	---	18	J	E	H
65	SC 22-73-36DAA	----	7,990	26	4	11-70	E8	-------	---	6	P	W	S
66	SC 22-73-36DCC	----	8,020	103	3	11-70	E8	-------	---	12	N	N	I
67	SC 23-71- 4DCC	1861	8,635	18	5	4-71	02	-------	---	60	-	-	S
68	SC 23-71- 9ABC	1971	8,650	110	70	4-71	F1	2	---	6	N	N	H
69	SC 23-71- 9DBB	----	8,660	300	71	4-71	F1	.5	---	6	N	N	H
70	SC 23-72- 1AAB	1953	8,400	13	9	4-71	02	-------	---	48	P	W	S
71	SC 23-72- 4CDB	1958	7,975	30	3	11-70	02	-------	---	7	J	E	H
72	SC 23-72- 5AAB1	1870	7,905	16	13	11-70	02	-------	---	--	P	E	H
73	SC 23-72- 5ABB2	----	7,895	12	4	11-70	02	-------	---	60	-	-	S
74	SC 23-72- 6AAB1	1971	7,930	1,200	F	7-71	E8	-------	---	5	N	N	U
75	SC 23-72- 6AAB2	1974	7,930	92	16	5-74	02	-------	---	3	N	N	U
76	SC 23-72- 6BDD	----	7,995	34	1	11-70	02	-------	---	6	P	W	S
77	SC 23-72- 6CBD	----	8,043	40	4	11-70	02	-------	---	6	P	-	S
78	SC 23-72- 7ADA1	----	8,000	16	4	11-70	02	-------	---	60	P	H	S
79	SC 23-72- 7ADA2	----	7,995	25	3	11-70	02	-------	---	8	P	E	S
80	SC 23-72- 7BCC1	----	8,130	180	10	10-70	E8	-------	---	12	T	E	I
81	SC 23-72- 7BCC2	----	8,132	22	3	8-71	02	-------	---	6	N	N	U
82	SC 23-72- 7CBB1	----	8,142	28	1	10-70	02	-------	---	12	N	N	U
83	SC 23-72- 7CBB2	----	8,142	115	1	10-70	02	-------	---	12	N	N	-
84	SC 23-72- 7CCC1	----	8,180	120	2	10-70	E8	-------	---	--	T	E	I
85	SC 23-72- 7CCC2	----	8,175	30	1	11-70	02	-------	---	8	N	N	U
86	SC 23-72- 8CCC	1962	8,035	60	3	11-70	E8	10	---	6	N	N	S
87	SC 23-72-10BBA	1960	8,070	115	85	12-70	E8	-------	---	6	P	W	S
88	SC 23-72-10BDD	1952	8,000	44	12	12-70	02	-------	---	8	J	E	H
89	SC 23-72-10DDD	----	8,020	54	10	10-70	E8	-------	---	12	T	-	I
90	SC 23-72-14BBD	----	8,060	52	44	12-70	02	-------	---	40	P	E	S

91	SC 23-72-14CAA	----	8,048	35	9	12-70	02	-------	---	6	-	E	H
92	SC 23-72-15BBB	----	8,005	45	7	11-70	02	-------	---	8	J	E	H
93	SC 23-72-16ABA	----	7,995	30	3	11-70	02	-------	---	6	C	E	H
94	SC 23-72-16CAC	----	8,025	66	2	11-70	E8	-------	---	8	C	E	H
95	SC 23-72-17BBC	1963	8,050	245	32	10-70	02	450	213	16	T	E	I
96	SC 23-72-18AAD	1974	8,059	75	9	5-74	02	-------	---	2	N	N	U
97	SC 23-72-18ABB	----	8,082	22	3	10-70	02	-------	---	--	N	N	S
98	SC 23-72-19AAD	----	8,165	28	9	11-70	02	-------	---	6	P	W	S
99	SC 23-72-19BCC	1961	8,375	83	11	11-70	E8	15	10	6	P	W	S
100	SC 23-72-20BBC	----	8,154	13	6	11-70	02	-------	---	36	C	E	S
101	SC 23-72-20CBC1	----	8,200	23	2	11-70	02	-------	---	--	C	G	S
102	SC 23-72-20CBC2	----	8,200	76	4	11-70	02	-------	---	10	N	N	S
103	SC 23-72-20CBC3	1947	8,198	900	11	7-71	02	-------	---	8	-	-	U
104	SC 23-72-21BCB	----	8,078	65	5	11-70	02	50	---	6	S	E	H
105	SC 23-72-21DCC	1951	8,105	40	6	11-70	02	-------	---	8	S	E	H
106	SC 23-72-22BAC	1960	8,061	51	12	11-70	E8	-------	---	8	-	-	-
107	SC 23-72-23BCB	----	8,073	50	4	12-70	02	-------	---	6	P	W	S
108	SC 23-72-23DDD	1940	8,125	180	F	11-70	02	16	---	--	T	-	S
109	SC 23-72-24ABB	1960	8,215	100	63	12-70	E8	25	8	6	P	W	S
110	SC 23-72-24CCC	----	8,130	23	15	11-70	02	-------	---	36	J	E	S
111	SC 23-72-24CDB	----	8,135	160	5	11-70	E8	-------	---	6	N	N	S
112	SC 23-72-24DBC	----	8,181	96	33	11-70	02	-------	---	6	S	E	H
113	SC 23-72-24DDA	1960	8,185	82	25	11-70	02	20	---	6	P	W	S
114	SC 23-72-26CBB	----	8,151	60	21	9-70	02	-------	---	6	P	W	S
115	SC 23-72-33DAA1	----	8,200	16	3	11-70	02	-------	---	48	J	E	H
116	SC 23-72-33DAA2	1964	8,215	100	2	11-70	E8	20	---	6	S	E	S
117	SC 23-72-36ADB	----	8,182	100	F	11-70	E8	-------	---	12	T	G	I
118	SC 23-73- 4CAC	1970	8,800	95	22	4-71	02	10	35	6	S	E	H
119	SC 23-73-13ACC	----	8,300	7	2	11-70	02	-------	---	36	P	H	H
120	SC 23-73-15AAB	1966	8,806	52	22	8-71	02	-------	---	--	J	E	H
121	SC 23-73-15ACD	----	8,895	113	67	9-70	02	-------	---	--	S	E	H
122	SC 23-73-15ADB	----	8,865	70	68	9-70	E8	-------	---	4	S	E	H
123	SC 23-73-23ADC	1970	8,760	57	34	8-71	02	14	---	6	S	E	H
124	SC 23-73-24ABB	----	8,405	8	2	11-70	02	-------	---	--	-	-	H
125	SC 24-71- 4CAD	----	8,455	220	187	12-70	02	-------	---	--	P	W	-

Records of Selected Wells--Continued

Site number on figure 2	Local well number	Year drilled	Altitude of land surface (ft)	Well depth (ft)	Depth to water (ft)	Date water level measured (M-Y)	Major aquifer	Yield (gal/min)	Drawdown (ft)	Casing diameter (in.)	Type lift	Power	Use of water
126	SC 24-71- 5BCA	----	8,320	99	90	12-70	E8	-------	---	--	P	W	S
127	SC 24-71- 6BAA	----	8,240	29	25	4-71	E7	-------	---	36	P	W	S
128	SC 24-71- 7ACD	----	8,358	142	138	4-71	E7	-------	---	6	P	W	S
129	SC 24-71-14DCA	1965	8,721	70	24	10-70	E7	10	5	5	P	W	S
130	SC 24-71-15BCC	----	8,480	228	219	4-71	E8	-------	---	--	P	W	S
131	SC 24-71-17ABA	----	8,438	---	---	-----	E7	-------	---	6	P	W	S
132	SC 24-71-17CBA	----	8,485	---	258	4-71	E7	-------	---	6	P	W	S
133	SC 24-71-18DAA	----	8,465	240	---	-----	E7	-------	---	6	P	W	S
134	SC 24-71-19BDD	1931	8,571	332	320	4-71	E7	-------	---	5	N	N	H
135	SC 24-71-22BBC	----	8,585	---	309	4-71	E8	-------	---	6	P	W	S
136	SC 24-71-25CBA	1966	9,038	400	165	6-66	E8	2	135	5	P	W	S
137	SC 24-71-35BAB	----	8,875	---	---	-----	02	-------	---	--	P	W	S
138	SC 24-72- 4DBB	1964	8,320	142	4	11-70	02	20	0	6	C	E	S
139	SC 24-72- 5ABB	1964	8,545	150	92	11-70	E8	-------	---	6	P	G	S
140	SC 24-72-10CCC	1969	8,440	220	180	7-69	E8	10	10	7	S	E	H
141	SC 24-72-15AAD	1959	8,495	310	295	12-59	02	5	2	6	P	W	S
142	SC 24-72-26BAC	----	8,755	387	Dry	4-71	E8	-------	---	6	P	G	-
143	SC 24-72-28CAA	----	8,170	12	5	11-70	02	-------	---	36	C	E	H
144	NA 45-12- 2DAA	----	8,835	110	---	-----	--	-------	---	6	S	E	H
145	NA 46-12- 3DDD	1954	7,650	150	F	10-70	E8	-------	---	5	T	-	I
146	NA 46-12-10BDD	----	7,860	---	143	5-74	02	-------	---	6	P	W	S
147	NA 46-12-10DCB	----	7,880	145	133	5-74	02	-------	---	6	P	W	S
148	NA 46-12-11ACC	----	7,620	130	51	10-70	E8	-------	---	--	T	-	I
149	NA 46-12-11CDA	----	7,749	196	24	10-70	E8	-------	---	6	P	W	S
150	NA 46-12-12DAC	----	7,620	104	F	10-70	E8	20	---	8	-	-	I
151	NA 46-12-12DBB1	----	7,630	161	F	11-70	E8	-------	---	8	N	N	H
152	NA 46-12-12DBB2	----	7,640	159	F	10-70	E8	2	---	8	-	H	H
153	NA 46-12-12DBC	----	7,650	184	F	10-70	E8	40	---	8	-	-	I
154	NA 46-12-12DBD1	----	7,600	89	F	10-70	E8	40	---	10	N	N	I
155	NA 46-12-12DBD2	----	7,615	121	F	10-70	E8	9	---	10	N	N	I

156	NA 46-12-12DDB	----	7,625	131	F	10-70	E8	18	---	10	N	N	I
157	NA 46-12-13ACB	----	7,740	53	8	4-71	02	-------	---	6	S	E	H
158	NA 46-12-14BBD	----	7,879	108	24	10-70	E8	-------	---	--	P	W	S
159	NA 46-12-15AAC	----	7,910	163	23	10-70	02	-------	---	6	P	W	S
160	NA 46-12-15ABC	----	7,935	---	86	5-74	02	-------	---	6	P	W	S
161	NA 46-12-22DDA	----	8,330	60	35	5-74	02	-------	---	6	N	N	H
162	NA 46-12-27ADB	----	8,465	70	63	5-74	02	5	---	6	N	N	H

Specific Conductance and Temperature of Water Data from Selected Surface-Water Stations

Site number on figure 2	U.S. Geological Survey station number	Station name	Date of sample	Temperature (degrees Celsius)	Specific conductance (μmho/cm at 25°C)
1-----	07093980	Lake Creek near Hillside, Colo.	7-31-74	11.5	
			8-19-74	12.5	
			9-16-74	9	
			10-16-74	7	
			11-15-74	3	
			12-18-74	0	
			4-18-75	2	150
			5-21-75	11.5	
			6-13-75	10	
			8- 6-75	10.5	
			9- 9-75	10	119
			10- 7-75	8	130
			11-11-75	1.5	
			12-23-75	1.5	123
			2- 3-76	2.5	
			4- 8-76	7	122
			5- 5-76	9.5	127
			8-13-76	10.5	120
			9-17-76	9.5	125
2-----	07094530	Grape Creek near Bradford, Colo.	7-31-74	19	
			8-19-74	12.5	
			10-16-74	3	
			11-15-74	0	
			12-18-74	0	
			5-20-75	9	
			6-13-75	6.5	
			7-10-75	9.5	
			8- 6-75	11.5	
			9- 9-75	5.5	101
			10- 7-75	9.5	155
			11-11-75	0	
			12-23-75	0.5	
			2- 3-76	0.5	
			4- 8-76	2.5	132
			5- 5-76	5.5	101
			6-30-76	14	115
			8-13-76	12.5	139
			9-17-76	20	115

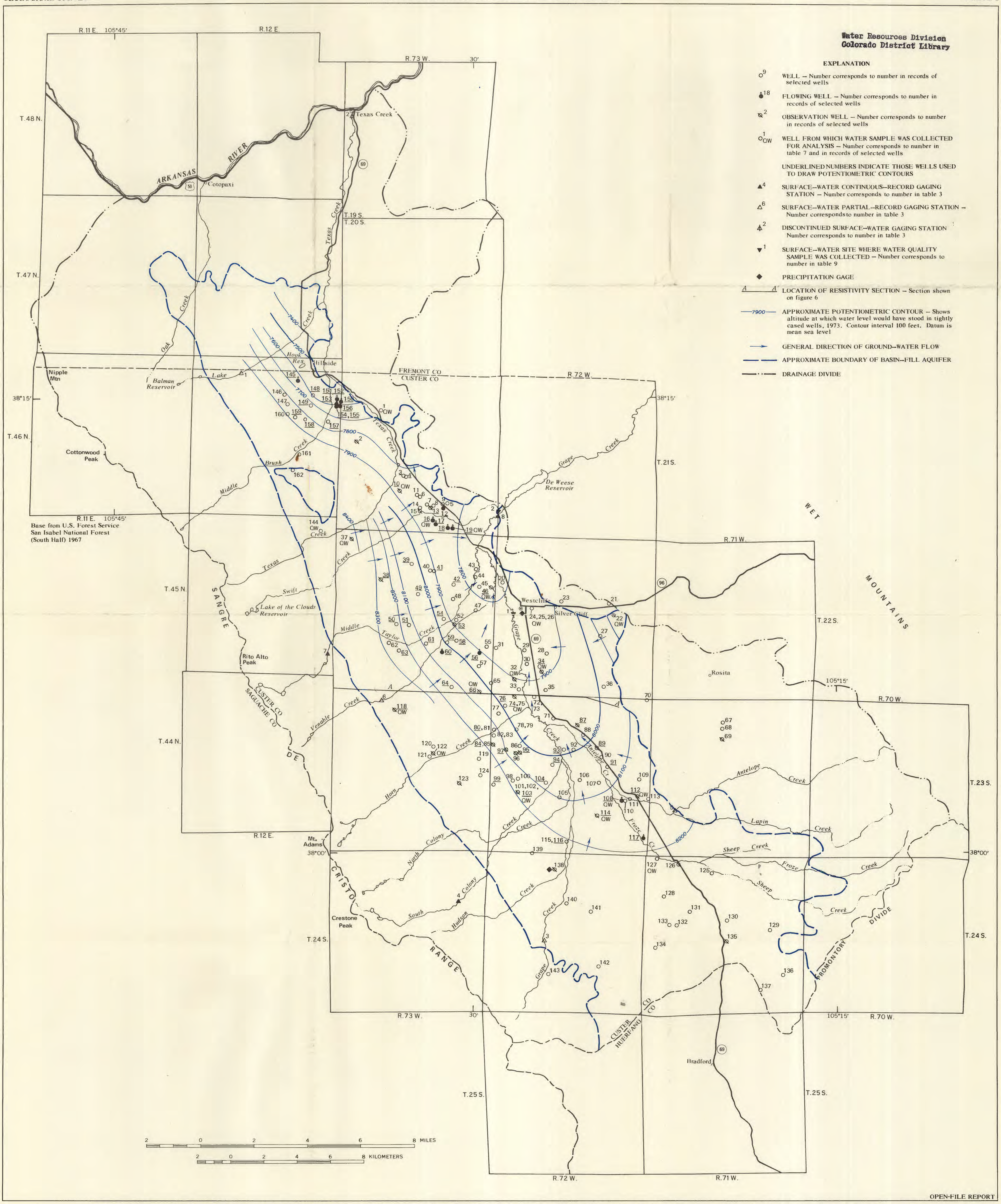
Specific Conductance and Temperature of Water Data from Selected Surface-Water Stations--Continued

Site number on figure 2	U.S. Geological Survey station number	Station name	Date of sample	Temperature (degrees Celsius)	Specific conductance (µmho/cm at 25°C)
4-----	07094600	South Colony Creek near Westcliffe, Colo.	8- 1-74	14	
			8-19-74	10.5	
			9-16-74	6.5	
			10-16-74	3	
			11-15-74	0	
			4-17-75	0.5	140
			5-20-75	4.5	
			6-13-75	6.5	
			7-10-75	7.5	
			8- 6-75	9	
			9- 9-75	9	95
			10- 7-75	6.5	100
			11-11-75	0	
			12-23-75	0	122
			2- 3-76	0.5	
			4- 8-76	2	116
			5- 5-76	3.5	91
			6-11-76	8	70
			7-12-76	13.5	70
			8-13-76	8.5	90
			9-17-76	10.5	105
5-----	07094700	Antelope Creek near Rosita, Colo.	7-31-74	30.5	
			4-17-75	10.5	310
			5-20-75	9	
			6-13-75	12	
			7-10-75	14.5	
			8- 6-75	16	
			9- 9-75	12	360
			11-11-75	0	
			2- 3-76	0	
			4- 8-76	9.5	362
			5- 5-76	10	370
			6-30-76	23	370

Specific Conductance and Temperature of Water Data from Selected Surface-Water Stations--Continued

Site number on figure 2	U.S. Geological Survey station number	Station name	Date of sample	Temperature (degrees Celsius)	Specific conductance (µmho/cm at 25°C)
6-----	07094800	Venable Creek near Westcliffe, Colo.	7-31-74	10.5	
			8-19-74	9.5	
			9-16-74	5.5	
			10-16-74	3.5	
			5-21-75	6	
			6-13-75	8	
			7-10-75	9	
			8- 6-75	10	
			9- 9-75	9	138
			10- 7-75	6	70
			11-11-75	0	
			12-23-75	0	170
			2- 3-76	0	
			4- 8-76	1	74
			5- 5-76	6	
			6-11-76	7	110
			6-30-76	11	120
			8-13-76	9.5	140
			9-17-76	9	160
7-----	07094900	Middle Taylor Creek near Westcliffe, Colo.	8- 1-74	16	
			8-19-74	15.5	
			9-16-74	7.5	
			10-16-74	9	
			11-26-74	0	240
			1-29-75	0	
			6-13-75	13	
			8- 6-75	17.5	
			9- 9-75	13.5	197
			10- 7-75	10.0	215
			10-16-75	7	218
			12-23-75	0	220
			2- 3-76	0	
			4- 8-76	0.5	215
			5- 5-76	6	150
			5-11-76	7.5	125
			6-11-76	10.5	105
			6-30-76	17	155
			7-12-76	12	50
			8-13-76	13	185
			9-17-76	10	210

GPO 844-958



OPEN-FILE REPORT

MAP SHOWING LOCATION OF WELLS, SURFACE-WATER GAGING STATIONS, AND POTENTIOMETRIC SURFACE OF THE BASIN-FILL AQUIFER, WET MOUNTAIN VALLEY, PARTS OF CUSTER AND FREMONT COUNTIES, COLORADO