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GROUND-WATER HYDROLOGY OF THE UPPER SEVIER RIVER BASIN, SOUTH-CENTRAL UTAH, AND SIMULATION OF GROUND-WATER FLOW IN THE VALLEY-FILL AQUIFER IN PANGUITCH VALLEY

By

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Prepared by the

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in cooperation with the

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Division of Water Rights

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
acre	0.4047	hectometer
	4,047	square meter
acre-foot (acre-ft)	0.001233	cubic hectometer
	1,233	cubic meter
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per year (ft/yr)	0.3048	meter per year
foot per day (ft/d)	0.3048	meter per day
foot per day per foot (ft/d/ft)	0.3048	meter per day per meter
foot squared per day (ft^2/d)[1]	0.0929	meter squared per day
foot squared per second (ft^2/s)	0.0929	meter squared per second
gallon per minute (gal/min)	0.06309	liter per second
inch (in.)	25.4	millimeter
	0.0254	meter
inch per year (in/yr)	0.0254	meter per year
mile (mi)	1.609	kilometer
square mile (mi^2)	2.59	square kilometer

Water temperature is reported in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\ (°C) + 32.$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Chemical concentration and water temperature are reported only in metric units. Chemical concentration is reported in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the 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 milligrams per liter, the numerical value is about the same as for concentrations in parts per million. Specific conductance is reported in microsiemens per centimeter (µS/cm) at 25 degrees Celsius.

Chemical concentration for water-quality diagrams shown on plate 1 are reported in milliequivalents per liter. Milliequivalent-per-liter values can be calculated by multiplying the milligrams per liter by the ionic charge divided by the molecular weight of the ions.

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[1] Expresses transmissivity. An alternative way of expressing transmissivity is cubic foot per day per square foot, times foot of aquifer thickness [$ft^3/d/ft^2$]ft.

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ABSTRACT

The ground-water hydrology of the upper Sevier River basin, primarily of the unconsolidated valley-fill aquifers, was studied from 1988 to 1989. Recharge to the valley-fill aquifers is mostly by seepage from surface-water sources. Changes in soil-moisture content and water levels were measured in Panguitch Valley both at a flood-irrigated and at a sprinkler-irrigated alfalfa field to quantify seepage from unconsumed irrigation water. Lag time between irrigation and water-level response decreased from 6 to 2 days in the flood-irrigated field as the soil-moisture content increased. Water levels measured in the sprinkler-irrigated field did not respond to irrigation. Discharge from the valley-fill aquifer to the Sevier River in Panguitch Valley is about 53,570 acre-feet per year.

Water levels measured in wells from 1951 to 1989 tend to fluctuate with the quantity of precipitation falling at higher elevations. Ground-water discharge to the Sevier River in Panguitch Valley causes a general increase in the specific conductance of the river in a downstream direction.

A three-layered ground-water-flow model was used to simulate the effects of changes in irrigation practices and increased ground-water withdrawals in Panguitch Valley. The establishment of initial conditions consisted of comparing simulated water levels and simulated gains and losses from the Sevier River and selected canals with values measured during the 1988 irrigation season. The model was calibrated by comparing water-level changes measured from 1961 to 1963 to simulated changes. A simulated change from flood to sprinkler irrigation resulted in a maximum decline in water level of 0.9 feet after the first year of change. Simulating additional discharge from wells resulted in drawdowns of about 20 feet after the first year of pumping.

INTRODUCTION

The ground-water hydrology of the upper Sevier River basin in south-central Utah (fig. 1) was studied from 1988 through 1989 by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. The study was conducted to provide the Division of Water Rights with additional information about ground water in the valley-fill aquifers and the consolidated rocks of the area. This information will help the Division better manage the development and distribution of water resources in the area. The primary objectives of the study were to (1) better define the ground-water hydrology of the valley-fill aquifers, most importantly the ground-water/surface-water relations, and (2) estimate the effects that changes in water-management practices might have on the hydrologic system.

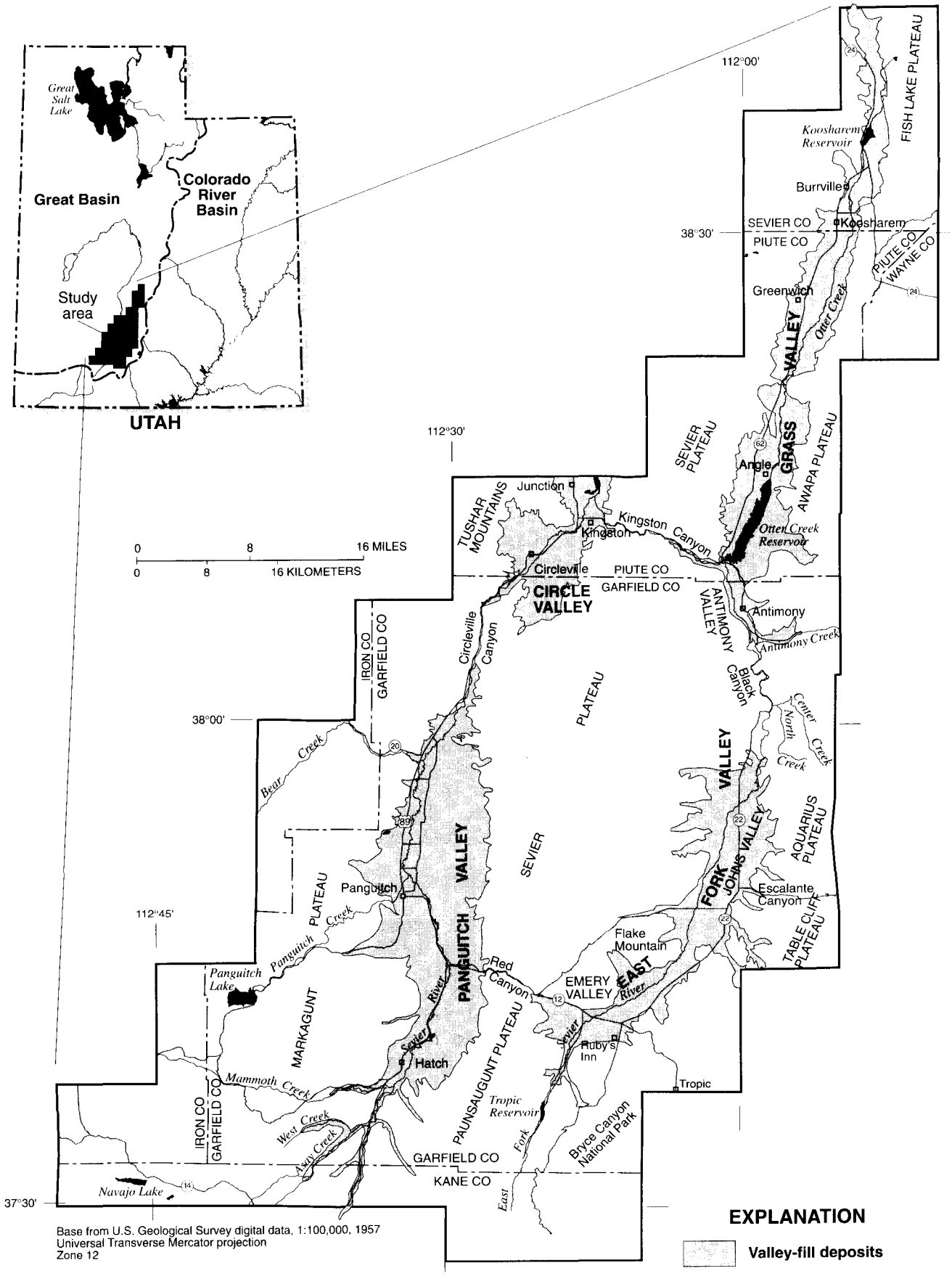

Figure 1. Location of the upper Sevier River basin in Utah and the geographic setting of the study area.

Purpose and Scope

This report describes the ground-water hydrology of the upper Sevier River basin and presents estimated effects on the valley-fill aquifers caused by changes in water-management practices. Reported aspects of the ground-water hydrology include characterization of the ground-water reservoirs, description of ground-water budget components, and definition of the chemical quality of the ground water. The construction and application of a digital-computer model simulating ground-water flow in a representative valley within the basin is also described.

Methods of Investigation

Information collected by the U.S. Geological Survey from 1951 to 1989, in addition to that of other State and Federal agencies, was used for this study. Previously collected water-level, discharge, and chemical-quality data from the upper Sevier River basin were compiled from U.S. Geological Survey files and studied along with data collected in conjunction with this study. Subsurface information from drillers' logs of wells obtained from the Division of Water Rights also were used. Land-use data, field checked in 1981, were used to delineate phreatophyte areas, irrigated areas, and crop type. Streamflow gain-loss studies were made on the Sevier and East Fork Sevier Rivers and on selected canals to determine the degree of connection between the shallow ground water and these surface-water bodies. Data collected from neutron-probe access tubes and monitoring wells installed during the study were used to help understand the process of seepage from unconsumed irrigation water. A three-dimensional ground-water-flow model was constructed to better understand the ground-water-flow system and to estimate the effects of changes in water-management practices in a representative valley within the basin.

Acknowledgments

The assistance and cooperation of local land owners and employees of irrigation companies, the Sevier River Commissioner, Bryce Canyon National Park, and the Soil Conservation Service greatly aided in the collection of data for this study. Information, time, and access to hydrologic-data sites supplied by these individuals and agencies are appreciated.

Numbering System for Hydrologic-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. The land-survey system divides the State into four quadrants separated by the Salt Lake Base Line and Meridian. 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[1] for regular sections. The lowercase 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 tract. The letter 'S' preceding the serial number designates a spring or seep. Thus, (C-32-5)26aca-2 designates the second well constructed or visited in the NE¼, SW¼, NE¼, sec. 26, T. 32 S., R. 5 W., and (C-27-1)35cad-S1 designates a spring in the SE¼, NE¼, SW¼, sec. 35, T. 27 S., R. 1 W. The numbering system is illustrated in figure 2.

Description of the Study Area

The upper Sevier River basin is in parts of Kane, Iron, Garfield, Piute, and Sevier Counties in south-central Utah, and includes an area of about 2,400 mi^2 (fig. 1). The basin consists of the Sevier River and East Fork Sevier River drainages upstream from the confluence of the East Fork Sevier River with the Sevier River.

The stream valleys of the basin are surrounded by north-south trending, high-elevation plateaus and mountains (fig. 1). The area is a transition zone between the Colorado Plateau physiographic province to the east and the Basin and Range physiographic province to the west (Fenneman, 1931). Seven plateaus and one mountain range bound or lie within the basin. The Markagunt Plateau and the Tushar Mountains form the western boundary while the Table Cliff, Aquarius, Awapa, and Fish Lake Plateaus form the eastern boundary. The Sevier and Paunsaugunt Plateaus lie within the basin. Elevations in parts of the basin reach more than 11,000 ft above sea level.

Separating the plateaus and mountains are four major valleys: Panguitch, Circle, Grass, and East Fork Valleys. The Sevier River flows through Panguitch and Circle Valleys, the East Fork Sevier River flows through East Fork Valley, and Otter Creek flows through Grass Valley.

Most of the unconsolidated valley-fill deposits in Panguitch Valley lie along a 31-mi reach, with a maximum width of about 10 mi, from the confluence of Mammoth Creek with the Sevier River at the southern end to the head of Circleville Canyon at the northern end. The valley-fill deposits encompass an area of about 102,000 acres, and elevations range from 7,000 ft above sea level at the southern end to 6,340 ft at the northern end. Bordering to the west is the Markagunt Plateau, and to the east are the Sevier and Paunsaugunt Plateaus. The valley-fill deposits pinch out or become very thin at the north and south ends of the valley.

The unconsolidated valley-fill deposits in Circle Valley are bounded by the Tushar Mountains to the west and the Sevier Plateau to the east and includes an area of about 29,000 acres. The northern part of the valley is marked by a consolidated-rock spur extending eastward from the Tushar

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[1]Although the basic land unit, the section, is theoretically 1 square mile, many sections are irregular in size and shape. Such sections are divided into 10-acre 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.

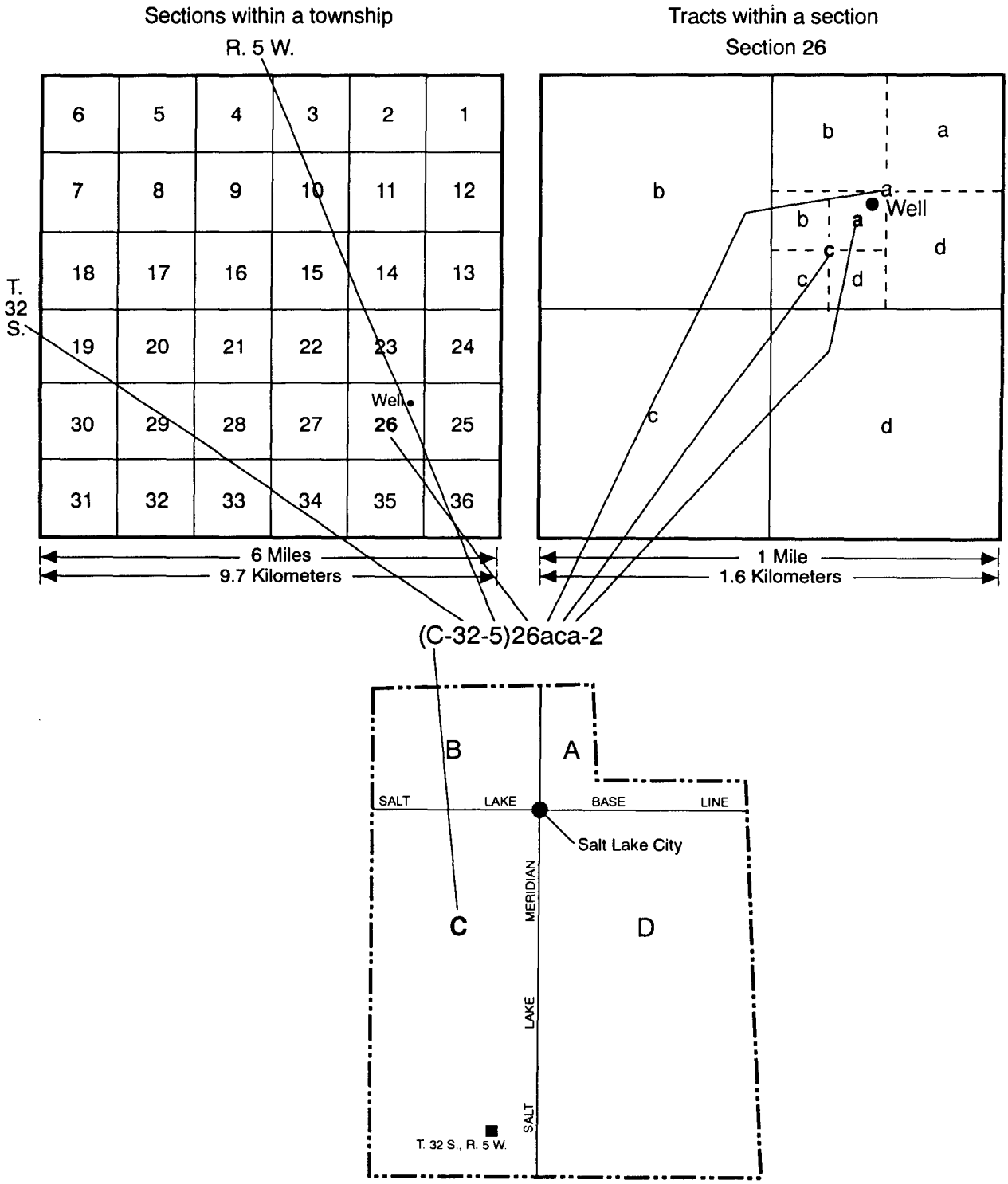


Figure 2. Numbering system used in this report for hydrologic-data sites.

Mountains almost to the mouth of the East Fork Sevier River. The valley is about 8 mi long and 6 mi wide and ranges in elevation from 6,200 ft above sea level at the southern end to 6,000 ft at the northern end.

East Fork Valley includes three smaller valleys containing valley-fill deposits oriented along the East Fork Sevier River but separated by consolidated-rock constrictions: Emery, Johns, and Antimony Valleys. Emery Valley extends from the north end of the Paunsaugunt Plateau north of Tropic Reservoir to Flake Mountain, a faulted volcanic rock outcrop about 14 mi to the north. The valley widens to more than 6 mi near Rubys Inn and north of the Bryce Canyon Airport and includes an area of about 18,000 acres. Emery Valley is bounded on the west by the Sevier Plateau and on the east by the Bryce Canyon area of the Paunsaugunt Plateau. Elevation ranges from 8,000 ft above sea level at the southern end to 7,600 ft at the northern end.

The valley-fill deposits in Johns Valley extend from Flake Mountain on the south to the head of Black Canyon, a volcanic rock constriction about 17 mi to the north. It includes an area of about 46,000 acres. The valley is bounded by the Sevier Plateau on the west and the Table Cliff and Aquarius Plateaus on the east. It ranges from 3 to 7 mi in width, and from 7,600 to 7,000 ft in elevation above sea level from south to north.

Antimony Valley extends from the mouth of Black Canyon north to the head of Kingston Canyon and the outlet of Otter Creek Reservoir. The Sevier Plateau lies along the western edge of the valley while the Aquarius Plateau abuts the eastern edge. The valley-fill deposits in Antimony Valley extend over an area about 5 mi long and 1 mi wide and encompass an area of about 6,600 acres. Elevation ranges from 6,450 to 6,340 ft above sea level from south to north.

Grass Valley extends from north of Koosharem Reservoir south to Otter Creek Reservoir, where it joins with Antimony Valley. Grass Valley is bounded on the west by the Sevier Plateau and on the east by the Awapa and Fish Lake Plateaus. The valley-fill deposits include an area of about 71,500 acres and cover an area about 40 mi long and 3 to 4 mi wide. Elevations range from 7,000 ft above sea level at Koosharem Reservoir to 6,370 ft at Otter Creek Reservoir.

Geologic Setting

Several unconsolidated- and consolidated-rock formations found in the upper Sevier River basin influence the occurrence and movement of ground water. A geologic map of the area was made by Carpenter and others (1967).

The oldest rock unit exposed in the study area is the Kaiparowits Formation-Wahweap Sandstone-Straight Cliffs Sandstone unit of Cretaceous age; however, this unit was not studied or reported on in this report. The oldest rock unit that was studied in the study area is the Claron Formation of Tertiary age. The Claron Formation can be seen throughout the plateaus of the study area except for the Awapa Plateau, the northern part of the Sevier Plateau, and the Tushar Mountains. Deposited in a fluvial and lacustrine environment, it forms the prominent pink to red limestone cliffs exposed in Bryce Canyon, Red Canyon, and much of the southern Markagunt and Sevier Plateaus, and caps the Paunsaugaunt Plateau. Called the Wasatch Formation by

Gregory (1949, 1951), the Claron Formation is Eocene and Oligocene in age, although the basal strata may be Cretaceous to Paleocene in age. The Oligocene to Miocene Spry Intrusion of Anderson (1986), a light-colored quartz monzonite, is near the head of Circleville Canyon at the base of the northern Markagunt Plateau. It intruded through the Claron Formation, forming a topographic high that affected subsequent deposition in the area.

The late Oligocene to early Miocene Mount Dutton Formation consists of alluvial strata eroded from volcanic material and lava flows. This formation extends throughout the northern plateaus in the study area and is exposed in the southern Tushar Mountains. The reddish-brown or light-gray densely welded Osiris Tuff of early Miocene time overlies the Mount Dutton Formation and in Black Canyon is almost 130 ft thick (Anderson and Rowley, 1975, p. 31 and Williams and Hackman, 1971, pl. 1). Exposed in the northern Markagunt Plateau, the Bear Valley Formation is mainly an eolian green, yellow, or gray sandstone of early Miocene age that also contains lava flows, volcanic mudflow breccia, conglomerate, and ash-flow tuffs.

The poorly to moderately consolidated Sevier River Formation of Miocene to Pleistocene age includes interlayered sandstone, siltstone, claystone, and conglomerate of fluvial and lacustrine origin. The Sevier River Formation is extensively eroded and is covered in most areas by more recent valley-fill deposits. Exposures of the formation are found along Panguitch Creek and as isolated outcrops in Panguitch Valley. Test wells drilled in Panguitch Valley indicate that it may be absent but can be more than 450 ft thick in places (Feltis and Robinson, 1963). The Sevier River Formation is generally considered to be the basal formation of the valley-fill deposits.

Basalt flows were extruded concurrently on the Markagunt Plateau with the deposition of the Sevier River Formation and the more recent valley-fill deposits. Some of the cinder cones on the southern Markagunt Plateau are Holocene in age.

Valley-fill material deposited during the Quaternary is exposed in the study area. These deposits vary from heavily dissected older valley-fill deposits to recently deposited flood-plain material. The known thickness of the Quaternary valley-fill deposits ranges from 0 to more than 800 ft in the upper Sevier River basin (Carpenter, 1967, p. 25). The older valley-fill deposits are exposed only in Panguitch Valley as isolated bluffs and as large dissected fans topographically higher than more recent alluvial fans. Gregory (1951, p. 55) described outcrops of lacustrine-deposited, stratified, buff-colored limey silt and white marl near the mouths of Red Canyon and Casto Wash. The top of this deposit unconformably underlies more recent alluvial fans of Panguitch Valley and is of Pleistocene age.

The younger valley-fill deposits exposed in all of the major valleys in the study area are of Holocene age. Found along intermittent and perennial streams, these sediments usually form terrace deposits and alluvial fans. In the Koosharem area of Grass Valley, possible lake or marsh deposits were penetrated by test wells.

Flood-plain deposits occur within the present flood plains of the Sevier River, East Fork Sevier River, and Otter Creek. The sediments are generally channel deposits of well sorted, stratified sand and gravel, and overbank deposits containing sand, silt, and clay. Extending into the subsurface, the flood-plain deposits intertongue and grade into the older Quaternary valley-fill deposits.

The north-northeast-trending plateaus and valleys of the area are a result of normal movement along the Sevier and Paunsaugunt fault zones during Tertiary and Quaternary time. The Sevier fault zone trends north-south through the basin separating the downthrown Circle and Panguitch Valleys on the west from the upthrown Paunsaugunt and Sevier Plateaus to the east. Estimated displacements of 900 ft on the south side of Red Canyon, 850 ft at Hillsdale Canyon, and 1,200 ft at Proctor Canyon were reported by Gregory (1951, p. 76). The north-south-trending Paunsaugunt fault also extends the length of the basin separating the upthrown Table Cliff, Aquarius, Awapa, and Fish Lake Plateaus on the east from the Paunsaugunt and Sevier Plateaus to the west. Offset of Claron Formation outcrops on the Table Cliff Plateau as compared with those at Bryce Canyon are about 2,300 ft down to the west (Doelling, 1975, p. 63). The downthrown valleys of the upper Sevier River basin are underlain by the Claron Formation and volcanic rocks of Tertiary age that also exist in the surrounding upthrown plateaus.

Smaller faults related to the Sevier fault zone cut through valley-fill deposits in Panguitch Valley. In the Sanford Creek area, two northeast-trending faults cut through Pleistocene alluvial-fan deposits forming a horst. Individual scarps of almost 40 ft were measured by Anderson and Christenson (1989). The faults also cut across the bottom of a Holocene wash in the northern quarter sections of (C-33-5)26 and 27, suggesting that faulting is still active (Anderson and Rowley, 1987, p. 7).

The axis of a Quaternary faulted anticline extends southwestward through Panguitch Valley and into the Markagunt Plateau, intersecting the Sevier River and the ground-water reservoir near Roller Mill Hill. Ground water near and at land surface in the Roller Mill Hill area may be the result of this uplift and the correspondingly thinner layer of valley-fill deposits.

Climate

The climate of the upper Sevier River basin varies from semi-arid at the valley floors to subhumid in the mountainous areas. Daytime temperature extremes in 1988 ranged from about -28 to 32 °C. The average temperature in 1988 at Panguitch was about 7 °C (National Oceanic and Atmospheric Administration, 1989).

The 1951 to 1980 average annual precipitation at Panguitch was 9.89 in. (U.S. Department of Commerce, 1982). The wettest period is the winter, when most of the yearly precipitation falls as snow. Scattered summer thunderstorms account for the rest of the precipitation. Average annual precipitation was generally exceeded during 1965-72 and 1978-85; precipitation was generally less than average during 1942-45, 1950-57, 1958-65, 1973-77, and 1987-89. Annual precipitation at Panguitch and cumulative departure from average annual precipitation for 1931-89 are shown in figure 3.

Snow depths were recorded from 1944 through 1989 at the Harris Flat snow course, on the southern end of the Markagunt Plateau about 11 mi southwest of Hatch. The elevation of the snow course is 7,700 ft above sea level. The average annual maximum water content of snow measured at the snow course was 9.3 in. (Whaley and Lytton, 1979 and U.S. Department of Agriculture, Soil Conservation Service, written commun., 1989). Annual evaporation from Piute Reservoir, near the north end of Circle Valley, was estimated to be 46.26 in. during 1931 to 1970 (Waddell and Fields, 1977, table 12).

Vegetation

The type of vegetation growing in the upper Sevier River basin varies with elevation. In the uncultivated parts of the valleys, greasewood, sagebrush, and various native grasses predominate. Phreatophytes such as rabbitbrush, salt grass, willows, and cottonwoods grow where the water table is within about 20 ft of land surface. Vegetation growing on the surrounding foothills and alluvial fans consists mostly of sagebrush, juniper, pinyon pine, and scrub oak. At the higher elevations, sagebrush, aspen, Ponderosa pine, spruce, and Douglas fir predominate.

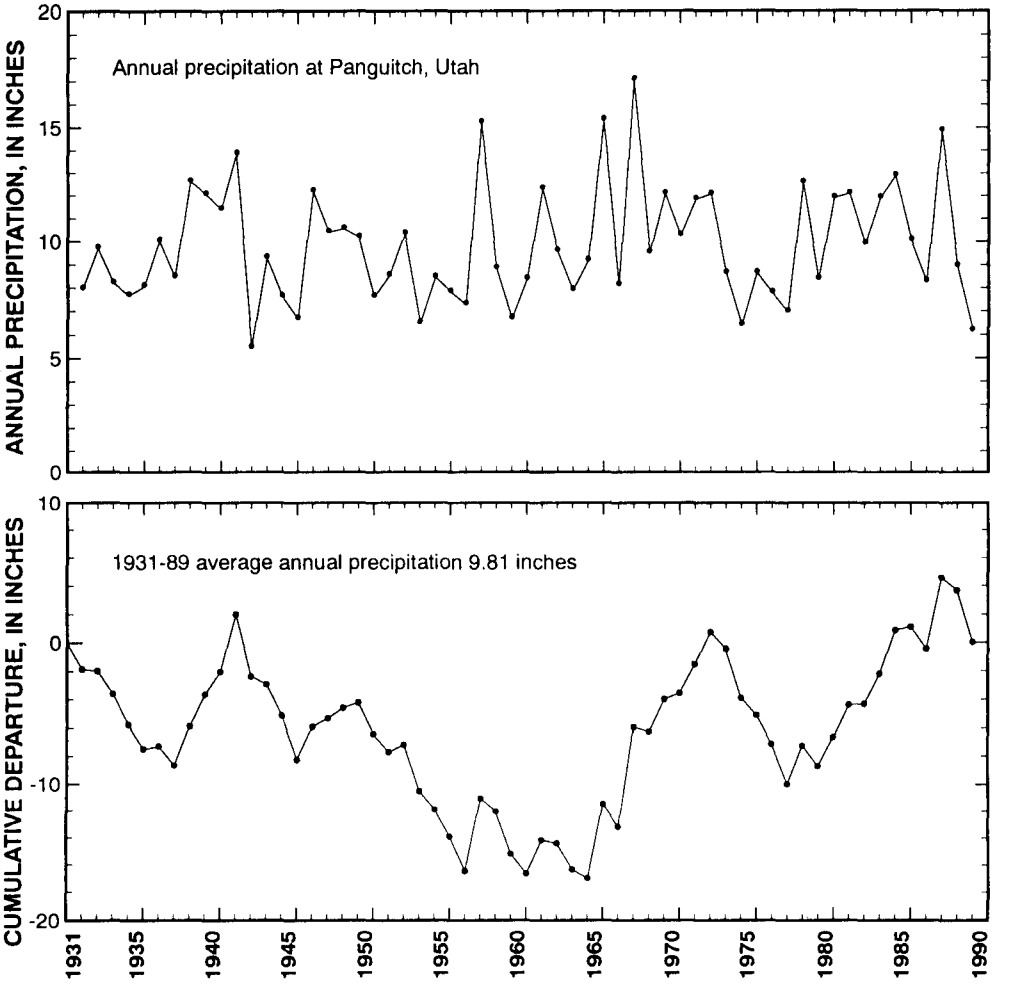


Figure 3. Annual precipitation, 1931-89, and cumulative departure from 1931-89 average annual precipitation, at Panguitch.

The area of cropland under irrigation in the upper Sevier River basin was determined from land-use data field-checked in 1981 (Jaynes and others, 1981). A total of 34,897 acres were irrigated, including pastures and alfalfa fields subject to spring flooding (table 1).

Table 1.—*Area of irrigated crops in the main valleys of the upper Sevier River basin*

Crop type	Panguitch Valley (acres)	Circle Valley (acres)	East Fork Valley (acres)	Grass Valley (acres)	Total (acres)
Alfalfa	3,357	4,531	2,174	3,318	
Pasture	8,593	4,028	440	1,749	
Hay	405	0	0	3,956	
Other	556	841	539	410	
Total	12,911	9,400	3,153	9,433	34,897

Land Use

The primary land uses in the upper Sevier River basin are farming, ranching, recreation, and timber harvesting. Farms and ranches are mainly in the valleys, while most of the summer livestock grazing occurs on the higher-elevation plateaus. Tourism is economically important in the area, and visitation increases yearly. The number of summer homes and associated domestic wells also is increasing in the southern part of Panguitch Valley and on the Markagunt Plateau.

Most of the land within the basin, 85 percent, is managed by Federal agencies (U.S. Department of Agriculture, 1969a). Most of the mountainous areas are in Dixie and Fish Lake National Forests, and much of the lower-elevation areas are managed by the U.S. Bureau of Land Management. Bryce Canyon National Park, in the southeastern part of the basin, attracts visitors from around the world to view its unusual scenery.

Surface-Water Hydrology

The upper Sevier River drainage basin includes the Sevier River, its major tributaries: Asay Creek, Mammoth Creek, Panguitch Creek, East Fork Sevier River, and Otter Creek, and many smaller perennial and ephemeral streams. During the irrigation season, water from the East Fork Sevier River is diverted below Tropic Reservoir out of the upper Sevier River basin into the Colorado River basin. The Tropic Ditch transfers an estimated 2,610 acre-ft of water annually from the East Fork Sevier River to irrigated fields near the town of Tropic (Carpenter and others, 1967, p. 39).

Relations between surface water and ground water are evident in Panguitch Valley. Streamflow in the Sevier River near Hatch (U.S. Geological Survey streamflow-gaging station 10174500)(pl. 1) averages about 85 ft^3/s in August, based on 45 years of record. Diversion of water into irrigation canals causes

some sections of the Sevier River near Panguitch to have almost no flow. Ground-water discharge, tributary inflow, and runoff from irrigated fields downgradient from these sections contribute flow to the Sevier River. Streamflow in the river at the Circleville Canyon streamflow-gaging station (10180000) (pl. 1) averages about 84 ft^3/s in August, based on 38 years of record. Gain-loss studies were done in 1988 on selected reaches of the Sevier River, East Fork Sevier River, and two canals in Panguitch Valley. Streamflow and water-quality data collected in the field at selected surface-water sites within the basin and calaculated streamflow gains and losses are presented by George W. Sandberg (U.S. Geological Survey, written commun., 1990).

GROUND-WATER HYDROLOGY OF CONSOLIDATED ROCKS

Ground water occurs in all the consolidated-rock formations in the basin. Water in consolidated rocks discharges to springs and to some streams as base flow but is not considered part of the primary ground-water resource of the upper Sevier River basin. Fractures in the volcanic rock and limestone are capable of transmitting large quantities of water. Springs in the Markagunt Plateau, such as Mammoth Spring, that discharge from fracture-derived solution channels in limestone of the Tertiary Claron Formation, are the principal source of base flow to the Sevier River in its upper reaches.

Where fractured, the Tertiary Mount Dutton Formation transmits water. Several springs issue from this formation with widely varying flows (Carpenter and others, 1964, p. 8). Carpenter and others (1967, p. 19) attributed the flow from springs in Black Canyon to the Brian Head Formation of Tertiary age. However, more recent geologic investigations indicate that the canyon is cut into volcanic alluvial facies of the Mount Dutton Formation and the Osiris Tuff. A gain-loss study of the East Fork Sevier River in Black Canyon indicated a small gain in flow in August 1988. A gain of 3 ft^3/s, calculated as a graphic average derived from three sets of measurements, was added to the 23 ft^3/s measured at the beginning of the 6.42 mi long reach (George W. Sandberg, U.S. Geological Survey, written commun., 1990). Most of this gain in flow can be attributed to discharge from the consolidated rocks in the canyon.

The Tertiary Bear Valley Formation transmits ground water in the northern Markagunt Plateau. Numerous seeps along the Bear Creek channel appear where the creek traverses the basal contact of the Bear Valley Formation and base flow increases.

Surficial Quaternary basalt flows in the southern Markagunt Plateau have followed and filled pre-existing drainages, forcing runoff to infiltrate and move through the underlying Claron Formation and valley-fill deposits, or to establish a new surface drainage. The basalt flows are impermeable except where broken by fractures and can have a very large hydraulic conductivity where broken blocks, lava tunnels, and contact zones exist (Wilson and Thomas, 1964, p. C19). A Quaternary basalt flow in and near the mouth of an old Mammoth Creek channel solidified on top of unconsolidated stream deposits, causing the creek to form a new channel. These covered stream deposits are now the source of seeps and springs at the base of the easternmost lobe of basalt.

The main source of recharge to consolidated rock is precipitation that falls on the higher elevations as snow. Snowmelt and rainfall on the Markagunt Plateau enter the consolidated rock through fractures on the surface of Quaternary basalt flows and move through interconnecting fractures in the basalt flows and solution channels in the Claron Formation. These openings allow large quantities of precipitation to infiltrate the consolidated rock.

Recharge also may occur where streams flow over consolidated rock. A gain-loss study done in August 1988 on the East Fork Sevier River in Kingston Canyon, a cut in consolidated rock of volcanic origin, indicated a loss in streamflow of 8 ft^3/s (George W. Sandberg, U.S. Geological Survey, written commun., 1990). Because discharge was relatively large, from 124 to 144 ft^3/s, this measured loss cannot be substantiated because it is within the margin of measurement error (estimated to be 5 to 8 percent).

Ground water in consolidated rocks in the study area moves from high-elevation recharge areas to lower-elevation discharge areas. Water movement in these rocks is through interconnecting fractures and solution channels. Water moves downgradient through these fractures and channels until it intersects land surface or valley-fill deposits at contacts along the mountain fronts.

Discharge from consolidated rocks is mainly from springs and seepage to streams. Subsurface outflow from consolidated rocks to unconsolidated material probably occurs in all of the valleys. Drillers' logs indicate that some wells completed in volcanic rocks that underlie valley-fill deposits in Grass Valley flow at land surface; however, the quantity of ground water moving to the valley-fill deposits from the volcanic rocks is unknown. Discharge from wells completed in consolidated rock in the upper Sevier River basin as a whole is small.

Most of the known ground-water discharge from consolidated rocks is from springs in the Claron Formation in the southern Markagunt Plateau and in volcanic rocks mainly in the Sevier Plateau. Base flow of most of the streams in the area is composed primarily of discharge from these springs. Discharge from consolidated-rock springs is used for public supply by many towns in the basin. Panguitch, Circleville, Kingston, Antimony, Greenwich, Koosharem, and Burrville all distribute spring water for municipal use. Some springs in the Bryce Canyon area and southern Markagunt Plateau discharge to the Colorado River Basin.

Water levels were measured in two wells completed in consolidated rock along the western margin of Panguitch Valley. Well (C-36-5)31cbd-1 is completed in a limestone member of the Claron Formation and is near a small irrigation ditch that carries diverted surface water. Monthly water-level measurements from 1988 to 1989 show the influence of spring runoff and surface-water diversions in the area on water levels in the well (fig. 4). A small rise in water levels in September and October 1988 is probably the result of leakage from the nearby irrigation ditch, and the peak water level in May 1989 is likely the result of infiltration of spring runoff and irrigation diversions.

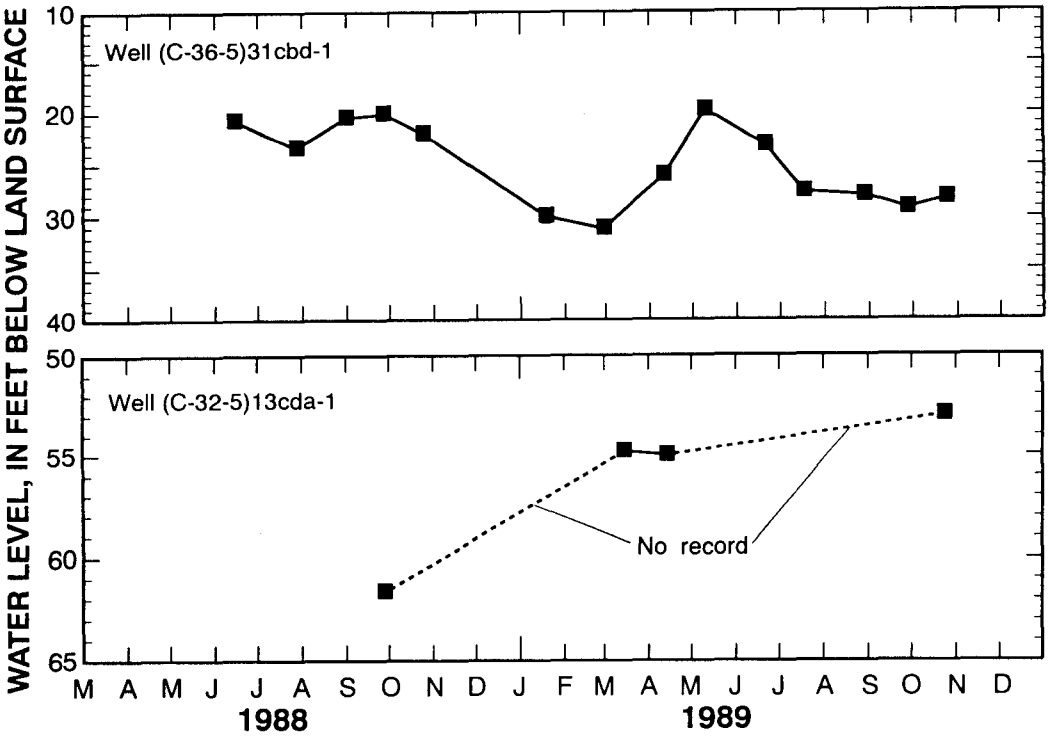


Figure 4. Water-level fluctuations from 1988 to 1989 in two wells completed in consolidated rocks.

Well (C-32-5)13cda-1 is completed in the Spry Intrusion (Anderson, 1986) at the northern end of Panguitch Valley. The water level rose 8.67 ft in the well from September 1988 to October 1989 (fig. 4) while water levels in most of the wells completed in the valley-fill deposits in Panguitch Valley declined. One possible reason for this anomaly is that the recharge area for the monzonite may be distant from the well, and the time required for recharge water to infiltrate through unsaturated rock before reaching the aquifer may be considerable. Thus, the anomalous water-level rise may have been a result of greater-than-average precipitation occurring in years past.

GROUND-WATER HYDROLOGY OF THE VALLEY-FILL AQUIFER IN PANGUITCH VALLEY

The saturated valley-fill deposits are defined as the valley-fill aquifer and are considered the main aquifer in Panguitch Valley. Ground water occurs mostly in permeable sand and gravel layers that are separated by less permeable clay layers in the alluvial-fan and flood-plain deposits. The alluvial fans consist of interbedded silt, sand, gravel, and cobble deposits that are coarse grained near the mountain fronts and finer grained toward the center of the valley. Older dissected deposits of the Sevier River Formation are more consolidated than more recent alluvial-fan deposits, and therefore are probably less permeable. Ground water in the alluvial-fan deposits is generally under water-table conditions.

Flood-plain deposits lie along major surface-water channels and generally are finer grained and better sorted than alluvial-fan deposits. Ground water in flood-plain deposits near consolidated-rock constrictions is generally under confined conditions.

Recharge

Recharge to the valley-fill aquifers is by seepage from streams, canals diverted from streams, and unconsumed flood-irrigation water; infiltration of precipitation; and seepage from consolidated rock at the margins of and underlying the valley-fill deposits. The components of recharge in Panguitch Valley are described and quantified in the following sections. Recharge varies annually, but was estimated to range from 71,740 to 80,740 acre-ft/yr under normal conditions.

Seepage from Streams

The principal source of recharge to the valley-fill aquifer in Panguitch Valley is seepage from the Sevier River and its tributaries. Seepage from streams in Panguitch Valley is estimated to be from 32,000 to 41,000 acre-ft/yr. Much of the stream losses occur at the valley margins where streams cross from consolidated rock into valley-fill deposits. Recharge from perennial streams, other than the Sevier River and Panguitch Creek, is estimated to range from 20 to 30 percent of the average annual streamflow or about 13,000 to 20,000 acre-ft/yr. Average annual streamflow was determined from gaging-station records or was estimated. The estimated rate of recharge is based on the geologic and topographic setting of these streams and the hydraulic conductivity of and hydraulic gradient in the material it traverses. Tributary perennial streams flow over a thin deposit of mostly saturated material within steep canyons in the consolidated rock. The gradient becomes less steep as the streams enter Panguitch Valley and traverse the coarse-grained unsaturated deposits of the valley. Water infiltrates through the streambed and banks into the valley-fill aquifer. Mammoth and Asay Creeks, large streams that flow across relatively short sections of valley-fill deposits before flowing into the Sevier River, contribute most of the recharge.

Ephemeral streams in Panguitch Valley flow out of canyons in consolidated rock with steep slopes onto less steep coarse-grained alluvial-fan deposits. Streamflow in ephemeral streams usually occurs as a result of snowmelt. Evapotranspiration at the time of snowmelt is usually small. Annual streamflow for major ephemeral streams in Panguitch Valley was estimated by Carpenter and others (1967) and from a regression equation developed for a region of the Colorado River Basin (Christensen and others, 1986, p. 10). The southwest part of this region is adjacent to the eastern part of the upper Sevier River basin. The equation requires values for the following independent variables of the ephemeral stream basin: contributing-drainage area, mean annual precipitation, and main-channel slope. Values calculated for ephemeral stream basins in Panguitch Valley were within the range of values used in the development of the regression equation. This equation for estimating mean annual streamflow was selected over methods using gaging-station records from streams in the valley because the gaged streams have very large drainage areas, contain large discharging springs, or are controlled by a dam. Recharge from ephemeral streams is estimated to range from 14,000 to 16,000 acre-ft/yr, about 80 percent of the estimated annual streamflow.

A gain-loss study of the Sevier River from about 1.5 mi south of the gaging station near Hatch (10174500) to the gaging station in Circleville Canyon (10180000) made in August 1988 measured only one losing reach, 9.96 mi long, with a graphic average loss of 3 ft^3/s (George W., Sandberg, U.S. Geological Survey, written commun., 1990). This section of the river is in the southern part of the valley where the water table is generally below the bottom of the riverbed. The quantity of stream discharge measured during the gain-loss study fluctuated, probably as a result of unconsumed irrigation water moving through the fields and into the river.

Because the gain-loss study was made in August at the peak of the irrigation season, the higher water table may have decreased the quantity of water seeping from the river into the valley-fill aquifer. Losses from perennial and ephemeral streams and recharge from unconsumed irrigation water to the valley-fill aquifer during the spring snowmelt and irrigation season result in a rise in the water table and a possible reversal of the gradient between the river and valley-fill aquifer. Losses from the river to the valley-fill aquifer are probably greater during the winter and early spring when the water table is lower than the river bottom. An average loss of about 7 ft^3/s or 5,000 acre-ft/yr is estimated for the Sevier River in Panguitch Valley.

Seepage from Canals

Recharge to the valley-fill aquifer from canal seepage was estimated to be some percentage of the average annual flow in the canal measured near its point of diversion from the stream. The percentage is based on the type of valley-fill deposit the canal crosses and on gain-loss studies. The Sevier River Commissioner maintains gages and/or flumes on these diversions and publishes records of the quantity of water diverted in an annual report to the Utah State Engineer. The average yearly quantity of water diverted in Panguitch Valley for irrigation from 1969 through 1985 was about 48,400 acre-ft, not including the quantity diverted for ditches at the northern end of the valley. These ditches probably do not lose water to the valley-fill aquifer because the surficial deposits in this part of the valley are clay and silt. Diversions from Panguitch Creek for irrigation were not measured but were estimated to be 20,000 acre-ft/yr. Because this stream is regulated by a dam, its losses are included with losses from the canals.

The rate of leakage from a canal depends on the hydraulic conductivity of the bed of the canal and of the valley-fill deposits, and on the hydraulic gradient between the canal and the aquifer it crosses. Finer-grained material, such as silt and clay, is less permeable and allows little water to seep from the canal into the ground. Coarser-grained material, such as sand and gravel, is more permeable and will transmit the water more readily if the hydraulic gradient between the canal and aquifer permits.

Most of the canals used in Panguitch Valley are cut into the flood-plain deposits of the Sevier River or cross the toes of alluvial fans that contain a large percentage of fine-grained material. Losses from these canals to the valley-fill aquifer were estimated to be 10 percent of the water diverted into the canals from streams, or about 4,840 acre-ft/yr. The two canals that receive water from Panguitch Creek are on alluvial fans and cross very permeable gravel deposits. Forty percent, or 8,000 acre-ft/yr, of the water diverted to these canals was estimated to recharge the valley-fill aquifer.

A gain-loss study of the Long-East Bench Canal and the McEwen Canal in late July and early August 1988 identified two losing reaches (George W. Sandberg, U.S. Geological Survey, written commun., 1990). Long Canal (pl. 1) was measured in sections from its point of diversion from the Sevier River to the East Bench Canal diversion, and then along the East Bench Canal for 0.5 mi. The Long-East Bench Canal lost about 4 ft^3/s from an average diversion of about 51 ft^3/s in a 1.35-mi reach northeast of Roller Mill Hill near Panguitch.

McEwen Canal (pl. 1) was measured from its point of diversion from the Sevier River to just beyond the dry ephemeral Sanford Creek channel, 5.46 mi downstream. The canal lost about 4.6 ft^3/s from an average diversion of about 16 ft^3/s in a 1.41-mi reach. This section of the canal is cut into the base and side of dissected alluvial-fan deposits.

Seepage from Unconsumed Irrigation Water

An average of 68,400 acre-ft of water is diverted from streams into canals and ditches in Panguitch Valley during the irrigation season. Recharge from unconsumed irrigation water in Panguitch Valley is dependent mainly on the quantity of water that is diverted from streams into canals for irrigation. Leakage from canals to the valley-fill aquifer was estimated to be 12,840 acre-ft/yr, and thus was not available for crop irrigation.

Some of the applied irrigation water was observed moving off the fields into downgradient ditches or into the Sevier River. Tail-water runoff was estimated to be about 11,110 acre-ft/yr, or 20 percent of the water applied to the fields after canal losses are subtracted from the diverted water. Tail-water runoff is subtracted from the seasonal diversion minus canal-loss value. An average annual consumptive-use rate of 1.78 ft/yr for alfalfa and pasture determined for Panguitch Valley by the Soil Conservation Service (U.S. Department of Agriculture, 1969b, Appendix IV, tables 37-40) and an irrigated area of about 12,900 acres determined from land-use data for 1981 (Jaynes and others, 1981) were used to calculate the quantity of applied water consumed by crops (22,950 acre-ft/yr). This quantity is subtracted from the remaining water diverted for irrigation. The remaining unconsumed water diverted for irrigation from streams into canals was assumed to recharge the valley-fill aquifer in those areas identified as being irrigated for alfalfa, hay, and pasture (21,500 acre-ft/yr).

Irrigated fields on alluvial fans that are underlain by more permeable sand and gravel transmit a greater percentage of irrigation water to the valley-fill aquifer than do those underlain by finer-grained sediments. In the center of the valley, water may be prevented from moving down to the regional water table by less permeable silty clay layers. The water moves downgradient along these less permeable layers toward the river.

The quantity and location of recharge from unconsumed irrigation water may vary as a result of changes in irrigation practices and the location of irrigated areas with time. The land-use data used to specify the location of irrigated areas and crop type were field checked in 1981. There has been an increase in sprinkler irrigation in some areas of the upper Sevier River basin, resulting in less recharge from unconsumed irrigation water. The land-use data did not differentiate between irrigation methods.

An attempt was made to quantify recharge to the valley-fill aquifer from unconsumed irrigation water on the basis of irrigation method. Observation wells were drilled at two sites north of Panguitch. Both sites were in alfalfa fields possessing similar soil profiles. One site was flood irrigated and the other was irrigated by a center-pivot sprinkler. Access tubes for a neutron probe were installed adjacent to each observation well to allow collection of soil-moisture data. Cores were collected at the time of drilling. After logging and photographing each core, sections were chosen for laboratory analyses. Among the analyses made were moisture retention, particle size, volumetric soil-moisture content (expressed as percent saturation), and saturated vertical hydraulic conductivity (expressed as feet per day). Water levels in the observation wells were recorded hourly by remote data recorders from November 1988 to March 1990. Soil moisture was measured with a neutron probe once a month during the winter, twice a month during the growing season, and daily for three days during a September application of irrigation water on the flood-irrigated field.

Soil texture in this area typically varies from very fine to coarse particles. The soil profiles include fine- to coarse-grained sands with stringers of clay and silt and layers of gravel and cobbles. The soils are generally well drained even though the stringers of clay and silt have small values of vertical hydraulic conductivity. The surface soil is a loamy sand with moderate aggregation and a large vertical hydraulic conductivity. The first clay layers that are more than one-half in. thick are 6 to 8 ft below land surface. Coarse-grained sediments, such as gravelly sands and small cobbles, underlie the clay layers. These coarse-grained sediments also contain silt and clay. The extreme variability in grain size over very short distances prevents defining a typical vertical hydraulic-conductivity value for the profile, or even for a single core, and results in wide variability in soil-moisture content and hydraulic conductivity over very short distances.

The unsaturated hydraulic conductivity of a soil is related to soil texture and moisture content. Surface tension on the soil particles is an adhesive force that holds water in the soil pore spaces. Fine-textured soils, composed of small particles and pore spaces, have more surface area than do coarse-textured soils. Fine-textured soils can retain larger quantities of water in the pore spaces because of surface-tension forces than do coarse-textured soils. As the pore spaces in a soil fill with water, the moisture content and unsaturated hydraulic conductivity increase. When the soil-moisture content reaches a point that surface-tension forces become inadequate to hold the added water, the water will begin to move downward.

Water-level records and soil-moisture measurements at the two sites were used to estimate the times required for irrigation water to move downward through the unsaturated zone into the aquifer. The estimated times were much shorter than laboratory values for vertical hydraulic conductivity would indicate.

In the flood-irrigated field, water levels in the observation well rose in response to applied irrigation water (fig. 5). The length of time between the start of irrigation and the water-level rise in the aquifer decreased as the soil-moisture content increased during the irrigation season (fig. 6a). On June 26, 1989, the water level in the observation well in the flood-irrigated field began to rise, six days after irrigation (fig. 5). The water

level in the well rose from about 29.8 ft on June 26, to 28.3 ft below land surface on July 9, when water levels began to decline. On July 23, the water level in the well began to rise four days after irrigation, with a rise from about 28.7 ft on July 23, to 26.6 ft below land surface on August 1. The lag times for the August and September irrigations were three and two days, with rises of about 4 and 3 ft, respectively. Although soil-moisture data are incomplete, there is a noticeable increase in soil-moisture content that corresponds with the decrease in lag times and the rise in water levels in the observation well (fig. 6a). This is because the soil moisture does not have enough time to drain from the soil profile before the next application of irrigation water.

The rises in water levels corresponding to local flood-irrigation applications were superimposed on regional changes in water levels measured in the observation well. Water levels fell to a regional base level after each water-level rise following irrigation. Each base level was higher than the preceding one. The same trend of rising regional water levels is evident in neighboring wells in both irrigated and non-irrigated areas. Rapid rises in water levels were followed by rapid declines back to the regional base level.

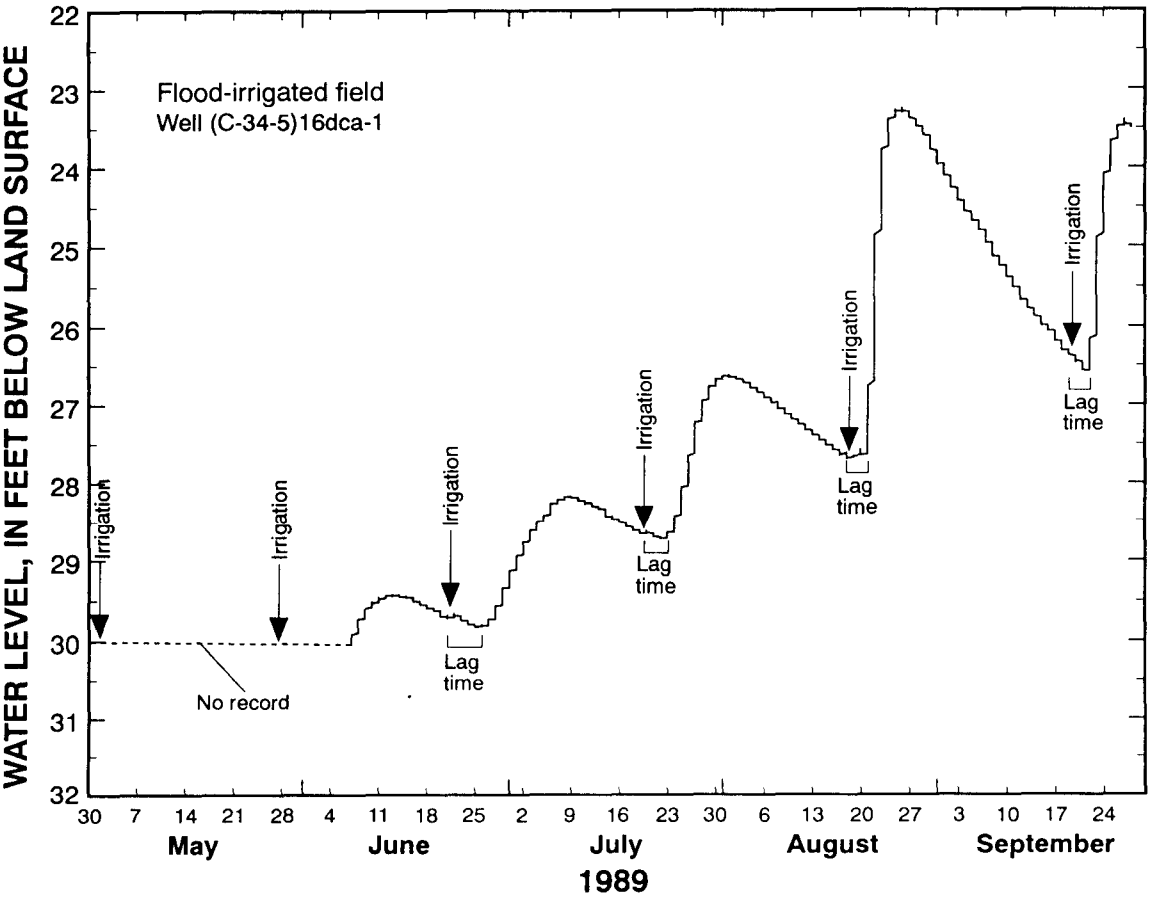


Figure 5. Water-level changes in well (C-34-5)16dca-1 caused by flood irrigation.

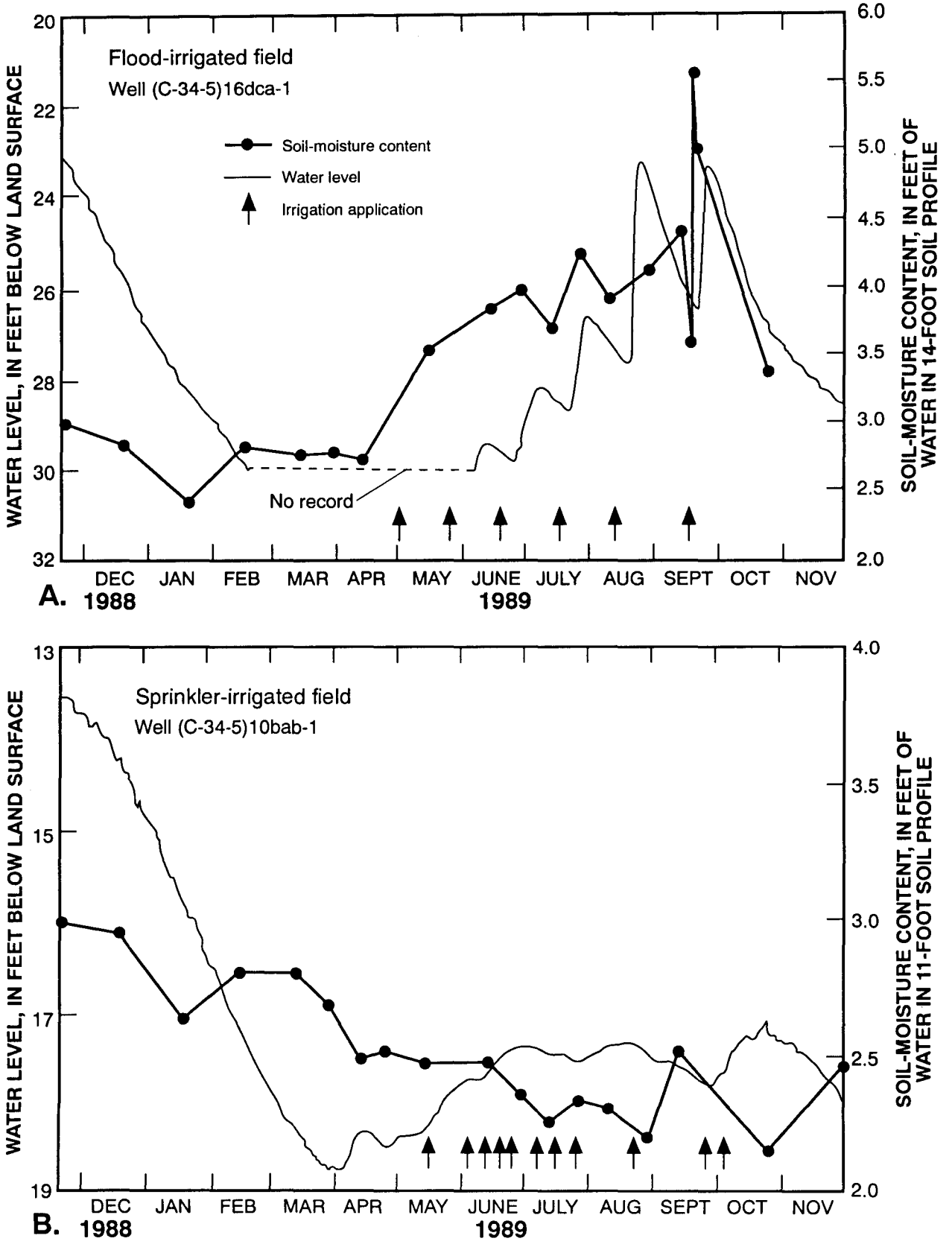


Figure 6. Soil-moisture content and water-level changes in neutron-probe access tubes and wells (A) (C-34-5)16dca-1 and (B) (C-34-5)10bab-1 from November 1988 to November 1989.

In contrast to the flood-irrigated field, water levels in the observation well in the sprinkler-irrigated field responded only to regional trends and not to individual irrigations (fig. 6b). Soil-moisture content gradually decreased early in the year in both fields. The sprinkler-irrigated field continued to show a decline during the growing season, the opposite response of the flood-irrigated field (fig. 6a). Any increases in soil-moisture content as a result of rainfall and irrigation are represented in the data only as an effect in the upper 1 to 3 ft of soil.

Exceptionally dry conditions prevailed during 1988 and 1989, and due to the resulting low streamflows and diversions for irrigation, the quantity of irrigation on the sprinkler-irrigated field was about 75 percent of what is normally applied. The decrease in soil-moisture content affected the water levels in late summer. Water levels gradually declined from August to late September even though the regional trend indicates that the water levels in the observation well should rise. Whether this deviation from the regional trend was caused by the smaller quantity of irrigation water applied to the field, or by the smaller quantity of flow in upgradient canals resulting in less recharge from canal seepage, is uncertain.

Evapotranspiration estimates provided by the Soil Conservation Service (U.S. Department of Agriculture, 1969b, Appendix IV) account for water consumption of about 1.67 ft during the irrigation season. Total precipitation at Panguitch for the 1989 growing season was about 0.6 ft, and irrigation applications account for another 1.4 ft. The surplus is about 0.33 ft of water for the entire growing season. During the same time, water levels in the observation well rose about 1.5 ft, indicating that irrigation and precipitation on the field had little or no effect on the water levels in the observation well.

Water-budget components for the sprinkler-irrigated field are similar to those of the flood-irrigated field except for the difference in quantity of water applied. While the sprinkler applied a controlled 1.4 ft of water over 125 acres during the irrigation season, about 10 ft of water was applied to about 4.5 acres in the flood-irrigated field in six different applications. During the growing season, soil-moisture losses resulting from evapotranspiration were estimated to be about 1.67 ft, and precipitation added about 0.6 ft. This difference represents about a 1-foot deficit in soil-moisture storage that must be overcome before there can be any recharge to the aquifer.

In the flood-irrigated field, soil-moisture data collected over the 14-foot depth of the soil profile show an approximate increase of 1.5 ft of water between the pre-irrigation period in April and the height of the growing season in August (fig. 6a). This 1.5 ft of water stored in the soil profile, plus the 1 ft of water from the water-budget deficit, indicates that a total of about 2.5 ft of water went into soil-moisture storage. Subtracting this 2.5 ft from the 10 ft of irrigation water applied leaves about 7.5 ft of water remaining as possible recharge. These estimates are probably large because they do not take into account tail-water runoff or evaporation from the free-water surface during irrigation. More frequent soil-moisture-content data collection might also reveal greater soil-moisture storage requirements.

Monitoring soil moisture twice a month during the growing season with the neutron probe was inadequate for calculating quantities of water moving downward through the soil. On the basis of the data collected during the summer, it was possible to estimate quantities of surplus soil moisture using a simple budget consisting of changes in soil-moisture content from one measuring period to the next. The sum of the changes in soil-moisture content in the flood-irrigated field indicate about 3 ft of surplus soil moisture. The sum of the changes in soil-moisture content in the sprinkler-irrigated field indicated a deficit of about 1 ft.

In September, soil-moisture content was measured at the flood-irrigated site the day before, during, and after irrigation. According to these data, the 14-foot soil profile gained about 2 ft of water during the day of irrigation (fig. 6a). Increases occurred in each of the 14 1-ft layers measured. On the day after irrigation, soil moisture in the upper 9 ft of the profile decreased, while it increased in the lower 5 ft. Soil moisture measured the day after irrigation indicates a net decrease of greater than 0.5 ft over the entire profile. Evapotranspiration during this period was negligible, indicating that lost water from the profile moved downward into the aquifer. A rate of 13 ft/d, calculated from the delay in response between time of irrigation and water-level rise, agrees fairly well with these data.

The water level in the observation well rose from 26.58 ft below land surface on September 22, 2 days after irrigation, to 23.39 ft below land surface on September 27 (fig. 5). On the basis of soil-moisture data recorded the day of and the day after irrigation, 0.5 ft of water moved through the soil profile. The water-level-data recorder indicated that the water level rose in well (C-34-5)16dca-1 for 6 days after irrigation in September, implying a net flow of 3 ft of water from the soil profile into the aquifer. August observation-well data indicate a 9-day period of water-level rise.

Using the September water-level-rise rate of 0.5 ft/d, a rise of 4.5 ft would be expected in 9 days, which is approximately the case in August. This relation fails, however, when used for early growing season periods by predicting much higher rises than those that actually occur. It is likely that substantial pore space in the soil must be filled before recharge can occur, and this requirement is met sometime before the August irrigation.

An estimate of ground-water recharge resulting from unconsumed flood-irrigation water was obtained using rising water levels associated with each irrigation and an estimated specific yield for the soil profile. Specific yield refers to the percentage of water in a saturated soil that will drain by the force of gravity. Using soil descriptions for the profile and values reported for different soils (Johnson, 1967, table 29), specific yield was estimated to be about 0.20. This value is multiplied by the depth of soil profile that is alternately saturated by irrigation water and drained by gravity (Clark and Appel, 1985, p. 34).

There is no estimate for the response to the first irrigation, on May 1, as water-level data were not available. The water-level rise caused by the May 27 irrigation was 0.63 ft; for the June 21 irrigation, 1.6 ft; for the July 19 irrigation, 2.1 ft; for the August 18 irrigation, 4.4 ft; and for the September 20 irrigation, 3.2 ft. The sum of the products of these water-level rises and the specific yield result in a recharge value of unconsumed

irrigation water of 2.40 ft. These calculations and estimates can be taken only as approximations of the local trends and not as exact quantities of recharge.

Infiltration of Precipitation

Recharge to the valley-fill aquifer by infiltration of direct precipitation was estimated to be 5 percent of the average annual precipitation from 1931 to 1960 (U.S. Weather Bureau, 1963) or about 4,900 acre-ft/yr in Panguitch Valley. This estimate is based on a range of values derived from previous studies for recharge from precipitation in other alluvial basins in Utah. Estimates of the percentage of precipitation recharging valley-fill aquifers ranged from 1 percent to 25 percent for areas receiving 8 to 16 in. of precipitation annually (Razem and Steiger, 1981, p. 13; Hood and Waddell, 1968, p. 24; and Feth and others, 1966, p. 43). Infiltration is greatest early in the spring when snow melts. Intense thunderstorms in the late summer months also recharge the valley-fill aquifer, but to a lesser degree because of short storm duration and large evapotranspiration rates. During periods of greater-than-average precipitation, recharge is probably greater than average because consumptive use by plants and soil-moisture retention do not increase beyond certain values depending on the plant and soil type.

Seepage from Consolidated Rock

Some of the consolidated-rock formations that border and underlie the valley-fill deposits of Panguitch Valley transmit water and probably recharge the valley-fill aquifer. Because data are lacking, it is not known how much water moves from consolidated rock into the valley-fill aquifer, but this seepage is assumed to be small compared with other components of recharge.

Movement

Ground water in Panguitch Valley generally moves from recharge areas at the southern end of the valley and from recharge areas along the mountain fronts toward discharge areas at the northern end of the valley and into the Sevier River. The potentiometric surface of the valley-fill aquifer in October 1989 is shown on plate 1.

Recharge water from the mountain fronts moves vertically downward through coarse-grained alluvial-fan deposits and laterally toward the Sevier River. Unconsumed applied irrigation water and seepage from canals and ditches infiltrates downward until it reaches the fully saturated deposits and then moves laterally toward the Sevier River. On the east side of the valley, some ground water is perched on the semiconsolidated Sevier River Formation and moves away from the mountain front in permeable material at shallow depths. Ground water flows between hills made of older Quaternary valley-fill deposits that protrude through younger Quaternary valley-fill deposits between the mountain front and the Sevier River, where it discharges from springs.

Comparison of water-level data collected from wells completed at different depths shows that the vertical direction of ground-water movement varies with location in the valley. The water level at well (C-34-5)4ddd-1 was measured to be 6,538 ft above sea level on April 11, 1989, and 6,539 ft

above sea level on October 25, 1989. The well is 21 ft deep and is next to a surface-water ditch. The water level at well (C-34-5)10bbb-1, about 100 ft east of well (C-34-5)4ddd-1, was measured to be 6,539 ft above sea level on April 11, 1989, and 6,551 ft above sea level on October 26, 1989. This well is 140 ft deep with perforations from 80 to 140 ft. The water levels at these two wells indicate an upward head gradient.

Water levels measured at wells (C-34-5)2bcc-1 and (C-34-5)2cbc-1 on October 26, 1989, were 6,574 and 6,545 ft above sea level, respectively. Well (C-34-5)2bcc-1 is 52 ft deep with an open end and well (C-34-5)2cbc-1 is 171 ft deep with an open end, indicating a downward gradient in head. Elevations above sea level were obtained from topographic maps with a contour interval of 20 ft.

Ground water moving downgradient through the valley-fill deposits, from the south to the north end of Panguitch Valley, is forced to discharge to the Sevier River because of a consolidated-rock barrier in the northern end of the valley. The predominant direction of movement in this area is upward.

Discharge

Ground water in Panguitch Valley discharges from the valley-fill aquifer by seepage to the Sevier River and canals, by evapotranspiration, through springs and wells, and by subsurface outflow at the north end of the valley. Discharge varies from year to year, but was estimated to be about 73,100 acre-ft/yr under normal conditions in Panguitch Valley.

Seepage to the Sevier River and Canals

Seepage to the Sevier River is the primary component of ground-water discharge from the valley-fill aquifer in Panguitch Valley, on the basis of analysis of gaging-station records and one gain-loss study made in August 1988. Flow in the Sevier River during the winter months increases between the gage near Hatch (gaging station 10174500) and a downstream gage in Circleville Canyon (gaging station 10180000). This increase in flow is attributed primarily to ground-water discharge from the valley-fill aquifer to the river.

Mean monthly discharges measured during 1950-89 at the gage near Hatch were added to the mean monthly discharges of Panguitch Creek measured during 1961-80 (gaging station 10176300) (pl. 1). Panguitch Creek is the only major tributary to the Sevier River in Panguitch Valley downstream from the gage near Hatch. The average gain in flow between the gage on the Sevier River near Hatch (combined with the flow from Panguitch Creek) and the gage in Circleville Canyon, from December to March, was about 58 ft^3/s (41,990 acre-ft/yr). The flow in the river from April to November is influenced by surface-water diversions, spring runoff, and tail-water inflow from irrigated fields, and thus was not used to compute the average gain in discharge.

A gain-loss study made on the Sevier River in August 1988 from a point about 1.5 mi upstream from the gage at Hatch to the Circleville Canyon gage indicates a graphic average (more than three measurements) gain of 125 ft^3/s (90,500 acre-ft/yr)(George W. Sandberg, U.S. Geological Survey, written commun., 1990). Because the gain-loss study was made during the irrigation

season, part of the measured gain is attributed to tail-water inflow from irrigated fields.

Calculated from 25 years of records (1964-89), the mean monthly discharge of Mammoth Creek above the West Hatch Ditch diversion (gaging station 10173450) (pl. 1) for December and January is about 15 ft^3/s. Carpenter and others (1967, p. 34) estimated the base flow of Asay Creek (including the West Fork) to be about 26 ft^3/s. The combined flow of Asay and Mammoth Creeks in December and January, which account for almost all of the flow in the Sevier River just downstream from its confluence with Mammoth Creek, is about 41 ft^3/s. This value is about 16 ft^3/s (11,580 acre-ft/yr) less than the December and January mean monthly discharge computed for the Sevier River at the Hatch gaging station. Because no major tributaries enter the Sevier River between the confluence with Mammoth Creek and the gage near Hatch, the increase in flow is attributed to ground-water discharge. Seepage to the Sevier River from the valley-fill aquifer is estimated to be about 53,570 acre-ft/yr in Panguitch Valley.

Seepage from the valley-fill aquifer to canals occurs where canals intersect the water table. A gain-loss study made on parts of the Long-East Bench and McEwen Canals in the summer of 1988 showed that some sections of the canals gain water (George W. Sandberg, U.S. Geological Survey, written commun., 1990). Gain in flow in the Long-East Bench Canal was measured to be about 4.7 ft^3/s out of a diversion that averages 51 ft^3/s. Gain in flow in the McEwen Canal was measured to be about 5.5 ft^3/s out of a diversion of about 16 ft^3/s. Most of the gain in flow in the McEwen Canal is from seepage from Long Canal and its irrigated fields upgradient from the McEwen Canal. The McEwen Canal also crosses the Sevier River floodplain, where the water table is near land surface, throughout most of the gaining reaches. Much of the gain measured during the seepage investigation is attributed to tail-water flow moving off irrigated fields into downgradient canals and ditches. This gain-loss study indicates an estimated 2,000 acre-ft/yr of water discharged from the valley-fill aquifer into canals in Panguitch Valley.

Evapotranspiration

Ground-water discharge from the valley-fill aquifer by evapotranspiration occurs primarily along perennial stream channels where the water table is near enough to land surface to support phreatophyte growth. This depth to the water table varies with each type of phreatophyte. The principal phreatophytes in the basin are meadow grasses and saltgrass with some rabbitbrush, greasewood, cottonwood, and willow.

About 5,770 acres in Panguitch Valley during 1981 were classified as covered by non-irrigated wetland pasture, irrigated wetland pasture and hayland, and riparian wetland (Jaynes and others, 1981). An annual consumptive-use rate of 23.0 in/yr (1.9 ft/yr) was computed as an average from monthly rates and acreages listed for phreatophytes in the area by the U.S. Department of Agriculture (1969b, Appendix IV, tables 37-40). Average monthly evapotranspiration rates for phreatophytes in Panguitch Valley are October, 1.7 in.; November, 0.5 in.; December, 0.2 in.; January, 0.1 in.; February, 0.2 in.; March, 0.5 in.; April, 1.2 in.; May, 2.1 in.; June, 3.5 in.; July, 5.2 in.; August, 4.5 in.; and September, 3.3 in. Total evapotranspiration from phreatophytes in Panguitch Valley was estimated to be about 11,060 acre-ft/yr.

Springs

Springs discharging ground water from the valley-fill aquifer are usually located where the water table intersects the land surface. In Panguitch Valley, springs also occur at the contact between consolidated rock and valley-fill deposits or where the hydraulic conductivity of the valley-fill deposits decreases abruptly. Information about selected springs in the basin is listed in table 5 at the back of this report.

The total quantity of water discharging from springs and seeps in Panguitch Valley is estimated to be 4,600 acre-ft/yr, on the basis of discharge measurements listed by Carpenter and others (1964). Most of the springs are along the base of hills composed of older Quaternary valley-fill deposits and south of Panguitch on the east side of the valley. These springs and seeps account for 1,900 acre-ft/yr of ground-water discharge and are perched above the valley-fill aquifer composed of younger Quaternary valley-fill deposits (see "Movement" section of "Ground-water hydrology of the valley-fill aquifer in Panguitch Valley" section of this report).

About 2,200 acre-ft/yr discharges from the valley-fill aquifer material into sloughs at the northernmost end of the valley. The consolidated rock that separates Circle Valley from Panguitch Valley forces the ground water moving downgradient through the valley-fill aquifer of Panguitch Valley to move toward the land surface and eventually discharge at the sloughs.

Three springs discharge about 500 acre-ft/yr from older Quaternary valley-fill deposits at the contact with the underlying consolidated rock. These springs are west of the Sevier River, between the Sandy Creek and Bear Creek drainages, and may be fed partly by water from more permeable consolidated rocks in the area.

Wells

Ground-water withdrawal from wells completed in the valley-fill aquifer of Panguitch Valley is a minor discharge component of the ground-water budget. Withdrawals have increased since 1962 because more wells have been drilled in the area. According to drillers' logs submitted to the Utah State Engineer's Office, 120 wells were drilled in Panguitch Valley from 1963 to 1989. Information on selected wells in the basin is listed in table 6 at the back of this report.

Ground-water withdrawal from wells in Panguitch Valley is estimated to be about 100 acre-ft/yr. Public supply wells withdraw about 45 acre-ft/yr on the basis of water-use data supplied by public water suppliers, and domestic and stock wells withdraw the remainder on the basis of the number of wells in the valley.

Subsurface Outflow

Ground-water outflow from Panguitch Valley through the subsurface is probably small because the valley-fill deposits at the north end of the valley are thin and narrow. The consolidated rock along the sides and bottom of the valley act as a barrier and cause the ground water to discharge to sloughs or to the Sevier River. A very small quantity of ground water may move into Circleville Canyon through valley-fill deposits along the bed of the Sevier River.

Water-Level Fluctuations

Measured water levels in most wells in Panguitch Valley fluctuate in response to changes in precipitation on the surrounding plateaus and the resulting streamflow in the Sevier River, its tributaries, and diversions. Water levels in selected wells completed in valley-fill deposits in Panguitch Valley were measured to determine seasonal and long-term variations. Except for a single well at the northern end of the valley, long-term water-level fluctuations generally follow climatic trends for the area. Water levels were measured in October 1961 and October 1989 in 10 wells. Water levels in all 10 wells were higher in 1989 than in 1961, probably because of the greater-than-average precipitation that occurred during the 1980's (6 out of the 9 years at the Panguitch weather station were greater than average (fig. 3)). Water-level data from selected wells in the upper Sevier River basin are listed in table 7 at the back of this report.

Seasonal Fluctuations

The sources of recharge and rates of inflow to the valley-fill aquifer vary throughout the year because of the seasonal nature of streamflow and irrigation in the valley. Water levels in wells in areas where the main component of recharge is seepage from streams, such as well (C-36-5)28bdc-1 near the Sevier River (fig. 7), generally rise soon after spring runoff and decline during the winter months. In areas where diversion losses and unconsumed irrigation water are the main components of recharge, the highest water levels occur in late summer and fall. Water levels, measured in observation wells installed at the sprinkler- and flood-irrigated soil-moisture test plots ((C-34-5)10bab-1 and (C-34-5)16dca-1), for example, rose during the irrigation season and declined during the non-irrigation season (fig. 6a and 6b). Seasonal water-level fluctuations measured from 1962 to 1963 and from 1988 to 1989 for four wells in Panguitch Valley near ditches or the Sevier River are shown in figure 7.

Water levels were measured in April and again in October 1989 in 36 wells completed in valley-fill deposits. Changes in water level ranged from a rise of 10.49 ft in well (C-34-5)17dbb-1 to a decline of 1.55 ft in well (C-37-5)19cad-1 (fig. 8). Seasonal water-level rises can be attributed to increased recharge from several surface-water sources. Water-level declines were probably caused by a local decrease in the quantity of recharge; primarily losses from surface-water diversions and unconsumed irrigation water.

Water levels in 25 wells were measured in July-November 1988 and in October 1989 to monitor annual water-level fluctuations (table 7). In

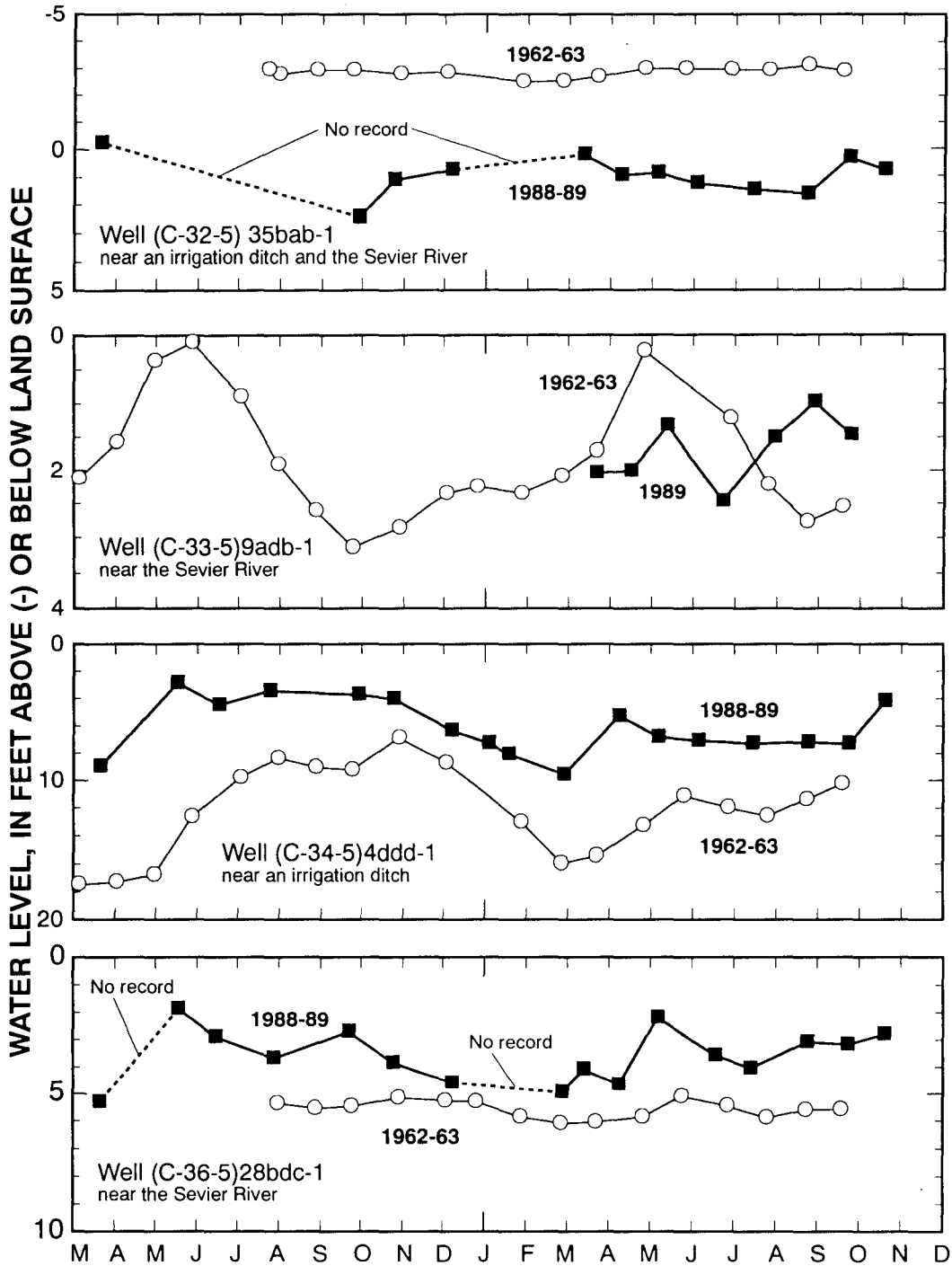


Figure 7. Seasonal water-level fluctuations from 1962 to 1963 and from 1988 to 1989 in four wells in Panguitch Valley.

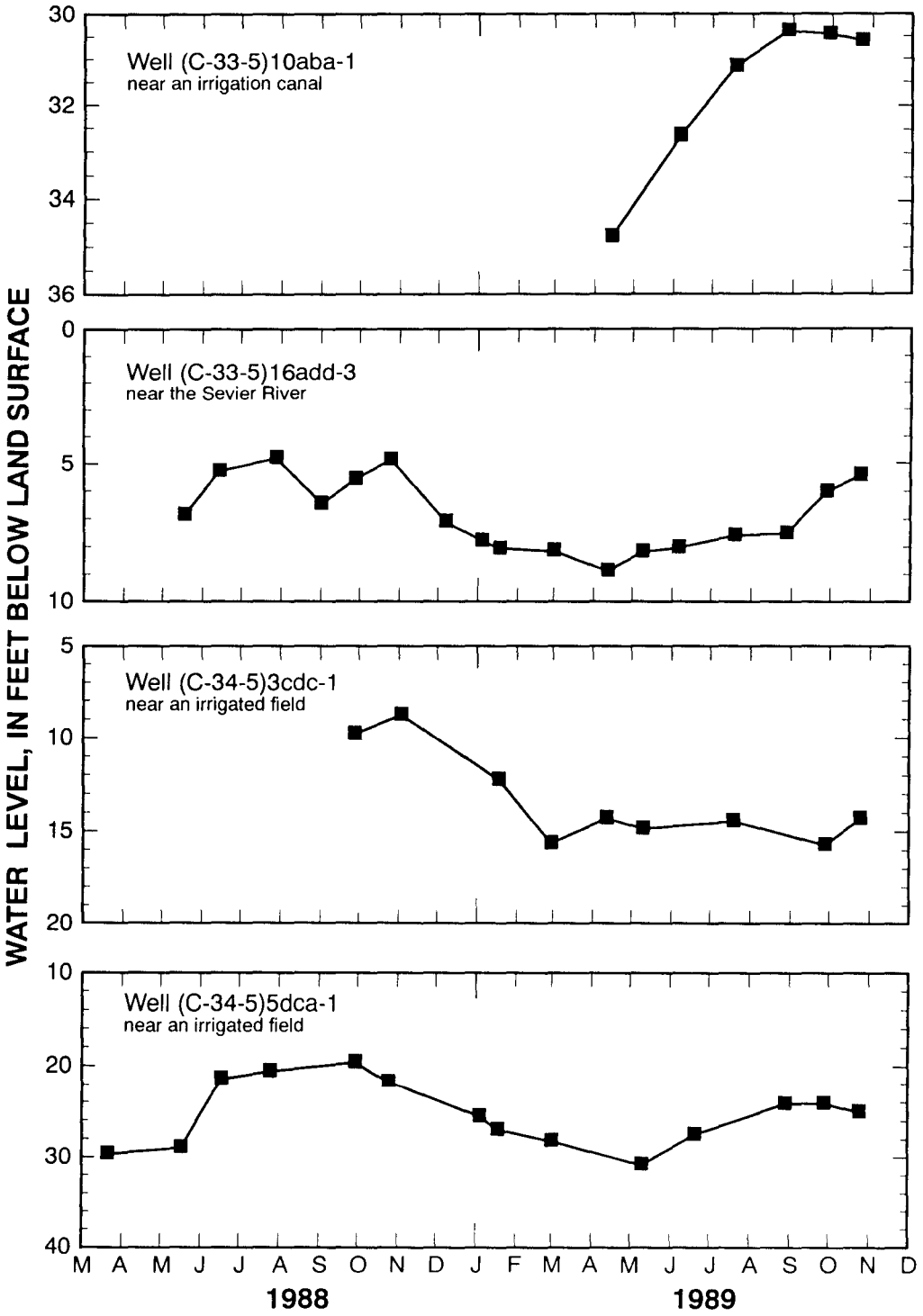


Figure 8. Seasonal water-level fluctuations from 1988 to 1989 in six wells in Panguitch Valley.

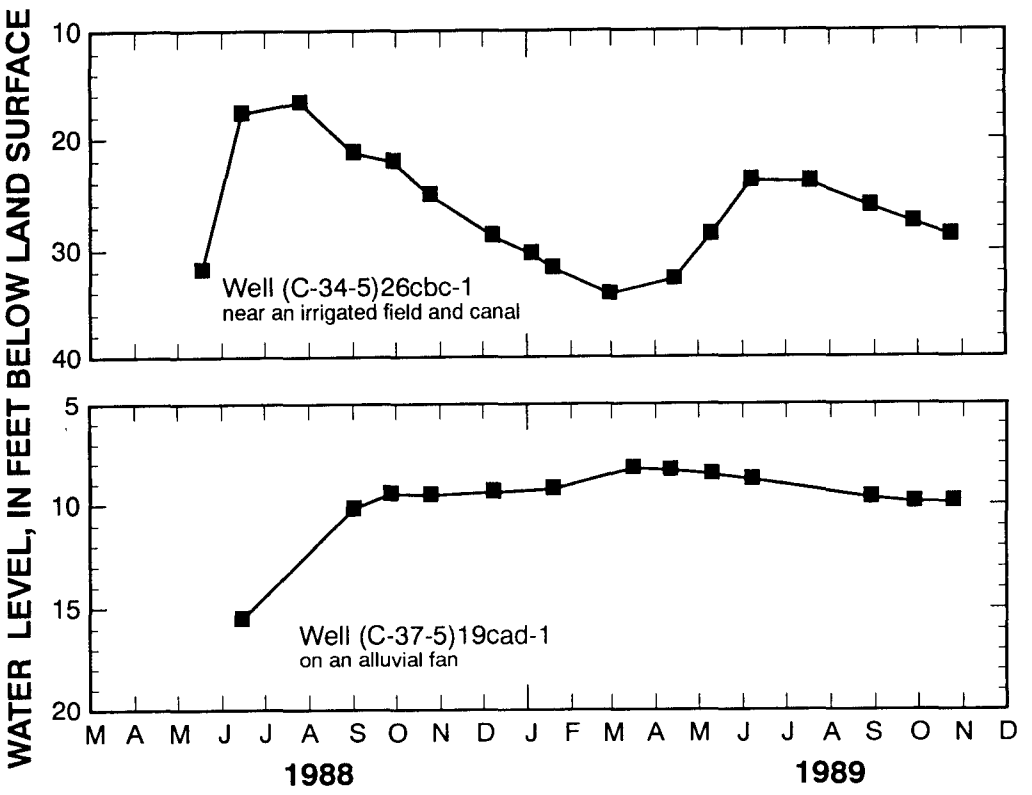


Figure 8. Seasonal water-level fluctuations from 1988 to 1989 in six wells in Panguitch Valley–Continued.

general, water levels declined throughout Panguitch Valley except at well (C-32-5)35bab-1 (fig. 7) at the northern end of the valley near an irrigation ditch and the Sevier River, and at well (C-36-5)28bdc-1 (fig. 7) at the southern end near a flood-irrigated pasture near the Sevier River. The water-level rises measured at these two wells may have been the result of continued diversion of surface water for irrigation late into the fall because of a shortage of water during the previous summer.

Long-Term Fluctuations

Water levels measured in wells during March and April in Panguitch Valley usually represent the lowest water levels of the year. Cumulative departure of the annual peak snow-water content from the 1951-89 average annual peak snow-water content at the Harris Flat snow course in the southern Markagunt Plateau is shown in figure 9. Fluctuations in March or April water levels in some wells measured from 1951 through 1989 tend to correspond in time with changes in the cumulative departure of the annual peak snow-water content. For example, a rise in water level measured in March or April as compared with the previous March or April water level measured in well (C-32-5)26aca-1 (at the northern end of Panguitch Valley) and an increase in the cumulative departure of the annual peak snow-water content was noted in 1954, 1958, 1962, 1969, and 1973 (fig. 9).

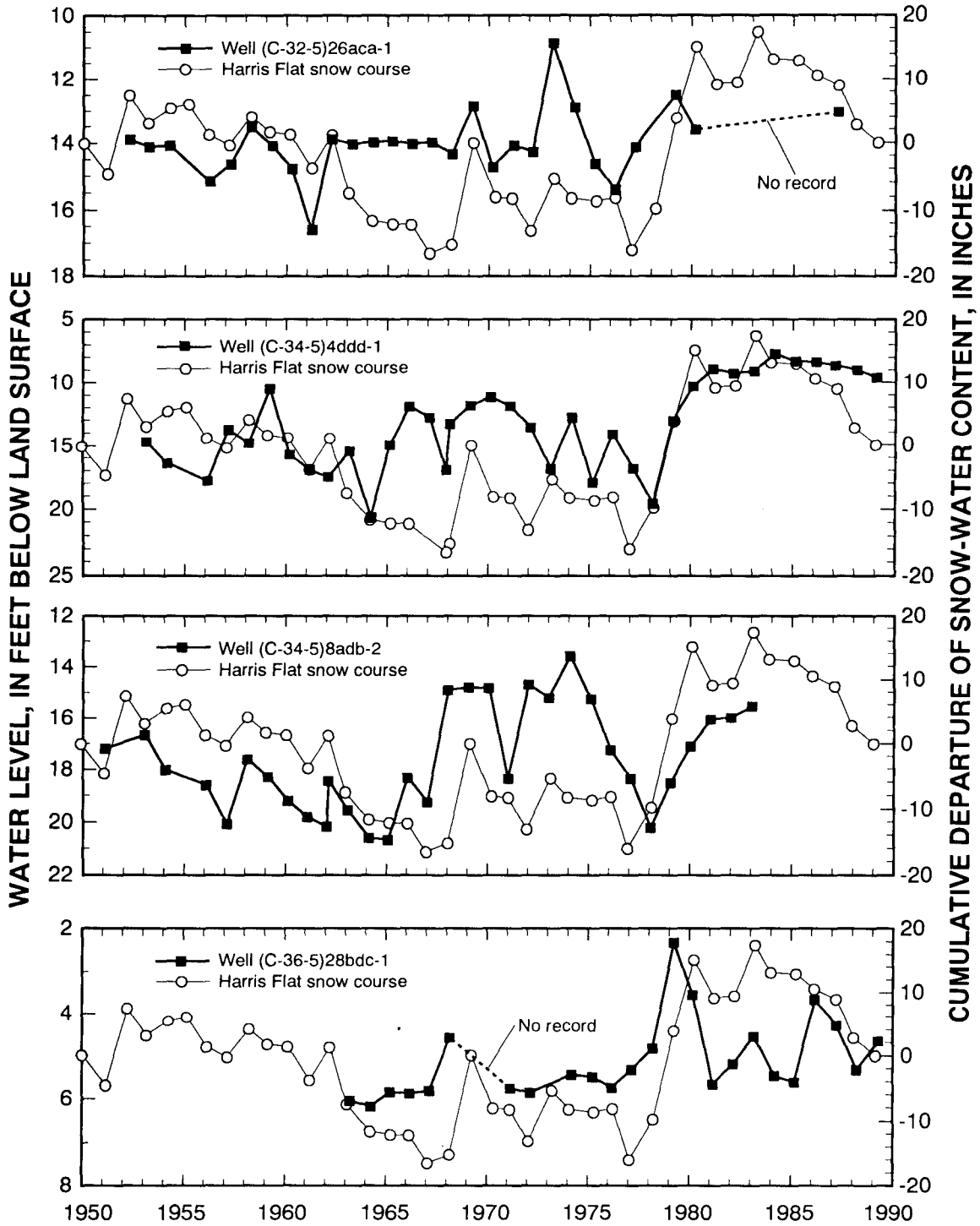


Figure 9. March or April water levels measured from 1951 to 1989 in four wells in Panguitch Valley and cumulative departure of the annual peak snow-water content from the 1951-89 average at the Harris Flat snow course.

A decline in water level measured in March or April as compared with the previous March or April water level measured in the well and a corresponding decrease in annual peak snow-water content was noted in 1953, 1959 through 1961, 1963, 1970, 1974, and 1975. A relatively large rise in water level in well (C-32-5)26aca-1 from 1976 to 1977 did not correspond with a decrease in the annual peak snow-water content for the same period. A water-level decline in the well from 1979 to 1980 did not correspond with an increase in the annual peak snow-water content for the same period. Water-levels in well (C-32-5)26aca-1 were not measured in 1955, 1978, or during 1981-86.

The same type of correlation between changes in March or April water levels and changes in annual peak snow-water content is evident in well (C-36-5)28bdc-1 at the southern end of the valley. Water-level rises and increases in peak snow-water content were determined for 1968, 1978, 1979, and 1983. Water-level declines and decreases in peak snow-water content were determined for 1964, 1972 (a leap year—water level was measured on February 29), 1981, 1984, 1987, and 1988 (fig. 9). March or April water levels were not measured in 1969 and 1973. Continued periods of less-than-average or near-average peak snow-water content, such as from 1963 to 1967, seem to result in minor changes in water levels measured in March and April at the above wells. Water levels in both wells may indicate confined conditions in the aquifer.

Well (C-34-5)4ddd-1 is 21 ft deep and next to an irrigation ditch. There is about a 1-year delay in response between water levels measured in the well to changes in the cumulative departure of the peak annual snow-water content (fig. 9). This correlation did not occur in 1965, 1966, 1976, and 1977, periods of less-than-average peak annual snow-water content. An adjustment in stream diversions to canals in response to these resulting low-flow years could be the cause for the exceptions. This relation indicates that water in well (C-34-5)4ddd-1 is under water-table conditions.

A delay of about 1 year is also evident between changes in annual March or April water levels measured in well (C-34-5)8adb-2 and changes in cumulative departure of peak annual snow-water content (fig. 9). A response in water levels opposite from the change in the cumulative departure of peak snow-water content occurred in 1958, 1959, and 1966 through 1968. Again, these exceptions to the correlation are probably caused by changes in surface-water diversions.

Seasonal and monthly fluctuations can mask long-term variations in water levels measured in wells in the valley (fig. 10). Water levels at the end of the 1951-89 period are slightly higher than those measured during other parts of the period because of greater-than-average precipitation in 1980, 1981, 1983, and 1984.

The ground-water system in Panguitch Valley is assumed to be stable (conditions do not change radically from year to year). The quantity of recharge to the valley-fill aquifer in Panguitch Valley is assumed to equal the quantity of discharge from the aquifer. An indication of a change in water levels in the valley would be a change in the quantity of ground water discharging from the valley-fill aquifer.

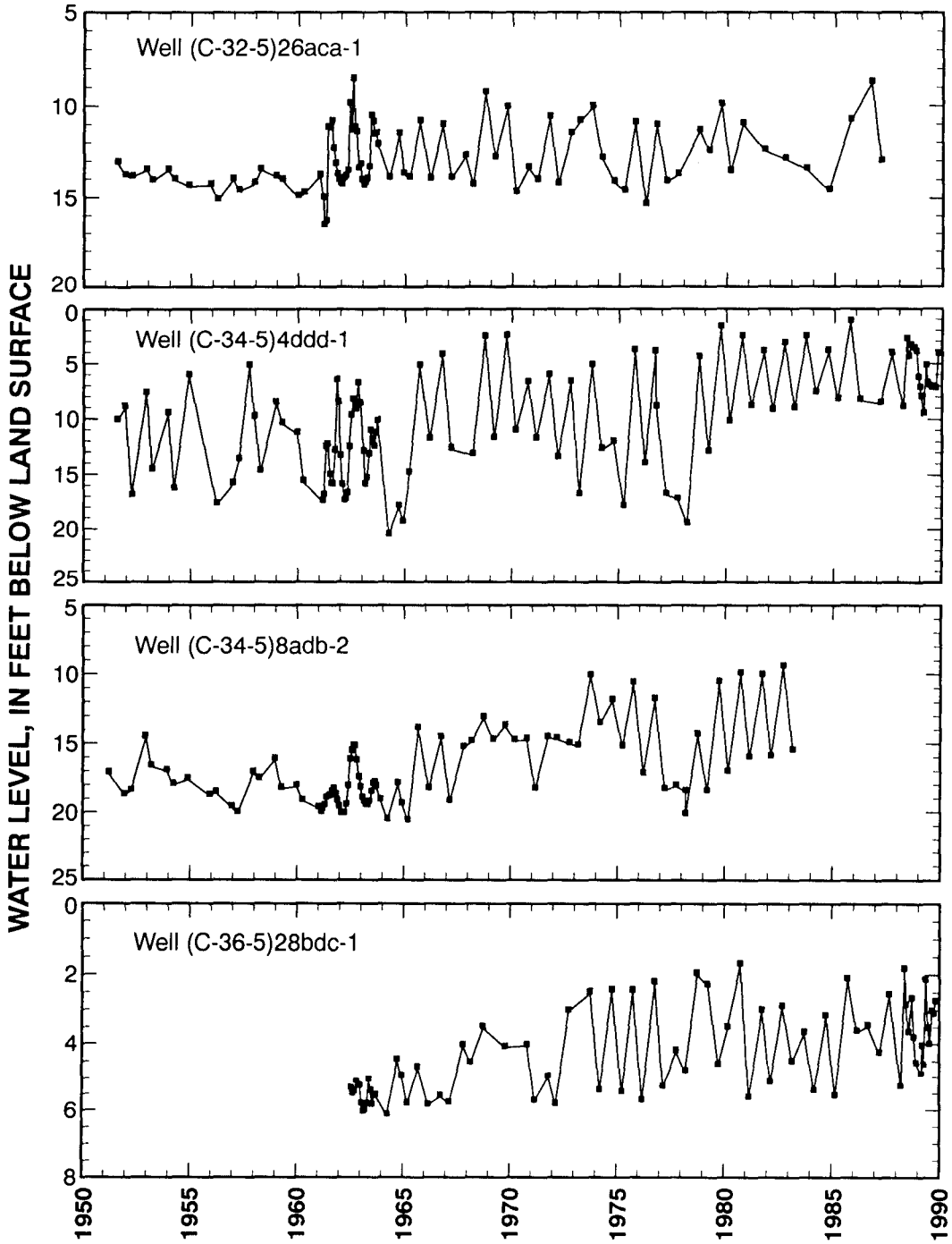


Figure 10. Long-term water-level fluctuations from 1951 to 1989 in four wells in Panguitch Valley.

The average monthly mean flow values of the Sevier River in Circleville Canyon (gaging station 10180000) from December through March from 1950 to 1989 were added together (fig. 11). Discharge during these winter months is only slightly influenced by surface-water inflows or outflows and best represents base flow derived from ground water. A straight line drawn from 1950 to 1980 generally corresponds to the cumulative average monthly mean flow for December through March. In 1980, the relation between time and average winter streamflow changed, indicating an increase in base flow derived from ground water (fig. 11). This change in slope corresponds to the beginning of a period of greater-than-average peak snow-water content (fig. 9).

Hydraulic Properties

Hydraulic properties of the valley-fill deposits in Panguitch Valley were estimated using (1) specific-capacity tests obtained from 71 drillers' logs, (2) one aquifer test, (3) ranges of values compiled for similar unconsolidated material-filled basins, and (4) descriptions of materials reported in drillers' logs. The many modes of deposition in the valley result in much layering and interbedding of the valley-fill deposits. The layers were not readily correlated with drillers' logs of wells. The gradational nature of the valley-fill deposits creates a broad range in both vertical and horizontal hydraulic conductivity. Values of hydraulic conductivity estimated from specific-capacity tests usually represent relatively permeable layers in the deposits.

In the northern part of the valley, hydraulic-conductivity values ranged from about 2 to 540 ft/d, with an average of about 120 ft/d. In the southern part, hydraulic-conductivity values ranged from about 0.2 to 150 ft/d, with an average of about 20 ft/d. A transmissivity of about 650 ft^2/d was calculated from an aquifer test at well (C-36-5)29dcd-1. The smaller values of hydraulic conductivity estimated for the southern part of the valley may be the result of the semiconsolidated Sevier River Formation occurring at shallower depths. A synthesis of hydraulic-conductivity values compiled for coarse-grained basin-fill materials in the Basin and Range province ranged from about 0.03 to 3,000 ft/d, with a mean value of about 30 ft/d (Bedinger and others, 1987, p. 39). Data were not available to determine vertical hydraulic-conductivity values of the valley-fill deposits in Panguitch Valley.

Specific yield of the valley-fill deposits in Panguitch Valley was estimated to range from about 0.03 for clay to 0.25 for gravel, with an average value of about 0.12, based on descriptions of materials reported in drillers' logs. The storage coefficient of the valley-fill deposits under artesian conditions was estimated by Carpenter and others (1967, p. 44) to range from 0.0001 to 0.001.

VALLEY-FILL AQUIFERS IN CIRCLE, GRASS, AND EAST FORK VALLEYS

The occurrence of ground water in the valley-fill deposits of Circle, Grass, and East Fork Valleys is similar to that in Panguitch Valley. The saturated valley-fill deposits are considered to be the main aquifers in the valleys. Each valley is bound on at least three sides by less permeable consolidated rock. Ground water in alluvial-fan and flood-plain deposits is mostly under water-table conditions. Fine-grained lacustrine deposits form a

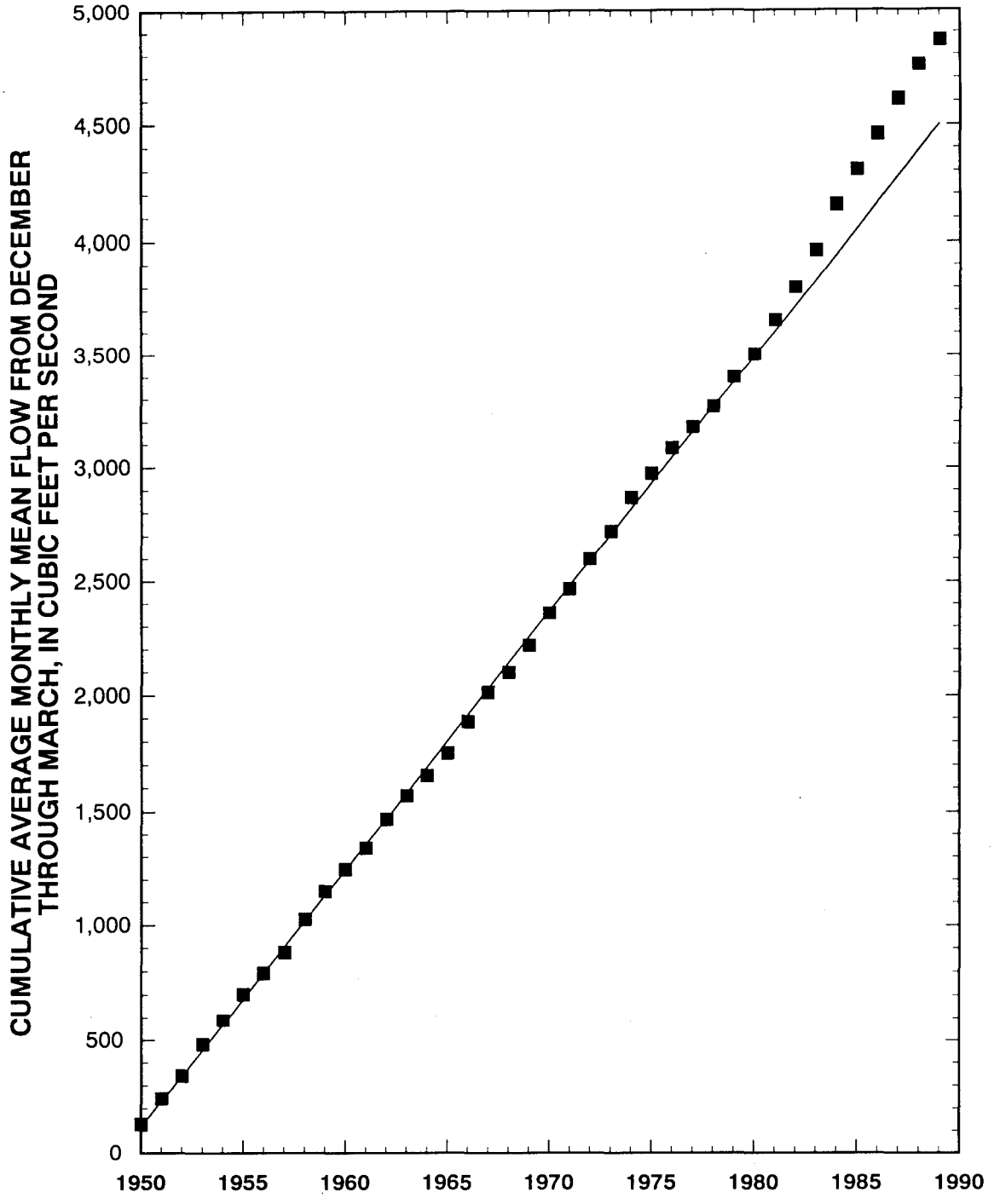


Figure 11. Cumulative average monthly mean flow from December through March at Sevier River in Circleville Canyon (streamflow-gaging station 10180000), 1950-89.

confining layer in the northern part of Grass Valley. Confined conditions also exist in the northern, or downgradient, parts of Circle, Johns, and Antimony Valleys because of an abundance of fine-grained unconsolidated material deposited in the lowest parts of the valleys. Flowing wells are present in these areas.

Recharge

Recharge to the valley-fill aquifers in Circle, Grass, and East Fork Valleys is mostly from infiltrating surface water and precipitation. Inflow from other valleys and from consolidated rock is another possible source of recharge. Few data were available to quantify seepage from the consolidated-rock contact, but it likely occurs to some degree in each valley.

Seepage from streams to the valley-fill aquifers depends on rate of flow, hydraulic conductivity of the valley-fill deposits, and elevation of the water table in relation to the stream. Average annual streamflow was determined from gaging-station records, or, where discharge data were not available, from the ratio of drainage area to discharge measured at gaged streams in the area. This ratio was multiplied by the drainage area of the ungaged stream to calculate an estimated streamflow.

The estimated average annual streamflow calculated for tributary drainages was about 20,300 acre-ft/yr in Circle Valley, 39,500 acre-ft/yr in Grass Valley, and 80,600 acre-ft/yr in East Fork Valley. Gaging-station records of streamflow measured at the upper and lower ends of the Sevier River in Circle Valley and of Otter Creek in Grass Valley indicate a gain in flow. This gain probably results from recharge to the ground-water reservoir from tributaries that in turn discharge to the controlling stream. On the basis of gaging-station records for streams in the area, seepage was estimated to range from 20 to 50 percent of the average annual streamflow.

The quantity of water diverted into canals from streams was calculated by averaging available data collected by the Sevier River Commissioner from 1960 to 1988. Estimates by Carpenter and others (1967) were used in areas where data were not available. Diversions to canals were about 35,600 acre-ft/yr in Circle Valley, 16,000 acre-ft/yr in Grass Valley, and 12,200 acre-ft/yr in East Fork Valley. Water diverted from Mitchell Slough for use in the Junction area north of Circle Valley was not included in the total diversion for Circle Valley. Losses from the canals to the valley-fill aquifers were estimated to be about 10 percent of these diversions.

Recharge from infiltration of unconsumed irrigation water occurs in areas irrigated with more water than can be consumed by the crops. The method used to estimate recharge from unconsumed irrigation water in Circle, Grass, and East Fork Valleys is the same as the method described for Panguitch Valley.

The total irrigated acreage mapped in Circle Valley in 1981 (Jaynes and others, 1981) was 6,650 acres. Assuming 10 percent in transmission losses from canals and ditches, an average 32,040 acre-ft/yr of water was applied to the fields while 20 percent of this quantity moved off of the fields as free-water evaporation or tail-water runoff. Because most of the irrigated fields in this valley consist of alfalfa and pasture, a consumptive-use rate from 25 to 30 in/yr for alfalfa and pasture (13,850 to 16,620 acre-ft/yr) was used

(U.S. Department of Agriculture, 1969b, Appendix IV, table 36). The remaining applied water not consumed by the crops was estimated to be 9,010 to 11,780 acre-ft/yr. This quantity was assumed to recharge the valley-fill aquifer in Circle Valley.

Grass Valley contained 4,520 acres of irrigated fields in 1981. Assuming that 11,520 acre-ft/yr of water is available to the fields after transmission losses, evaporation, and tail-water runoff, and a consumptive-use rate from 23 to 27 in/yr (8,660 to 10,170 acre-ft/yr) for alfalfa and pasture (U.S. Department of Agriculture, 1969b, Appendix IV, tables 31-32) is subtracted, 1,350 to 2,860 acre-ft/yr was estimated to recharge the valley-fill aquifer in Grass Valley.

East Fork Valley contained 3,130 irrigated acres in 1981, and this acreage received about 8,760 acre-ft/yr of water after losses. The consumptive-use rate for alfalfa in this area is about 27 in/yr (7,040 acre-ft/yr) (U.S. Department of Agriculture, 1969b, Appendix IV, tables 33-34). The remaining unconsumed irrigation water, about 1,720 acre-ft/yr, is available to recharge the valley-fill aquifer in East Fork Valley.

On the basis of similar rates determined in other areas in Utah, infiltration of precipitation is estimated to be about 5 percent of the average annual precipitation on the valley-fill deposits. On the basis of average annual precipitation from 1931 through 1960 (U.S. Weather Bureau, 1963), recharge to the valley-fill aquifers was estimated to be about 1,000 acre-ft/yr in Circle Valley, 2,700 acre-ft/yr in Grass Valley, and 3,500 acre-ft/yr in East Fork Valley.

The quantity of subsurface inflow from surrounding consolidated rocks into the valley-fill aquifers is not known. A gain-loss study in August 1988 indicated that a small increase in base flow occurs on the East Fork Sevier River in Black Canyon (see "Ground-water hydrology of consolidated rocks" section of this report). In Grass Valley, drillers' logs indicate that three flowing wells in the Koosharem area are completed in underlying volcanic rock. These wells reportedly discharge from 50 to 1,250 gal/min (81 to 2,017 acre-ft/yr).

Movement

Ground water in the upper Sevier River basin generally moves from higher-elevation recharge areas near the mountain fronts and at the heads of the major valleys, downgradient toward lower-elevation discharge areas. Discharge areas are primarily along the principal stream and at the lowest part of the valley where the principal stream exits. Consolidated rock that crops out and is found at shallow depths below the valley-fill deposits at the downstream ends of Circle, Johns, and Antimony Valleys causes ground water to move vertically upward toward land surface in these areas. Movement of ground water between adjacent valleys is probably minor because of relatively impermeable consolidated rock that separates the valleys. Carpenter and others (1967, p. 55) reported that about 1,000 acre-ft/yr of subsurface flow from Grass Valley recharges the valley-fill aquifer in Antimony Valley. Contours showing the potentiometric surface of ground water in parts of Circle, Grass, and East Fork Valleys in October 1989 are shown on plate 1. The gradient in Circle Valley is much less steep than that of the other valleys because of the rounder shape and gentler topography of the valley.

Discharge

The main components of discharge from the valley-fill aquifers are discharge to streams, evapotranspiration, springs, and wells. Increases in base flow along the principal stream in a valley occur where the water table is at a higher elevation than the streambed. For example, a large quantity of ground water is discharged to the Sevier River in Circle Valley. The difference in the winter (December through March) average mean monthly flow in the Sevier River measured at gaging station 10180000 in Circleville Canyon and at downstream gaging station 10183500 near Kingston (pl. 1) is about 24 ft^3/s (17,380 acre-ft/yr), based on 40 years of record (1950 to 1989). Because inflows from tributary streams to the Sevier River and diversions to canals are typically minimal during the winter, most of this quantity is attributed to ground-water inflow. Ground-water inflow to the Sevier River probably occurs throughout the year, although its presence is masked during all but the winter months.

Monthly streamflow data are available from 1972 to 1980 at gaging station 10187300 on Otter Creek (pl. 1) at the upstream end of Grass Valley and at gaging station 10187500 on Otter Creek (pl. 1) above Otter Creek Reservoir. Peak flow from spring runoff usually occurs in May at gaging station 10187300, 2 to 3 months later than at the downstream gage, because of differences in the elevations of the drainage basin. About 6 ft^3/s more flow was measured during December and January at the downstream gage than at the upstream gage. Tributary streamflow to Otter Creek between these two gages has not been measured but is thought to be less than the gain measured.

Ground-water discharge by evapotranspiration occurs where the water table is near enough to the land surface to support phreatophyte growth. In 1981, Circle Valley contained about 3,760 acres of phreatophytes, Grass Valley contained about 6,740 acres, and East Fork Valley contained about 2,140 acres. Average evapotranspiration rates were calculated from potential consumptive-use rates listed by the U.S. Department of Agriculture (1969b, Appendix IV, tables 31-36) for phreatophytes in the area. Discharge from the valley-fill aquifers by evapotranspiration was about 7,890 acre-ft/yr in Circle Valley, about 14,690 acre-ft/yr in Grass Valley, and about 3,360 acre-ft/yr in East Fork Valley.

Discharge from springs in the valley-fill aquifers was estimated by Carpenter and others (1967, p. 51) to be about 6,200 acre-ft/yr in Circle Valley, 440 acre-ft/yr in Grass Valley, and 5,940 acre-ft/yr in East Fork Valley. Ground water discharges at seeps and sloughs in the northern parts of Circle Valley and Grass Valley. Discharge at Mitchell Slough, in Circle Valley, was measured at 8.2 ft^3/s in August 1960 (Carpenter and others, 1964, p. 9). Information on springs in the basin inventoried during this study is listed in table 5 at the back of this report.

The number of wells drilled in the study area from 1963 to 1989 was compiled using drillers' logs submitted to the Utah State Engineer's Office. Thirteen wells were drilled in Circle Valley; 31 in Grass Valley with 13 that flow; and 40 in East Fork Valley (Utah State Engineer, written commun., 1989). In East Fork Valley, 7 wells were drilled in the Antimony area, 9 in Johns Valley, and 24 in Emery Valley. Wells drilled prior to 1963 are listed by valley in Carpenter and others (1967, p. 50).

Ground-water withdrawals from wells is a small part of the discharge from the valley-fill aquifers in Circle, Grass, and East Fork Valleys. Ground-water withdrawals from wells were estimated on the basis of discharge measurements in the field and discharge measurements reported on drillers' logs. The estimated ground-water withdrawal from wells in Circle Valley was 223 acre-ft/yr, 200 acre-feet of which came from two irrigation wells. About 1,700 acre-ft/yr was estimated to be discharged from wells in Grass Valley, mostly from flowing wells for irrigation and stock use. Flowing wells in the Koosharem area of Grass Valley account for about half of the total withdrawals from wells in the upper Sevier River basin. An estimated 4 acre-ft/yr was pumped for public supply in Grass Valley. Withdrawals in East Fork Valley are estimated to be 124 acre-ft/yr; 110 acre-ft/yr for public supply and 14 acre-ft/yr for domestic and stock use. Most of the water pumped in East Fork Valley is used for public supply in Emery Valley.

Water-Level Fluctuations

Fluctuations in water levels measured in selected wells in Circle, Grass, and East Fork Valleys, which include Antimony, Johns, and Emery Valleys, generally correspond to changes in the quantity of precipitation falling on the surrounding high plateaus. Water-level data from wells in the upper Sevier River basin are presented in table 7 at the back of this report.

Water levels measured monthly during 1988 and 1989 in selected observation wells show some seasonal fluctuation and an overall decline (fig. 12). The decline in water level measured in wells in all four valleys can be attributed to less-than-average precipitation during 1988 and 1989 (fig. 3). At well (C-30-4)35dab-1 in Circle Valley, water levels rose in February 1989 in response to the impoundment of water behind a constriction of ice on the nearby Sevier River. The river overflowed its banks and flooded the adjacent area, including the field where the observation well is located. Water levels in the well peaked sometime in late February or early March and returned to the regional trend by April 1989.

Water-level declines were measured in most wells between April and October 1989. Water levels usually rise in irrigated areas such as Circle Valley during this period when surface water is diverted and applied to crops. Less-than-average precipitation in 1988 and 1989, however, decreased surface-water diversions and tributary inflow, and caused water-level declines in Circle, Grass, and East Fork Valleys. The largest declines in water level from 1988 to 1989, up to 13 ft, were measured in East Fork Valley. Water-level rises are normally measured in the spring and probably correspond to tributary inflow from snowmelt runoff.

Long-term changes in water levels were measured in eight wells, and are shown in figure 13. Water levels were measured annually, usually in March and September. Seasonal water-level fluctuations can be seen in most of the well hydrographs, but long-term trends associated with precipitation are still evident (fig. 13). Water levels measured in wells (C-30-4)35dab-1 in Circle Valley, (C-27-1)27abc-2 in Grass Valley, (C-30-2)34bcc-1 in Antimony Valley, (C-33-2)22aab-1 and (C-34-2)30ccc-1 in Johns Valley, and (C-36-3)6dba-1 in Emery Valley responded to greater-than-average or near-average precipitation from 1978 to 1987 (fig. 3). The water level in well (C-26-1)25acc-1 in Grass Valley declined 6.4 ft from 1951 to 1988. Annual precipitation in the area

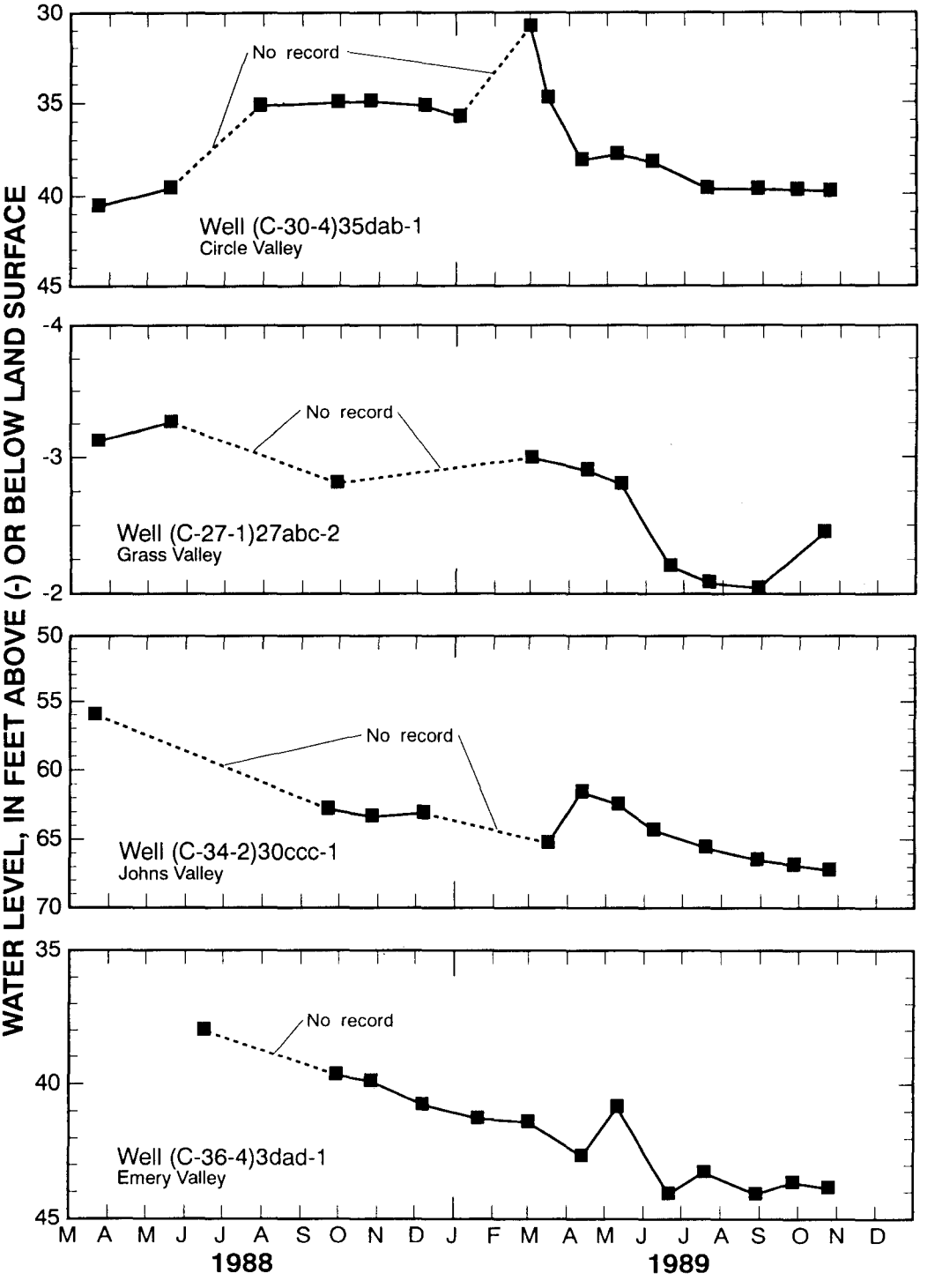


Figure 12. Seasonal water-level fluctuations from 1988 to 1989 in four wells in Circle, Grass, Johns, and Emery Valleys.

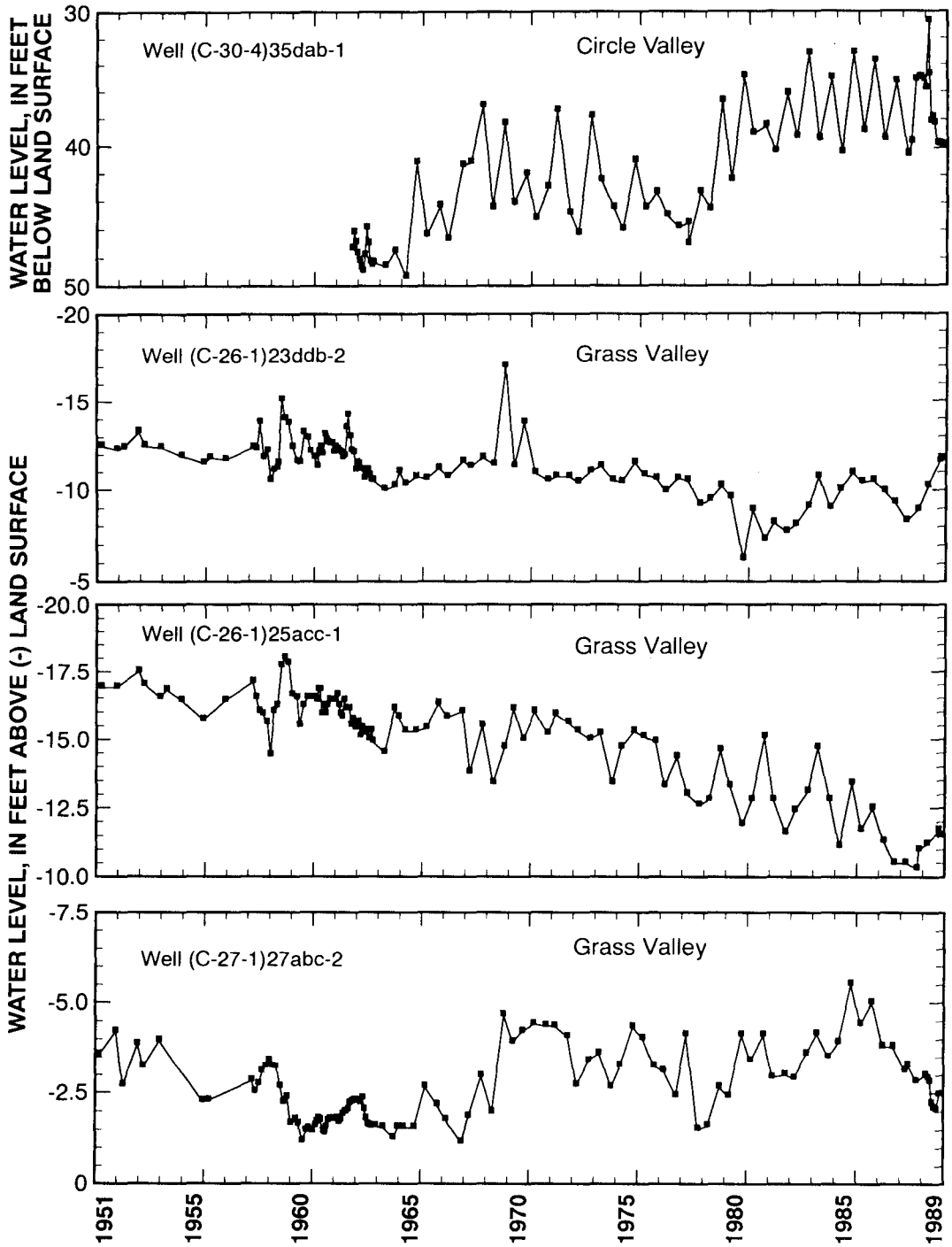


Figure 13. Long-term water-level fluctuations from 1951 to 1989 in eight wells in Circle, Grass, Antimony, Johns, and Emery Valleys.

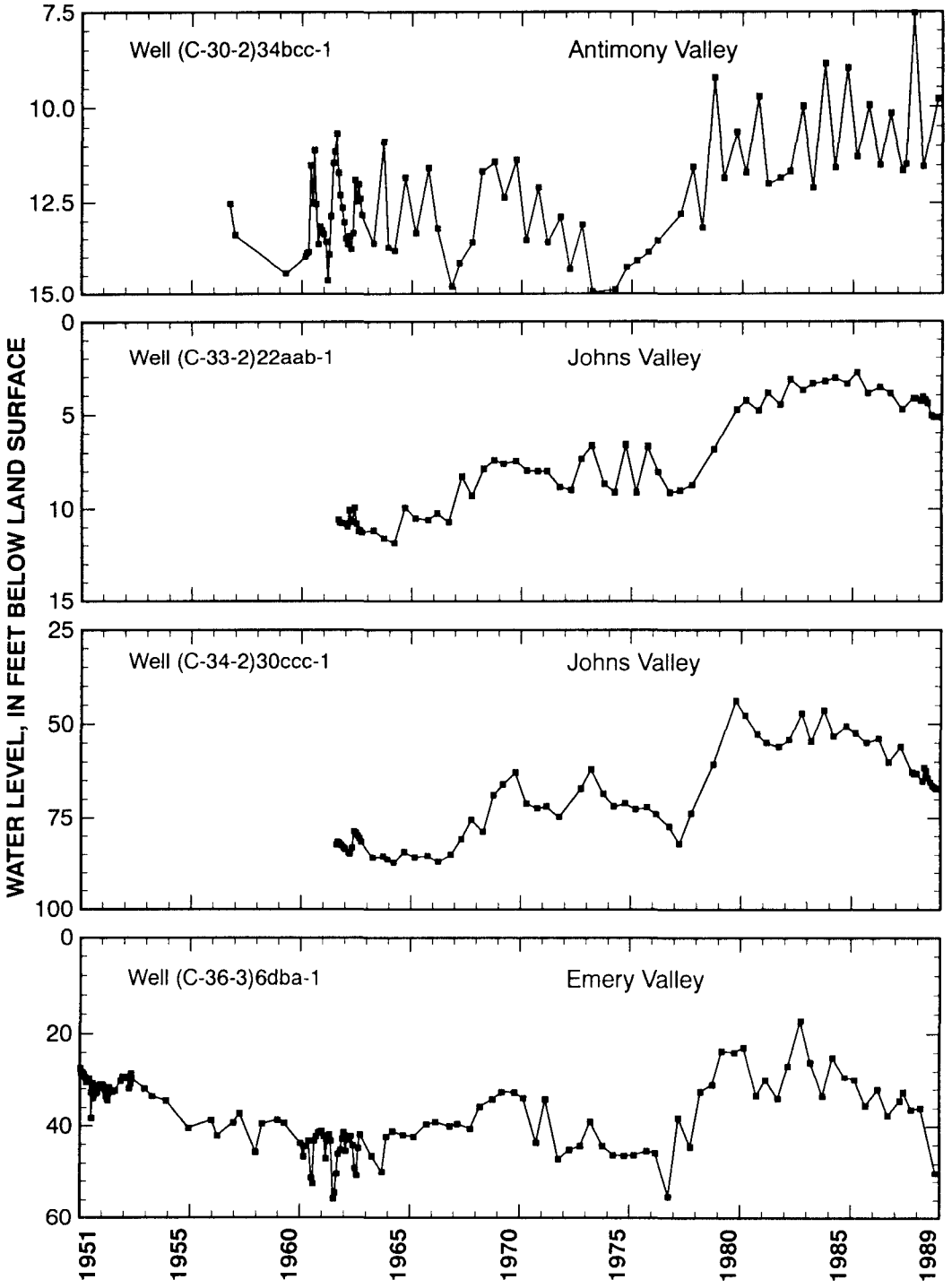


Figure 13. Long-term water-level fluctuations from 1951 to 1989 in eight wells in Circle, Grass, Antimony, Johns, and Emery Valleys--Continued.

was less than or near average from 1951 to 1977 and greater than or near average from 1978 to 1987 (fig. 3). The continued decline in water levels measured during the period of greater-than-average precipitation may be the result of ground-water discharge from flowing wells in the area.

Hydraulic Properties

Hydraulic properties of the valley-fill aquifers in Circle, Grass, and East Fork Valleys were estimated from aquifer tests and specific-capacity data and from lithologic descriptions from drillers' logs. Transmissivity of the valley-fill deposits in Circle Valley ranged from 80 to 15,000 ft^2/d on the basis of one aquifer test and 11 specific-capacity tests. Transmissivity values were calculated from recovery tests conducted on five flowing wells in the northern part of Grass Valley. Values ranged from 14 to 190 ft^2/d with an average value of 130 ft^2/d. The straight-line solutions of Cooper and Jacob (1946) were used to calculate transmissivity values from recovery tests.

Hydraulic-conductivity values, estimated from specific-capacity tests and perforated intervals in wells completed in the valley-fill deposits in East Fork Valley ranged from 0.2 ft/d for a well located on an alluvial fan in Johns Valley to 1,500 ft/d for a well completed in sand and gravel in Emery Valley. An aquifer test at a well in Emery Valley yielded a transmissivity of 6 ft^2/d, and most values of hydraulic conductivity estimated from specific-capacity data and perforated intervals for wells in the area ranged from 6 to 20 ft/d.

Specific-yield values for the valley-fill aquifers in Circle, Grass, and East Fork Valleys were estimated on the basis of descriptions of materials reported in drillers' logs and ranged from about 0.03 for clay to 0.25 for gravel. The average specific-yield values were 0.16 for Circle Valley, 0.08 for the northern part of Grass Valley near Koosharem, and 0.13 for the southern part of Grass Valley and East Fork Valley. The storage coefficient of the valley-fill aquifers under artesian conditions was estimated by Carpenter and others (1967, p. 44) to range from 0.0001 to 0.001.

The ground-water budgets for Panguitch, Circle, Grass, and East Fork Valleys are rough estimates calculated from limited data; however, they present the major components of recharge and discharge to and from the aquifers and emphasize the importance of relations between surface water and ground water in each valley. The unknown contribution of recharge from the consolidated-rock boundary is possibly a major budget component and might account for some of the difference between inflow to and outflow from the valley-fill aquifers.

CHEMICAL QUALITY OF WATER

The chemical quality of water in the upper Sevier River basin was determined from samples collected from 19 wells, 12 springs and seeps, and 12 surface-water sites in 1988 and 1989. Five of the analyses are from springs discharging from consolidated rock. Chemical-quality data available for ground-water and surface-water sites inventoried during this study are shown in tables 8 and 9, respectively, at the back of this report.

The type of rock that ground water comes in contact with while moving from recharge to discharge areas is the major factor controlling the chemical composition of the water. Ground water in the study area has mainly been in contact with limestones of the Claron Formation in the Paunsaugunt and southern Markagunt Plateaus; Tertiary volcanic rocks of the Awapa, Aquarius, Sevier, and northern Markagunt Plateaus, and the southern Tushar Mountains; or unconsolidated material eroded from these rocks.

The dominant ions in ground water discharged downgradient from the Claron Formation are calcium, magnesium, and bicarbonate. Magnesium is present in large concentrations because the limestone of the Claron Formation contains dolomite.

The chemical composition of the Sevier River between the southern part of Panguitch Valley and the town of Panguitch is similar to the chemical composition of ground water in the same area. Sodium concentrations in the Sevier River increase north of Panguitch because of the presence of volcanic rocks in the surrounding plateaus and in the valley-fill deposits. Water that has discharged from or has been in contact with rocks of volcanic origin is mostly a calcium bicarbonate type, generally containing more sodium than magnesium. The volcanic rocks contain a large percentage of plagioclase feldspar in relation to other minerals from which sodium is derived.

The ground-water samples from the northern end of Panguitch Valley have a lower dissolved-solids concentration than other ground water in the area, except for water from Mammoth Spring, Panguitch Creek, and some of the wells in the valley that discharge from valley-fill deposits eroded from volcanic rocks. The water is also similar to ground water sampled in Circle Valley and Grass Valley, and in Black Canyon, where the rocks are primarily of volcanic origin.

Ground water at the northern end of Panguitch Valley is forced vertically upward toward land surface by a constriction of the valley-fill deposits and may represent water that has traveled through the deeper parts of the valley-fill deposits. This water may have been recharged to the valley-fill aquifer from volcanic-rock sources in the northern part of Panguitch Valley, or it may have been recharged in the southern part of the valley from ephemeral streams with chemical quality similar to that of Mammoth Spring and Navajo Lake. Water with a small dissolved-solids concentration could mix with water that has been in contact with volcanic rock, resulting in water with a chemical composition similar to that sampled at the northern end of the valley.

Calcium and bicarbonate are the dominant ions in ground water that discharges near the Sevier River in Panguitch Valley, downgradient from irrigated areas. These ions occur at concentrations about two times greater

than water sampled elsewhere in the valley. The high bicarbonate concentration in this water is probably the result of movement through and reaction with soils that contain high concentrations of carbon dioxide. Ground water flowing into the Sevier River at seeps (C-34-5)4cdc-S1 and -S2, and (C-34-5)27cad-S1 contained larger dissolved-solids concentrations in August 1988 and 1989 than the river water or the diverted water that irrigated the upgradient fields.

All of the samples collected during this study contained minor concentrations of sulfate, except for water from one flowing well in the northwestern part of Circle Valley, (C-30-4)13ccb-1, where the dominant anion is sulfate. The dominant cation in water from well (C-33-5)4ddd-1 in Panguitch Valley is sodium, probably because of the proximity of volcanic rocks. Nitrogen concentrations varied from 3.80 mg/L in water from well (C-35-5)35dad-1 in Panguitch Valley to less than the detection limit of 0.100 mg/L in water from wells (C-35-5)25bbc-3 and (C-37-5)19cad-1 and seep (C-34-5)4cdc-S1 in Panguitch Valley, and well (C-36-3)6dba-1 in Emery Valley. Water-quality diagrams showing the concentration, in milliequivalents per liter, of major ions in ground water sampled from 1986 through 1989 are shown on plate 1.

Dissolved-solids concentrations of ground water sampled from valley-fill aquifers during this study range from 148 mg/L at well (C-26-1)23ddb-2 in Grass Valley to 473 mg/L at well (C-30-3)19dbb-1 in Circle Valley. Dissolved-solids concentrations of ground water sampled from consolidated-rock sources ranged from 85 mg/L at (C-30-4)16abb-S1 (Circleville Spring) to 233 mg/L at (C-34-3)27ddc-S1 (Tom Best Spring). Dissolved-solids concentrations at selected sites on the Sevier and East Fork Sevier Rivers ranged from 18.5 mg/L at the Sevier River near Hatch (gaging station 10174500) to 318 mg/L at the Sevier River, (C-33-5)3aaa.

Specific conductance provides an indication of the concentration of ions in water. Specific conductance and temperature measured during this study for water from selected ground-water sites are listed in tables 5, 6, and 8.

Specific conductance was measured at several locations on the Sevier River in Panguitch Valley during the summers of 1988 (George W. Sandberg, U.S. Geological Survey, written commun., 1990) and 1989. A general increase in specific conductance was measured from the southern (upstream) end to northern (downstream) end of the valley. Because flow from tributary streams is low during the summer months, inflow from ground-water sources to the Sevier River is the primary cause of the increase in specific conductance of the river water. Evapotranspiration and water-management practices also contribute to this increase.

An example of ground water influencing the specific conductance of surface water in Panguitch Valley is the mixing of flow from Casto Wash with that of the Sevier River. Water is diverted from the Sevier River into an irrigation canal just above the mouth of Casto Wash. The ratio of water in the river at the confluence to water in the spring-derived Casto Wash approached one to one in the summer of 1989; whereas, the ratio was much larger in the summer of 1988. The specific conductance of the river above Casto Wash was measured in July 1989 at 330 µS/cm and at 480 µS/cm below the confluence; the specific conductance of Casto Wash was 520 µS/cm. Downstream from Casto Wash, the specific conductance of the Sevier River remained larger than the premixing value of 330 µS/cm.

Data collected in July and August 1989 indicated that ground-water inflow to the Sevier River occurred both above and below the water surface, at many locations north of Roller Mill Hill near Panguitch. The river was at a very low stage at these times because of less-than-average precipitation and near-average diversions of water for irrigation. The specific conductance of ground-water inflow to the river ranged from 380 to 980 µS/cm, and the effect on the specific conductance of the river depended on the quantity of inflow added. Where the quantity of inflow was large, such as at Casto Wash, the change in the specific conductance of the river was large. Where the quantity of inflow was small, more dilution would occur, and the specific conductance of the river would change accordingly. The specific conductance of the Sevier River and selected inflows to the river from ground water in Panguitch Valley are shown in figure 14.

Long-term changes in water quality were small at ground-water sites where data were available. Eight wells and four springs were sampled both in 1954-62 and in 1986-89. Little change in chemical composition was noted in the resampled waters, with only (C-32-5)35abb-S1 (Marshall Slough) showing a noticeable decrease in dissolved-solids concentration (table 8). This decrease may be caused by greater-than-average precipitation in the early 1980's on the surrounding plateau recharge areas. Long-term record of dissolved-solids concentrations at wells (C-32-5)35bab-1, (C-26-1)23dbb-2, and (C-29-2)35bab-1 show no major change with time.

SIMULATION OF GROUND-WATER FLOW IN THE VALLEY-FILL AQUIFER IN PANGUITCH VALLEY

A digital-computer model was constructed to simulate ground-water flow in the valley-fill aquifer in Panguitch Valley. The model was used as a tool to integrate the inflow, outflow, and flow components of the ground-water system in Panguitch Valley and to estimate the effects of changes in irrigation practices and increased ground-water withdrawals on the valley-fill aquifer. The modeled area represents the area containing valley-fill deposits and extends from the confluence of Asay Creek with the Sevier River in the south to the head of Circleville Canyon in the north (fig. 15). The consolidated rocks of the Sevier, Paunsaugunt, and Markagunt Plateaus form the eastern and western hydrologic boundaries of the modeled area.

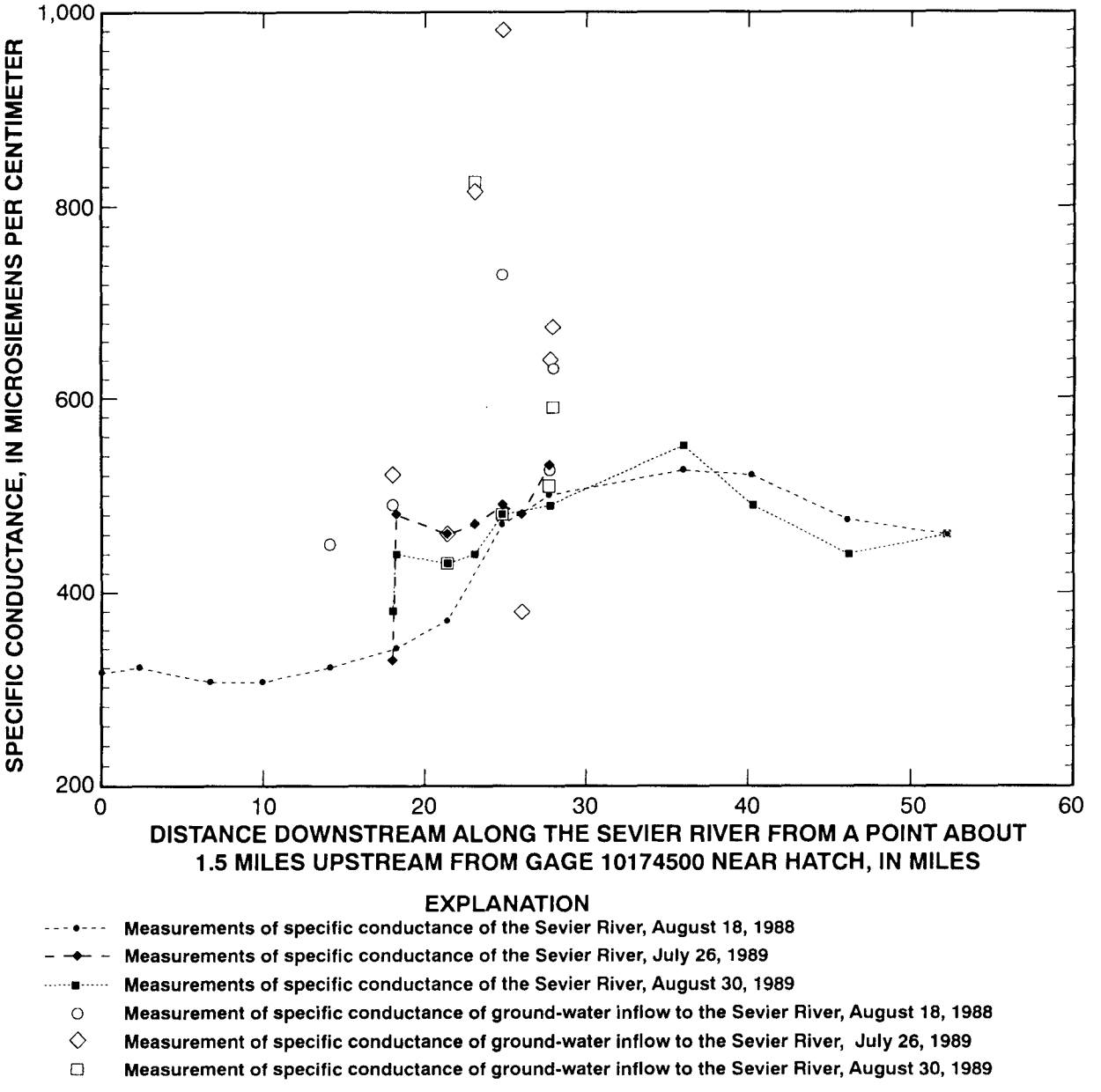


Figure 14. Specific conductance of the Sevier River and selected inflows to the river from ground water in Panguitch Valley.

The modular three-dimensional, finite-difference ground-water-flow model documented by McDonald and Harbaugh (1988) was used for this simulation. The model uses a series of rectangular blocks, or cells, in which hydraulic properties are assumed to be uniform. Hydraulic head is calculated by the model at the point, or node, at the center of each cell. With the calculated head values, the rate and direction of ground-water flow through the aquifer can be determined.

A single stress period model was used to approximate the ground-water conditions in Panguitch Valley during the irrigation season of 1988. Refinement of the hydraulic parameters used in the simulation was made with a transient-state model consisting of monthly stress periods.

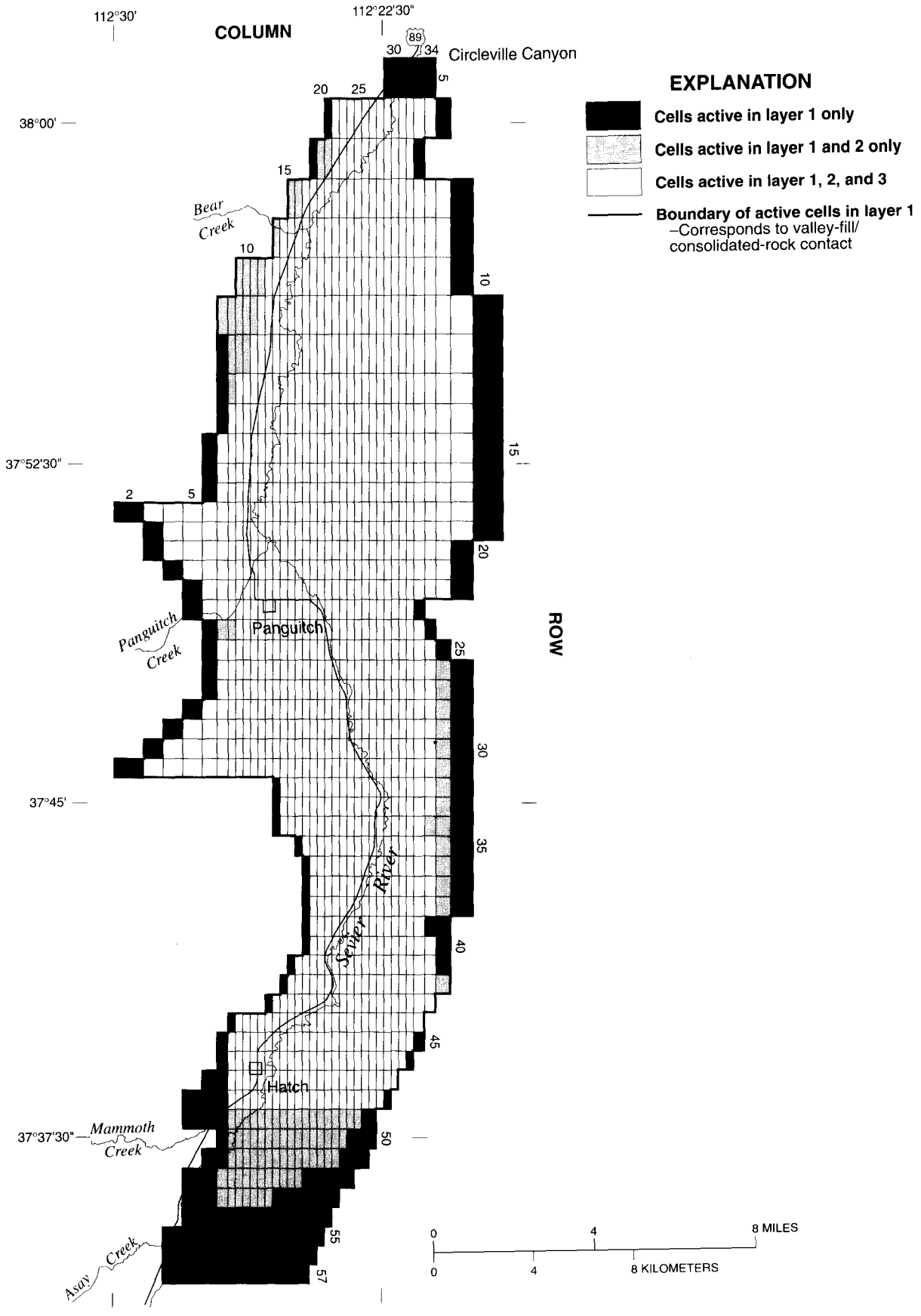


Figure 15. Grid and extent of the three layers used in the digital-computer model representing Panguitch Valley.

Diversions from the Sevier River and its tributary streams to canals and irrigated fields from May to October of each year are the primary cause of the annual rise in water levels in most of Panguitch Valley. After irrigation begins in the spring, water levels continue to rise until the diversion of stream water into canals for irrigation ceases in late October or early November. Water levels then decline until the diversion of stream water for irrigation begins again the following spring. This relatively uniform recurring irrigation has created a pattern of monthly water-level fluctuation that is repeated year after year.

Long-term declines or rises in irrigation-season water levels caused by climatic fluctuations are minor when compared with monthly changes caused by irrigation, indicating that the valley-fill aquifer responds to the stress the same way every year. Because the most complete set of irrigation-season data was for 1988, these data were used to establish initial conditions in the valley on the basis of the seasonal relation between water-level fluctuation and stresses.

The model was modified to simulate water levels and gains and losses from the Sevier River and selected canals measured during this period. The final heads simulated and values of aquifer hydraulic characteristics used by the initial single stress period model were used as initial data for the transient-state model.

The transient-state model was calibrated by comparing water-level changes measured from 1961 through 1963 at 13 wells in the valley to simulated water-level changes. This 3-year period was divided into 36 1-month long stress periods. The stress-period interval of 1 month was used instead of the more conventional interval of 1 year because of a limited amount of data. Only four wells in the modeled area had long-term yearly water-level measurements available.

Aquifer hydraulic characteristics adjusted during the transient-state model calibration process were then used to reestablish initial conditions. This process was iterative and resulted in both the model representing initial conditions and the transient-state model using the same values of aquifer hydraulic characteristics. Both models simulate, within a reasonable range, water levels measured during the simulated periods.

Changes in the ground-water system were simulated using input data from both models. A change from flood irrigation to sprinkler irrigation in part of the valley and the addition of two large discharging wells were also simulated.

Model Design and Construction

A variably spaced, block-centered model grid composed of 58 rows, 38 columns, and 3 layers was used to represent the valley-fill deposits in Panguitch Valley (fig. 15). There are a total of 6,612 cells of which 3,492 are active. Cells represent areas that range in size from 640 acres (1 mi^2) near the boundaries where data were sparse, to 60.8 acres (0.095 mi^2) near the center of the modeled area where more water-level data were available.

Layer 1 was determined to represent the upper 50 ft of saturated valley-fill deposits. Generally unconfined, layer 1 represents interbedded gravel, sand, silt, and clay. Thin silty-clay and clay intervals are confining layers that can result in locally confined conditions in the upper 50 ft of saturated material. The top of layer 1 was initially determined from depth-to-water measurements. Changes in recharge and discharge rates can cause the saturated thickness to vary.

Layer 2 extends 100 ft below the bottom of layer 1. Layer 2 was simulated as a confined interval, with the possibility of becoming unconfined if water-level declines of greater than 50 ft cause water levels to decline below the bottom of layer 1.

Layer 3 represents the interval from the bottom of layer 2 to the consolidated-rock valley floor. The thickness of layer 3 ranges from 0 ft at the mountain fronts, where valley-fill deposits pinch out, to more than 500 ft in the vicinity of test hole (C-33-5)13bdd-1 in the northeast part of the valley (Feltis and Robinson, 1963). Layer 3 is composed of interbedded gravel, sand, silt, and clay in the upper part and the semiconsolidated and less permeable Sevier River Formation in the lower part. Layer 3 is assumed to be under confined conditions.

The contact between the unconsolidated valley-fill deposits and the surrounding and underlying consolidated rock is assumed to be a no-flow boundary for modeling purposes. Transmissivity values of zero were used to simulate the contact between active and inactive cells.

The consolidated rock in the modeled area includes the Claron Formation in the southern part, the Mount Dutton Formation and other rocks of volcanic origin in the northern part, and the Spry Intrusion of Anderson (1986) at the northern end of the area. The consolidated rock was assumed to be substantially less permeable than the valley-fill deposits, and ground-water flow probably occurs only through localized fractures, although data were not available to verify these assumptions. The probability of recharge from consolidated rock to the valley-fill deposits on the east side of Panguitch Valley is less than on the west side because the strata dip about 3 degrees northeast and east (Gregory, 1949, p. 995; 1951, p. 73).

Consolidated rock is near or at land surface where the Sevier River crosses the valley-fill deposits of Panguitch Valley along the southern and northern boundaries. These areas are considered no-flow boundaries because of the small saturated thickness of the valley-fill deposits and the low permeability of the underlying consolidated rock.

A gain-loss study on the Sevier River in August 1988 measured only a slight gain in flow, within the margin of measurement error, in a reach that included the northern boundary of the modeled area. At the southern end of the modeled area, most of the ground water that could move into the valley-fill deposits from outside the area is accounted for as recharge from perennial and ephemeral streams. Surficial basalt flows underlain by permeable unconsolidated material in the Mammoth Creek area were modeled as valley-fill deposits.

Head-dependent flux boundaries were used to simulate ground-water discharge to and ground-water recharge from the Sevier River and selected canals. Head-dependent flux boundaries were also used to simulate ground-water discharge by evapotranspiration and drains in the modeled area (fig. 16).

Data Entry

Data required in the construction of the ground-water-flow model include initial water levels; horizontal and vertical hydraulic conductivity; transmissivity; storage values; recharge; conductance values for the interface between the Sevier River and selected canals and drains, and the underlying porous material; and evapotranspiration rates. Initial water levels used in the model were measured mostly during the summer of 1988. Water levels measured by Carpenter and others (1967) and reported in drillers' logs were also used where data were not available for 1988.

Hydraulic characteristics of the valley-fill aquifer used in the model are based on specific-capacity data from drillers' logs, values of transmissivity and storage reported by Carpenter and others (1967), and reported values for hydrologically similar basin-fill deposits (Bedinger and others, 1987, p. 39). The conceptual limits for values of hydraulic properties used in the model are discussed in this report in the "Hydraulic properties" section for Panguitch Valley. The final range of values used in the model after calibration to transient-state conditions is shown in figures 17 through 23.

Final values of hydraulic conductivity used in layer 1 vary from 5 ft/d where the consolidated Claron Formation crops out in the southern part of the valley to 40 ft/d for sand and gravel deposits near the Sevier River (fig. 17). Initial storage values required for the transient-state calibration were from values reported by Carpenter and others (1967). Final values of specific yield for layer 1 range from 0.005 at the northern end of the valley where fine-grained deposits predominate to 0.2 in the southern part (fig. 18).

Final values of transmissivity for layer 2 range from 100 ft^2/d for the thinnest valley-fill deposits near the consolidated-rock boundary to 5,000 ft^2/d in the center of the valley where the layer represents the entire 100-foot thickness of saturated deposits (fig. 19). Final values for storage coefficient range from 5×10^{-5} for areas mapped or extrapolated as being the Sevier River Formation to 2×10^{-3} for the northeast part of the valley, which contains the thickest valley-fill deposits (fig. 20). In the event that layer 2 becomes unconfined, specific-yield values are used by the model. A secondary set of specific-yield values for layer 2 was available if water levels dropped below the top of the cell during the simulation. The final set of specific-yield values used for layer 2 was the same as that used for layer 1.

Vertical movement of water between layers 1 and 2 is controlled by the difference in water levels, the vertical hydraulic conductivity of the layers, and the distance the water must travel. A term called vertical leakance (expressed in ft/d/ft), the vertical hydraulic conductivity divided by the distance from the center of a cell in a layer to the center of a cell in an underlying adjacent layer, is used to simulate vertical movement. The model

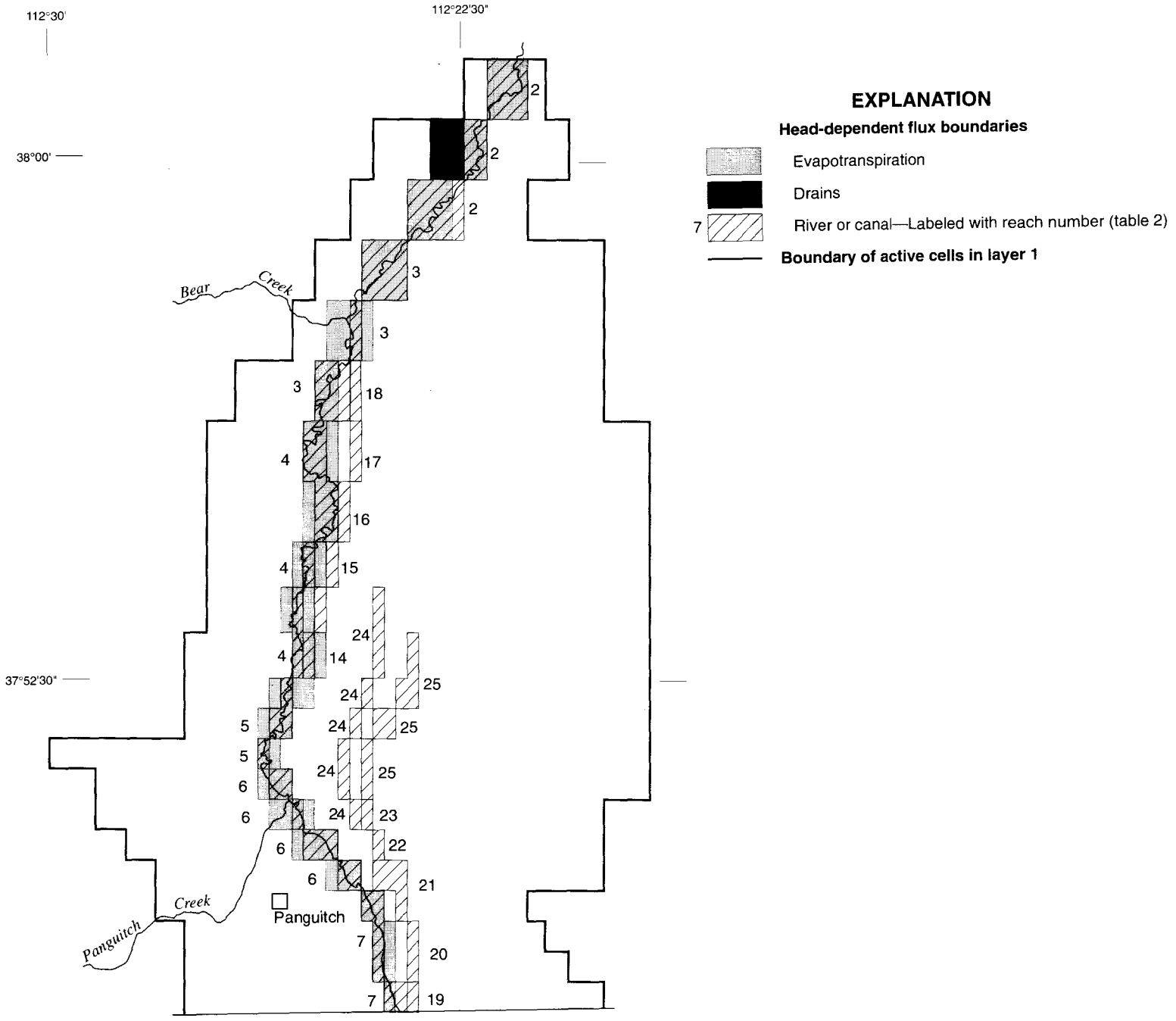
multiplies the leakance by the cell area to obtain vertical conductance (McDonald and Harbaugh, 1988, p. 5-12). Initial values of vertical leakance between layers 1 and 2 use a vertical hydraulic-conductivity value that is roughly 0.1 to 1 percent of the horizontal hydraulic conductivity assigned to the adjacent cells. Final values vary from 0.001 ft/d/ft in the north, to 0.01 ft/d/ft in the interior, to 0.1 ft/d/ft along the consolidated-rock boundary (fig. 21). This distribution is consistent with the characteristic grain-size distribution of valley-fill deposits.

The thickness of layer 3 is not accurately known throughout Panguitch Valley, but it is generally assumed that the valley-fill deposits are thickest along the axis of the valley, where the valley is the deepest, and thinnest near the margins. As a result of consolidation, deeper semiconsolidated material in the interior part of the valley is assumed to have a smaller hydraulic conductivity than the unconsolidated material nearer the mountain fronts. Thus, as the layer thickness decreases and the hydraulic conductivity becomes larger, transmissivity would tend to be relatively constant throughout the interior part of the valley. Near the edge of the valley where the deposits are thin, transmissivity is small even though hydraulic conductivity may be large.

Final values of transmissivity for layer 3 ranged from 100 ft^2/d for the material near the consolidated-rock boundary to 2,000 ft^2/d in the interior part of the valley (fig. 22). A final constant value of 1×10^{-4} was used as the storage coefficient for layer 3. The vertical leakance between layers 2 and 3 varied from 0.01 ft/d/ft along the east and west sides of the valley to 0.001 ft/d/ft throughout the rest of the valley (fig. 23). These final values were calculated from an estimated vertical hydraulic conductivity that was 0.1 to 1 percent of the horizontal hydraulic conductivity and a vertical distance of travel between the centers of layers 2 and 3 that ranged from near 0 ft at the valley margins to about 300 ft at the thickest part of the valley-fill deposits.

Recharge applied in the model for the establishment of initial conditions includes estimates of seepage from tributaries (perennial and ephemeral) of the Sevier River, selected canals and ditches, and unconsumed irrigation water; and infiltration of precipitation (fig. 24). The basis for these estimates is discussed in this report in the "Recharge" section for Panguitch Valley. These estimates were adjusted only slightly during the establishment of initial conditions because they were believed to be some of the most reliable data available.

Recharge to cells representing perennial streams other than the Sevier River was simulated at a rate of 13,080 acre-ft/yr, an estimated 20 percent of the average annual flow. Recharge in areas representing ephemeral streams was simulated at a rate of about 14,230 acre-ft/yr. This is about 80 percent of the estimated annual flow calculated from a regression equation developed for an area in the Colorado River Basin adjacent to the upper Sevier River basin (Christensen and others, 1986, p. 10). Simulated losses from selected canals and ditches to layer 1 were estimated to be about 12,600 acre-ft/yr, 10 percent of the average annual diversion from the Sevier River or a tributary to a canal or ditch. The quantity of seepage to the valley-fill aquifer determined for each stream or canal was applied to cells representing each stream or canal.


112°30'
112°22'30"
38°00'
37°52'30"
Bear Creek
Panguitch Creek
Panguitch
EXPLANATION
Head-dependent flux boundaries
Evapotranspiration
Drains
River or canal—Labeled with reach number (table 2)
Boundary of active cells in layer 1

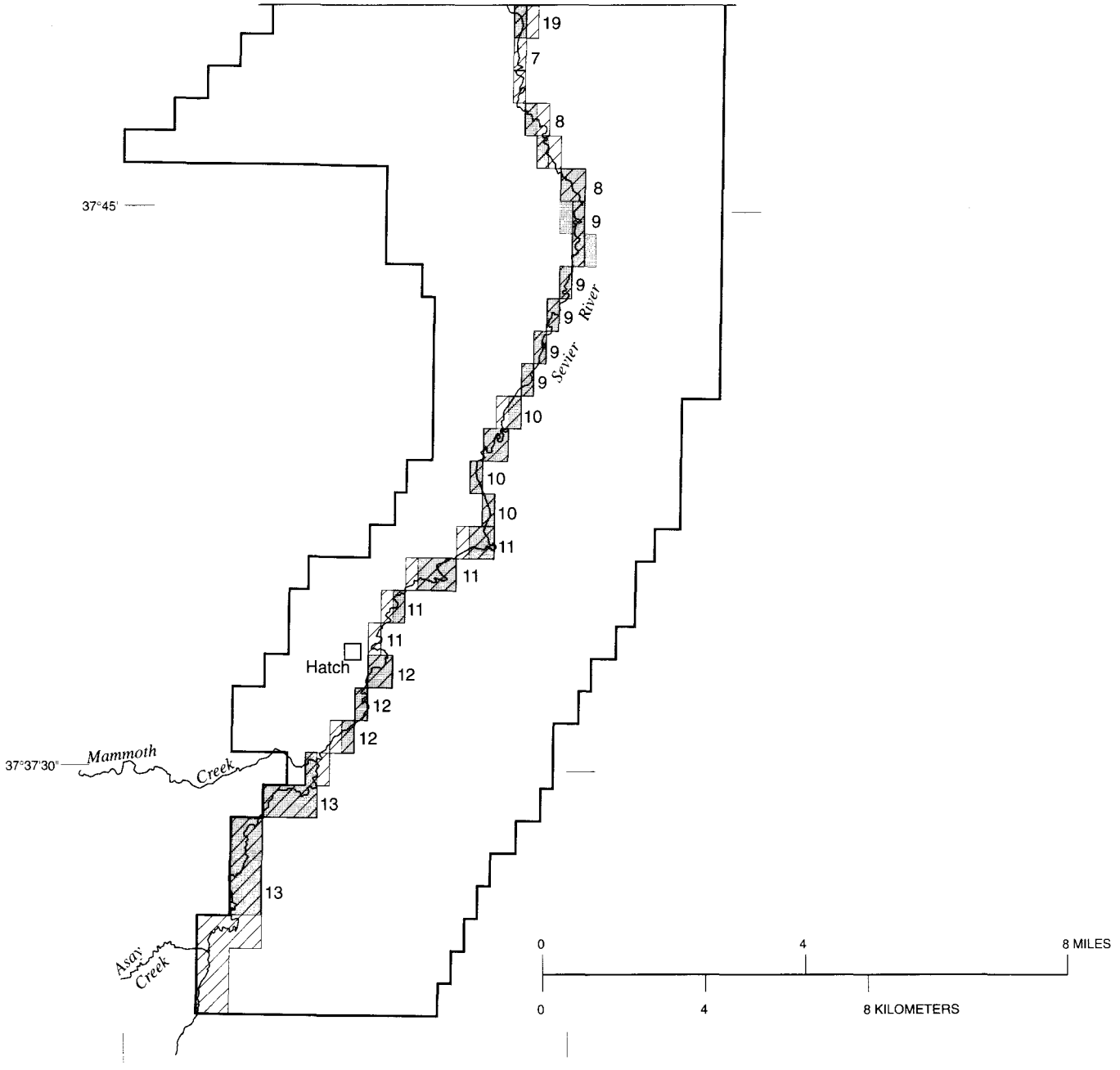


Figure 16. Location of cells in layer 1 of the digital-computer model simulating head-dependent flux boundaries.

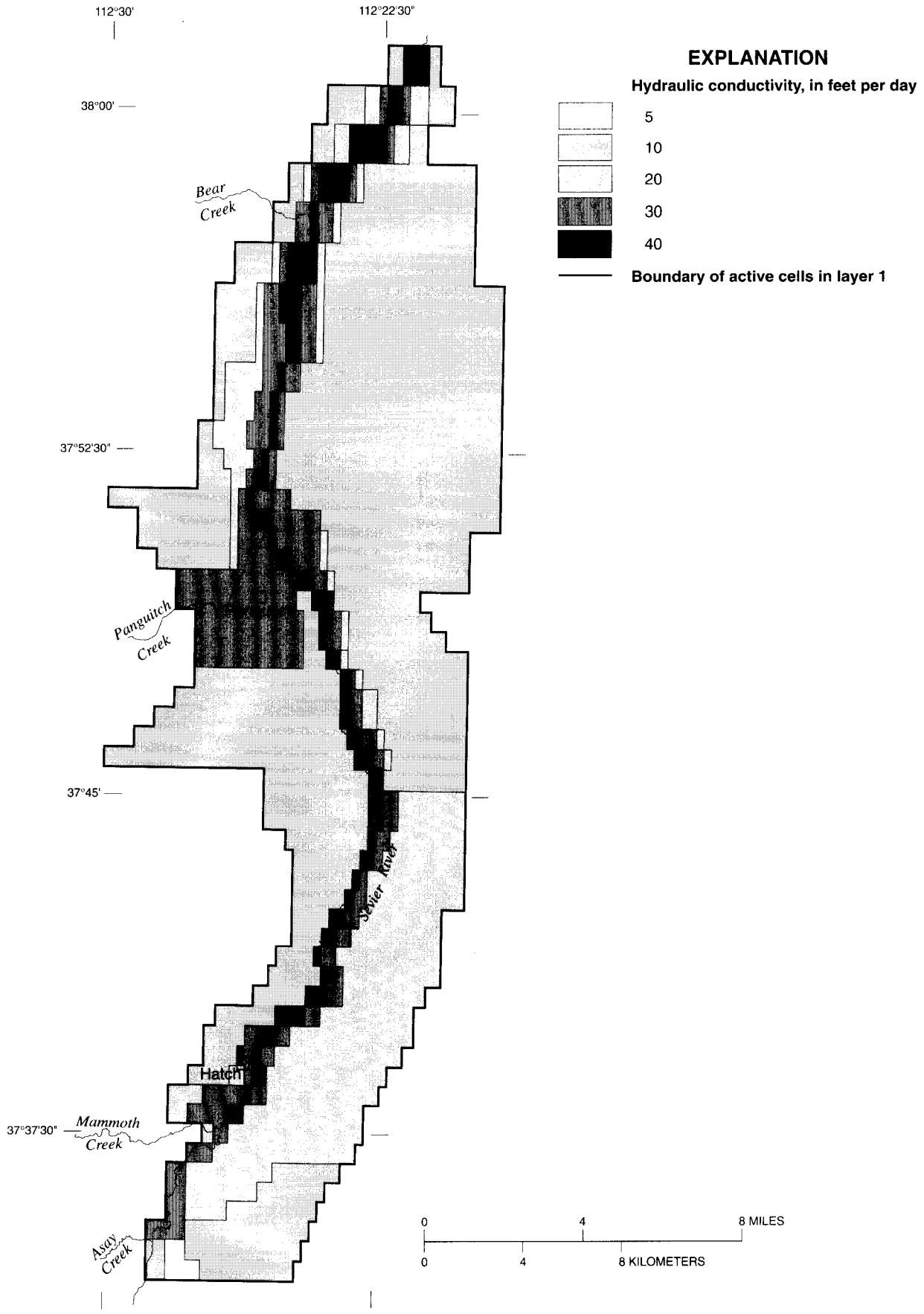


Figure 17. Distribution of hydraulic conductivity used in layer 1 of the digital-computer model.

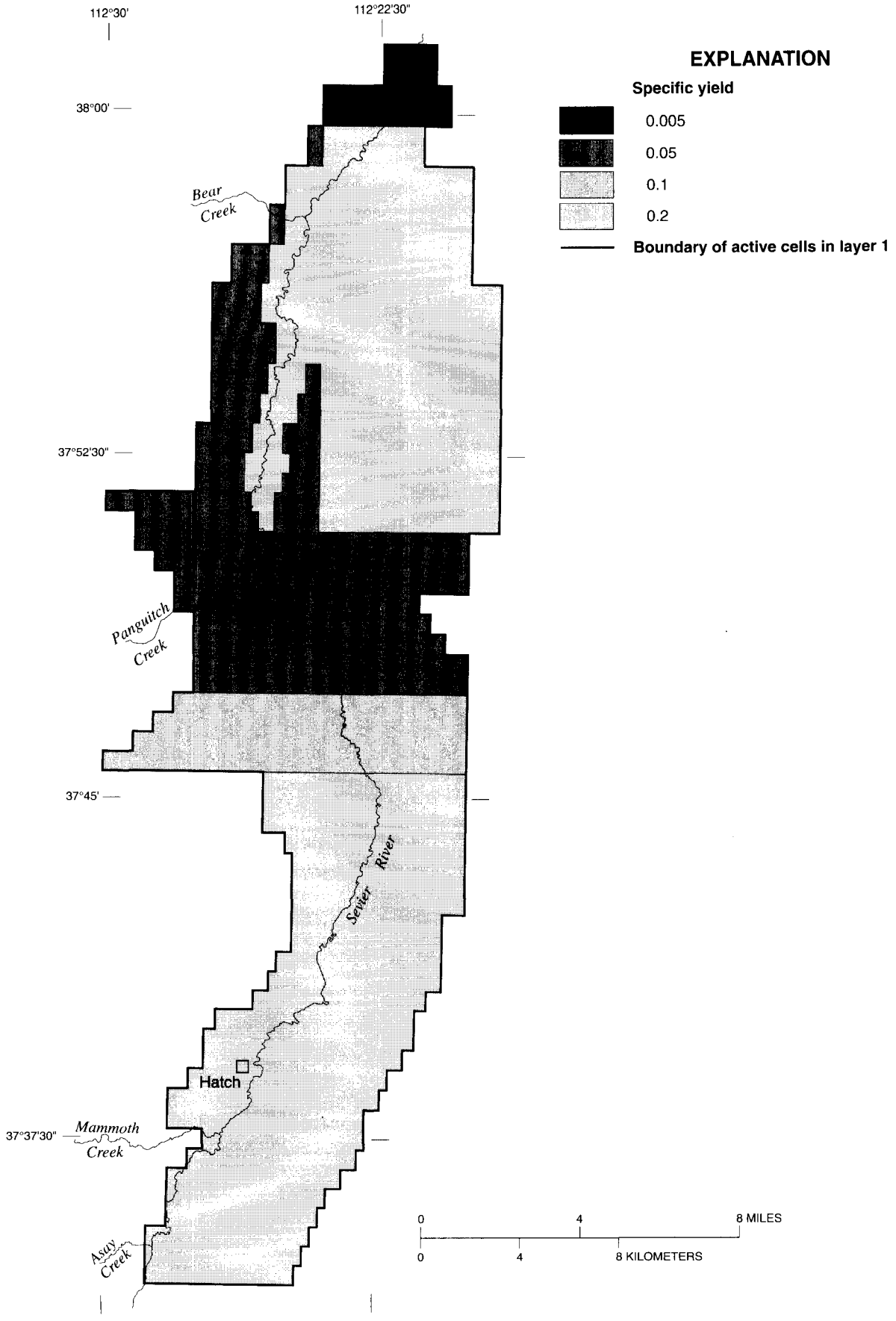


Figure 18. Distribution of specific yield used in layer 1 of the digital-computer model.

Figure 19. Distribution of transmissivity used in layer 2 of the digital-computer model.

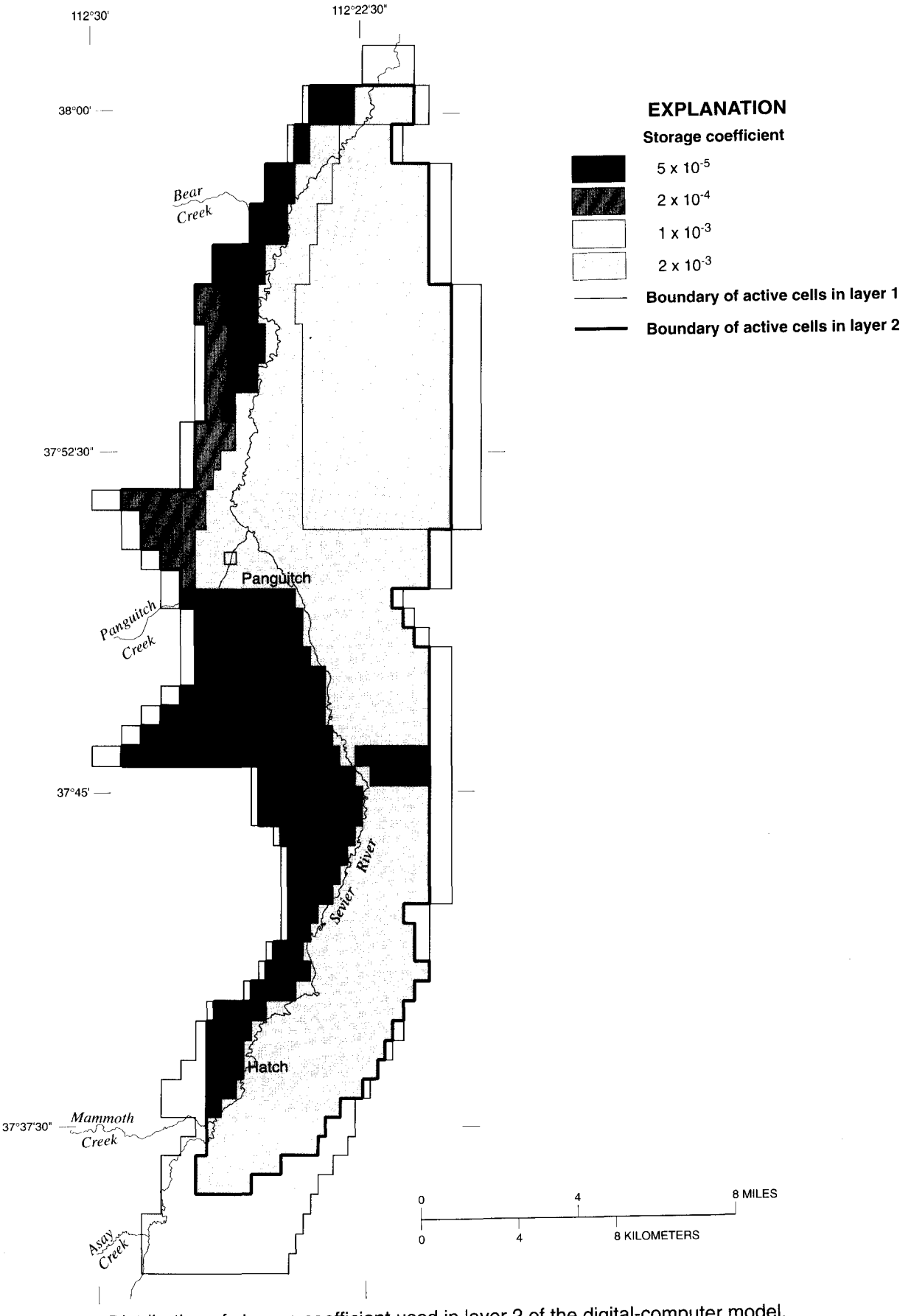


Figure 20. Distribution of storage coefficient used in layer 2 of the digital-computer model.

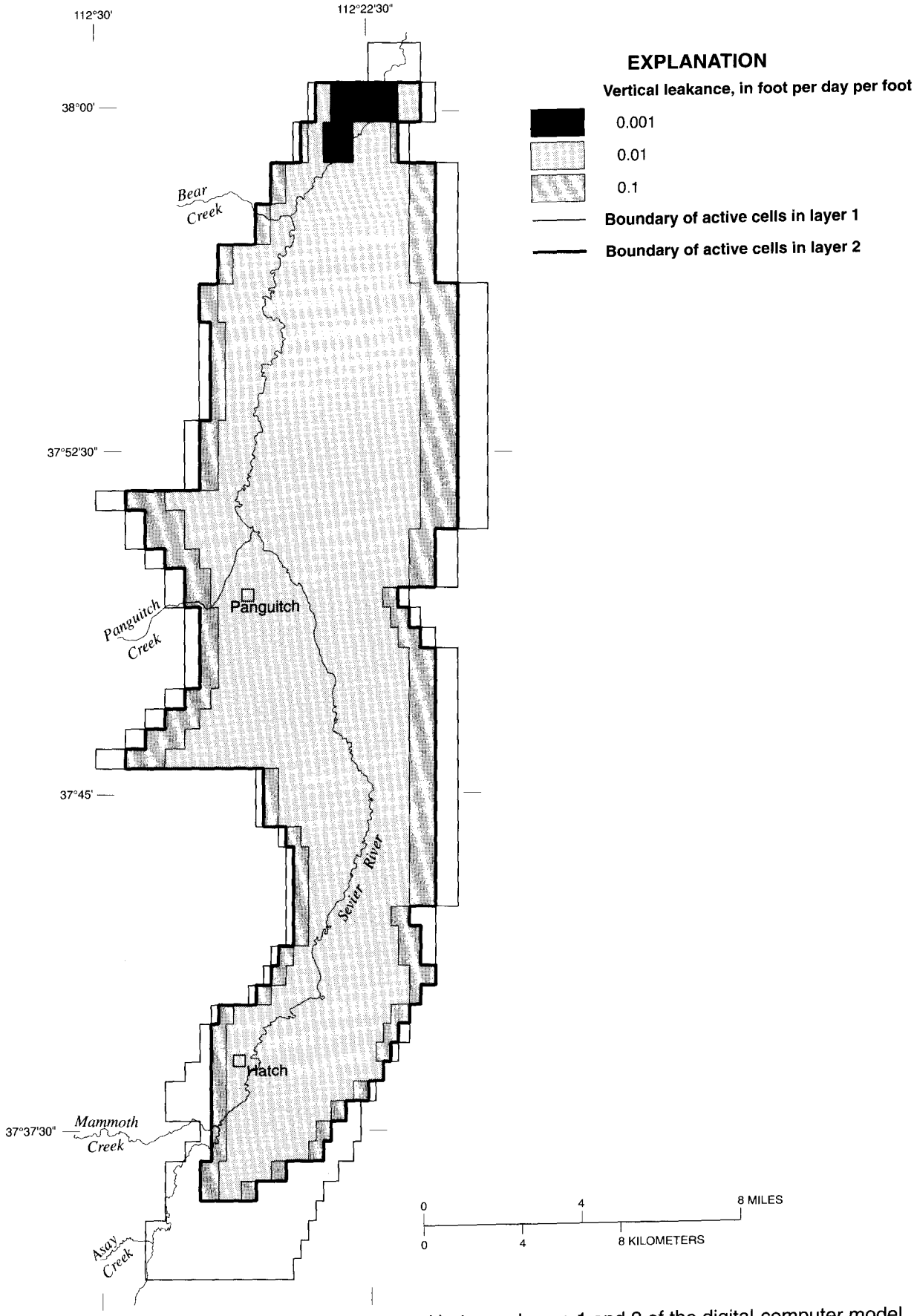


Figure 21. Distribution of vertical leakance used between layers 1 and 2 of the digital-computer model.

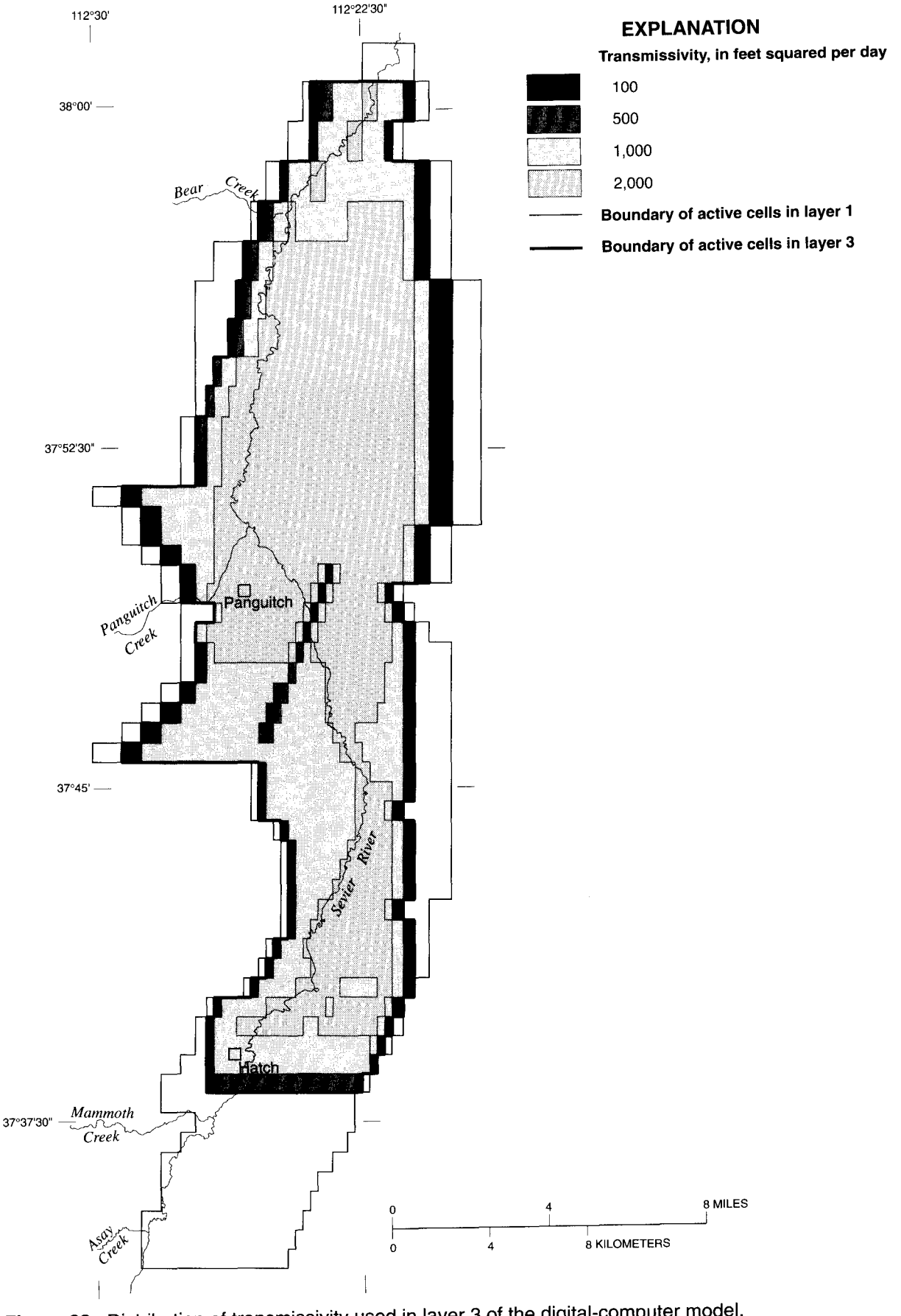


Figure 22. Distribution of transmissivity used in layer 3 of the digital-computer model.

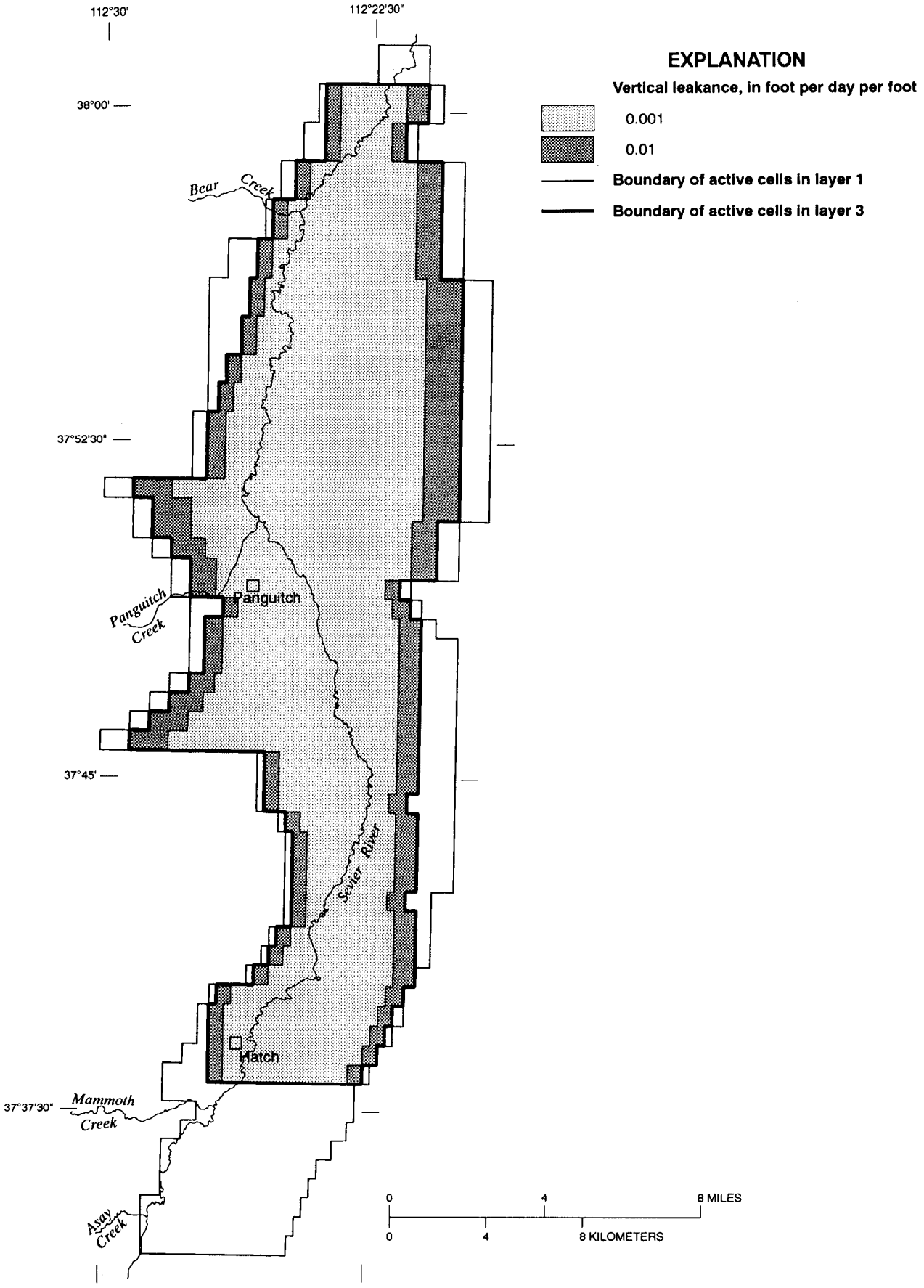


Figure 23. Distribution of vertical leakance used between layers 2 and 3 of the digital-computer model.

Simulated recharge from unconsumed irrigation water was estimated to be the average annual diversion from a surface-water source to an irrigated field after transmission losses, tail-water runoff, and the consumptive use of water by crops have been subtracted. A recharge rate of 15,730 acre-ft/yr was applied to cells simulating irrigated areas in the valley. Simulated recharge from precipitation was estimated to be 5 percent of the 1931 to 1960 average annual precipitation or about 0.5 to 0.6 in/yr (0.042 to 0.05 ft/yr). Recharge from precipitation was applied to all active cells in layer 1 at a total rate of 4,910 acre-ft/yr.

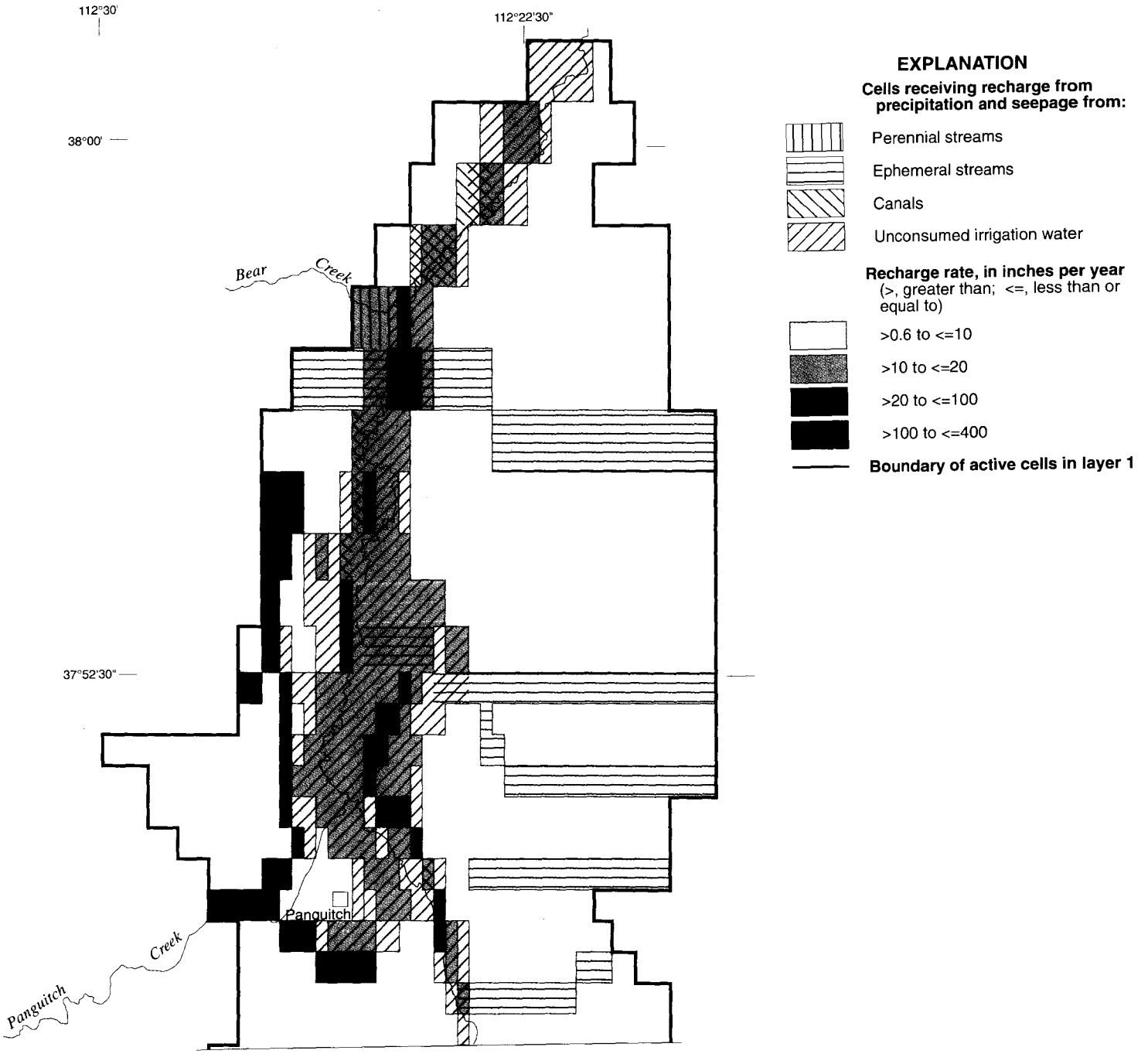
Ground-water discharge to and ground-water recharge from the Sevier River and selected canals was simulated by use of head-dependent flux boundaries (fig. 16). Depending on the head gradient, cells representing head-dependent flux boundaries simulate the loss of water from the river or canal to the aquifer, or the gain of water into the river or canal from the aquifer. Parts of the Long-East Bench and McEwen Canals were simulated using these cells. The head in the river or canal, elevation of the bottom of the riverbed, and hydraulic conductance of the river-aquifer interface are required data (McDonald and Harbaugh, 1988, p. 6-14).

Discharge to or from the river is determined by multiplying the hydraulic conductance by the difference between the head in the river and the elevation of the riverbed. A water depth of 3 ft was used for the Sevier River in order to establish initial conditions. The simulated depth of water in the canals ranged from 1 to 2 ft. These values represent generalized water depths obtained from field observations. The elevation of the bottom of the riverbed was determined from topographic maps of the area. Initial riverbed conductance values were calculated for each cell using the equation:

$$\text{Riverbed conductance} = \frac{KLW}{M} \qquad (1)$$

where K is the hydraulic conductivity of the riverbed material, L is the length of the river within a cell, W is the width of the river, and M is the thickness of the riverbed (McDonald and Harbaugh, 1988, p. 6-5). The initial hydraulic conductivity of the riverbed was estimated to be about 1 ft/day, on the basis of general knowledge of aquifer properties in similar areas. The width of the Sevier River obtained from field observations and approximations was set at 30 ft. The thickness of the riverbed was unknown and an approximation of 10 ft was used.

Initial conductance values were adjusted during establishment of initial conditions and the transient-state calibration to better match model-computed values of stream seepage to field measurements. Final conductance values for the interface between the Sevier River and the valley-fill aquifer ranged from 0.1 to 1.0 ft^3/s. Large conductance values were used for the head-dependent flux cells representing unlined ponds downstream from the split in the Long-East Bench Canal. These ponds were assumed to lose a large quantity of water to the valley-fill aquifer.


112°30'
112°22'30"
38°00'
37°52'30"
Bear Creek
Panguitch
Panguitch Creek
EXPLANATION
Cells receiving recharge from precipitation and seepage from:
Perennial streams
Ephemeral streams
Canals
Unconsumed irrigation water
Recharge rate, in inches per year
(>, greater than; <=, less than or equal to)
>0.6 to <=10
>10 to <=20
>20 to <=100
>100 to <=400
Boundary of active cells in layer 1

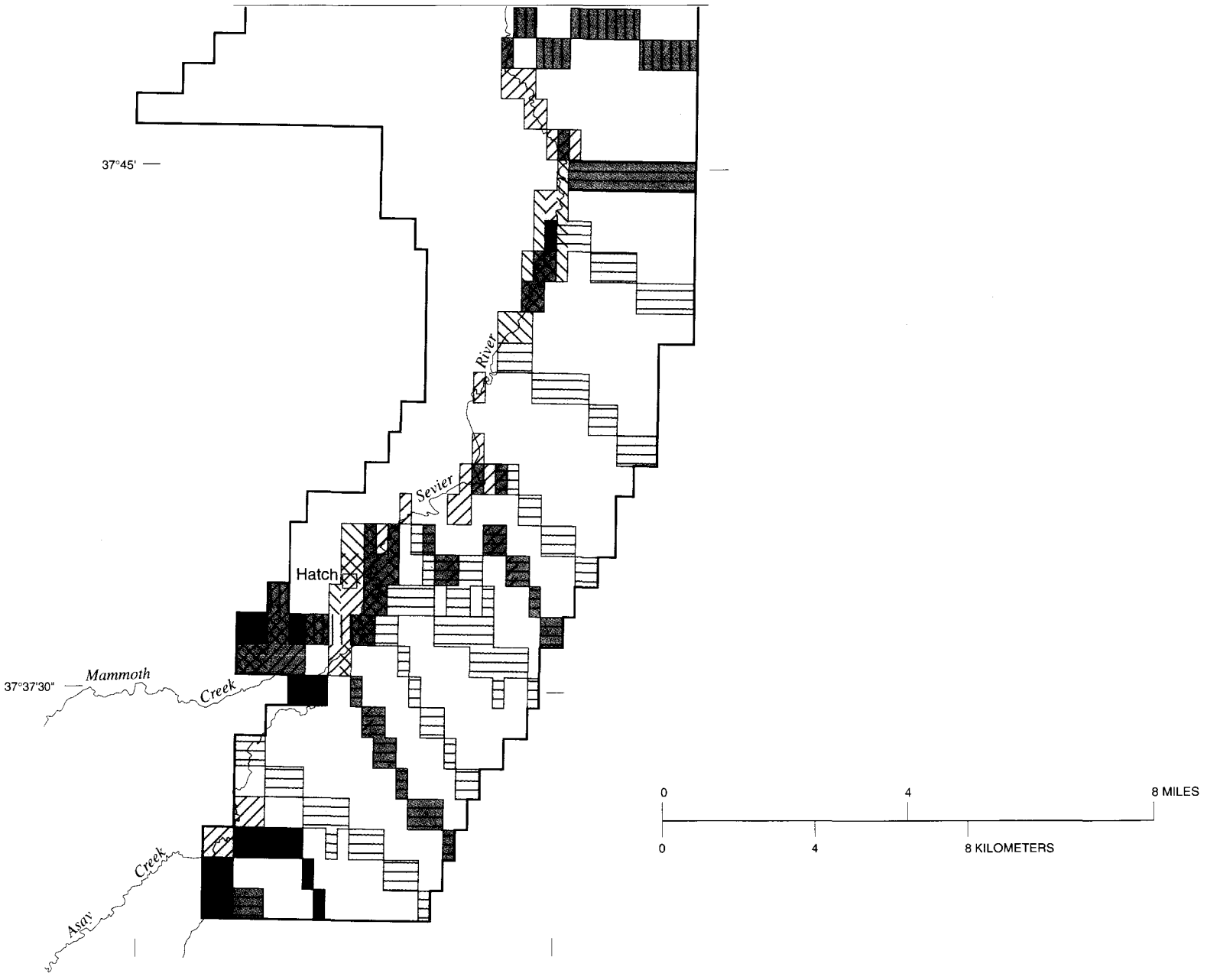


Figure 24. Location of cells in layer 1 of the digital-computer model that receive recharge from seepage from perennial and ephemeral streams, canals, and unconsumed irrigation water; and infiltration of precipitation.

Ground-water discharge by evapotranspiration is simulated in the model using head-dependent flux boundaries (fig. 16). Simulation of evapotranspiration requires the following data: (1) a maximum evapotranspiration rate, (2) a depth at which no evapotranspiration occurs, and (3) the elevation of land surface where evapotranspiration is occurring (McDonald and Harbaugh, 1988, p. 10-8). A maximum evapotranspiration rate of 2 ft/yr was used (see "Discharge" section for Panguitch Valley in this report) when the water level in a cell was at or above land surface. No evapotranspiration took place when the water level in a cell was at or below a specified depth of 5 ft. The evapotranspiration rate between these limits varied linearly with the water level in the cell. Varying the specified depth at which no evaporation took place to 10 and 20 ft below land surface resulted in a slight increase in the quantity of evapotranspiration.

Marshall Slough, (C-32-5)35abb-S1, in the northern part of Panguitch Valley, was simulated using head-dependent drains in model layer 1 (fig. 16). The elevation of the drain and a conductance value for the interface between the cell and the drain are required (McDonald and Harbaugh, 1988, p. 9-7). An initial conductance value of 1 ft^2/s was used for the three cells simulated as drains. Drain conductances and elevations were varied during the establishment of initial conditions in order to approximate measured discharge rates. A final conductance value of 5 ft^2/s was used. The elevation of the southernmost part of Marshall Slough is listed in table 5. The slough extends almost 1 mile downstream from this point to an elevation of about 6,345 ft above sea level. Initial elevations for the drain area were determined from topographic maps with contour intervals of 20 and 40 ft. Drain elevations were adjusted within the accuracy range of elevations interpolated from topographic map contours and range from 6,350 to 6,352 ft above sea level.

Establishment of Initial Conditions

The establishment of initial conditions consisted of comparing simulated water levels and simulated gains and losses from the Sevier River and selected canals with actual measured values from 1988 as discussed below. To obtain the best overall agreement with measured values, adjustments of selected model values were made within an acceptable range (see "Hydraulic properties" section for Panguitch Valley in this report).

Fields are irrigated during the growing season with water diverted from the Sevier River and its tributary streams. Ground-water withdrawal from wells was not simulated because ground water was not used in the valley for irrigation, and withdrawal for other uses was minor. Water levels in wells respond to the diversion of streams and application of irrigation water in a seasonal pattern. Data collected during the irrigation season of 1988 were used to establish initial conditions in Panguitch Valley because of the seasonal relation between water-level changes and stresses.

The establishment of initial conditions required adjusting the model to match water levels measured at 38 wells in Panguitch Valley. One water level measured at each well during the summer or fall of 1988 was used in this process. These measurements usually represented the peak water levels measured during the year if the well was in an irrigated area. Twenty-one water levels were available to represent hydraulic heads for layer 1, 14 for layer 2, and 3 for layer 3 (fig. 25). The three water levels representing

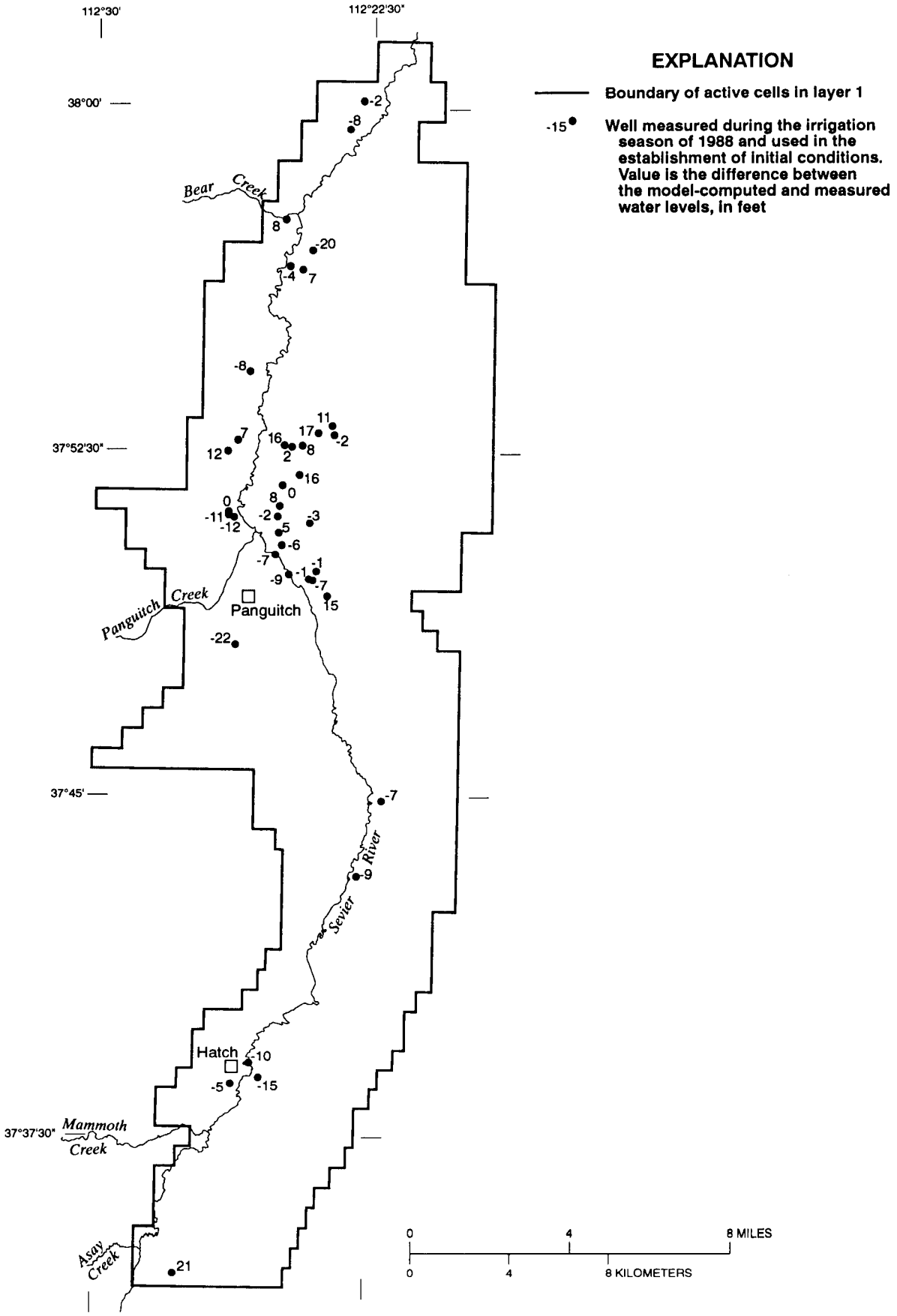


Figure 25. Location of wells measured during the irrigation season of 1988.

layer 3 are from the southern part of the modeled area. Land-surface datum was established from 7½-minute topographic maps with contour intervals from 20 to 40 ft. Simulated water levels ranged from 22 ft above to 21 ft below measured water levels. Simulated water levels greater than or less than the measured water levels in layers 1 and 2 were distributed randomly.

Differences between measured and simulated water levels are referred to as residuals. The mean of the residuals for water levels representing layer 1 was 0.19 ft; for layer 2, 0.07 ft; and for layer 3, -9.0 ft. A large negative mean of the residuals indicates that, overall, the model computed higher water levels than were measured. A small mean of the residuals (positive or negative) indicates nearly an equal number of positive and negative residuals. The mean of the absolute values of the residuals was 8.8 ft for layer 1, 7.9 ft for layer 2, and 9.2 ft for layer 3.

Aquifer storage was not considered in establishing initial conditions. In some areas where water levels peak later than those in other areas because of aquifer storage, the use of irrigation-season recharge rates results in water levels that do not match as well as in other areas.

Gains and losses measured on the Sevier River in August 1988 and on two canals in late July and early August 1988 were also used to establish initial conditions (table 2 and fig. 16). Interactions between ground water and surface water vary with irrigation practices during a year, but the initial conditions derived from the model correspond only to flow that occurred during the irrigation season.

Streambed conductances were adjusted locally during the establishment of initial conditions to approximate the magnitude and location of gains and losses in measured flow. Because tail-water runoff and shallow ground water below irrigated fields flows back to the river, seepage values measured during the gain-loss studies are larger than actual values of ground-water seepage to the river. Tail-water runoff was estimated to be about 20 percent of the applied irrigation water (see "Seepage from unconsumed irrigation water" section of this report). Some water applied to irrigated fields near the Sevier River infiltrates below land surface and drains to the river. The scale of recirculation for this shallow ground water is small and was not simulated because of the relatively large model-grid size. For these reasons, values of model-computed flows were purposely simulated to be less than measured values. The total model-computed change in flow in the Sevier River from reach 2 to reach 12 (+54 ft^3/s, table 2) is about the same as the gain computed from gaging-station records along this stretch of the river (see "Seepage to the Sevier River and canals" section of this report).

Discharge from Marshall Slough (pl. 1) was about 3 ft^3/s in August 1955 (Carpenter and others, 1964, p. 8). The simulated drain flow of about 1.7 ft^3/s is probably a reasonable approximation of initial-condition discharge because August usually represents the maximum seasonal discharge from Marshall Slough according to records from the Sevier River Commissioner. The ground-water budget for initial conditions computed by the model is shown in table 3.

Table 2.—*Measured and model-computed gains and losses in the Sevier River, McEwen Canal, and Long-East Bench Canal in Panguitch Valley*

[ft^3/s, cubic feet per second]

Reach (see fig. 16)	Measured gains (+) and losses (-), July-August 1988 (ft^3/s)	Model-computed gains (+) and losses (-), 1988 irrigation, initial conditions (ft^3/s)	Model-computed gains (+) and losses (-), August 1962, transient-state conditions (ft^3/s)
		Sevier River	
2-3	+14	+6	+7
4	+43	+19	+20
5-7	+49	+23	+23
8	0	-1	0
9	+14	+3	+3
10-12	-3	+4	+6
Total	+117	+54	+59
13	not measured	+17	+16
		McEwen Canal	
14	+3.5	+0.09	+0.06
15	0	+0.05	+0.02
16	-4.6	-0.02	-0.02
17-18	+2.0	-0.03	-0.03
Total	+0.9	+0.09	+0.03
		Long-East Bench Canal	
19-20	+2.7	-0.08	-0.08
21	-4.0	-1.22	-1.22
22	+2.0	-0.02	-0.02
23	0	-0.01	-0.01
Total	+0.7	-1.33	-1.33
24	not measured	-1.63	-1.63
25	not measured	-3.64	-3.64

Table 3.--*Model-computed ground-water budgets for initial and transient-state conditions and ground-water budget for estimated initial conditions for Panguitch Valley*

[in acre-feet per year; --, not applicable]

	Model computed				Estimated initial conditions
	Initial conditions	Transient-state conditions			
Budget element		1961	1962	1963	
WATER ENTERING THE VALLEY-FILL AQUIFER					
Infiltration from: precipitation, unconsumed irrigation, perennial streams, ephemeral streams, and canals	61,130	47,170	55,880	53,180	66,740-75,740
Seepage from Sevier River, McEwen and Long-East Bench Canals	7,960	5,180	5,170	5,210	5,000
Added to storage	—	31,720	29,740	29,980	--
Total in	69,090	84,070	90,790	88,370	71,740-80,740
WATER LEAVING THE VALLEY-FILL AQUIFER					
Evapotranspiration	13,730	11,060	11,360	11,210	11,060
Drains (Marshall Slough)	1,220	1,000	1,150	1,120	2,200
Seepage to Sevier River, McEwen and Long-East Bench Canals	54,140	51,980	53,820	52,920	55,570
Pumped from wells	0	0	0	0	100
Removed from storage	—	20,310	24,820	23,530	--
Total out	69,090	84,350	91,150	88,780	68,930

Transient-State Calibration

A lack of significant change in land use, irrigation practices, or well discharge in Panguitch Valley made it possible to assume that hydrologic conditions in 1988 were representative of conditions in the early 1960's. The model was calibrated by simulating monthly water-level changes from 1961 through 1963 and comparing these changes with measured values. November 1, 1960, through October 31, 1963, was divided into 36 1-month stress periods because monthly water-level measurements were available for 13 wells during most of this period. Monthly water-level measurements began in January 1961 at 4 of the 13 wells. Measurements began at different times at the other wells (fig. 26). Recharge rates to layer 1 were estimated for each month on the basis of gaging-station and canal-diversion records, consumptive-use rates, and precipitation records. Ground-water withdrawal from wells was not simulated because ground water is a minor component of discharge from the valley-fill aquifer and was not used in the valley for irrigation. Adjustments were made to storage and vertical leakance values, within an acceptable range (see "Data entry" section of this report), in order to better match simulated changes with measured changes in water levels.

Twenty percent of the monthly flow in perennial streams, excluding the Sevier River and Panguitch Creek, was estimated to recharge the cells that the streams traversed (see "Seepage from streams" section of this report). This value is at the smaller end of the estimated range of values determined from average annual streamflow. The transient-state model required recharge rates computed from monthly flow in perennial streams from November 1960 through October 1963. Streamflow data were not available for any of the streams in the area during this period except the Sevier River.

Records were available for the gaging station on Mammoth Creek (10173450) from 1965 through 1988 and for the gaging station on the Sevier River at Hatch (10174500) (pl. 1) discontinuously from 1911 through 1988. Monthly flows for Mammoth Creek from November 1960 through October 1963 were estimated from monthly mean flows computed for the Sevier River during this period. Monthly flows for Mammoth Creek were estimated for each of the 12 months by first developing a ratio between the monthly flow in Mammoth Creek and the monthly flow in the Sevier River, for which simultaneous record was available (1965 through 1988). The ratios obtained were then multiplied by the monthly discharges on the Sevier River for the simulation period to determine estimates of monthly flows for Mammoth Creek for the same period. The monthly flows were then multiplied by 20 percent to obtain recharge values to use in the model.

Monthly flows for ungaged perennial streams in the area were estimated using reported or estimated annual streamflow and relating these values to streamflow recorded at the gaging station on the Sevier River at Hatch. The monthly mean flows of the Sevier River were calculated as a percentage of the annual flow from November 1960 to October 1963. The annual streamflow of the ungaged perennial streams was then multiplied by these percentages to estimate monthly flow. Twenty percent of the monthly flow was applied as recharge in the model.

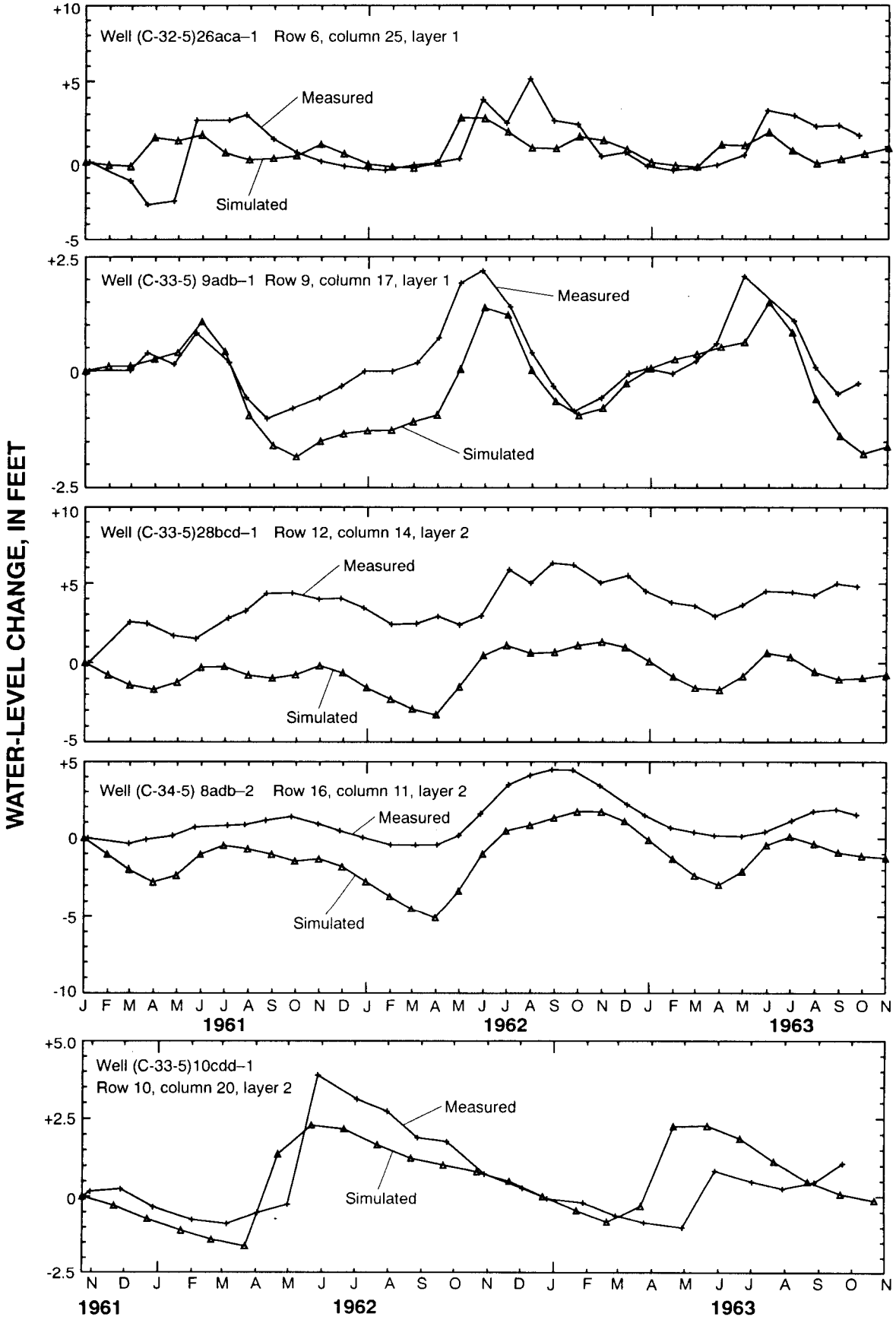


Figure 26. Measured and simulated water-level changes for 13 selected observation wells in Panguitch Valley.

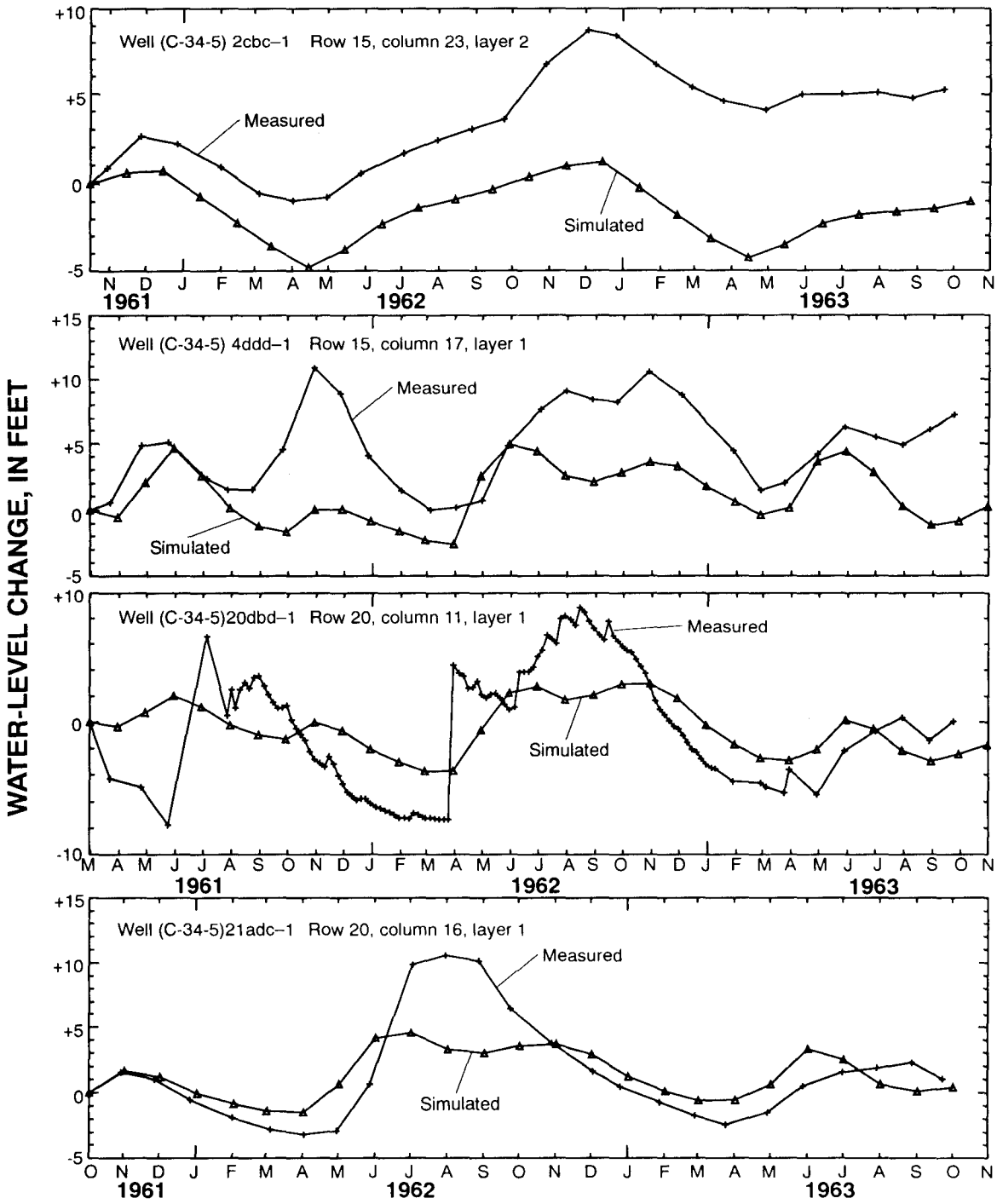


Figure 26. Measured and simulated water-level changes for 13 selected observation wells in Panguitch Valley–Continued.

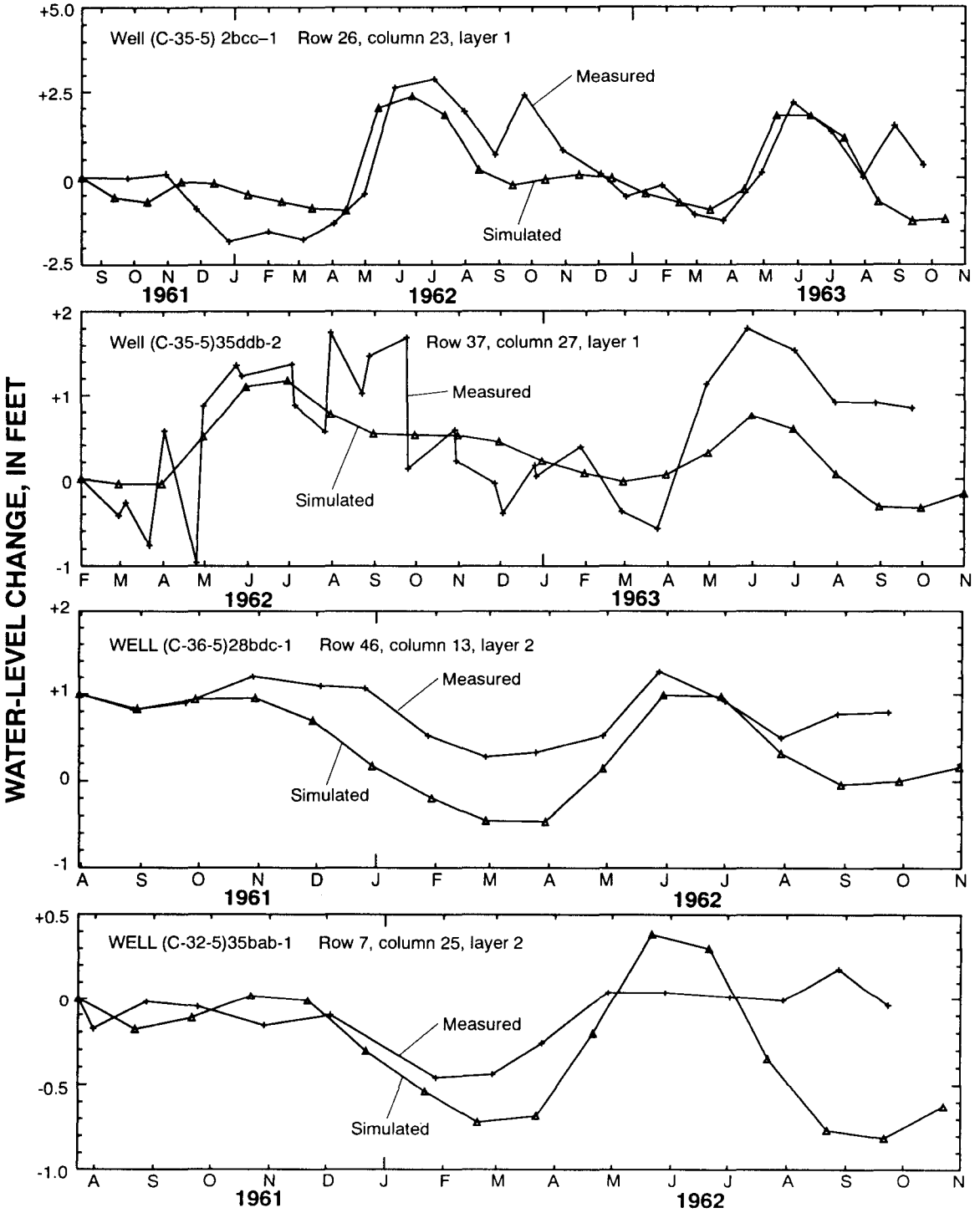


Figure 26. Measured and simulated water-level changes for 13 selected observation wells in Panguitch Valley–Continued.

Recharge from ephemeral streams was estimated to be 80 percent of the calculated annual streamflow using a regression equation developed for an area in the Colorado River Basin adjacent to the upper Sevier River basin (see "Seepage from streams" section of this report). On the basis of monthly temperature changes, this recharge was simulated by applying percentages representative of streamflow in March, April, and May to active cells that the stream traversed.

Losses from selected canals and ditches simulated in Panguitch Valley were estimated to be 10 percent of the monthly quantity diverted from the Sevier River and its tributaries, as recorded by the Sevier River Commissioner. Forty percent of the monthly mean flow measured in Panguitch Creek and then diverted to the South and West Panguitch Ditches is estimated to recharge the valley-fill aquifer. This monthly mean flow was estimated for 1961 and was measured at gaging station 10176300 for 1962-63. Simulated recharge was applied to active cells that the canal or ditch traversed. Panguitch Creek was treated as an extension of the West Panguitch Ditch because of a control at Panguitch Lake.

Recharge to the valley-fill aquifer from unconsumed irrigation water was estimated using numerous factors. The following components were subtracted from the total quantity of water diverted by canals and ditches from surface-water sources each month to determine the rate of recharge from unconsumed irrigation water: (1) the quantity of water lost from canals or ditches to the valley-fill aquifer from that month's diversion total (estimated at 10 percent), (2) the quantity of tail-water runoff returned to the Sevier River, and (3) the quantity of water consumed by the irrigated crops. Tail-water runoff was estimated from field observations to be 20 percent of the remaining water diverted for irrigation after canal losses. This estimate also includes any free-water evaporation that occurred before and after the water was applied. The monthly consumptive-use rates were estimated by the U.S. Department of Agriculture (1969b, Appendix IV, tables 37-40) and are an average of values listed for alfalfa and pasture in Panguitch Valley. They are: October, 0.67 in.; November, 0.27 in.; December and January, 0 in.; February, 0.22 in.; March, 0.34 in.; April, 0.65 in.; May, 2.12 in.; June, 4.46 in.; July, 5.71 in.; August, 4.85 in.; and September, 2.06 in. The total annual consumptive use for irrigated land in Panguitch Valley was 21.35 in. (1.78 ft).

Recharge from precipitation (see "Infiltration of precipitation" section of this report) was simulated for March 1961 and 1962 and for April 1963 at an estimated rate of 10 percent of the total precipitation for the preceding November through March (or April in the case of 1963). Most of the yearly precipitation falls as snow during the winter months (see "Climate" section of this report). This snow can remain throughout the winter if temperatures are near or below freezing. The month for which recharge from winter accumulated precipitation was applied in the model was determined on the basis of when the average monthly temperature for that year first exceeded freezing. Recharge from precipitation for 1961 includes an additional 5 percent of the precipitation that fell in April 1961 because of the near-freezing temperatures in March and April and the resulting low evapotranspiration rates. Rainfall from summer thunderstorms must fill evapotranspiration and soil-moisture requirements before it can recharge the valley-fill aquifer. These requirements were estimated to be met if more than 1.5 in. of precipitation fell during a month because of the short duration of the storms.

This recharge was applied at an estimated rate of 2 to 3 percent of each month's total precipitation.

The simulated stage in the Sevier River and selected canals was varied to represent high- and low-flow periods on the basis of field observations. The simulated water depth used for the Sevier River ranged from 1 ft during low-flow periods to 3 ft during high-flow periods. The simulated water depth used for selected canals was 1 ft during low-flow periods, 1 to 2 ft during high-flow periods, and 0 ft during the nonirrigation season.

Evapotranspiration rates were also differentiated into monthly rates for a 1-year period, and these monthly rates were used in all three simulated years. Average monthly evapotranspiration rates are reported in the "Evapotranspiration" section of this report.

Recharge and discharge values were changed only slightly during the transient-state calibration because they were considered to be some of the most reliable data entered in the model. A summary of the components of recharge and discharge used in the transient-state simulation, when they were applied, and at what rate they were applied, is shown in table 4.

Most of the 13 comparisons (fig. 26) show some agreement between simulated and measured water levels. The model-computed water levels determined from the establishment of initial conditions were specified as the initial water levels representing November 1960 in the transient-state calibration. The final water levels computed for the end of November 1960, and probably for several subsequent months also, were not as close to the actual water levels as they would be if the initial water levels had been calibrated to conditions in November 1960. The difference between model-computed water levels for the end of December 1960 and water levels in the four wells measured in early January 1961 are: -10 ft in well (C-32-5)26aca-1 in row 6, column 25, layer 1; 8 ft in well (C-33-5)9adb-1 in row 9, column 17, layer 1; -17 ft in well (C-33-5)28bcd-1 in row 12, column 14, layer 2; and -10 ft in well (C-34-5)8adb-2 in row 16, column 11, layer 2. Other reasons for divergence between measured and simulated values are discussed in the section of this report titled "Limitations of the model."

The difference between model-computed water levels for the end of October 1961 and water levels measured during October 1961 in 28 wells completed in layers 1 and 2 ranges from -27 to 16 ft. The model-computed potentiometric surface of layer 1 in stress period 12, October 1961, and the difference between model-computed and measured water levels in October 1961 are shown in figure 27.

Sensitivity Analysis

A sensitivity analysis of a model is used to determine the response of a model to changes in hydraulic properties. A detailed sensitivity analysis was not done separately from the calibration process. Sensitivity analysis of hydraulic parameters for which ranges of estimates were large were done as part of the simulation process. Vertical leakance values between layers 1 and 2 were increased by an order of magnitude, which resulted in a substantial decline in model-computed water levels in layers 1 and 2. An order-of-magnitude increase in vertical-leakance values between layers 2 and 3 resulted in a slight decline in model-computed water levels in all three layers.

Table 4.--*Times and rates of recharge and discharge applied in the transient-state simulation*

	November	December	January	February	March	April	May	June	July	August	September	October
Recharge												
Perennial streams other than Sevier River and Panguitch Creek	20 percent of monthly mean streamflow											
Ephemeral streams					80 percent of annual streamflow computed from equations developed for the Colorado River Basin and applied at varying rates based on monthly temperature changes							
Canals and ditches	10 percent of monthly mean diversions from the Sevier River and tributaries (40 percent of monthly mean diversion from Panguitch Creek)											
		Diversion mainly for stock use										
Unconsumed irrigation	The quantity of water diverted for irrigation remaining after transmission losses (10 percent of monthly diversion), tail-water runoff and free-water evaporation (20 percent of monthly diversion), and consumptive use by crops (varies monthly) are subtracted											
Consumptive-use rate, in inches	0.27			0.22	0.34	0.65	2.12	4.46	5.71	4.85	2.06	0.67
Precipitation					10 percent of the November-March or April precipitation total (depending on when the average monthly temperature first exceeds freezing)				2-3 percent of the monthly precipitation, if the monthly precipitation was more than 1.5 inches			
Discharge												
River and canals simulated using river nodes	Gains or losses in flow throughout the year depending on stage and head gradient in surrounding cells											
River	Low stage					High stage			Low stage			
Canals	Low stage					Low stage	High stage					Low stage
Evapotranspiration rate, in inches	Evapotranspiration is determined from monthly maximum evapotranspiration rates and a depth of 5 feet below which no evapotranspiration occurs											
	0.5	0.2	0.1	0.2	0.5	1.2	2.1	3.5	5.2	4.5	3.3	1.7
Marshall Slough	Modeled with head-dependent drains using a conductance value of 5 feet squared per second. Rate depends on water level in drain											

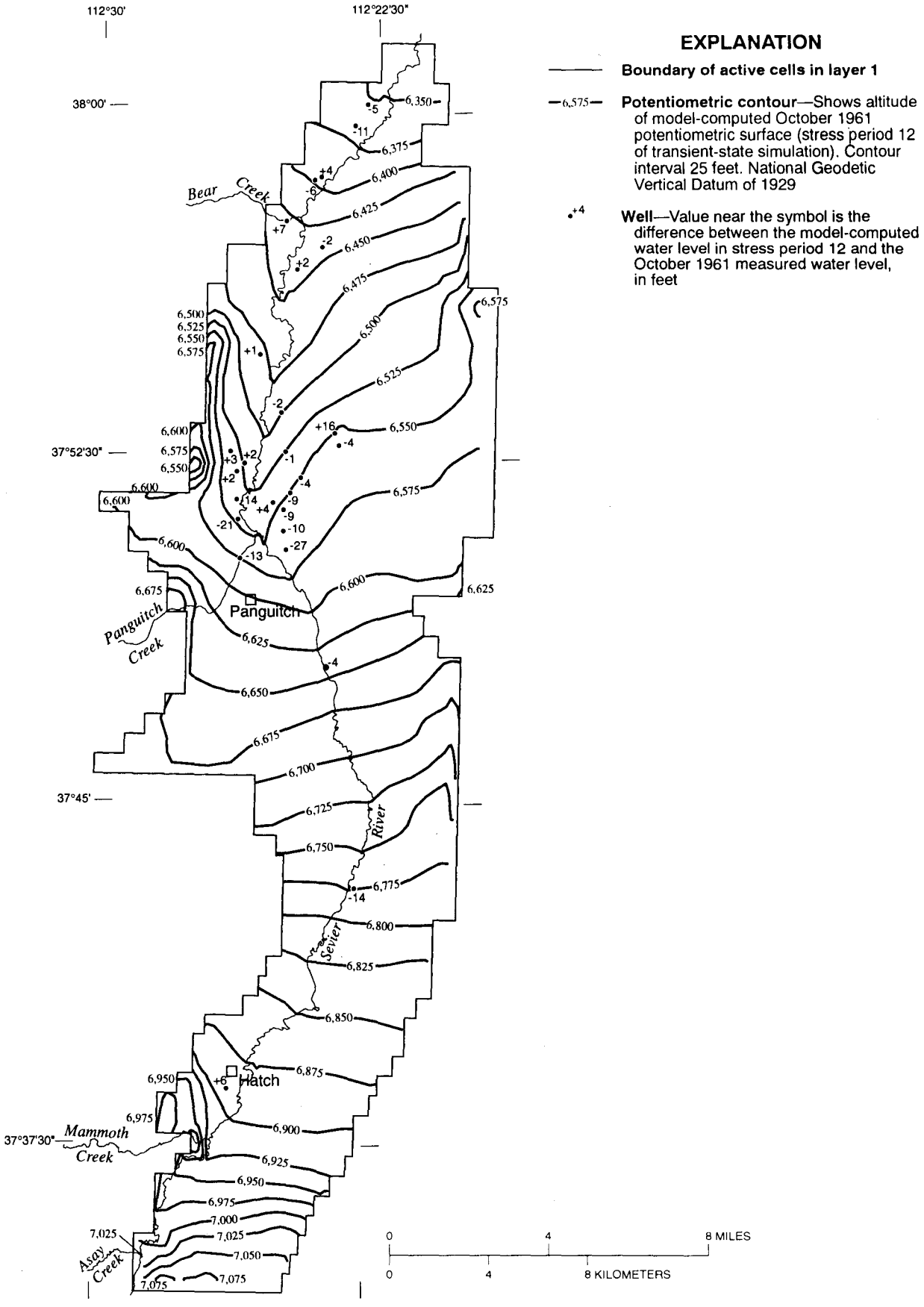


Figure 27. Model-computed potentiometric surface of layer 1 in October 1961 (stress period 12 of transient-state simulation) and the difference between model-computed and measured water levels in October 1961 at selected wells.

The model was also sensitive to changes in hydraulic-conductivity and transmissivity values. When transmissivity values in layer 2 were increased by an order of magnitude, water levels in many cells declined below the bottom of the layer, causing the cells to become dry. A decrease in transmissivity by the same quantity resulted in a substantial rise in water levels. For layers 2 and 3, variations in storage coefficients by an order of magnitude in either direction resulted in minimal changes in water levels. Storage coefficient values for layers 2 and 3 were increased by 2 orders of magnitude with values ranging from 5×10^{-3} to 2×10^{-1}. This increase resulted in a decline in head of up to 9 ft in row 22, column 7, layers 1 through 3, at the end of stress period 12 of the transient-state model.

Because recharge is areally distributed, a change in any one component will affect certain areas of the model differently. Recharge from ephemeral streams was decreased from 80 to 40 percent of the average annual streamflow in order to determine its effect on the simulated system. This decrease resulted in a slight overall decline in model-computed water levels except in the southern part of the modeled area, where most of the recharge is from ephemeral streams. A substantial decline in water levels was simulated in the southern part of the valley.

Simulated Effects of Changing from Flood Irrigation to Sprinkler Irrigation

A change from flood to sprinkler irrigation was simulated to learn more about how changes from flood to sprinkler irrigation might affect ground-water and surface-water relations. An area north of Panguitch that is flood irrigated was chosen as a test area for simulation of the effects of changes in irrigation methods (fig. 28). The test area is supplied with irrigation water by the Barton-Tebbs-LeFevre Ditch from the Sevier River. The average annual quantity of water diverted by the ditch from the Sevier River was 3,840 acre-ft/yr for 1969-85. The ditch is 5.2 mi long. Data used in the establishment of initial conditions were altered to simulate no recharge from unconsumed irrigation water and less flow in the canal transporting surface water to the area.

According to land-use data that was field checked in 1981 (Jaynes and others, 1981), the Barton-Tebbs-LeFevre Ditch supplies irrigation water to about 900 cultivated acres. An estimated 3.8 ft per acre are delivered after losses in transport are subtracted. Assuming that 900 acres would require 1,600 acre-ft/yr of water to satisfy a consumptive-use rate of 21.35 in/yr (1.78 ft/yr) for alfalfa and pasture, 1,780 acre-ft/yr of streamflow would have to be diverted to the canal to be applied on the sprinkler-irrigated fields. Ten percent of this quantity was simulated as leakage from the canal to the aquifer. The storage values used are those determined from the transient-state calibration. The initial water levels used in the simulation were the final water levels computed by the model in the establishment of initial conditions.

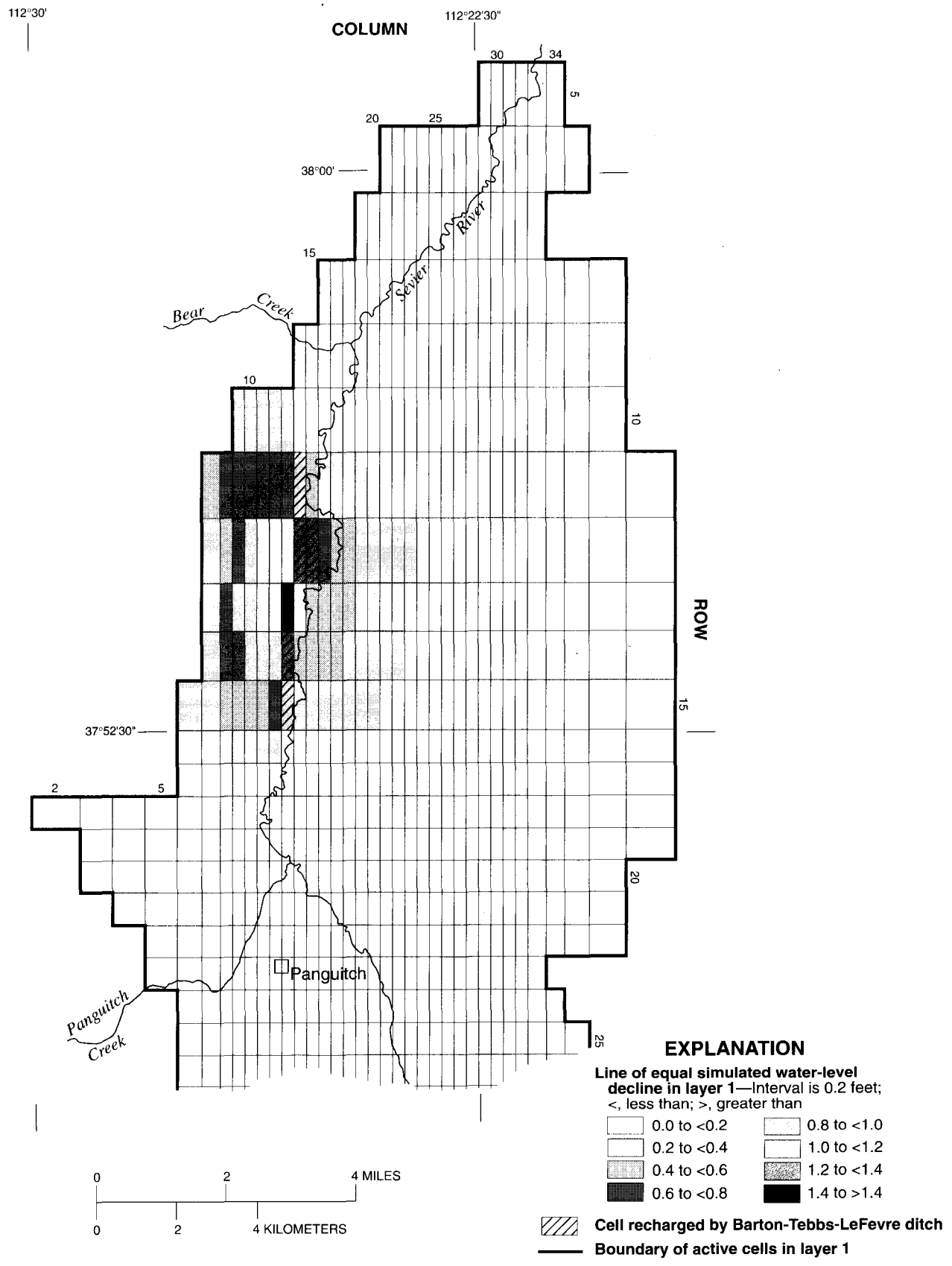


Figure 28. Model-computed water-level changes in layer 1 caused by the simulated conversion from flood to sprinkler irrigation.

The simulation included 11 stress periods representing a total of 25 years. Stress periods 1 through 5 included the first 5 years and represented the period of flood irrigation on the test area. Stress period 1 was divided into 4 time steps of equal length and lasted 1 year. Stress period 2 was divided into 2 time steps of equal length and lasted 1 year. Stress periods 3 through 5 included a total of 3 time steps, each representing 1 year.

Stress periods 6 through 11 included the next 20 years and represented the period of sprinkler irrigation on the test area. Stress period 6 was divided into 20 time steps, each of which was 1.2 times longer than the previous time step. The length of the first time step in stress period 6 was 1.96 days, and the total length of the time steps equaled 1 year. Stress period 7 simulated 1 year and was divided into 10 equal-length time steps. Years 3 through 5 after the conversion to sprinklers were simulated as stress periods 8 through 10. Stress period 8 included 6 time steps, stress period 9 included 4 time steps, and stress period 10 included 2 time steps of equal length. Stress period 11 was divided into 15 equal-length time steps representing a total of 15 years. The large number of time steps used in the early parts of the simulation was necessary to justify early response of the system to changes in stress. Truncation error in the calculation of the partial-differential equation describing transient ground-water flow used by the finite-difference model can occur if the time-step size at the beginning of the stress change is too large.

A major assumption made in this simulation is that the average annual recharge and discharge rates used to establish initial conditions in the valley-fill aquifer are appropriate to simulate the application of seasonal recharge and discharge components. In actuality, most of the stresses last only a part of the year, and storage is a large part of the volumetric budget. The changes in the ground-water system simulated by this model are probably larger than would actually occur.

The influence of the simulated change in irrigation on cells irrigated by the Barton-Tebbs-LeFevre Ditch on surrounding parts of the modeled area at the end of 20 years of sprinkler irrigation is shown in figure 28. Simulated water-level declines on the east side of the area are affected by recharge from the Sevier River, which compensates for the decreased recharge from unconsumed irrigation water. Major sources of recharge are not available on the west side of the area. Smaller values of specific yield on the west side of the area as compared with the east side (fig. 17) result in less water available from storage and a greater water-level decline farther from the sprinkler-irrigated area on the west side. The no-flow boundary representing the contact between the valley fill and consolidated rock on the west side of the valley slightly affects the extent of changes in water level.

The results of the simulation indicate that the change from flood to sprinkler irrigation probably would result in a maximum lowering of water levels by the end of the first year of the conversion (stress period 6, time step 20) of about 0.9 ft. Decreases in water levels were simulated in all three layers, but less of a decrease was simulated in layers 2 and 3. Water levels probably would decrease gradually until the system approached a new state of equilibrium about 5 years after the conversion to sprinklers (stress period 10, time step 2)(fig. 29).

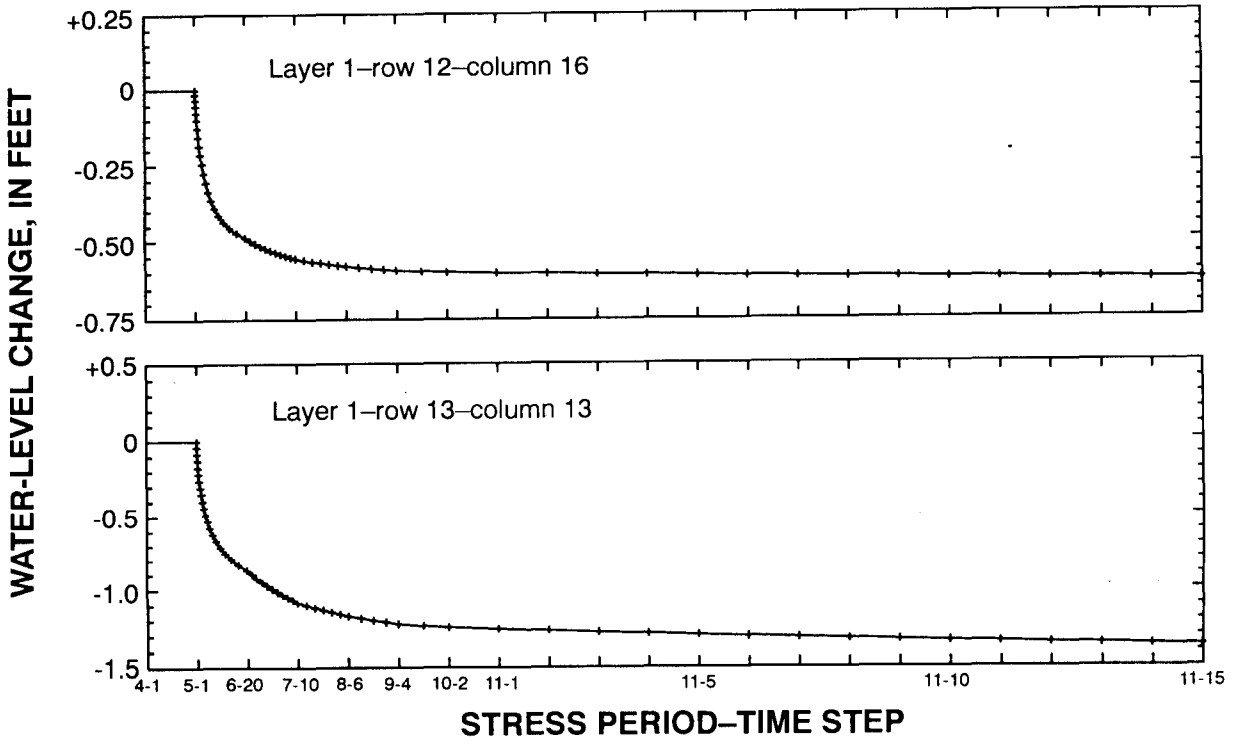


Figure 29. Simulated water-level changes in layer 1 for two cells in the Panguitch Valley model that represent areas converted from flood to sprinkler irrigation.

The results of this simulation indicate that total gains to the Sevier River from the valley-fill aquifer downgradient from the test area probably would decrease by about 660 acre-feet from year 5 (stress period 5, time step 1) the last year of flood irrigation, to year 6 (stress period 6, time step 20), the first year of the conversion to sprinkler irrigation. The system, in relation to the river, likely would approach a new equilibrium 5 years after the conversion from flood to sprinkler irrigation (stress period 10, time step 2), with a loss of 940 acre-ft/yr of ground water that would no longer be discharged to the river downgradient from the test area.

Simulated Effects of Increased Ground-Water Development

Increased ground-water development was simulated using two hypothetical discharging wells in Panguitch Valley to learn more about the effects of increased ground-water development on relations between ground water and surface water. One well is near the town of Panguitch, and the other is in the northeastern part of the valley where the valley-fill deposits are believed to be the thickest (fig. 30). Well 1 represents ground-water withdrawal near Panguitch and simulates pumping from layer 2 of the model at a rate of 1,450 acre-ft/yr (2 ft^3/s). Well 2 represents ground-water withdrawal in the northeastern part of the valley, and simulates pumping from layer 3 of the model at a rate of 2,170 acre-ft/yr (3 ft^3/s). The pumping rates of the two wells represent the addition of large-diameter public-supply, industrial, or irrigation wells to the valley.

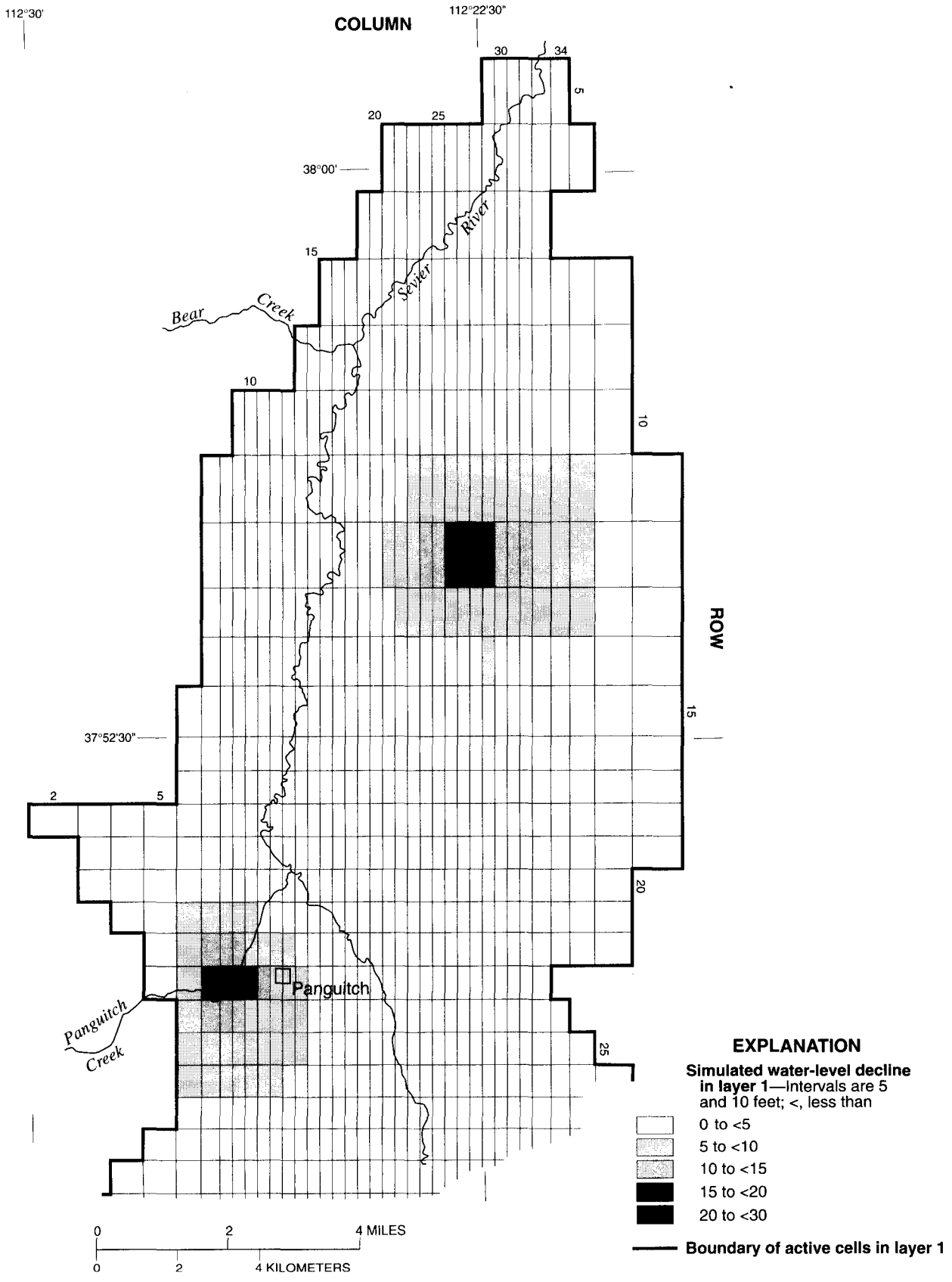


Figure 30. Model-computed water-level changes in layer 1 caused by the simulated increase in ground-water development.

The simulation included 11 stress periods representing a total of 25 years. Stress periods 1 through 5 represented the unstressed ground-water-flow system, and stress periods 6 through 11 represented the addition of pumpage from the two hypothetical wells to the system. The stress periods are divided into time steps as described in the "Simulated effects of changing from flood irrigation to sprinkler irrigation" section of this report. Initial water levels used in the simulation were the final water levels computed by the model in the establishment of initial conditions. Storage values were determined from the transient-state calibration.

Ground-water withdrawals from wells in Panguitch Valley are estimated to be about 100 acre-ft/yr for domestic, stock, and public-supply use. Withdrawal of ground water from wells was not simulated because it is a minor stress when compared with seepage to the Sevier River, canals, and drains, and losses by evapotranspiration. These discharge stresses are applied to layer 1 and their effects propagate down to layers 2 and 3; therefore, these layers were essentially uncalibrated to large changes in stresses. The accuracy of this simulation cannot be tested without additional data, such as an aquifer test using a large discharging well or water-level changes in response to ground-water withdrawals from wells.

According to the results of the simulation, the influence of the simulated pumping extended as much as 1.8 mi from well 1 and as much as 3.2 mi from well 2, at the end of 20 years of pumping (fig. 30). The shape of the cone of depression around well 1 was in part a result of the smaller values of storage coefficient and transmissivity used in this area of the model. The close proximity of well 1 to the no-flow boundary simulating the edge of the valley-fill deposits also affected the cone of depression. The more gradual drawdown gradient and larger area of influence (fig. 30) simulated by well 2 is the result of the relatively large storage coefficient values used in the model for that area.

Results of the simulation indicate that at the end of stress period 6, time step 20, the first year of pumping for the two hypothetical wells, water levels in layer 2 probably would decline about 26 ft at the cell containing well 1, and water levels in layer 3 probably would decline about 20 feet in the cell containing well 2. The water level in layer 2 at well 1 probably would decrease gradually for another 6 years, when a new state of equilibrium would be reached (fig. 31). Water levels in layer 3 at well 2 probably would continue to decline from stress period 7, time step 10 (year 2 of ground-water withdrawals from the well) to stress period 11, time step 13 (year 18 of ground-water withdrawals from the well), when a new state of equilibrium would be reached.

Simulated ground-water withdrawals from the wells probably would result in a decrease in flow of 510 acre-ft between the valley-fill aquifer and the Sevier River during the first year of pumping. Discharge from the valley-fill aquifer to the river probably would continue to decrease until the change in seepage became very small, 12 years after pumping began. Seepage to the river computed at the end of stress period 11, time step 7, the end of the twelfth year of pumping, was 1,930 acre-ft/yr less than seepage that was simulated before the wells were added.

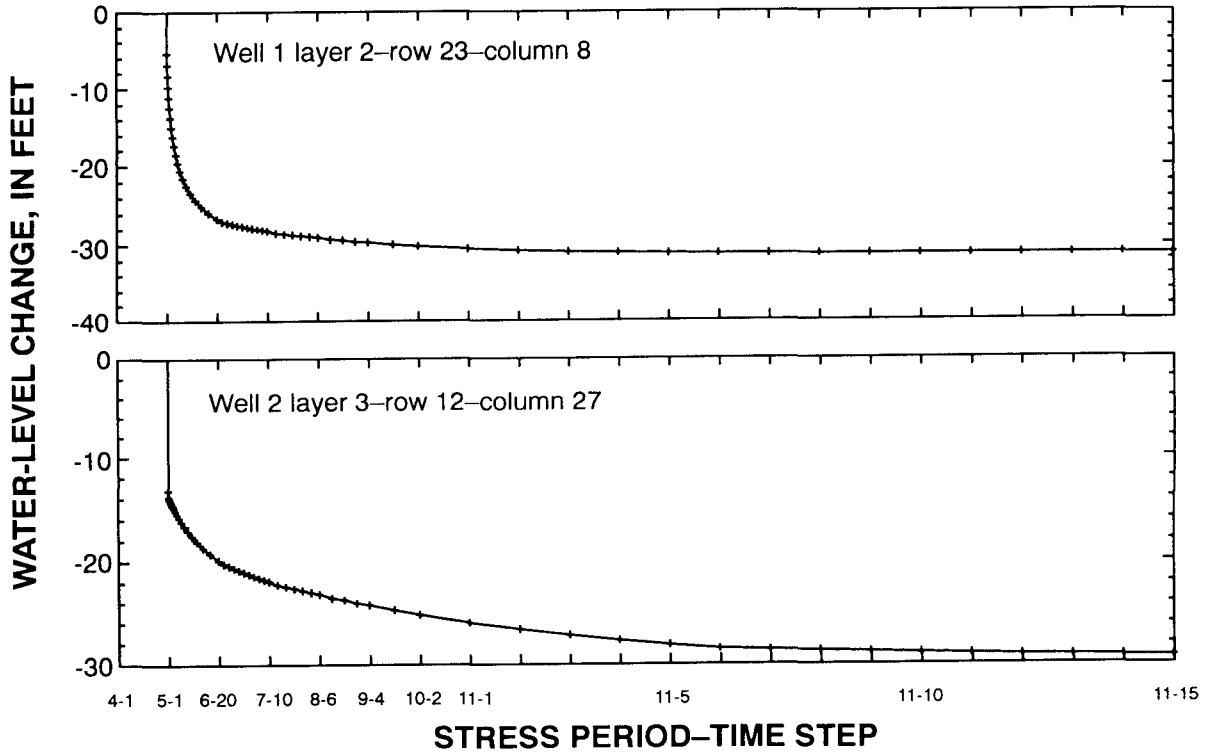


Figure 31. Simulated water-level changes in two cells in the Panguitch Valley model that represent withdrawals from wells.

Limitations of the Model

The ground-water-flow model developed for this study is a simplification of a complex flow system and is one of many models of the system that could be constructed. The accuracy of simulation results is limited by the accuracy of the data that describe boundary conditions, hydraulic properties, and areal recharge and evapotranspiration rates. Most of the data entered into the model represent average conditions or estimates if few data were available. Therefore, the simulation results need to be applied with discretion.

Because of the size of the modeled area, each cell was much larger than the width of the canal, river, drain, or well that it contained. Water levels for each cell represent a computed average for the entire cell rather than for a precise location. Discretization in the vertical direction was very general because of the many stratigraphic changes and the apparent lack of lateral continuity in the layers. The no-flow boundaries surrounding the valley-fill aquifer may have caused larger simulated water-level declines than would have occurred if water was available from the boundaries. Where model cells were large and the hydraulic gradient steep, model-calculated water levels could be quite different from measured water levels.

Hydraulic conditions in the valley-fill aquifer fluctuate throughout the year in Panguitch Valley in response to surface-water irrigation. Irrigation has been practiced in the valley for at least as long as water-level data have been collected. This made determining when the ground-water system was at a steady-state condition (the quantity of water entering the aquifer equals the quantity leaving the aquifer) difficult.

The method used to simulate a period assumed to be representative of conditions resulting from surface-water irrigation in the valley required a model calibrated to a transient-state period. The model used to represent initial conditions is not calibrated to a steady-state condition, but rather simulates conditions during the irrigation season of 1988. The assumption is that conditions during the irrigation season of 1988 are similar to those of any other irrigation season. In actuality, the natural system varies with climatic conditions and the resulting quantity of precipitation, streamflow, and diversion of streamflow to be applied on irrigated fields.

Equal-length stress periods, consisting of one time step each, were used in the transient-state calibrated model. The relatively large time-step size at the beginning of the simulation can cause a poor approximation of the partial-differential equation used by the finite-difference model to describe transient ground-water flow. The large time-step size may cause heads calculated for the beginning part of the simulation to be not as close to measured heads as those calculated later in the simulation.

The paucity of data and simplification of the ground-water-flow system creates some limitations in using the ground-water-flow model for site-specific applications. The areal extent of land being irrigated during the simulated period was not known but was assumed to be equal to that irrigated during 1981, when land-use data were available. If land-use practices were changed substantially from those of 1981, recharge from unconsumed irrigation water might not be properly distributed in the model.

Time of travel through the unsaturated zone was assumed to be short, as indicated by data collected at the soil-moisture monitoring sites, and therefore was not accounted for in applying recharge in the transient-state simulations. This assumption may not be true elsewhere in the valley.

Unconsumed irrigation water was simulated as areal recharge uniformly applied to all areas mapped as irrigated land and not as water from individual canals to downgradient fields. This simplification does not take into account the quantities of water applied or the transmissivity of the soil for a particular area.

Different irrigation practices can also affect the quantity of recharge available from unconsumed irrigation water. Fields irrigated by sprinklers, if correctly managed, contribute less recharge to the valley-fill aquifer than do flood-irrigated fields. This factor must be considered to more accurately determine the quantity of unconsumed irrigation water simulated as recharge in the model.

Recharge from perennial and ephemeral streams and canals was determined to be some percentage of that stream's average annual streamflow by generalizing the type of valley-fill material that it flowed across. These

generalizations were applied to each body of water, regardless of site-specific conditions, so that the percentage of recharge is consistent with the type of stream. Recharge from perennial and ephemeral streams and canals most likely varies significantly with location in the valley. These generalizations result in varying degrees of divergence between model-simulated and measured water levels. Ground-water withdrawals from wells were not simulated in Panguitch Valley because the volume was not significant; therefore, the model is not calibrated to this type of stress.

SUMMARY

The unconsolidated valley-fill deposits that are the primary ground-water reservoirs in the upper Sevier River basin in south-central Utah were studied from 1988 to 1989. Recharge to the valley-fill aquifer in Panguitch Valley, estimated to be from 71,740 to 80,740 acre-ft/yr, is mostly by seepage from streams, canals, and unconsumed irrigation water. Changes in soil-moisture content and water levels were measured in Panguitch Valley at a flood-irrigated alfalfa field and at a sprinkler-irrigated alfalfa field to quantify seepage from unconsumed irrigation water. The lag time between irrigation and water-level response decreased from 6 days to 2 days in the flood-irrigated field as the soil-moisture content increased. Water levels measured in the sprinkler-irrigated field did not respond to irrigation on the field. Seepage from the valley-fill aquifer to the Sevier River in Panguitch Valley is about 53,570 acre-ft/yr.

The occurrence of ground water in the valley-fill deposits of Circle, Grass, and East Fork Valleys is similar to that in Panguitch Valley. Recharge to the valley-fill aquifers is mostly from infiltration of surface water and precipitation.

Water levels fluctuate in response to changes in precipitation occurring at higher elevations and in response to the resulting flow in streams and canals. Water levels measured in wells in irrigated areas rise in the late summer and fall; whereas, those near streams rise in the spring. Most water levels measured in wells in the upper Sevier River basin declined from April to October 1989.

The chemical composition of ground water in the basin is primarily a calcium bicarbonate type and is influenced by the rock that it has come in contact with during its flow history. Dissolved-solids concentrations of ground-water sampled from valley-fill aquifers during this study range from 148 mg/L at a well in Grass Valley to 473 mg/L at a well in Circle Valley. Ground-water inflow to the Sevier River in Panguitch Valley generally increases the specific conductance of the river in a downstream direction.

A three-layer ground-water-flow model was used to estimate the effects of changes in irrigation practices and increased ground-water withdrawals. The establishment of initial conditions consisted of comparing simulated water levels and simulated gains and losses from the Sevier River and selected canals to values of those factors measured during the 1988 irrigation season. The model was calibrated using transient-state information from 1961 to 1963 divided into 36 1-month stress periods. A simulated change from flood- to sprinkler-irrigation in a small area in the northern part of the valley

resulted in a maximum water-level decline of 0.9 ft by the end of the first year of change. Simulation of additional discharge from two wells in the valley resulted in drawdowns of about 20 ft after the first year of pumping.

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Table 5.--*Records of selected springs in the upper Sevier River basin*

[Dashes indicate that data were not collected or information was not available]

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Altitude of land surface: ft, feet above sea level. Interpolated from U.S. Geological Survey topographic maps.
Source of water: Geologic unit from which spring discharges: Valley fill--undivided alluvial, colluvial, and lacustrine deposits of Quaternary and Tertiary age; Claron, Claron Formation of Tertiary age; Consolidated, other rocks of Cretaceous to Tertiary age.
Discharge: gal/min, gallons per minute; E, discharge estimated.
Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius; C, see table 8 for results of chemical analysis; measured in the field except where noted L, laboratory value.
Water temperature: °C, degrees Celsius.

Location	Name of spring	Altitude of land surface (ft)	Source of water	Discharge (gal/min)	Specific conductance (µS/cm)	Water temperature (°C)	Date
			Sevier River drainage area				
(C-30- 3)17cba-S1	Mitchell Slough	6,040	Valley fill	3,670	--	--	08-09-60
(C-30- 3)18bcb-S1	Mitchell Slough	6,040	Valley fill	--	240 C	--	07-20-89
(C-30- 4)16abb-S1	Circleville Spring	7,000	Valley fill	60	85 C	7.0	12-03-62
				--	95 C	14.0	08-31-88
(C-32- 5)35abb-S1	Marshall Slough	6,365	Valley fill	1,350	-- C	--	08- -56
(C-33- 5) 9dcc-S1	South LeFevre Spring	6,460	Valley fill	25	410	18.0	06-17-88
(C-34- 5) 4cdc-S1	--	6,500	Valley fill	--	720 C,L	18.5	08-30-89
(C-34- 5) 4cdc-S2	--	6,500	Valley fill	94	700	11.0	07-27-88
				58	650	11.5	08-02-88
				63	720 C	13.0	08-03-88
(C-34- 5)27cad-S1	--	6,580	Valley fill	--	480 C,L	13.0	08-30-89
(C-35-4.5)19cb-S1	--	6,840	Valley fill	200 E	500	--	05-16-89
(C-35-4.5)25bd-S1	--	7,480	Valley fill	7	540	8.0	11-15-81
				6	--	7.5	05-12-89
(C-35- 5) 1dbd-S1	Bill Phinney Spring	6,840	Valley fill	80 E	--	11.0	05-16-89
(C-35- 5)12dac-S1	Casto Springs	6,860	Valley fill	60 E	465 C,L	12.0	06-07-89
				27	500	12.0	07-27-89
(C-35- 5)25abd-S1	Meyers Springs	6,840	Valley fill	30 E	520	9.0	07-25-89
(C-36-4.5)15bc-S1	--	7,500	Valley fill	60 E	--	--	05-10-89
(C-36- 5)14cdd-S1	Johnson Creek Springs	6,920	Valley fill	--	670	11.0	07-25-89
(C-36- 5)33bd- S1	--	6,960	Valley fill	15	--	--	04-12-89
(C-36- 5)34bd- S1	--	7,120	Valley fill	0.2	--	--	04-12-89
(C-36- 7)31dac-S1	Mammoth Spring	8,250	Claron	--	170 C	5.0	06-17-89
(C-37- 5)32abb-S1	--	7,400	Valley fill	76	455 C,L	8.5	07-25-81
				80	425	9.0	09-17-81
				84 E	475 C	8.0	05-25-82
				69	455	10.0	06-15-88
				80 E	460 C,L	12.0	06-07-89
(C-37- 6)32dac-S1	Upper Asay Spring	7,120	Claron	--	440 C	9.0	07-26-89
(C-37- 6)32ddc-S1	--	7,120	Claron	--	410	11.5	07-26-89
(C-37- 6)33bc -S1	Lower Asay	7,100	Consolidated	13,000	400 C	8.0	10-01-68
(C-37- 6)33ddc-S1	Cub Spring	7,280	Claron	15 E	510	9.0	07-26-89
(C-38- 8)12cdc-S1	Duck Creek Spring	8,560	Claron	--	235	7.0	07-26-89
(C-38- 9)12bdb-S1	--	9,120	Consolidated	33.5	400 C,L	4.0	07-15-81
				20	385	4.5	07-26-89
			East Fork Sevier River drainage area				
(C-27- 1)35cad-S1	Parker Spring	7,260	Valley fill	--	270 C	12.0	06-20-89
(C-32- 2)13bdd-S1	--	6,960	Consolidated	--	205 C	12.0	07-19-89
(C-34- 3)27ddc-S1	Tom Best Spring	7,600	Consolidated	500 E	410 C	10.0	07-31-62
(C-38- 4)31aaa-S1	Yovimpa Spring	8,320	Claron	--	430	7.5	10-22-81
				1.0	460	10.0	06-16-88

Table 6.--*Records of selected wells in*

[Dashes indicate data were not collected

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Owner or user: Refers to last known owner or user.
Use of water: H, domestic or household; I, irrigation; P, public supply; S, stock; U, unused.
Depth drilled: ft, feet below land surface.
Casing: Diameter: in., inches, reported from drillers' logs or measured in the field. Depth: ft, feet
screen reported in feet below land surface, if known, and questioned (?) if extent of perforated
Altitude of land surface: ft, feet above sea level.
Water level: ft, in feet and decimal fractions. Measured except where noted R, reported.
Yield: Rate: gal/min, gallons per minute. F, natural flow; P, pumped.
Water quality: Temperature: °C, degrees Celsius. Specific conductance: µS/cm, microsiemens per
Other data available: W, water-level measurement. See table 7 for additional water-level measurements.

Location	Owner or user	Year drilled	Use of water	Depth drilled (ft)	Casing Diameter (in.)	Casing Depth (ft)	Casing Finish
	Sevier River drainage area						
(C-30- 3)15bba- 1	O. P. Jessen	1920	U	40	24	--	--
16acc- 1	M. Allen	1965	S	120	2	120	P114-120
16bbb- 1	P. J. Jensen	1948	U	407	6	--	--
19dbb- 1	A. Gottfredson	1965	S	65	4	61	P 56- 61
29cbb- 1	S. Smith	1969	S	160	4	160	0
32bbb- 1	U.S. Geological Survey	1962	U	680	1	414	P 27-414
(C-30- 4)13ccb- 1	--	--	H	--	--	--	--
13ddc- 1	R. Wiltshire & R. Sudweeks	1967	S	115	4	115	P110-115
25bcc- 1	P. Morgan	1977	I	165	16	165	P 40-165
25bcc- 2	Circleville & Lost Creek Irrigation Co.	1934	U	133	13	129	P 38-127
35dab- 1	U.S. Geological Survey	1962	U	510	1	207	P 18-207
36ccc- 1	D. Dalton & Sons Inc.	1976	I	185	16	185	P 85-185
(C-32- 5)13cda- 1	T. Perkins	1979	U	140	6	56	0
26aca- 1	V. Perkins	1905	H	20	36	--	--
26aca- 2	D. Perkins	1947	H	88	6	--	--
35bab- 1	U.S. Geological Survey	1962	U	456	1	18	P 9- 18
(C-33- 5) 4ddd- 1	W. P. Woodard	1950	H	83	6	83	0
9adb- 1	C. LeFevre	1930	U	8	38	8	0
9dcd- 1	--	--	U	--	--	--	--
10aba- 1	B. Michaud	1976	H	100	6	100	P 65- 95
10cdd- 1	H. LeFevre	1952	U	111	6	106	0
15cba- 1	C. LeFevre	1947	H	458	4,6	152	0
16add- 3	--	--	U	--	6	--	--
21ccd- 1	M. Schaefer	1972	H	80	7	80	P 40- 50 55- 70
29ddd- 1	L. V. Henrie	1968	S	89	8	89	P 83- 87
32aad- 1	O. K. Nielson	1967	S	86	6	86	0
34bdc- 1	J. Graf	--	H	--	6	--	--
(C-34- 5) 2bcc- 1	A. Alexander	--	U	52	48	52	0

or information was not available]

below land surface. Finish: O, open end; P, perforated. Upper and lower limits of perforations or interval is unknown.

centimeter at 25 degrees Celsius. Measured in field except where noted L, laboratory value. C, see table 8 for results of chemical analysis.

Altitude of land surface (ft)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date	Yield: Rate (gal/min)	Yield: Date	Water quality: Temperature (°C)	Water quality: Specific conductance (µS/cm)	Water quality: Date	Other data available
				Sevier River drainage area				
6,007	-21.69	03-23-88	--	--	--	--	--	W
6,000	-3.83	08-02-88	--	--	--	--	--	
	-8.55	04-14-89						
	-5.10	10-20-89						
6,000	-16.17	10-20-88	--	--	--	--	--	W
6,032	--	--	--	--	13.0	800L	08-02-88	C
6,060	-23.46	08-02-88	--	--	--	--	--	
	-26.52	10-20-88						
	-25.24	04-14-89						
6,100	-66.74	09-29-88	--	--	--	--	--	W
6,038	--	--	--	--	15.0	500	08-31-88	C
6,030	+6.40	08-11-88	0.4F	04-14-89	16.0	600	04-14-89	-
	+6.01	04-14-89	0.6F	10-24-89	15.0	600	10-24-89	
	+5.02	10-24-89						
6,060	-10.82	09-28-88	--	--	13.0	610	06-22-89	W,C
6,060	-11.22	09-28-88	1,475P	08-01-62	12.0	700	05-14-62	W,C
6,086	-39.60	05-19-88	--	--	--	--	--	W
6,110	-60.58	06-17-88	--	--	--	--	--	
	-67.60	04-14-89						
	-65.10	10-24-89						
6,400	-61.68	09-28-88	--	--	--	--	--	
	-54.85	03-15-89						
	-55.02	04-14-89						
	-53.01	10-24-89						
6,360	-11.32	06-17-88	--	--	--	--	--	W
6,360	--	--	--	--	13.0	270	08-31-88	C
6,370	-2.46	09-29-88	0.12F	03-02-87	13.5	285	03-02-87	W,C
6,475	--	--	--	--	16.0	720L	08-31-88	C
6,440	-0.70	05-17-88	--	--	--	--	--	W
6,460	-2.10	04-12-89	--	--	--	--	--	
	-3.05	10-26-89						
6,450	-34.77	04-14-89	--	--	--	--	--	W
6,455	-5.80	05-18-88	--	--	--	--	--	W
6,470	-17.22	09-28-88	--	--	--	--	--	
	-18.13	04-12-89						
	-18.57	10-26-89						
6,445	-6.85	05-18-88	--	--	--	--	--	W
6,505	-35.28	04-14-89	--	--	--	--	--	
	-32.70	10-26-89						
6,520	-44.00	04-12-89	--	--	--	--	--	
	-45.17	10-24-89						
6,510	-32.85	05-17-88	5.7P	09-28-88	12.0	500	05-17-88	C
	-34.10	04-12-89			11.5	--	--	
	-33.00	10-24-89						
6,550	-47.98	04-12-89	--	--	11.0	520	04-12-89	C
	-47.65	10-26-89						
6,610	-45.90	10-16-61	--	--	--	--	--	
	-29.89	10-26-88						
	-39.03	04-12-89						
	-36.37	10-26-89						

Table 6.--*Records of selected wells in*

Location	Owner or user	Year drilled	Use of water	Depth drilled (ft)	Casing Diameter (in.)	Casing Depth (ft)	Casing Finish
(C-34- 5)2cbc- 1	A. Alexander	1947	H	171	6	170	O
3cdc- 1	E. Fransden	--	U	--	--	--	--
3dbd- 1	E. Henrie	1900	U	42	48	42	O
3ddb- 1	W. B. Proctor	1947	H	169	6	164	O
4abd- 1	J. E. Heywood	1931	U	22	4	21	O
4bbc- 1	W. Houston	--	S	--	6	--	--
4ddd- 1	J. Yardley	--	S	21	36	--	--
5dac- 1	S. E. Allen	1968	S	85	6	83	--
5dca- 1	H. Hatch	1978	S	101	6	101	P 70- 85
8abd- 1	D. A. Tebbs	1967	H	74	6	73	O
8adb- 2	D. Wordward	1935	U	166	4	--	--
9ddc- 1	H. Sevy	1968	S	87	6	87	O
10bab- 1	U.S. Geological Survey	1988	U	26	2	26	P 18- 23
10bbb- 1	J. Peterson	1963	S	140	4	140	P 80-140
10cac- 1	F. Proctor	1973	S	152	6	152	P 50- 85 95-150
15ccc- 1	S. Henrie	1964	H	90	8	90	P 70- 90
16acb- 1	J. Orton	1968	S	154	4	154	P151-154
16adc- 1	D. V. Worthen	1961	S	59	4	59	O
16dbd- 1	T. Simkins	--	H	--	--	--	--
16dca- 1	U.S. Geological Survey	1988	U	31	2	29	P 24- 29
17dba- 1	--	--	S	--	--	--	--
17dbb- 1	P. Dickinson	1979	S	118	6	118	P100-118
17dbd- 1	K. Henrie	--	S	--	6	--	--
17dcb- 1	K. Henrie	1967	S	75	6	74	O
20dba- 1	D. Moser	1965	H	122	7	118	--
21aac- 1	R. J. Excell	1968	S	68	6	68	O
21adc- 1	G. Excell	--	S	30	8,24	30	O
21dbd- 1	--	--	U	--	--	--	--
26cbc- 1	S. Allen	1981	U	100	5	95	P 55- 95
27aba- 1	O. DeMaree	--	H	--	5	--	--
27aca- 1	--	--	U	--	6	--	--
27acb- 1	--	--	U	--	32	--	--
27bbc- 1	--	--	U	--	--	--	--

Altitude of land surface (ft)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date	Yield: Rate (gal/min)	Yield: Date	Water quality: Temperature (°C)	Water quality: Specific conductance (µS/cm)	Water quality: Date	Other data available
6,617	-66.81	10-26-88	--	--	--	--	--	W
6,560	-9.80	09-28-88	--	--	--	--	--	W
6,585	-15.34	10-26-88	--	--	--	--	--	
	-22.19	04-12-89						
	-22.68	10-26-89						
6,595	--	--	--	--	10.0	530	10-25-88	
6,495	-13.22	10-16-61	--	--	--	--	--	
	-11.55	05-18-88						
	-12.67	04-12-89						
	-11.61	10-25-89						
6,505	-24.72	05-18-88	--	--	--	--	--	
6,543	-3.74	09-29-88	--	--	--	--	--	W
6,535	--	--	10P	04-11-89	10.0	390	04-11-89	C
6,550	-28.95	05-17-88	--	--	--	--	--	W
6,550	-11.23	07-28-88	--	--	--	--	--	
	-24.61	04-13-89						
	-19.80	10-25-89						
6,535	-15.54	03-08-83	--	--	--	--	--	W
6,570	-23.37	07-28-88	10.5P	04-12-89	11.5	620	04-12-89	
	-37.60	04-13-89						
	-29.08	10-25-89						
6,570	-12.97	11-01-88	--	--	--	--	--	W
6,554	-11.50	05-18-88	15P	07-30-63	10.5	--	07-30-63	W
6,590	-18.08	07-28-88	24P	09-28-88	10.0	530	09-28-88	C
	-35.84	04-12-89						
	-26.09	10-25-89						
6,610	-53.09	07-28-88	--	--	--	--	--	
6,570	-38.62	04-13-89	--	--	--	--	--	
	-35.64	10-25-89						
6,587	-43.09	05-17-88	--	--	--	--	--	W
6,590	-35.65	09-28-88	--	--	--	--	--	
	-35.88	11-03-88						
	-43.68	01-19-89						
	-43.67	02-28-89						
6,585	-21.45	11-02-88	--	--	--	--	--	
6,540	-9.29	04-13-89	--	--	--	--	--	
	-8.74	10-25-89						
6,560	-27.20	09-28-88	--	--	--	--	--	
	-32.69	04-14-89						
	-22.20	10-26-89						
6,540	-3.50	09-28-88	--	--	--	--	--	
	-6.73	04-13-89						
	-5.90	10-25-89						
6,570	-25.53	07-28-88	--	--	--	--	--	
	-31.58	04-13-89						
	-29.79	10-25-89						
6,580	-10.48	04-13-89	--	--	--	--	--	
	-9.40	10-25-89						
6,585	-20.48	07-28-88	--	--	--	--	--	
	-30.32	04-12-89						
	-24.74	10-24-89						
6,570	-16.34	10-26-88	--	--	--	--	--	W
6,560	-10.59	07-28-88	--	--	--	--	--	
	-16.15	04-11-89						
	-14.48	10-24-89						
6,640	-17.68	06-15-88	--	--	--	--	--	W
6,665	-88.59	07-26-88	--	--	--	420	07-26-88	
	-92.32	04-13-89						
	-91.50	10-25-89						
6,640	-55.42	07-26-88	--	--	--	--	--	
	-58.98	04-13-89						
	-57.47	10-25-89						
6,600	-11.56	06-14-88	--	--	--	--	--	
6,570	-0.20	07-28-88	--	--	--	--	--	

Table 6.--*Records of selected wells in*

Location	Owner or user	Year drilled	Use of water	Depth drilled (ft)	Casing Diameter (in.)	Casing Depth (ft)	Casing Finish
(C-34- 5)30ddd- 1	Panguitch City Corp.	1977	P	351	12	351	P225-345
32dcd- 1	R. Nowers	1987	H	110	6	110	P 70-110
(C-35- 4)30cbc- 1	U.S. Forest Service	--	P	--	7	--	--
(C-35- 5) 3aac- 1	T. A. Garrard	1973	H	56	6	56	P 35- 55
24ccb- 1	V. J. Myers	1953	U	350	4,5,6	350	P201-206 258-264 280-290
24dac- 1	A. Tebbs	1975	H	99	12	99	P 57- 63 71- 79
25bbc- 3	K. Duncan	1973	H	130	6	130	P 55-130
35dad- 1	A. M. & K. Waycastor	1978	H	60	6	60	P 52- 60
35ddb- 1	P. Koenings	1967	H	75	8	75	P 70- 75
(C-36- 5)28bdc- 1	U.S. Geological Survey	1962	U	577	1	117	P 18-117
28cda- 1	C. Reber	1982	H	242	8	242	P215-240
29dcb- 1	Town of Hatch	1971	P	350	8,12	208	P120-184
29dcd- 1	do.	1948	P	216	10	--	P105-?
29ddc- 1	do.	1975	P	175	6	173	P 40-170
31cbd- 1	Bryce Woodland Estates	1971	U	100	8	30	0
(C-37- 5)19cad- 1	E. Hoyt	1973	H	89	6	72	P 45- 68
(C-38- 6)14cbd- 1	M. Swapp	1982	U	252	6	252	P190-210 240-250
	East Fork Sevier River drainage area						
(C-26- 1)12dbc- 1	D. Sorenson	1979	S	89	6	89	0
23ddb- 2	A. E. Delange	--	-	200	2	--	--
25acc- 1	A. R. Brown	1905	S	127	2	50	0
25bab- 1	--	--	S	--	--	--	--
25bac- 1	F. Brown	--	S	--	2	--	--
25bdd- 1	Erickson	--	S	--	2	--	--
35dcb- 2	C. Helquist	1945	U	225	10	--	--
36cbb- 1	--	1923	S	200	2	--	--
(C-27 -1) 2cdb- 1	R. Torgeson	1966	S	152	2	152	0 --
3bca- 1	--	--	S	--	2	--	--
3dac- 1	E. Torgeson	1976	S	78	6	78	0
3dba- 1	A. Anderson	1965	S	138	2	138	0
10acb- 1	T. Torgeson	1976	H	95	6	95	0
10ada- 1	T. Torgeson	--	S	--	6	--	--

Altitude of land surface (ft)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date	Yield: Rate (gal/min)	Yield: Date	Water quality: Temperature (°C)	Water quality: Specific conductance (µS/cm)	Water quality: Date	Other data available
6,800	-210.35	08-03-88	--	--	--	--	--	
6,700	-86.22	08-31-88	--	--	13.0	390L	08-31-88	C
	-93.62	04-12-89						
	-92.11	10-25-89						
7,580	-67.74	08-04-88	--	--	--	--	--	
6,690	-30.31	04-13-89	--	--	10.0	550	04-13-89	
	-29.11	10-25-89						
6,730	-64.70	06-15-88	--	--	--	--	--	
	-66.07	10-26-88						
	-63.85	04-12-89						
6,810	-29.97	04-14-89	--	--	--	--	--	
6,740	--	--	--	--	12.0	430	08-31-88	C
6,790	-24.12	09-27-88	--	--	12.0	750L	06-21-89	C
	-31.14	04-14-89						
	-27.70	10-26-89						
6,790	-26.67	04-14-89	--	--	--	--	--	
6,870	-1.87	05-18-88	--	--	--	--	--	W
6,960	-95.29	09-28-88	--	--	--	--	--	
	-95.86	10-25-89						
7,020	-104.54	06-15-88	--	--	--	--	--	
	-106.27	10-25-89						
6,940	-46.5	09-25-61	55P	09-01-88	12.0	340	09-01-88	C
	-49.0	05-28-62						
	-46.0	10-29-62						
	-44.0	12-03-62						
6,910	-27.61	05-27-81	--	--	--	--	--	
	-28.39	06-15-88						
	-28.12	10-25-89						
7,090	-25.99	04-11-89	--	--	--	--	--	W
7,113	-8.35	04-11-89	--	--	--	700	06-15-88	W,C
7,320	-152.75	06-15-88	--	--	--	--	--	
			East Fork Sevier River drainage area					
6,915	+8.26	05-19-88	0.75F	04-15-89	9.0	370	05-19-88	C
	+7.40	04-15-89			12.0	375L	09-01-88	
					9.0	385	04-15-89	
					10.5	370	10-21-89	
6,872	+8.90	09-28-88	--	--	13.0	200L	07-27-88	W,C
6,863	+11.20	03-15-89	2F	01-06-61	--	--	--	W
6,890	+7.50	08-11-88	--	--	12.5	120	04-15-89	
6,870	+8.40	08-11-88	0.8F	08-11-88	13.0	130	04-15-89	
	+7.90	04-15-89	0.7F	04-15-89	10.0	130	10-21-89	
	+8.80	10-21-89	0.3F	10-21-89				
6,860	+11.47	08-11-88	6F	08-11-88	10.0	75	10-21-89	
	+11.00	10-28-88	3.6F	10-21-89	11.0	115	04-15-89	
	+13.65	04-15-89						
	+14.15	10-21-89						
6,835	+17.55	08-31-62	10F	08-31-62	11.5	265	09-30-88	C
6,830	+15.40	08-14-62	4F	08-14-62	11.5	235	04-15-89	
	+12.50	04-15-89			10.0	235	10-21-89	
	+13.90	10-21-89						
6,795	+6.25	04-15-89	0.3F	04-15-89	10.0	220	04-15-89	
	+4.20	10-21-89	0.45F	10-21-89	9.0	215	10-21-89	
6,875	+4.97	08-03-88	7.1F	08-03-88	14.5	250	08-03-88	
	+7.78	10-21-89	4F	10-21-89	13.5	232	10-21-89	
6,810	+1.88	08-10-88	0.25F	04-15-89	12.0	200	04-15-89	
	+1.05	04-15-89			8.0	195	08-21-89	
6,830	-7.59	08-10-88	--	--	--	--	--	
6,825	-6.15	08-10-88	--	--	--	--	--	
	-10.90	10-21-89						
6,790	+2.85	08-10-88	0.5F	04-15-89	10.0	620	04-15-89	
	+3.07	04-15-89	0.35F	10-21-89	9.5	630	10-21-89	
	+2.20	10-21-89						

Table 6.--*Records of selected wells in*

Location	Owner or user	Year drilled	Use of water	Depth drilled (ft)	Casing Diameter (in.)	Casing Depth (ft)	Casing Finish
(C-27- 1)10dab- 1	I. Torgeson	1980	S	169	6	169	0
16aaa- 1	W. Bagley	1978	S	47	6	47	0
16aab- 1	J. Bagley	--	S	--	6	--	--
27abc- 2	H. B. Crandall	1910	S	260	2	--	0
(C-29- 2)35bad- 1	G. D. Moore	1952	H	197	6	161	0
(C-30- 2)28bdc- 1	Utah Parks and Recreation	--	P	135	10	--	--
34bcc- 1	J. Wyley	--	H	20	24	--	--
(C-31- 2)10add- 2	G. Proctor	1971	U	310	12	213	0
10dad- 1	--	--	U	--	--	--	--
24cbc- 1	E. Gleave	1952	U	114	6	114	0
35bda- 1	C. Wiley	1942	-	63	4	63	0
(C-33- 2) 3dab- 1	State Lands and Forestry	1984	S	92	6	92	P 50- 92
4dad- 1	do.	1984	S	268	6	268	P168-268
8dad- 1	do.	1984	S	128	6	128	P 40-128
10ada- 1	M. Johnson	--	U	--	6	--	--
10adb- 1	do.	--	H	--	8	--	--
22aab- 1	U.S. Geological Survey	1962	U	290	1	117	P 18-117
(C-34- 2)30ccc- 1	do.	1962	U	520	1	117	P 18-117
(C-34- 3)25dcd- 1	--	--	U	--	3	--	--
(C-35- 4)25aab- 1	--	--	U	--	6	--	--
34dca- 1	M. Rich	1933	U	14	48	14	0
34dca- 2	do.	1952	U	170	6	10	0
(C-36- 3) 6dba- 1	U.S. Federal Aviation Administration	1945	H	123	6	--	--
7bbc- 1	U.S. Bureau of Land Management	1952	P	230	6	230	P 46-230
7bca- 1	do.	1946	P	131	6	131	P 50-130
7dcd- 1	C. Syrett	1978	U	165	4	165	P 45-165
7ddc- 1	do.	1978	U	195	4 6	195 43	P 50- 85 95-110 150-185
7ddd- 1	do.	1981	U	145	4	145	P 45-145
7ddd- 2	do.	1978	U	145	4,6	145	P 30-145
7ddd- 3	do.	1978	U	145	4	145	P 35-143
8bcb- 1	D. Hatch	1976	U	103	8	103	P 65-100
18acd- 1	C. Syrett	1960	U	100	12	100	P 5-100

Altitude of land surface (ft)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date	Yield: Rate (gal/min)	Yield: Date	Water quality: Temperature (°C)	Water quality: Specific conductance (µS/cm)	Water quality: Date	Other data available
6,790	+7.33	09-30-88	2F	08-10-88	12.0	235L	08-10-88	W,C
			1.15F	04-15-89	11.5	230	09-30-88	
			1.10F	10-21-89	12.5	240	04-15-89	
					11.5	235	10-21-89	
6,830	-18.69	08-03-88	--	--	--	--	--	
	-18.15	04-15-89						
	-24.80	10-21-89						
6,830	-24.30	08-04-88	--	--	--	--	--	W
6,739	+2.90	04-15-89	0.25F	04-15-89	11.0	240	05-19-88	W,C
			--	--	11.0	245	04-15-89	
6,405	-19.20	10-31-61	--	--	15.0	460L	07-27-88	C
6,400	-42.65	03-01-89	--	--	13.0	410	07-27-88	W,C
6,370	-11.55	03-01-89	--	--	--	--	--	W
6,450	-158.78	09-30-88	--	--	--	--	--	
	-176.75	10-27-88						
6,540	-152.47	03-01-89	--	--	--	--	--	W
6,590	-90.60	04-15-89	--	--	--	--	--	
6,500	-19.52	04-15-89	--	--	--	--	--	
7,215	-37.50	08-30-88	--	--	--	--	--	W
7,300	-173.30	08-02-88	--	--	--	--	--	
7,345	-16.16	08-02-88	--	--	--	--	--	
	-22.48	10-25-89						
7,197	-1.09	08-30-88	--	--	--	--	--	
7,199	-6.50	08-30-88	--	--	--	--	--	
7,225	-4.18	09-22-88	--	--	--	--	--	W
7,405	-62.81	09-22-88	--	--	--	--	--	W
7,416	-75.75	08-30-88	--	--	--	--	--	W
7,630	-1.90	09-29-88	--	--	--	--	--	
	-0.93	04-13-89						
7,690	-6.84	09-29-88	--	--	--	--	--	W
7,690	-6.98	06-14-81	--	--	--	--	--	
	-8.58	09-29-88						
7,580	-32.48	05-17-88	--	--	10.0	415	08-30-88	W,C
7,610	-28.23	04-13-89	--	--	--	--	--	W
7,610	-14.82	06-15-81	--	--	--	--	--	
	-12.90	09-29-88						
	-15.82	03-01-89						
	-16.08	04-13-89						
	-13.71	10-25-89						
7,630	-22.50	06-16-88	--	--	--	--	--	W
7,630	-22.87	06-16-88	--	--	--	--	--	W
7,630	-13.32	06-13-81	--	--	--	--	--	
	-13.70	07-17-81						
	-13.77	07-25-81						
	-15.20	06-16-88						
7,630	-13.80	07-17-81	--	--	--	--	--	
	-13.45	06-13-81	--	--	--	--	--	
	-15.39	06-16-88	--	--	--	--	--	
7,630	-8.50	06-13-81	--	--	--	--	--	
	-9.01	07-17-81						
	-9.11	07-25-81						
	-10.10	06-16-88						
7,600	-5.25	07-25-81	--	--	--	--	--	
	-4.84	06-16-88						
	-5.80	10-25-89						
7,650	-1.75	08-28-61	--	--	--	--	--	
	-1.50	09-29-88						
	-1.15	10-27-88						

Table 6.—*Records of selected wells in the*

Location	Owner or user	Year drilled	Use of water	Depth drilled (ft)	Casing Diameter (in.)	Casing Depth (ft)	Casing Finish
(C-36- 4) 1aab- 1	L. Chynoweth	1982	U	91	6	91	P 60- 85
2dca- 1	R. Ott	1950	U	310	6	66	0
2dca- 2	D. Wintch	1978	U	216	6	78	0
2dca- 3	Utah Department of Transportation	1969	P	125	8,12	125	P100-125
3dad- 1	Ott	--	H	--	6	--	--
10bbd- 1	L. Ott	1956	U	136	6	136	P 70- 76 116-122 130-136
12baa- 1	C. Syrett	1978	P	153	6	114	P 94-113
12baa- 2	do.	1978	P	114	8	114	P 94-114
12baa- 3	do.	1978	P	140	6	122	P110-?
15cbc- 1	U.S. Forest Service	1965	U	51	10	38	P 22- 32
34bda- 3	U.S. National Park Service	--	U	34	12,16	34	--
36acc- 1	do.	1948	U	80	8,12,48	80	0

Altitude of land surface (ft)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date	Yield: Rate (gal/min)	Yield: Date	Water quality: Temperature (°C)	Water quality: Specific conductance (µS/cm)	Water quality: Date	Other data available
7,600	-40.59	09-29-88	--	--	--	--	--	
	-39.94	04-13-89						
	-42.96	10-25-89						
7,620	-18.99	06-16-88	--	--	--	--	--	W
7,620	-21.63	04-13-89	--	--	--	--	--	W
7,620	-14.22	06-14-81	--	--	--	--	--	
	-19.52	06-16-88						
	-31.85	10-25-89						
7,660	-38.00	06-16-88	--	--	--	--	--	W
7,670	-51.77	06-16-88	--	--	--	--	--	W
7,640	-42.42	06-15-81	--	--	--	--	--	
	-54.90	07-28-88						
7,640	-42.45	06-15-81	--	--	--	--	--	
	-52.40	07-28-88						
7,640	-59.19	10-25-89	--	--	--	--	--	W
7,690	5.80	05-20-68						
	-6.25	06-14-81	--	--	--	--	--	
	-5.50	06-04-88						
7,780	-4.19R	06-26-89	--	--	--	--	--	W
7,920	-30.0	09-11-61	10P	02-22-59	--	--	--	
	-26.74	06-12-81						
	-26.60	06-16-88						

Table 7.--*Water levels in selected wells in the upper Sevier River basin*

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Altitude (ALT.): Altitude of land surface, in feet above sea level.
Water levels are in feet above (+) or below (-) land surface.
Letters appearing after measurements: E, estimated; F, flowing; R, reported; S, nearby well being pumped; T, recently pumped; X, water level influenced by flow in nearby ditch or canal.

Sevier River drainage area

(C-30- 3)15bba- 1 ALT. 6,007

SEP 09, 1935	-13.90	OCT 31	-19.84	NOV 25	-21.52	OCT 10	-14.45
OCT 12	-15.71	NOV 05	-20.48	30	-21.94	15	-15.33
JAN 27, 1936	-24.80	10	-21.03	DEC 05	-22.30	20	-16.11
APR 20	-26.46	15	-21.57	10	-22.72	25	-16.70
JUN 17	-12.39	20	-22.04	15	-23.08	31	-17.00
AUG 04	-12.84	25	-22.36	20	-23.43	NOV 05	-17.24
SEP 28	-14.55	30	-22.68	25	-23.77	10	-17.34
NOV 26	-20.56	DEC 05	-23.05	31	-24.12	15	-17.54
FEB 09, 1937	-26.58	10	-23.42	JAN 05, 1958	-24.40	20	-17.67
MAR 26	-28.05	15	-23.79	10	-24.68	25	-17.80
JUN 07	-10.38	20	-24.12	15	-24.95	DEC 05	-18.45
AUG 24	- 8.13	25	-24.45	20	-25.18	10	-18.95
DEC 07	-19.43	31	-24.81	25	-25.41	15	-19.48
FEB 22, 1938	-24.17	JAN 05, 1957	-25.10	31	-25.66	20	-19.92
APR 12	-24.73	10	-25.37	FEB 05	-25.85	25	-20.34
JUL 15	- 8.18	20	-25.64	10	-26.03	31	-20.85
AUG 24	- 8.38	25	-26.06	15	-26.21	JAN 05, 1959	-21.19
OCT 05	-10.30	31	-26.32	20	-26.30	10	-21.50
DEC 19	-20.59	FEB 05	-26.52	25	-26.49	15	-21.82
MAR 02, 1939	-23.19	10	-26.71	28	-26.58	20	-22.08
APR 21	-24.21	25	-27.19	MAR 05	-26.70	25	-22.35
AUG 21	- 8.56	28	-27.26	10	-26.83	31	-22.65
OCT 18	-16.89	MAR 05	-27.35	15	-26.94	FEB 05	-22.98
DEC 07	-21.85	10	-27.37	20	-27.04	10	-23.19
MAR 25, 1940	-25.82	15	-27.38	25	-27.10	15	-23.38
DEC 07	-23.34	APR 10	-27.17	31	-27.16	20	-23.53
MAR 21, 1941	-26.79	15	-25.66	APR 05	-27.21	25	-23.66
OCT 08	-13.88	20	-24.91	10	-27.25	28	-23.72
DEC 03	-19.12	25	-24.38	15	-27.30	MAR 05	-23.80
MAR 17, 1942	-23.19	MAY 05	-22.52	20	-27.27	10	-23.89
AUG 08	- 8.21	20	-19.90	25	-26.63	15	-23.96
DEC 07	-19.36	JUN 15	-17.33	30	-25.64	20	-24.02
MAR 10, 1943	-22.03	20	-17.72	MAY 05	-24.16	25	-23.90
DEC 15	-19.42	25	-16.47	10	-22.62	31	-23.90
MAR 18, 1944	-23.10	30	-15.96	15	-20.40	APR 05	-23.96
DEC 03	-18.75	JUL 05	-16.55	20	-19.12	10	-23.36
APR 03, 1945	-22.90	10	-15.84	25	-15.42	15	-20.93
DEC 07	-20.23	15	-15.24	31	-14.31	20	-21.40
MAR 20, 1946	-23.58	20	-15.91	JUN 05	-13.28	25	-20.38
DEC 16	-20.27	25	-14.52	10	-12.71	30	-18.82
MAR 26, 1947	-23.61	31	-14.45	15	-13.05	MAY 05	-18.86
DEC 10	-20.56	AUG 05	-14.36	20	-11.72	10	-18.04
MAR 16, 1948	-24.15	10	-14.18	25	-12.10	15	-16.94
JUL 21	-10.36	15	-13.49	30	-12.60	20	-16.97
DEC 10	-19.70	20	-13.79	JUL 05	-10.71	25	-16.63
APR 03, 1949	-23.76	25	-13.92	10	-11.78	30	-16.03
DEC 10	-19.81	31	-13.77	15	-11.89	JUN 05	-15.68
MAR 29, 1950	-23.87	SEP 05	-12.68	20	-10.56	10	-15.08
DEC 09	-19.83	10	-11.91	25	-11.95	15	-15.43
MAR 26, 1951	-24.79	15	-13.00	31	-11.56	20	-15.30
DEC 09	-21.70	20	-12.80	AUG 05	-11.04	25	-13.98
APR 06, 1952	-26.66	25	-13.89	10	-12.21	30	-15.07
DEC 07	-18.70	30	-14.68	15	-11.97	JUL 05	-14.48
MAR 16, 1953	-23.87	OCT 05	-15.10	20	-11.04	10	-13.59
DEC 10	-20.92	10	-16.02	25	-11.87	15	-14.53
MAR 25, 1954	-25.57	15	-16.77	31	-11.04	20	-14.42
DEC 02	-21.53	20	-17.55	SEP 05	-10.74	25	-13.86
DEC 04, 1955	-19.37	25	-18.31	10	-11.38	31	-14.80
MAR 20, 1956	-26.44	31	-19.08	15	-11.52	AUG 05	-13.93
SEP 11	-15.65	NOV 05	-19.66	20	-11.36	10	-13.97
OCT 04	-15.70	10	-20.17	25	-12.34	15	-14.75
13	-16.90	15	-20.62	30	-12.78	20	-13.94
26	-19.15	20	-21.08	OCT 05	-13.46	25	-13.31

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-30- 3)15bba- 1--Continued

AUG 31, 1959	-14.48	MAR 05, 1960	-25.76	MAR 30, 1962	-27.58	OCT 04, 1971	-11.09
SEP 05	-13.38	10	-25.96	APR 30	-22.44	MAR 01, 1972	-23.58
10	-13.47	15	-26.16	MAY 28	-16.08	OCT 05	-10.44
15	-14.27	20	-26.36	JUL 03	-13.41	MAR 08, 1973	-23.75
20	-13.16	25	-26.56	AUG 01	-12.29	OCT 12	-11.84
25	-13.59	31	-26.76	28	-12.78	MAR 20, 1974	-22.56
30	-13.06	APR 05	-26.85	SEP 24	-12.39	OCT 07	-11.86
OCT 05	-14.78	10	-26.10	OCT 29	-17.19	MAR 13, 1975	-22.69
10	-16.02	15	-25.45	DEC 03	-20.57	OCT 21	-12.88
15	-16.94	20	-23.90	26	-22.24	MAR 25, 1976	-23.80
20	-17.70	25	-22.28	JAN 28, 1963	-23.87	OCT 04	- 9.87
25	-18.29	30	-22.04	FEB 27	-25.05	MAR 01, 1977	-23.51
31	-18.75	MAY 05	-20.78	MAR 25	-25.80	OCT 05	-10.53
NOV 05	-19.15	10	-18.83	APR 29	-20.80	OCT 03, 1978	- 9.31
10	-19.55	23	-16.53	MAY 28	-15.77	MAR 12, 1979	-24.09
15	-19.95	JUN 20	-15.14	JUL 01	-13.85	OCT 01	- 6.58
20	-20.35	JUL 25	-13.81	30	-12.48	MAR 05, 1980	-21.29
25	-20.51	AUG 31	-14.73	AUG 28	-11.95	OCT 01	- 7.82
30	-20.50	SEP 26	-14.70	SEP 23	-11.24	MAR 03, 1981	-20.89X
DEC 05	-20.56	OCT 25	-18.73	DEC 04	-19.26	OCT 01	- 8.43
10	-20.87	NOV 25	-20.60	APR 08, 1964	-26.93	MAR 02, 1982	-21.78
15	-21.29	DEC 29	-23.75	SEP 24	-10.44	SEP 21	-12.66
20	-21.74	JAN 26, 1961	-25.68	DEC 07	-19.41	MAR 02, 1983	-21.28
25	-22.12	FEB 23	-27.65	MAR 19, 1965	-25.53	SEP 19	-10.25
31	-22.53	MAR 20	-28.08	SEP 10	-10.86	MAR 08, 1984	-19.68
JAN 05, 1960	-22.88	APR 21	-25.90	MAR 07, 1966	-24.30	SEP 26	- 9.40
10	-23.23	MAY 22	-17.60	OCT 04	-10.81	MAR 12, 1985	-18.17
15	-23.58	JUL 03	-15.19	MAR 03, 1967	-24.40	SEP 30	- 8.71
20	-23.93	25	-12.38	SEP 13	- 8.94	MAR 06, 1986	-21.74
25	-24.18	AUG 22	-13.84	MAR 04, 1968	-25.41	SEP 17	- 8.88
31	-24.46	SEP 25	-13.19	SEP 30	- 8.88	MAR 18, 1987	-21.63
FEB 05	-24.66	OCT 30	-18.50	MAR 12, 1969	-23.83	JUL 21	- 8.61
10	-24.84	NOV 27	-21.50	OCT 07	-12.72	SEP 28	- 9.77
15	-25.05	DEC 27	-23.61	MAR 09, 1970	-23.10	MAR 23, 1988	-21.69
20	-25.26	FEB 01, 1962	-25.40	OCT 06	-10.66	SEP 20, 1989	-10.06
25	-25.40	MAR 05	-26.59	MAR 12, 1971	-24.23		
29	-25.56						

(C-30- 3)16bbb- 1 ALT. 6,000

MAR 25, 1987	-16.99	MAR 23, 1988	-17.33	SEP 14, 1988	-16.12	MAR 09, 1989	-16.62
JUL 21	-16.48	APR 29	-16.48	OCT 20	-16.17	APR 12	-16.73
AUG 20	-16.40	MAY 18	-16.25	NOV 30	-16.87	MAY 24	-16.42
SEP 28	-15.78	JUN 23	-15.99	DEC 29	-17.21	JUN 26	-16.51
OCT 14	-15.65	JUL 12	-16.17	JAN 26, 1989	-17.57	JUL 19	-16.88
DEC 07	-16.27	AUG 16	-15.90	FEB 23	-17.14	SEP 20	-16.29

(C-30- 3)32bbb- 1 ALT. 6,100

OCT 01, 1962	-67.49	SEP 23, 1963	-74.12	SEP 26, 1984	-66.98	DEC 07, 1988	-66.70
29	-73.78	MAR 12, 1979	-73.62	MAR 14, 1985	-66.80	JAN 04, 1989	-66.41
DEC 03	-73.16	OCT 01	-71.52	OCT 01	-66.51	18	-66.60
26	-73.10	MAR 05, 1980	-69.82	MAR 20, 1986	-66.60	MAR 01	-66.45
JAN 28, 1963	-73.43	OCT 01	-69.03	SEP 17	-66.49	APR 11	-66.45
FEB 27	-73.61	MAR 03, 1981	-68.32	MAR 02, 1987	-66.35	MAY 09	-66.49 S
MAR 25	-73.73	OCT 01	-68.53	SEP 10	-66.66	JUN 06	-66.57
APR 29	-73.81	MAR 02, 1982	-68.46	MAR 23, 1988	-66.73	JUL 19	-66.69
MAY 29	-73.88	SEP 21	-68.52	MAY 19	-66.78	AUG 28	-66.84
JUL 02	-73.93	MAR 02, 1983	-67.98	JUL 29	-66.76	SEP 28	-66.97
30	-73.97	SEP 19	-67.93	SEP 29	-66.74	OCT 24	-67.06
AUG 28	-74.06	MAR 08, 1984	-67.28	OCT 25	-66.62		

(C-30- 4)25bcc- 1 ALT. 6,060

SEP 28, 1988	-10.82	MAR 01, 1989	-10.62	MAY 09, 1989	-13.23	OCT 24, 1989	-14.43
OCT 25	-11.85	APR 14	-13.54	SEP 28	-15.05		

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-30- 4)25bcc- 2 ALT. 6,060

APR 12, 1938	-20.50	AUG 08, 1942	-13.38	DEC 10, 1949	-18.33	NOV 27, 1961	-23.5
JUL 15	-15.00	DEC 17	-16.59	MAR 29, 1950	-16.82	DEC 27	-24.0
AUG 24	-14.76	MAR 11, 1943	-19.57	JUL 27	-14.18	FEB 01, 1962	-23.5
OCT 06	-16.08	DEC 15	-18.10	DEC 09	-16.77	MAR 05	-24.5
DEC 19	-18.23	MAR 18, 1944	-19.05	MAR 26, 1951	-19.19	30	-24.5
MAR 02, 1939	-19.88	DEC 03	-17.43	MAR 20, 1956	-22.71	APR 30	-23.14
APR 21	-23.22	APR 03, 1945	-19.86	OCT 25, 1960	-23.0	MAY 28	-18.70
AUG 21	-18.70	DEC 07	-17.82	NOV 25	-22.0	JUL 03	-17.52
OCT 18	-18.73	MAR 26, 1946	-18.90	DEC 29	-23.0	AUG 01	-35.0
DEC 07	-19.39	DEC 16	-20.25	JAN 26, 1961	-24.0	28	-35.5
MAR 25, 1940	-21.04	MAR 26, 1947	-20.68	FEB 23	-24.5	SEP 24	-36.00
DEC 07	-20.95	DEC 10	-20.00	MAR 22	-24.0	OCT 29	-20.07
MAR 21, 1941	-23.20	MAR 16, 1948	-20.52	SEP 25	-22.5	DEC 03	-20.87
OCT 08	-16.06	JUL 21	-16.36	26	-21.54	SEP 28, 1988	-11.22
DEC 03	-18.22	DEC 10, 1948	-19.08	OCT 30, 1961	-22.5		
MAR 17, 1942	-21.68	APR 03, 1949	-18.29				

(C-30- 4)35dab- 1 ALT. 6,086

OCT 01, 1962	-47.34	OCT 24, 1967	-41.35	OCT 05, 1977	-45.80	SEP 17, 1986	-33.72
29	-46.20	MAR 04, 1968	-41.14	MAR 12, 1978	-45.51	MAR 02, 1987	-39.41
DEC 03	-46.93	SEP 30	-37.06	17	-47.03	SEP 10	-35.29
26	-47.70	MAR 14, 1969	-44.43	OCT 03	-43.25	MAR 23, 1988	-40.46
JAN 28, 1963	-48.23	OCT 07	-38.34	MAR 12, 1979	-44.51	MAY 19	-39.60
FEB 27	-48.73	MAR 09, 1970	-44.09	OCT 01	-36.70	JUL 29	-35.17
MAR 25	-48.96	OCT 06	-41.97	MAR 05, 1980	-42.38	SEP 29	-35.01
APR 29	-47.85	MAR 12, 1971	-45.20	OCT 01	-34.90	OCT 25	-34.96
MAY 29	-45.88	OCT 04	-42.94	MAR 03, 1981	-39.03	DEC 07	-35.20
JUL 02	-47.00	MAR 01, 1972	-37.41	OCT 01	-38.47	JAN 04, 1989	-35.82
30	-48.29	OCT 05	-44.79	MAR 02, 1982	-40.29	MAR 01	-30.79
AUG 28	-48.52	MAR 02, 1973	-46.25	SEP 21	-36.18	15	-34.79
SEP 23	-48.33	OCT 02	-37.83	MAR 02, 1983	-39.25	APR 11	-38.18
APR 07, 1964	-48.60	MAR 18, 1974	-42.42	SEP 19	-33.18	MAY 09	-37.88
SEP 24	-47.52	OCT 07	-44.40	MAR 08, 1984	-39.41	JUN 06	-38.29
MAR 19, 1965	-49.37	MAR 13, 1975	-45.96	SEP 26	-35.03	JUL 19	-39.71
SEP 10	-41.16	OCT 01	-41.00	MAR 14, 1985	-40.38	AUG 28	-39.76
MAR 07, 1966	-46.38	MAR 25, 1976	-44.41	OCT 01	-33.13	SEP 28	-39.80
OCT 04	-44.31	OCT 04	-43.33	MAR 20, 1986	-38.84	OCT 24	-39.87
MAR 03, 1967	-46.70	MAR 23, 1977	-44.94				

(C-32- 5)26aca- 1 ALT. 6,360

AUG 01, 1951	-13.11	DEC 23, 1959	-14.97	MAR 28, 1962	-13.88	JUL 30, 1963	-11.57
DEC 09	-13.81	APR 09, 1960	-14.78	APR 28	-13.61	AUG 28	-11.51
APR 06, 1952	-13.89	JAN 06, 1961	-13.82	MAY 28	- 9.91	SEP 23	-12.13
DEC 07	-13.49	FEB 28	-15.04	JUN 28	-11.37	APR 07, 1964	-13.97
MAR 16, 1953	-14.11	MAR 22	-16.58	JUL 28	- 8.61	SEP 24	-11.54
DEC 10	-13.50	APR 25	-16.36	AUG 28	-11.22	DEC 07	-13.74
MAR 25, 1954	-14.06	MAY 24	-11.20	SEP 28	-11.46	MAR 19, 1965	-13.94
DEC 02	-14.39	JUL 05	-11.19	OCT 28	-13.46	SEP 10	-10.86
DEC 04, 1955	-14.32	JUL 27	-10.87	NOV 28	-13.23	MAR 07, 1966	-14.03
MAR 20, 1956	-15.15	AUG 31	-12.35	DEC 26	-14.10	OCT 04	-11.05
DEC 21	-14.03	SEP 30	-13.19	JAN 28, 1963	-14.37	MAR 03, 1967	-13.97
MAR 30, 1957	-14.63	OCT 31	-13.78	FEB 27	-14.22	OCT 24	-12.74
DEC 20	-14.25	NOV 30	-14.09	MAR 25	-14.03	MAR 06, 1968	-14.34
APR 03, 1958	-13.50	DEC 31	-14.26	APR 29	-13.39	SEP 30	- 9.30
DEC 23	-13.89	JAN 22, 1962	-14.34	MAY 29	-10.59	MAR 14, 1969	-12.84
APR 11, 1959	-14.07	FEB 28	-14.00	JUL 02	-10.90	OCT 07	-10.10

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-32- 5)26aca- 1--Continued

MAR 09, 1970	-14.73		MAR 18, 1974	-12.89		OCT 03, 1978	-11.35		SEP 19, 1983	-13.48	
OCT 07	-13.40		OCT 07	-14.16		MAR 12, 1979	-12.50		SEP 26, 1984	-14.60	
MAR 12, 1971	-14.08		MAR 31, 1975	-14.63		OCT 01	- 9.97		OCT 01, 1985	-10.79	X
OCT 04	-10.64		OCT 01	-10.95		MAR 05, 1980	-13.60		SEP 17, 1986	- 8.75	
MAR 01, 1972	-14.27		MAR 25, 1976	-15.40		OCT 01	-11.00		MAR 02, 1987	-13.05	
OCT 05	-11.51		OCT 04	-11.08		OCT 01, 1981	-12.45		JUN 17, 1988	-11.32	
MAR 02, 1973	-10.84		MAR 23, 1977	-14.13		SEP 21, 1982	-12.92				
OCT 02	-10.07		OCT 05	-13.77							

(C-32- 5)35bab- 1 ALT. 6,370

JUL 23, 1962	+2.96		SEP 10, 1965	+3.35		MAR 31, 1975	+2.05		SEP 26, 1984	+2.67	
31	+2.78		MAR 07, 1966	+2.75		OCT 01	+2.80		MAR 13, 1985	+1.90	
AUG 28	+2.94		OCT 04	+3.23		MAR 25, 1976	+2.55		OCT 01	+2.91	
SEP 24	+2.91		MAR 03, 1967	+2.80		OCT 04	+2.40		MAR 20, 1986	+1.73	
OCT 29	+2.80		OCT 24	+2.78		MAR 23, 1977	+2.30		SEP 17	+2.34	
DEC 03	+2.86		MAR 06, 1968	+2.90		OCT 05	+2.18		MAR 02, 1987	+1.30	
JAN 28, 1963	+2.50		SEP 30	+3.65		MAR 17, 1978	+2.17		MAR 21, 1988	+0.24	
FEB 27	+2.52		MAR 14, 1969	+2.90		OCT 03	+2.37		SEP 29	-2.46	
MAR 25	+2.70		OCT 07	+3.05		MAR 12, 1979	+2.29		OCT 25	-1.13	
APR 29	+3.00		MAR 09, 1970	+2.78		OCT 01	+1.75		DEC 07	-0.77	
MAY 29	+3.00		OCT 07	+2.89		MAR 04, 1980	+2.30		MAR 15, 1989	-0.22	
JUL 02	+2.97		MAR 12, 1971	+2.20		OCT 01	+2.52		APR 12	-0.97	
JUL 30	+2.95		OCT 04	+2.43		MAR 03, 1981	+2.37		MAY 09	-0.90	
AUG 28	+3.14		MAR 01, 1972	+2.68		OCT 01	+2.52		JUN 07	-1.28	
SEP 23	+2.92		OCT 05	+2.37		MAR 01, 1982	+2.10		JUL 19	-1.50	
APR 07, 1964	+3.05		MAR 02, 1973	+2.32		SEP 21	+2.64		AUG 28	-1.66	
SEP 24	+2.97		OCT 02	+2.50		MAR 08, 1983	+2.21		SEP 28	-0.34	
DEC 07	+3.20		MAR 18, 1974	+2.20		SEP 19	+2.57		OCT 24	-0.80	
MAR 19, 1965	+2.70		OCT 07	+2.15		MAR 08, 1984	+2.01				

(C-33- 5) 9adb- 1 ALT. 6,440

AUG 01, 1951	-0.75		APR 11, 1959	-1.09		FEB 01, 1962	-2.30		APR 29, 1963	-0.23	
DEC 09	-2.51		DEC 23		F	MAR 05	-2.12		MAY 29		F
APR 06, 1952	-0.87		APR 09, 1960	-1.34		APR 02	-1.58		JUL 02	-1.22	
DEC 07		F	JAN 06, 1961	-2.29		30	-0.37		30	-2.22	
MAR 16, 1953	-0.44		FEB 28	-2.28		MAY 28	-0.10		AUG 28	-2.77	
DEC 10	+0.5	F	MAR 22	-1.91		JUL 03	-0.90		SEP 23	-2.55	
MAR 25, 1954	-0.54		APR 25	-0.15		31	-1.91		MAY 17, 1988	-0.70	
DEC 02	-0.21		MAY 24	-1.47		AUG 28	-2.61		APR 12, 1989	-2.04	
DEC 04, 1955	-2.34		JUL 05	-2.11		SEP 24	-3.14		MAY 09	-2.01	
MAR 20, 1956	-1.87		27	-2.85		OCT 29	-2.86		JUN 06	-1.33	
DEC 22	-3.03		AUG 23	-3.30		DEC 03	-2.35		JUL 19	-2.47	
MAR 30, 1957	-1.98		SEP 25	-3.08		26	-2.25		AUG 28	-1.51	
SEP 23	-0.79		OCT 30	-2.86		JAN 28, 1963	-2.35		SEP 28	-0.98	
DEC 20	-0.32		NOV 27	-2.61		FEB 27	-2.09		OCT 26	-1.47	
APR 03, 1958	-1.10		DEC 27	-2.30		MAR 25	-1.71				

(C-33- 5)10aba- 1 ALT. 6,450

APR 14, 1989	-34.77		JUL 19, 1989	-31.17		SEP 29	-30.45		OCT 24, 1989	-30.60	
JUN 06	-32.64		AUG 28	-30.38							

(C-33- 5)10cdd- 1 ALT. 6,455

OCT 23, 1961	-28.50		APR 30, 1962	-28.76		DEC 03, 1962	-28.23		JUL 02, 1963	-28.02	
30	-28.34		MAY 28	-24.61		26	-28.57		30	-28.25	
NOV 27	-28.26		JUL 03	-25.39		JAN 28, 1963	-28.70		AUG 28	-28.04	
DEC 27	-28.84		31	-25.77		FEB 27	-29.11		SEP 23	-27.43	
FEB 01, 1962	-29.25		AUG 28	-26.60		MAR 25	-29.34		MAY 18, 1988	- 5.80	
MAR 05	-29.38		SEP 24	-26.73		APR 29	-29.50		APR 12, 1989	- 5.80	
APR 02	-29.02		OCT 29	-27.76		MAY 29	-27.66		OCT 24	- 5.86	

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-33- 5)16add- 3 ALT. 6,445

MAY 18, 1988	- 6.85	OCT 25, 1988	- 4.86	MAR 01, 1989	- 8.15	JUL 19, 1989	- 7.59
JUN 14	- 5.28	DEC 07,	- 7.10	APR 12	- 8.87	AUG 28	- 7.52
JUL 28	- 4.80	JAN 04, 1989	- 7.79	MAY 09	- 8.18	SEP 28	- 6.01
SEP 01	- 6.46	JAN 18,	- 8.07	JUN 06	- 8.03	OCT 24	- 5.43
SEP 28	- 5.57						

(C-34- 5) 2cbc- 1 ALT. 6,617

OCT 01, 1961	-89.0	APR 02, 1962	-90.36	OCT 29, 1962	-82.67	MAY 29, 1963	-84.41
16	-89.40	30	-90.18	DEC 03	-80.67	JUL 01	-84.40
30	-88.54	MAY 28	-88.86	26	-80.98	30	-84.29
NOV 27	-86.77	JUL 03	-87.73	JAN 28, 1963	-82.70	AUG 28	-84.62
DEC 27	-87.20	31	-87.00	FEB 27	-84.01	SEP 23	-84.13
FEB 01, 1962	-88.50	AUG 28	-86.40	MAR 25	-84.80	OCT 26, 1988	-66.81
MAR 05	-89.95	SEP 24	-85.85	APR 29	-85.32	OCT 26, 1989	-72.45

(C-34- 5) 3cdc- 1 ALT. 6,560

SEP 28, 1988	-9.80	FEB 28, 1989	-15.63	JUL 19, 1989	-14.44
NOV 03	-8.77	APR 12	-14.28	SEP 28	-15.70
JAN 18, 1989	-12.25	MAY 10	-14.84	OCT 25	-14.30

(C-34- 5) 4ddd- 1 ALT. 6,543

AUG 01, 1951	-10.18	FEB 01, 1962	-16.03	SEP 30, 1968	-2.67	SEP 21, 1982	- 3.25
DEC 09	-9.00	MAR 05	-17.46	MAR 13, 1969	-11.80	MAR 08, 1983	- 9.08
APR 06, 1952	-16.92	APR 02	-17.29	OCT 07	-2.58	SEP 19	- 2.65
DEC 07	-7.75	30	-16.77	MAR 10	-11.14	MAR 08, 1984	- 7.70
MAR 16, 1953	-14.64	MAY 28	-12.64	OCT 07, 1970	-6.77	SEP 26	- 3.94
DEC 10	- 9.56	JUL 03	-9.80	MAR 02, 1971	-11.84	MAR 13, 1985	- 8.28
MAR 25, 1954	-16.37	31	-8.38	OCT 04	-6.12	OCT 01	- 1.22 X
DEC 02	-6.12	AUG 28	-9.05	MAR 01, 1972	-13.53	MAR 20, 1986	- 8.35
MAR 20, 1956	-17.74	SEP 24	-9.24	OCT 05	-6.73	MAR 02, 1987	- 8.62
DEC 22	-15.87	OCT 29	-6.88	MAR 02, 1973	-16.82	SEP 03	- 4.18
MAR 30, 1957	-13.70	DEC 03	-8.71	OCT 02	-5.25	MAR 21, 1988	- 8.99
SEP 23	-5.24	JAN 28, 1963	-13.03	MAR 19, 1974	-12.76	MAY 17	- 2.89 X
DEC 20	-9.87	FEB 27	-15.98	OCT 07	-12.10	JUN 17	- 4.48
APR 03, 1958	-14.77	MAR 25	-15.44	MAR 31, 1975	-17.94	JUL 25	- 3.47
DEC 23	-8.62	APR 29	-13.28	OCT 01	-3.91	SEP 29	- 3.74
APR 11, 1959	-10.45	MAY 29	-11.15	MAR 25, 1976	-14.08	OCT 25	- 4.05
DEC 23	-11.37	JUL 01	-11.98	SEP 17	-4.00	DEC 07	- 6.37
APR 09, 1960	-15.70	30	-12.58	OCT 04	-8.96	JAN 04, 1989	- 7.27
FEB 28, 1961	-17.47	AUG 28	-11.39	MAR 23, 1977	-16.80	19	- 8.09
MAR 22	-16.90	SEP 23	-10.25	OCT 04	-17.26	MAR 01	- 9.59
APR 25	-12.64	APR 07, 1964	-20.59	MAR 17, 1978	-19.55	APR 11	- 5.27
MAY 24	-12.37	SEP 24	-17.95	OCT 03	-4.48	MAY 10	- 6.82
JUL 05	-15.13	DEC 07	-19.43	MAR 12, 1979	-13.01	JUN 09	- 7.09
27	-15.95	MAR 19, 1965	-14.93	OCT 03	-1.78 X	JUL 19	- 7.29
AUG 23	-15.94	SEP 10	-5.27	MAR 04, 1980	-10.28	AUG 29	- 7.19
SEP 25	-12.93	MAR 07, 1966	-11.89	OCT 01	-2.63 X	SEP 28	- 7.31
OCT 30	-6.57	OCT 04	-4.29	MAR 03, 1981	-8.91	OCT 25	- 4.20
NOV 27	-8.60	MAR 03, 1967	-12.75	OCT 01	-3.98		
DEC 27	-13.41	MAR 06, 1968	-13.27	MAR 01, 1982	-9.26		

(C-34- 5) 5dca- 1 ALT. 6,550

MAR 13, 1985	-27.65	MAR 21, 1988	-29.66	JAN 04, 1989	-25.56	AUG 29, 1989	-24.14
OCT 01	-20.70	MAY 17	-28.95	18	-27.00	SEP 28	-24.12
MAR 20, 1986	-27.85	JUN 17	-21.41	MAR 01	-28.19	OCT 25	-25.04
SEP 17	-22.68 T	JUL 25	-20.59	MAY 10	-30.82		
MAR 02, 1987	-28.20	SEP 29	-19.62	JUN 20	-27.49		
SEP 03	-23.39	OCT 25	-21.73	JUL 19	-25.69		

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-34- 5) 8adb- 2 ALT. 6,535

SEP 09, 1935	-13.62	NOV 14, 1941	-12.90	DEC 23, 1958	-16.18	DEC 07, 1964	-19.43
OCT 12	-15.29	DEC 03	-14.75	APR 11, 1959	-18.29	MAR 19, 1965	-20.66
JAN 27, 1936	-18.79	MAR 17, 1942	-18.52	DEC 23	-18.11	SEP 10	-13.93
APR 20	-17.52	MAY 09	-17.80	APR 09, 1960	-19.19	MAR 07, 1966	-18.32
JUN 17	-14.57	JUN 29	-11.80	JAN 06, 1961	-19.71	OCT 04	-14.59
AUG 04	-14.71	AUG 08	-10.20	FEB 28	-20.07	MAR 03, 1967	-19.23
SEP 28	-17.03	SEP 05	-9.40	MAR 22	-19.80	OCT 24	-15.30
NOV 26	-19.65	DEC 17	-15.34	APR 25	-19.55	MAR 06, 1968	-14.90
FEB 09, 1937	-20.15	JAN 14, 1943	-16.80	MAY 24	-19.01	SEP 30	-13.15
MAR 27	-20.12	MAR 11	-18.12	JUL 05	-18.90	MAR 14, 1969	-14.79
JUN 07	-14.48	DEC 15	-16.70	27	-18.86	OCT 07	-13.72
AUG 24	-9.95	MAR 18, 1944	-18.17	AUG 23	-18.57	MAR 10, 1970	-14.82
SEP 26	-11.77	DEC 03	-14.20	SEP 25	-18.34	OCT 07	-14.74
DEC 07	-16.75	APR 03, 1945	-17.61	OCT 30	-18.80	MAR 02, 1971	-18.35
FEB 22, 1938	-19.40	DEC 07	-16.14	NOV 27	-19.24	OCT 04	-14.59
APR 12	-19.40	MAR 20, 1946	-18.35	DEC 27	-19.67	MAR 01, 1972	-14.68
JUL 15	-9.95	DEC 16	-17.55	FEB 01, 1962	-20.15	OCT 05	-15.04
AUG 24	-9.68	MAR 26, 1947	-19.30	MAR 05	-20.16	MAR 02, 1973	-15.20
OCT 06	-12.81	DEC 10	-15.60	APR 02	-20.15	OCT 02	-10.15
DEC 19	-17.12	MAR 16, 1948	-17.85	30	-19.54	MAR 19, 1974	-13.58
MAR 02, 1939	-19.46	JUL 20	-11.58	MAY 28	-18.15	OCT 07	-11.90
APR 21	-19.08	DEC 10	-15.15	JUL 03	-16.24	MAR 31, 1975	-15.25
AUG 21	-10.74	APR 03, 1949	-17.87	31	-15.61	OCT 01	-10.68
OCT 18	-13.42	DEC 10	-13.73	AUG 28	-15.23	MAR 25, 1976	-17.24
DEC 07	-16.68	MAR 29, 1950	-16.51	SEP 24	-15.26	OCT 04	-11.83
MAR 25, 1940	-19.20	DEC 09	-15.40	OCT 29	-16.31	MAR 23, 1977	-18.35
AUG 05	-13.45	MAR 26, 1951	-17.18	DEC 03	-17.54	OCT 04	-18.12
28	-15.20	DEC 09	-18.75	26	-18.25	MAR 12, 1978	-18.50 T
OCT 25	-16.90	APR 06, 1952	-18.44	JAN 28, 1963	-19.04	17	-20.20
NOV 14	-17.80	DEC 07	-14.58	FEB 27	-19.33	OCT 03	-14.39
28	-18.10	MAR 16, 1953	-16.67	MAR 25	-19.54	MAR 12, 1979	-18.50
DEC 07	-18.43	DEC 10	-17.01	APR 29	-19.58	OCT 03	-10.62 T
JAN 03, 1941	-18.90	MAR 25, 1954	-18.01	MAY 29	-19.30	MAR 04, 1980	-17.10 T
28	-19.20	DEC 02	-17.61	JUL 02	-18.57	OCT 01	-9.99 T
MAR 00	-19.80	DEC 04, 1955	-18.80	30	-17.99	MAR 03, 1981	-16.05
21	-19.77	MAR 20, 1956	-18.60	AUG 28	-17.87	OCT 01	-10.11 T
JUN 10	-14.90	DEC 21	-19.66	SEP 23	-18.20	MAR 01, 1982	-15.99 T
JUL 03	-12.50	MAR 30, 1957	-20.07	DEC 04	-19.16	SEP 21	-9.46
AUG 25	-10.00	DEC 20	-17.13	APR 07, 1964	-20.59	MAR 08, 1983	-15.54 T
SEP 20	-10.20	APR 03, 1958	-17.60	SEP 24	-17.95		

(C-34- 5)10bab- 1 ALT. 6,570

NOV 01, 1988	-12.97	MAY 10, 1989	-18.39	JUL 20, 1989	-17.49	SEP 28, 1989	-17.84
APR 12, 1989	-18.42	JUN 09	-17.76	AUG 29	-17.52	OCT 25	-17.20

(C-34- 5)10bbb- 1 ALT. 6,554

JUL 30, 1963	-7.99	SEP 28, 1988	-9.22	MAR 01, 1989	-4.48	OCT 26, 1989	-2.57
MAY 18, 1988	-11.50	NOV 03	-9.55	APR 11	-14.60		

(C-34- 5)16adc- 1 ALT. 6,587

OCT 10, 1961	-45.50	SEP 28, 1988	-24.50	JAN 18, 1989	-36.35	OCT 25, 1989	-34.90
MAY 17, 1988	-43.09	NOV 03	-27.93	APR 11	-42.39		

(C-34- 5)21adc- 1 ALT. 6,570

OCT 03, 1961	-23.98	APR 30, 1962	-26.86	DEC 03, 1962	-22.35	JUL 01, 1963	-22.42
30	-22.43	MAY 28	-23.34	26	-23.51	30	-22.10
NOV 27	-22.97	JUL 03	-14.12	JAN 28, 1963	-24.70	AUG 28	-21.71
DEC 27	-24.53	31	-13.43	FEB 27	-25.69	SEP 23	-22.93
FEB 01, 1962	-25.85	AUG 28	-13.85	MAR 25	-26.40	OCT 26, 1988	-16.34
MAR 05	-26.76	SEP 24	-17.49	APR 29	-25.46		
APR 02	-27.16	OCT 29	-20.22	MAY 29	-23.46		

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-34- 5)26cbc- 1 ALT. 6,640

MAY 18, 1988	-31.85	OCT 25, 1988	-25.07	APR 14, 1989	-32.73	SEP 28, 1989	-27.54
JUN 15	-17.68	DEC 08	-28.75	MAY 10	-28.67	OCT 24	-28.73
JUL 26	-16.70	JAN 04, 1989	-30.33	JUN 07	-23.82		
SEP 01	-21.29	19	-31.67	JUL 18	-23.95		
29	-22.11	FEB 28	-34.12	AUG 29	-26.09		

(C-36- 5)28bdc- 1 ALT. 6,870

JUL 31, 1962	-5.37	MAR 07, 1966	-5.87	OCT 12, 1977	-4.23	SEP 03, 1987	- 2.60
AUG 28	-5.55	OCT 04	-5.61	MAR 20, 1978	-4.83	MAR 21, 1988	- 5.32
SEP 24	-5.47	MAR 03, 1967	-5.81	OCT 02	-2.00	MAY 18	- 1.87
OCT 29	-5.16	OCT 24	-4.07	MAR 27, 1979	-2.32	JUN 15	- 2.90
DEC 03	-5.27	MAR 05, 1968	-4.58	OCT 03	-4.63	JUL 28	- 3.69
26	-5.30	OCT 01	-3.55	MAR 04, 1980	-3.55	SEP 22	- 2.71
JAN 28, 1963	-5.85	OCT 16, 1969	-4.12	OCT 03	-1.73	OCT 25	- 3.85
FEB 27	-6.09	OCT 22, 1970	-4.07	MAR 03, 1981	-5.65	DEC 08	- 4.60
MAR 25	-6.04	MAR 03, 1971	-5.75	OCT 08	-3.05	FEB 28, 1989	- 4.96
APR 29	-5.85	OCT 21	-5.00	MAR 01, 1982	-5.19	MAR 16	- 4.08
MAY 28	-5.10	FEB 29, 1972	-5.85	SEP 21	-2.93	APR 11	- 4.66
JUL 01	-5.45	OCT 05	-3.06	MAR 08, 1983	-4.55	MAY 10	- 2.18
JUL 30	-5.88	OCT 02, 1973	-2.53	SEP 26	-3.70	JUN 22	- 3.57
AUG 28	-5.60	MAR 18, 1974	-5.44	MAR 12, 1984	-5.46	JUL 18	- 4.04
SEP 23	-5.58	OCT 08	-2.47	SEP 27	-3.21	AUG 29	- 3.07
APR 07, 1964	-6.17	APR 01, 1975	-5.49	MAR 03, 1985	-5.60	SEP 28	- 3.16
SEP 24	-4.50	OCT 02	-2.49	SEP 26	-2.15	OCT 25	- 2.79
DEC 07	-4.98	MAR 12, 1976	-5.74	MAR 06, 1986	-3.66		
MAR 19, 1965	-5.84	OCT 07	-2.25	SEP 04	-3.50		
SEP 10	-4.72	MAR 02, 1977	-5.32	MAR 25, 1987	-4.29		

(C-36- 5)31cbd- 1 ALT. 7,090

MAY 27, 1981	-22.63	SEP 01, 1988	-20.47	FEB 28, 1989	-31.14	JUL 18, 1989	-27.63
JAN 05, 1988	-29.44	27	-20.12	APR 11	-25.99	AUG 29	-27.98
JUN 15	-20.75	OCT 25	-22.06	MAY 10	-19.82	SEP 28	-29.19
JUL 28	-23.36	JAN 19, 1989	-29.98	JUN 21	-23.14	OCT 25	-28.23

(C-37- 5)19cad- 1 ALT. 7,113

JUL 09, 1973	-5.0 R	SEP 27, 1988	-9.49	MAR 16, 1989	-8.25	AUG 29, 1989	-9.69
JUN 15, 1988	-15.53 T	OCT 25	-9.55	APR 11	-8.35	SEP 28	-9.91
AUG 01	-28.40	DEC 08	-9.40	MAY 10	-8.55	OCT 25	-9.90
SEP 01	-10.21	JAN 19, 1989	-9.26	JUN 07	-8.82		

East Fork Sevier River drainage area

(C-26- 1)23ddb- 2 ALT. 6,872

SEP 29, 1936	+13.50	DEC 03, 1941	+13.00	DEC 04, 1955	+11.50	NOV 01, 1960	+12.15
NOV 27	+13.90	AUG 09, 1942	+13.40	MAR 20, 1956	+11.80	JAN 06, 1961	+11.80
APR 09, 1937	+14.15	DEC 08	+13.30	DEC 04	+11.70	FEB 24	+11.30
AUG 02	+14.30	DEC 16, 1943	+12.50	MAR 11, 1958	+12.40	MAR 20	+12.15
SEP 25	+13.75	DEC 05, 1944	+13.20	MAY 08	+12.30	APR 21	+12.40
DEC 08	+13.45	DEC 07, 1945	+13.30	JUL 07	+13.80	MAY 23	+12.00
FEB 23, 1938	+13.20	DEC 16, 1946	+12.60	SEP 05	+11.80	JUL 03	+13.10
APR 11	+13.95	DEC 11, 1947	+13.10	NOV 07	+12.20	27	+12.80
JUN 05	+13.90	MAR 17, 1948	+13.00	JAN 05, 1959	+10.50	AUG 25	+12.65
AUG 24	+13.80	DEC 12	+12.80	MAR 02	+11.10	SEP 27	+12.60
OCT 07	+13.65	DEC 10, 1949	+13.30	MAY 01	+11.20	OCT 31	+12.60
DEC 20	+13.80	MAR 29, 1950	+13.00	13	+11.50	NOV 28	+12.10
MAR 01, 1939	+13.80	DEC 09	+12.20	JUL 02	+15.10	DEC 28	+12.40
APR 18	+13.80	MAR 26, 1951	+12.50	SEP 02	+14.00	FEB 02, 1962	+12.30
AUG 21	+11.80	DEC 09	+12.30	NOV 02	+13.75	MAR 06	+12.15
OCT 18	+12.45	APR 06, 1952	+12.40	JAN 06, 1960	+12.40	30	+12.10
DEC 06	+12.90	DEC 07	+13.30	MAR 24	+11.60	MAY 01	+11.80
MAR 25, 1940	+12.50	MAR 16, 1953	+12.50	MAY 11	+11.50	JUN 01	+11.90
DEC 05	+12.70	DEC 15	+12.40	JUL 12	+13.20	JUL 05	+13.50
MAR 20, 1941	+12.80	DEC 01, 1954	+11.90	SEP 16	+12.90	26	+14.20

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-26- 1)23ddb- 2 --Continued

AUG 31, 1962	+13.00	MAR 18, 1965	+10.30	OCT 03, 1973	+11.00	MAR 02, 1982	+8.20
SEP 26	+12.20	SEP 13	+10.70	MAR 22, 1974	+11.30	SEP 30	+7.70
OCT 31	+12.10	MAR 08, 1966	+10.60	OCT 11	+10.50	MAR 02, 1983	+8.10
DEC 05	+11.10	OCT 05	+11.20	MAR 12, 1975	+10.40	SEP 27	+9.10
27	+11.50	MAR 02, 1967	+10.70	OCT 06	+11.50	MAR 13, 1984	+10.70
JAN 29, 1963	+11.40	NOV 14	+11.60	MAR 24, 1976	+10.80	SEP 27	+9.00
MAR 01	+11.10	MAR 20, 1968	+11.30	OCT 06	+10.60	MAR 12, 1985	+10.00
26	+11.10	OCT 08	+11.80	MAR 09, 1977	+9.90	SEP 30	+10.90
APR 30	+10.60	APR 16, 1969	+11.40	OCT 05	+10.60	MAR 12, 1986	+10.40
MAY 27	+10.80	OCT 22	+17.00	MAR 17, 1978	+10.50	SEP 16	+10.50
JUN 28	+11.10	MAR 27, 1970	+11.30	OCT 10	+9.20	MAR 18, 1987	+9.90
JUL 29	+10.80	SEP 09	+13.80	MAR 26, 1979	+9.45	SEP 10	+9.30
AUG 29	+10.50	MAR 10, 1971	+10.90	OCT 02	+10.20	MAR 23, 1988	+8.30
SEP 23	+10.50	OCT 18	+10.50	MAR 05, 1980	+9.60	SEP 28	+8.90
APR 08, 1964	+10.00	MAR 02, 1972	+10.70	OCT 03	+6.20	MAR 15, 1989	+10.20
SEP 25	+10.20	OCT 06	+10.70	MAR 10, 1981	+8.90	SEP 27	+11.60
DEC 08	+11.00	MAR 07, 1973	+10.40	OCT 07	+7.30	OCT 24	+11.70

(C-26- 1)25acc- 1 ALT. 6,863

NOV 23, 1935	+16.80	MAR 16, 1953	+17.00	MAR 30, 1962	+15.90	OCT 06, 1972	+15.60
APR 22, 1936	+17.10	DEC 10	+16.50	MAY 01	+15.80	MAR 07, 1973	+15.30
AUG 05	+17.10	MAR 25, 1954	+16.80	JUN 01	+16.40	OCT 03	+15.00
SEP 29	+17.50	DEC 01	+16.40	JUL 05	+16.10	MAR 22, 1974	+15.20
NOV 27	+17.80	DEC 04, 1955	+15.70	26	+16.10	OCT 11	+13.40
APR 09, 1937	+17.70	DEC 04, 1956	+16.40	AUG 31	+16.10	MAR 12, 1975	+14.70
JUN 08	+18.00	MAR 11, 1958	+17.10	SEP 26	+15.50	OCT 06	+15.30
AUG 02	+18.00	MAY 08	+16.50	OCT 31	+15.70	MAR 24, 1976	+15.10
SEP 25	+17.90	JUL 07	+16.00	DEC 05	+15.40	OCT 06	+14.90
DEC 08	+18.05	SEP 05	+15.90	JAN 27, 1963	+15.60	MAR 09, 1977	+13.30
APR 11, 1938	+18.00	NOV 07, 1958	+15.60	JAN 29	+15.60	OCT 05	+14.35
JUN 05	+17.80	JAN 05, 1959	+14.40	MAR 01	+15.10	MAR 17, 1978	+13.00
AUG 24	+17.90	MAR 02	+16.00	26	+15.40	OCT 10	+12.60
DEC 20	+18.25	MAY 01	+16.20	APR 30	+15.20	MAR 26, 1979	+12.80
APR 18, 1939	+18.50	JUL 02	+17.70	MAY 27	+15.20	OCT 02	+14.60
AUG 21	+17.80	SEP 02	+18.00	JUN 28	+15.30	MAR 05, 1980	+13.30
OCT 18, 1939	+17.60	NOV 02	+17.80	JUL 26	+15.00	OCT 03, 1980	+11.90
DEC 06	+17.70	JAN 06, 1960	+16.60	AUG 29	+15.30	MAR 10, 1981	+12.80
MAR 25, 1940	+18.20	MAR 24	+16.50	SEP 23	+14.90	OCT 07	+15.10
DEC 06	+17.30	MAY 11	+15.50	APR 08, 1964	+14.50	MAR 02, 1982	+12.80
MAR 20, 1941	+17.30	JUL 12	+16.20	SEP 25	+16.10	SEP 30	+11.60
DEC 03	+17.60	SEP 16	+16.50	DEC 08	+15.80	MAR 02, 1983	+12.40
AUG 09, 1942	+12.80	NOV 01	+16.50	MAR 18, 1965	+15.30	SEP 27	+13.10
DEC 18	+13.10	JAN 06, 1961	+16.50	SEP 13	+15.30	MAR 13, 1984	+14.70
DEC 16, 1943	+14.80	FEB 24	+16.40	MAR 08, 1966	+15.40	SEP 27	+12.80
DEC 05, 1944	+15.00	MAR 20	+16.80	OCT 05	+16.30	MAR 12, 1985	+11.10
DEC 07, 1945	+15.90	APR 21	+16.80	MAR 02, 1967	+15.80	SEP 30	+13.40
MAR 21, 1946	+15.50	MAY 23	+15.90	NOV 11	+16.00	MAR 12, 1986	+11.70
DEC 16	+15.80	JUL 03	+16.20	MAR 20, 1968	+13.80	SEP 16	+12.50
DEC 11, 1947	+16.40	27	+15.90	OCT 08	+15.50	MAR 18, 1987	+11.30
MAR 17, 1948	+16.10	AUG 25	+16.20	APR 16, 1969	+13.40	SEP 10	+10.50
DEC 12	+16.30	SEP 27	+16.40	OCT 22	+14.70	MAR 23, 1988	+10.50
DEC 10, 1949	+17.00	OCT 31	+16.40	MAR 27, 1970	+16.10	SEP 28	+10.30
MAR 29, 1950	+17.00	NOV 28	+16.40	SEP 09	+15.00	OCT 28	+11.00
DEC 09	+16.50	DEC 28	+16.40	MAR 10, 1971	+16.00	MAR 15, 1989	+11.20
MAR 26, 1951	+16.90	FEB 02, 1962	+16.60	OCT 18	+15.20	SEP 27	+11.70
DEC 09	+16.90	MAR 06	+16.20	MAR 02, 1972	+15.90	OCT 24	+11.50
DEC 07, 1952	+17.50						

(C-27- 1)10dab- 1 ALT. 6,790

AUG 10, 1988	+7.35	MAR 15, 1989	+5.56	JUL 21, 1989	+6.06
SEP 30	+7.33	APR 15	+4.30	SEP 27	+4.70
OCT 28	+7.82	JUN 20	+6.44	OCT 21	+4.55

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-27-1)16aab-1 ALT. 6,830

AUG 04, 1988	-24.30	APR 15, 1989	-24.22	JUN 20, 1989	-26.35	SEP 27, 1989	-28.70
JAN 20, 1989	-19.77	MAY 12	-25.39	AUG 29	-27.88	OCT 21	-29.36
MAR 02	-21.99						

(C-27-1)27abc-2 ALT. 6,739

APR 09, 1937	+3.24	MAR 20, 1956	+2.27	AUG 29, 1962	+2.02	OCT 10, 1974	+2.65
AUG 02	+4.25	MAR 11, 1958	+2.82	SEP 25	+2.19	MAR 12, 1975	+3.25
SEP 25	+4.43	MAY 08	+2.50	OCT 31	+2.23	OCT 06	+4.32
DEC 08	+4.39	JUL 07	+2.72	DEC 04	+2.27	MAR 24, 1976	+4.00
FEB 23, 1938	+4.16	SEP 05	+3.08	27	+2.28	OCT 06	+3.23
AUG 24	+4.65	NOV 07	+3.22	JAN 28, 1963	+2.25	MAR 09, 1977	+3.10
DEC 20	+5.33	JAN 05, 1959	+3.39	MAR 01	+2.25	OCT 05	+2.41
MAR 01, 1939	+4.61	MAR 02	+3.22	26	+2.20	MAR 17, 1978	+4.10
APR 18	+4.35	MAY 01	+3.20	APR 30	+2.32	OCT 10	+1.51
AUG 21	+3.87	JUL 02	+2.65	MAY 27	+2.02	MAR 26, 1979	+1.60
OCT 18	+4.02	SEP 02	+2.22	JUN 28	+1.77	OCT 02	+2.65
DEC 06	+3.84	NOV 02	+2.35	JUL 29	+1.62	MAR 05, 1980	+2.40
MAR 25, 1940	+3.45	JAN 06, 1960	+1.65	AUG 29	+1.59	OCT 03	+4.10
DEC 06	+3.39	MAR 24	+1.75	SEP 22	+1.57	MAR 10, 1981	+3.40
MAR 26, 1941	+3.78	MAY 11	+1.63	DEC 04	+1.58	OCT 07	+4.10
DEC 11	+4.80	JUL 12	+1.16	APR 08, 1964	+1.55	MAR 02, 1982	+2.93
AUG 09, 1942	+4.79	SEP 16	+1.45	SEP 25	+1.25	SEP 30	+3.00
DEC 18	+4.35	NOV 01	+1.51	DEC 08	+1.55	MAR 02, 1983	+2.90
DEC 16, 1943	+3.32	JAN 06, 1961	+1.43	MAR 18, 1965	+1.55	SEP 27	+3.60
DEC 05, 1944	+4.40	FEB 24, 1961	+1.58	SEP 13	+1.55	MAR 13, 1984	+4.14
DEC 07, 1945	+4.90	MAR 20	+1.67	MAR 08, 1966	+2.65	SEP 27	+3.50
DEC 16, 1946	+4.10	APR 21	+1.77	OCT 05	+2.15	MAR 12, 1985	+3.90
MAR 26, 1947	+3.38	MAY 23	+1.73	MAR 02, 1967	+1.75	SEP 30	+5.50
DEC 11	+4.60	JUL 03	+1.43	NOV 14	+1.14	MAR 12, 1986	+4.40
MAR 16, 1948	+3.47	27	+1.38	MAR 20, 1968	+1.85	SEP 16	+5.00
DEC 13	+4.33	AUG 25	+1.53	OCT 08	+2.95	MAR 18, 1987	+3.80
APR 03, 1949	+3.85	SEP 27	+1.72	APR 16, 1969	+1.95	SEP 10	+3.79
DEC 10	+4.53	OCT 31	+1.76	OCT 22	+4.65	MAR 23, 1988	+3.12
MAR 29, 1950	+4.50	NOV 28	+1.76	MAR 27, 1970	+3.90	MAY 19, 1988	+3.26
DEC 09	+3.87	DEC 28	+1.77	SEP 09	+4.20	SEP 28	+2.81
MAR 06, 1951	+3.55	FEB 02, 1962	+1.75	MAR 10, 1971	+4.40	MAR 02, 1989	+2.99
DEC 09	+4.18	MAR 06	+1.78	OCT 05	+4.35	APR 15	+2.90
APR 06, 1952	+2.69	30	+1.67	MAR 02, 1972	+4.34	MAY 12	+2.80
DEC 07	+3.84	MAY 01	+1.73	OCT 06	+4.05	JUN 20	+2.20
MAR 16, 1953	+3.22	JUN 01	+1.89	MAR 07, 1973	+2.70	JUL 21	+2.08
DEC 10	+3.93	JUL 05	+1.95	OCT 01	+3.40	AUG 29	+2.04
DEC 04, 1955	+2.25	26	+1.96	MAR 22, 1974	+3.60	OCT 20	+2.45

(C-30-2)28bdc-1 ALT. 6,400

SEP 21, 1982	-52.71 T	SEP 27, 1984	-49.28 T	SEP 17, 1986	-52.22 T	MAY 19, 1988	-42.97
MAR 02, 1983	-45.40	MAR 12, 1985	-50.95	MAR 18, 1987	-44.93 T	SEP 28	-52.49 T
SEP 26	-45.40 T	OCT 14	-51.39	SEP 10	-53.21 T	MAR 01, 1989	-42.65
MAR 08, 1984	-49.89	MAR 06, 1986	-46.57 T	MAR 23, 1988	-42.40 T	SEP 27	-56.82

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-30-2)34bcc-1 ALT. 6,370

SEP 24, 1957	-12.55	SEP 25, 1962	-12.32	MAR 04, 1968	-14.18	MAR 05, 1980	-11.85
DEC 20	-13.40	OCT 30	-12.66	OCT 03	-13.61	OCT 01	-10.66 T
APR 09, 1960	-14.45	DEC 04	-13.05	MAR 12, 1969	-11.68	MAR 03, 1981	-11.70 T
FEB 28, 1961	-14.00	27	-13.50	OCT 09	-11.43	OCT 01	-9.75 T
MAR 20	-13.91	JAN 29, 1963	-13.67	MAR 11, 1970	-12.38	MAR 02, 1982	-12.00 T
APR 21	-13.88	FEB 28	-13.44	OCT 06	-11.37	SEP 21	-11.84
MAY 24	-11.52	MAR 26	-13.80	MAR 12, 1971	-13.55	MAR 02, 1983	-11.67
JUL 05	-12.53	APR 30	-13.36	OCT 05	-12.10	SEP 26	-10.00
27	-11.12	MAY 27	-11.91	MAR 02, 1972	-13.61	MAR 08, 1984	-12.11 T
AUG 23	-12.56	JUL 01	-12.49	OCT 06	-12.90	SEP 27	-8.89 T
SEP 27	-13.66	31	-12.03	MAR 08, 1973	-14.34	MAR 12, 1985	-11.58 T
OCT 31	-13.17	AUG 28	-12.42	OCT 01	-13.12	SEP 30	-9.00 T
NOV 28	-13.27	SEP 24	-12.85	MAR 20, 1974	-14.96	MAR 06, 1986	-11.29 T
DEC 27	-13.38	APR 08, 1964	-13.64	MAR 31, 1975	-14.90	SEP 17	-9.98 T
FEB 01, 1962	-13.59	SEP 24	-10.90	OCT 08	-14.29	MAR 18, 1987	-11.51
MAR 06	-14.65	DEC 07	-13.76	MAR 24, 1976	-14.12	SEP 10	-10.19 T
30	-13.95	MAR 18, 1965	-13.85	OCT 01	-13.89	MAR 23, 1988	-11.66 T
APR 30	-12.88	SEP 13	-11.84	MAR 01, 1977	-13.56	MAY 19	-11.49
JUN 07	-11.46	MAR 08, 1966	-13.36	MAR 17, 1978	-12.82	SEP 28	-7.55
JUL 05	-11.16	OCT 04	-11.59	OCT 10	-11.56	MAR 01, 1989	-11.55
31	-10.69	MAR 02, 1967	-13.23	MAR 12, 1979	-13.20 T		
AUG 29	-11.72	OCT 24	-14.82	OCT 01	-9.26 T		

(C-31-2)10dad-1 ALT. 6,540

MAR 01, 1989	-152.47	MAY 12, 1989	-152.48	JUL 19, 1989	-152.52	SEP 27, 1989	-152.46
APR 15	-152.60	JUN 08	-152.46	AUG 29	-152.47	OCT 26	-152.27

(C-33-2)3dab-1 ALT. 7,215

AUG 02, 1988	-38.43	JAN 20, 1989	-38.57	JUN 22, 1989	-38.84	OCT 26, 1989	-39.15
30	-37.50	MAR 01	-38.68	JUL 19	-39.02		
OCT 27	-38.16	APR 12	-39.21	AUG 29	-37.06		
DEC 08	-38.60	MAY 17	-38.78	SEP 27	-39.15		

(C-33-2)22aab-1 ALT. 7,225

AUG 29, 1962	-10.58	OCT 04	-10.59	OCT 03	-6.59	MAR 14, 1985	-3.09
SEP 25	-10.73	MAR 02, 1967	-10.23	MAR 26, 1976	-9.12	SEP 26	-3.39
OCT 30	-10.76	SEP 13	-10.71	OCT 01	-6.69	MAR 06, 1986	-2.80
DEC 04	-10.78	APR 17, 1968	-8.27	MAR 23, 1977	-8.03	SEP 04	-3.90
JAN 31, 1963	-10.96	OCT 03	-9.31	OCT 03	-9.12	MAR 25, 1987	-3.58
FEB 28	-10.08	APR 16, 1969	-7.87	MAR 20, 1978	-9.03	SEP 10	-3.90
MAR 25	-10.58	OCT 09	-7.41	OCT 02	-8.73	MAR 21, 1988	-4.75
APR 25, 1963	-10.70	MAR 11, 1970	-7.59	OCT 05, 1979	-6.82	SEP 22, 1988	-4.18
MAY 28	-9.93	OCT 07	-7.45	OCT 03, 1980	-4.75	OCT 27	-4.18
JUL 01	-10.79	APR 07, 1971	-7.96	MAR 03, 1981	-4.28	JAN 20, 1989	-4.31
31	-11.21	OCT 05, 1971	-8.00	OCT 01	-4.80	MAR 01	-4.10
AUG 28	-11.16	MAR 02, 1972	-7.99	MAR 01, 1982	-3.88	APR 12	-4.26
SEP 24	-11.25	OCT 05	-8.84	SEP 21	-4.49	MAY 17	-4.42
APR 08, 1964	-11.16	APR 05, 1973	-9.00	MAR 08, 1983	-3.17	JUL 19	-5.07
SEP 24, 1964	-11.59	OCT 01	-7.33	SEP 26, 1983	-3.74	AUG 29	-5.16
MAR 19, 1965	-11.86	MAR 20, 1974	-6.64	MAR 08, 1984	-3.38	SEP 27	-5.16
SEP 13	-9.93	OCT 10	-8.67	SEP 27	-3.28	OCT 25	-5.17
MAR 08, 1966	-10.50	APR 01, 1975	-9.12				

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-34-2)30ccc-1 ALT. 7,405

AUG 06, 1962	-82.37	SEP 10, 1965	-84.36	APR 01, 1975	-71.94	MAR 14, 1985	-53.25
29	-81.75	MAR 07, 1966	-85.77	OCT 03	-71.11	SEP 26	-50.66
SEP 25	-82.05	OCT 04	-85.39	MAR 26, 1976	-72.64	MAR 06, 1986	-52.37
OCT 30	-82.51	MAR 31, 1967	-86.96	OCT 01	-72.20	SEP 04	-54.93
DEC 04	-83.19	OCT 24	-85.09	MAR 01, 1977	-74.00	MAR 25, 1987	-53.87
27	-83.55	APR 17, 1968	-80.87	OCT 03	-77.37	SEP 03	-60.14
FEB 28, 1963	-84.56	OCT 03	-75.55	MAR 20, 1978	-82.14	MAR 21, 1988	-55.99
MAR 25	-84.83	APR 16, 1969	-78.90	OCT 02	-73.78	SEP 22	-62.81
APR 25	-83.28	OCT 08	-68.97	OCT 05, 1979	-60.70	OCT 27	-63.34
MAY 28	-78.80	MAR 11, 1970	-66.06	OCT 03, 1980	-43.85	DEC 07	-63.10
JUL 01	-79.20	OCT 07	-62.90	MAR 03, 1981	-47.80	MAR 16, 1989	-65.26
31	-79.98	APR 07, 1971	-71.15	OCT 01	-52.73	APR 12	-61.60
AUG 28	-80.61	OCT 04	-72.38	MAR 01, 1982	-54.95	MAY 11	-62.49
SEP 24	-81.67	MAR 02, 1972	-71.98	SEP 21	-56.00	JUN 08	-64.32
APR 08, 1964	-85.90	OCT 05	-74.74	MAR 08, 1983	-54.19	JUL 19	-65.59
SEP 24	-85.54	OCT 01, 1973	-67.24	SEP 26	-47.25	AUG 29	-66.49
DEC 07	-86.32	MAR 20, 1974	-62.00	MAR 08, 1984	-54.65	SEP 27	-66.87
MAR 19, 1965	-87.26	OCT 10	-68.55	SEP 27	-46.42	OCT 25	-67.22

(C-34-3)25dcd-1 ALT. 7,416

AUG 30, 1988	-75.75	MAR 16, 1989	-80.15	JUN 08, 1989	-80.47	SEP 27, 1989	-82.93
OCT 27	-76.91	APR 12	-80.29	JUL 19	-81.39	OCT 25	-83.50
DEC 07	-75.20	MAY 11	-80.73	AUG 29	-82.21		

(C-35-4)34dca-1 ALT. 7,690

OCT 05, 1938	-6.50	DEC 03, 1941	-5.46	MAR 25, 1947	-5.60	MAR 15, 1953	-6.18
DEC 19	-6.69	AUG 08, 1942	-6.51	DEC 10	-7.47	DEC 08	-7.69
APR 21, 1939	-5.54	DEC 17	-6.79	JUL 20, 1948	-6.20	APR 13, 1954	-6.42
AUG 19	-7.14	MAR 10, 1943	-5.70	DEC 10	-7.12	DEC 02	-9.70
OCT 18	-6.10	DEC 14	-7.59	DEC 09, 1949	-6.36	DEC 03, 1955	-12.15
DEC 07	-6.15	MAR 18, 1944	-7.20	MAR 28, 1950	-6.12	MAR 19, 1956	-10.51
MAR 25, 1940	-5.50	DEC 03	-7.74	DEC 08	-7.31	AUG 21, 1961	-12.80
SEP 16	-8.90	APR 02, 1945	-7.05	MAR 25, 1951	-6.75	JUN 14, 1981	-6.25
DEC 07	-8.01	DEC 07	-7.11	DEC 08	-9.57	SEP 29, 1988	-6.84
MAR 21, 1941	-6.76	MAR 19, 1946	-6.47	DEC 06, 1952	-8.04	APR 13, 1989	-6.54 S
OCT 08	-6.31	DEC 15	-7.92				

(C-36- 3) 6dba- 1 ALT. 7,580

DEC 15, 1946	-55.90	OCT 24	-24.10	SEP 25, 1951	-32.26	JAN 16, 1953	-29.27
MAR 25, 1947	-62.70	NOV 08, 1949	-22.20	31	-30.81	MAR 13	-29.70
MAY 08	-54.88	DEC 09	-22.93	AUG 05	-34.00	15	-29.30
JUN 13	-54.79	JAN 27, 1950	-28.30	14	-33.30	20	-29.60
JUL 02	-51.12	MAR 28	-26.95	SEP 06	-31.90	27	-31.80
AUG 01	-48.14	AUG 16	-25.95	24	-32.86	APR 03	-29.68
SEP 17	-41.90	SEP 05	-27.07	OCT 05	-32.36	13	-29.50
OCT 04	-48.60	DEC 08	-26.36	17	-32.56	20	-30.80
NOV 06	-39.50	JAN 09, 1951	-27.30	NOV 03	-31.55	27	-28.50
DEC 24, 1947	-32.70	20	-28.39	28	-31.17	MAY 05	-29.68
JAN 23, 1948	-30.30	FEB 05, 1951	-28.27	DEC 08	-31.09	DEC 08	-31.88
FEB 29	-36.30	11	-28.17	10	-31.37	APR 13, 1954	-33.48
MAR 30	-36.70	21	-28.71	JAN 16, 1952	-31.17	DEC 02	-34.49
APR 20	-33.00	MAR 03	-28.83	FEB 17	-32.01	DEC 03, 1955	-40.37
MAY 25	-37.97	08	-28.54	MAR 03	-33.30	DEC 21, 1956	-38.65
JUN 14	-43.37	21	-29.31	09	-33.49	MAR 30, 1957	-42.01
JUL 29	-32.90	25	-29.37	19	-32.81	DEC 20	-39.20
AUG 04	-33.10	28	-29.33	27	-34.11	APR 03, 1958	-37.18
SEP 24, 1948	-31.10	APR 07	-29.47	APR 04	-34.41	DEC 23	-45.56
OCT 04	-29.64	16	-30.52	06	-33.21	APR 11, 1959	-39.41
DEC 10	-35.34	26	-29.80	29	-31.70	DEC 23	-38.62
JAN 18, 1949	-30.50	MAY 10	-29.79	JUN 18	-32.59	APR 09, 1960	-39.28
FEB 07	-28.10	23	-29.64	AUG 04, 1952	-32.30	JAN 06, 1961	-43.64
MAR 15	-26.60	JUN 02	-29.73	NOV 06	-30.30	FEB 28	-46.48
APR 15	-33.70	JUL 05	-32.70	DEC 06	-29.58	MAR 22	-44.33
MAY 09	-36.10	10	-38.23	12	-29.17	MAY 24	-43.14

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-36-3)6dba-1--Continued

JUL 05, 1961	-51.06	MAR 25, 1963	-42.93	OCT 07, 1970	-32.60	OCT 03	-23.88 T
27	-52.43	APR 25	-42.08	MAR 03, 1971	-33.86	MAR 03, 1981	-22.83 T
AUG 23	-43.15	MAY 28	-44.05	OCT 04	-43.52	OCT 01	-33.32 T
SEP 25	-42.15	JUL 01	-49.06	MAR 02, 1972	-34.08	MAR 01, 1982	-29.96 T
OCT 30	-41.39	31	-50.57	OCT 05, 1972	-46.98	SEP 21	-33.92
NOV 28	-41.20	AUG 28	-44.70	APR 05, 1973	-45.02	MAR 07, 1983	-26.82
DEC 27	-41.04	SEP 24	-41.77	OCT 03	-44.20	SEP 26	-17.25 T
FEB 01, 1962	-42.17	APR 07, 1964	-46.35	MAR 19, 1974	-38.94	MAR 12, 1984	-26.04 T
MAR 05	-46.88	SEP 24	-49.82	OCT 08	-44.19	SEP 27	-33.43 T
APR 02	-43.13	DEC 07	-42.22	APR 01, 1975	-46.10	MAR 13, 1985	-24.94 T
30	-41.82	MAR 19, 1965	-41.07	OCT 03	-46.23	SEP 26	-29.35 T
MAY 28	-43.14	SEP 10	-41.88	MAR 12, 1976	-46.08	MAR 06, 1986	-29.93
JUL 06	-55.62	MAR 07, 1966	-42.20	OCT 12	-45.27	SEP 04	-35.47
31	-54.41	OCT 04	-39.52	MAR 01, 1977	-45.67	MAR 25, 1987	-31.97 T
AUG 29	-50.24	MAR 03, 1967	-39.03	OCT 03	-55.19	SEP 03	-37.56 T
SEP 25	-45.90	OCT 24	-39.95	MAR 20, 1978	-38.10	MAR 21, 1988	-34.42
OCT 30	-45.03	MAR 04, 1968	-39.44	OCT 02	-44.39	MAY 17	-32.48 T
DEC 04	-42.71	OCT 01	-40.50	MAR 22, 1979	-32.42	SEP 22	-36.24 T
27	-41.33	MAR 13, 1969	-35.70	OCT 05	-31.01	MAR 01, 1989	-35.97 T
JAN 31, 1963	-45.36	OCT 08	-34.12	MAR 04, 1980	-23.58	OCT 25	-50.05 T
FEB 28	-42.12	MAR 10, 1970	-32.56				

(C-36-3)7bbc-1 ALT. 7,610

SEP 11, 1961	-48.0	DEC 07, 1988	-27.60	MAY 11, 1989	-28.17	AUG 29, 1989	-28.90
SEP 19, 1981	-21.19 S	JAN 19, 1989	-28.02	JUN 21	-28.54	SEP 27	-29.07
JUN 16, 1988	-27.06	MAR 01	-27.11	JUL 19	-28.75	OCT 25	-28.89
OCT 27	-27.16	APR 13	-28.23				

(C-36-3)7dcd-1 ALT. 7,630

JUN 13, 1981	-20.82	NOV 11, 1981	-21.72	APR 06, 1982	-21.93	SEP 15, 1982	-22.25
JUL 17	-21.13	DEC 07	-21.93	MAY 05	-21.81	JUN 13, 1988	-20.82
25	-21.19	JAN 14, 1982	-21.99	JUN 06	-21.77	16	-22.50
SEP 17	-21.54	FEB 09	-22.17	JUL 22	-22.01	APR 13, 1989	-21.29
OCT 15	-21.59	MAR 02	-22.16	AUG 18	-22.17	OCT 25	-24.59

(C-36-3)7ddc-1 ALT. 7,630

JUN 13, 1981	-20.88	JUL 25, 1981	-21.22	OCT 25, 1989	-24.78
JUL 17	-21.18	JUN 16, 1988	-22.87		

(C-36-4)2dca-1 ALT. 7,620

SEP 04, 1961	-41.77	APR 02, 1962	-39.51	OCT 30, 1962	-36.43	MAY 28, 1963	-30.20
25	-40.30	30	-36.55	DEC 04	-35.18	JUL 01	-31.98
OCT 30	-41.50	MAY 28	-34.98	27	-34.46	31	-33.79
NOV 28	-42.32	JUL 06	-34.72	JAN 31, 1963	-34.44	AUG 28	-35.60
DEC 27	-42.86	31	-35.54	FEB 28	-32.65	SEP 24	-37.58
FEB 01, 1962	-43.25	AUG 29	-36.59	MAR 25	-31.27	JUN 14, 1981	-13.69
MAR 05	-42.75	SEP 25	-37.76	APR 25	-30.45	JUN 16, 1988	-18.99

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-36-4)2dca-2 ALT. 7,620

JUN 14, 1981	-14.62	MAR 02, 1982	-21.07	SEP 15, 1982	-25.60	APR 13, 1989	-21.63
SEP 17	-22.15	APR 06	-19.35	JUN 16, 1988	-19.99	MAY 11	-21.03
OCT 15	-24.19	MAY 05	-17.90	OCT 27	-28.41	JUN 21	-24.84
NOV 11	-24.57	JUN 06	-18.08	DEC 07	-30.20	JUL 19	-27.04
DEC 07	-18.03	JUL 09	-20.04	JAN 05, 1989	-30.68	AUG 29	-29.02
JAN 14, 1982	-19.11	22	-20.89	19	-30.86	SEP 27	-31.57
FEB 09	-21.13	AUG 17	-23.21	MAR 01	-26.43	OCT 25	-32.95

(C-36-4)3dad-1 ALT. 7,660

JUN 16, 1988	-38.00	JAN 20, 1989	-41.26	JUN 21, 1989	-44.06	OCT 25, 1989	-43.84
SEP 29	-39.67	MAR 01	-41.40	JUL 19	-43.25		
OCT 27	-39.91	APR 13	-42.64	AUG 29	-44.06		
DEC 07	-40.75	MAY 11	-40.84	SEP 27	-43.64		

(C-36-4)10bbd-1 ALT. 7,670

DEC 20, 1957	-59.79 R	JUL 27, 1961	-61.80 R	SEP 25, 1962	-62.54 R	MAR 03, 1982	-55.79
APR 11, 1959	-60.15 R	AUG 23	-61.73 R	OCT 30	-62.74 R	APR 06	-55.84
DEC 23	-60.90 R	SEP 25	-61.92 R	DEC 04	-62.73 R	MAY 05	-55.87
APR 09, 1960	-60.84 R	OCT 30	-61.76	JUN 14, 1981	-56.99	JUN 06	-55.80
JAN 06, 1961	-61.33 R	NOV 28	-62.05 R	SEP 17	-56.74	JUL 09	-55.82
FEB 28	-61.68 R	APR 30, 1962	-62.37 R	OCT 15	-56.46	22	-55.84
MAR 22	-61.70 R	MAY 28	-62.19 R	NOV 11	-56.48	AUG 17	-55.79
APR 25	-61.65 R	JUL 06	-62.36 R	DEC 07	-56.45	SEP 15	-55.63
MAY 24	-61.66 R	31	-62.47 R	JAN 14, 1982	-56.23	JUN 16, 1988	-51.77
JUL 05	-61.70 R	AUG 29	-62.33 R	FEB 10	-56.03	OCT 25, 1989	-52.56

(C-36-4)12baa-3 ALT. 7,640

JUN 15, 1981	-42.02	SEP 29, 1988	-54.70	APR 13, 1989	-53.35	OCT 25, 1989	-59.19
JUL 28, 1988	-54.50						

(C-36-4)34bda-3 ALT. 7,780

MAR 02, 1957	-6.48	OCT 01, 1957	-13.84	SEP 10, 1958	-2.61 R	MAY 17, 1959	-3.41
09	-6.72	05	-13.97	15	-2.34 R	22	-3.27 R
APR 26	-6.03 R	10	-14.03	20	-2.53 R	27	-3.24
MAY 14	-6.76 R	15	-13.60	25	-2.24 R	JUN 01	-3.23
18	-7.02 R	20	-13.24	30	-2.42	05	-3.18 R
27	-6.64	OCT 23	-12.54	OCT 05	-2.47	10	-3.17
JUN 03	-7.62	29	-11.73 R	10	-2.50	15	-3.09
17	-8.90	NOV 22	-9.33 R	15	-2.49	20	-3.01
22	-8.58	25	-9.13	20	-2.48	25	-2.90
27	-9.17	27	-9.10	25	-2.39	30	-2.76
30	-9.58	DEC 05	-8.36	OCT 30	-2.53	JUL 05	-2.45 R
JUL 01	-9.72	JAN 03, 1958	-7.34 R	NOV 05	-2.62	10	-2.66
05	-10.30	MAR 03	-7.10	10	-2.51 R	15	-2.60 R
10	-10.96	APR 22	-1.30 R	15	-2.47	20	-2.54
15	-11.43	JUN 20	-2.37 R	20	-2.45	25	-2.48
20	-11.83 R	25	-2.40 R	25	-2.45	31	-2.47 R
25	-12.24	30	-2.48 R	30	-2.50	AUG 05	-2.50
30	-12.56	JUL 01	-2.48 R	DEC 05	-2.44 R	10	-2.30 R
AUG 01	-12.60	05	-2.48	09	-2.86	15	-2.33 R
05	-12.78	10	-2.58	MAR 12, 1959	-2.86 R	20	-2.24 R
10	-12.99	15	-2.53	17	-2.92 R	25	-2.15
15	-13.14	20	-2.56	22	-3.11	31	-2.04
20	-13.25	25	-2.48	27	-3.23	SEP 05	-2.25
25	-13.28 R	JUL 31, 1958	-2.55 R	APR 01	-3.25 R	10	-2.20 R
30	-13.37 R	AUG 05	-2.58 R	05	-3.26 R	15	-2.34
SEP 01	-13.47 R	10	-2.58	10	-3.29	20	-2.31 R
05	-13.86 R	15	-2.63	15	-3.27	25	-2.31 R
15	-13.20 R	20	-2.75	20	-3.29	30	-2.28
20	-13.66 R	25	-2.46 R	23	-3.38 R	APR 27, 1960	-4.03 R
25	-13.65	31	-2.53 R	MAY 07	-3.38 R	MAY 12	-4.16 R
30	-13.82 R	SEP 05	-2.63	12	-3.48	17	-4.17

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-36- 4)34bda- 3--Continued

MAY 22, 1960	-4.23	MAY 05, 1961	-4.45 R	JUL 25	-1.92 R	SEP 17	-3.89 R
27	-4.27 R	10	-4.45	SEP 18, 1983	-1.50 R	18	-3.90 R
JUN 01	-4.25	15	-4.51	JUL 08, 1984	-2.29 R	19	-3.92 R
05	-4.24	20	-4.31	15	-2.00 R	22	-3.94 R
10	-4.26 R	25	-4.40 R	AUG 05	-1.90 R	24	-4.00 R
15	-4.27 R	31	-4.46 R	SEP 02	-2.11 R	27	-3.79 R
20	-4.27 R	JUN 05	-4.53 R	09	-2.19 R	30	-3.69 R
25	-4.27 R	10	-4.57 R	23	-2.27 R	OCT 03	-3.71 R
30	-4.27	15	-4.60	APR 23, 1985	-1.17 R	06	-3.69 R
JUL 05	-4.27 R	23	-6.67	JUL 05	-1.83 R	07	-3.50 R
10	-4.29	28	-6.43 R	12	-1.79 R	08	-3.50 R
15	-4.32 R	JUL 05	-6.86 R	JUL 29, 1985	-1.56 R	09	-3.50 R
20	-4.39	12	-7.05 R	AUG 09	-1.75 R	14	-3.50 R
25	-4.36	JUL 18, 1961	-7.08	APR 21, 1986	-2.62 R	15	-3.46 R
31	-4.25	28	-6.50 R	25	-2.67 R	16	-3.46 R
AUG 05, 1960	-4.30	AUG 02	-6.88 R	28	-2.71 R	17	-3.46 R
10	-4.28 R	18	-6.89 R	MAY 01	-2.77 R	20	-3.46 R
15	-4.27	25	-6.74 R	05	-2.79 R	21	-3.42 R
20	-4.28 R	28	-6.65 R	07	-2.81 R	22	-3.42 R
25	-4.26 R	SEP 06	-6.03	08	-2.82 R	23	-3.42 R
31	-4.26 R	14	-5.71 R	12	-2.86 R	24	-3.42 R
SEP 05	-4.25 R	26	-5.05 R	14	-2.96 R	27	-3.69 R
10	-4.25	OCT 12	-5.00 R	15	-3.12 R	NOV 10	-3.58 R
15	-4.22	NOV 06	-4.80	16	-3.00 R	17	-3.75 R
20	-4.25	24	-4.78 R	19	-3.04 R	20	-3.71 R
25	-4.20	JAN 03, 1962	-4.72 R	22	-3.12 R	DEC 01	-3.79 R
30	-4.22 R	APR 18	-1.96 R	JUN 02	-3.31 R	19	-3.96 R
OCT 05	-4.22	MAY 04	-3.20 R	05	-3.35 R	JAN 27, 1987	-4.33 R
10	-4.20	JUN 05	-3.45 R	06	-3.38 R	APR 13	-1.00 R
15	-4.21 R	30	-2.52 R	10	-3.44 R	21	-1.06 R
20	-4.21 R	AUG 02	-2.67 R	13	-3.47 R	27	-1.10 R
25	-4.21 R	31	-2.75 R	16	-3.54 R	MAY 04	-1.23 R
31	-4.23 R	DEC 03	-2.74 R	18	-3.71 R	06	-1.21 R
NOV 05	-4.32	MAR 03, 1963	-3.75 R	19	-3.73 R	07	-1.33 R
10	-4.30 R	APR 02	-3.45 R	20	-3.75 R	08	-1.42 R
15	-4.31 R	25	-3.77 R	23	-3.62 R	14	-1.50 R
20	-4.29 R	30	-3.67 R	24	-3.67 R	15	-1.46 R
25	-4.28 R	MAY 05	-3.87 R	25	-3.69 R	18	-1.40 R
30	-4.28 R	10	-4.13 R	27	-3.71 R	20	-1.48 R
DEC 05	-4.29	15	-4.10 R	30	-3.75 R	28	-1.69 R
10	-4.30 R	20	-4.10 R	JUL 02	-3.67 R	JUN 01	-1.73 R
15	-4.30 R	25	-4.17 R	03	-3.73 R	02	-1.75 R
20	-4.30 R	31	-4.37 R	07	-3.77 R	05	-1.81 R
25	-4.31 R	JUN 05	-4.42	08	-3.78 R	07	-1.83 R
31	-4.32	10	-4.57 R	10	-3.79 R	10	-1.88 R
JAN 04, 1961	-4.33 R	15	-4.62 R	14	-3.81 R	12	-1.92 R
08	-4.33	20	-4.74 R	17	-3.82 R	15	-1.90 R
16	-4.33	25	-4.82 R	18	-3.83 R	16	-1.92 R
20	-4.34	30	-4.93 R	21	-3.80 R	17	-1.92 R
25	-4.34	JUL 05	-5.03 R	23	-3.71 R	18	-1.92 R
31	-4.35	10	-4.98 R	24	-3.65 R	19	-1.92 R
FEB 05	-4.36 R	15	-5.19 R	29	-3.71 R	22	-2.02 R
10	-4.38	20	-5.33 R	30	-3.73 R	24	-2.04 R
15	-4.36	25	-5.22 R	31	-3.75 R	26	-2.06 R
20	-4.37	31	-5.47 R	AUG 01	-3.79 R	JUL 01	-2.04 R
25	-4.37 R	AUG 04	-4.46	04	-3.85 R	03	-2.06 R
MAR 01	-4.37	22	-3.45 R	07	-3.88 R	06	-2.08 R
05	-4.37 R	27	-3.62 R	11	-3.88 R	10	-2.12 R
10	-4.37 R	SEP 01	-3.27 R	12	-3.85 R	15	-2.15 R
15	-4.33 R	06	-3.44 R	15	-3.79 R	21	-2.12 R
20	-4.25 R	11	-3.65 R	18	-3.81 R	23	-2.00 R
25	-4.25 R	24	-3.23 R	19	-3.83 R	27	-1.98 R
31	-4.27 R	JUN 12, 1981	-2.68	21	-3.79 R	28	-1.96 R
APR 05	-4.26 R	JUL 10	-3.08 R	27	-3.75 R	30	-1.94 R
10	-4.26 R	25	-3.00 R	SEP 03	-3.75 R	31	-1.90 R
15	-4.28 R	AUG 08	-3.58 R	04	-3.75 R	AUG 03	-2.02 R
20	-4.29 R	29	-3.04 R	08	-3.79 R	10	-1.99 R
25	-4.35 R	OCT 21	-3.08 R	11	-3.83 R	17	-2.01 R
30	-4.33 R	JUN 13, 1982	-1.85 R	12	-3.88 R	19	-2.00 R

Table 7.--*Water levels in selected wells in the upper Sevier River basin*--Continued

(C-36-4)34bda-3--Continued

AUG 24, 1987	-1.96 R	AUG 22, 1988	-2.04 R	JUN 05, 1989	-3.85 R	JUL 12, 1989	-4.71 R
31	-2.00 R	25	-2.15 R	07	-3.90 R	13	-4.71 R
SEP 03	-2.04 R	29	-2.00 R	08	-3.94 R	14	-4.71 R
11	-2.06 R	SEP 07	-2.00 R	09	-3.94 R	16	-4.71 R
16	-2.00 R	12	-2.08 R	12	-3.96 R	17	-4.71 R
18	-2.02 R	14	-1.94 R	13	-3.96 R	18	-4.76 R
21	-2.06 R	23	-2.00 R	14	-3.96 R	21	-4.69 R
OCT 01	-2.04 R	27	-2.00 R	16	-4.00 R	22	-4.73 R
06	-2.06 R	OCT 03	-2.02 R	19	-4.05 R	24	-4.82 R
21	-2.10 R	06	-1.96 R	20	-4.08 R	AUG 28	-4.76 R
NOV 05	-1.89 R	11	-2.01 R	21	-4.12 R	30	-4.79 R
APR 04, 1988	-2.00 R	13	-2.00 R	22	-4.13 R	31	-4.84 R
18	-1.42 R	OCT 19	-2.06 R	23	-4.17 R	SEP 01	-4.83 R
20	-1.67 R	26	-2.00 R	25	-4.17 R	11	-4.95 R
21	-1.62 R	NOV 04	-2.04 R	26	-4.19 R	13	-4.96 R
MAY 12	-1.81 R	10	-2.08 R	28	-4.25 R	14	-5.01 R
17	-1.73 R	23	-2.21 R	30	-4.25 R	15	-5.11 R
JUN 03	-1.94 R	30	-2.27 R	JUL 02	-4.25 R	18	-5.08 R
06	-2.00 R	DEC 04	-2.33 R	05	-4.36 R	19	-5.00 R
13	-2.10 R	17	-2.46 R	07	-4.42 R	20	-5.08 R
14	-2.12 R	22	-2.54 R	09	-4.35 R	21	-5.02 R
15	-2.17 R	MAR 21, 1989	-2.67 R	10	-4.43 R	25	-5.14 R
16	-2.19 S	APR 14	-2.94 R	11	-4.40 R	28	-5.04 R
20	-2.17 R	17	-3.00 R	12	-4.35 R	OCT 02	-5.02 R
22	-2.19 R	20	-3.08 R	13	-4.42 R	06	-5.08 R
27	-2.12 R	25	-3.15 R	17	-4.46 R	11	-5.02 R
29	-2.10 R	MAY 03	-3.33 R	19	-4.48 R	16	-4.94 R
JUL 05	-2.21 R	05	-3.35 R	20	-4.54 R	17	-4.93 R
JUL 06, 1988	-2.22 R	08	-3.42 R	25	-4.54 R	20	-5.00 R
07	-2.25 R	09	-3.46 R	26	-4.54 R	25	-4.79 R
11	-2.23 R	11	-3.52 R	27	-4.52 R	31	-4.83 R
12	-2.26 R	15	-3.45 R	29	-4.48 R	NOV 06	-4.64 R
19	-2.29 R	17	-3.50 R	31	-4.52 R	27	-4.62 R
20	-2.33 R	19	-3.53 R	AUG 01	-4.56 R	30	-4.70 R
27	-2.27 R	22	-3.60 R	02	-4.55 R	DEC 13	-4.69 R
29	-2.21 R	23	-3.67 R	03	-4.62 R	14	-4.73 R
AUG 03	-2.16 R	24	-3.66 R	04	-4.59 R	18	-4.75 R
04	-2.07 R	25	-3.68 R	07	-4.70 R	27	-4.79 R
05	-2.12 R	26	-3.75 R	08	-4.67 R	JAN 03, 1990	-4.82 R
12	-2.14 R	30	-3.83 R	09	-4.76 R	05	-4.88 R
15	-2.21 R	JUN 01	-3.83 R	10	-4.64 R	16	-4.84 R
18	-2.17 R	02	-3.83 R	11	-4.69 R	17	-4.84 R

Table 8.--*Results of chemical analysis of ground water*

[mg/L, milligrams per liter; µg/L, micrograms per liter;

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Water temperature: °C, degrees Celsius.
Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius. Measured in the field except where noted L,
Solids, dissolved: Sum of constituents except where noted R, residue on evaporation at 180 degrees Celsius.

Location	Date	Water temperature (°C)	Specific conductance (µS/cm)	pH (standard units)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sodium+potassium, dissolved (mg/L as Na)	Alkalinity, lab (mg/L as $CaCO_3$)
				Sevier River drainage area								
(C-30- 3)17cba-S1	05-14-62	15.0	420	7.6	150	3	52	6.1	--	--	30	--
(C-30- 3)18bcb-S1	07-20-89	--	240	6.9	87	--	25	5.9	14	3.2	--	166
(C-30- 3)19dbb- 1	08-02-88	13.0	800 L	6.5	370	--	93	33	24	3.7	--	425
(C-30- 4)13ccb- 1	08-31-88	15.0	500	7.8	170	--	55	7.4	34	7.1	--	117
(C-30- 4)16abb-S1	12-03-62	7.0	85	7.2	35	0	9.6	2.7	--	--	6.0	--
	08-31-88	14.0	95	7.5	36	--	9.1	3.3	3.5	3.0	--	43
(C-30- 4)25bcc- 1	06-22-89	13.0	610	7.3	260	--	76	16	30	6.4	--	288
(C-30- 4)25bcc- 2	05-13-59	12.0	700	7.5	310	0	90	20	--	--	36	--
(C-32- 5)26aca- 2	05-14-62	14.0	245	7.5	100	0	31	5.6	--	--	16	--
	08-31-88	13.0	270	8.1	110	--	31	6.7	14	4.0	--	121
(C-32- 5)35abb-S1	05-14-62	14.0	570	7.8	270	0	72	22	--	--	26	--
	06-07-89	18.0	360	--	150	--	43	11	16	4.6	--	168
(C-32- 5)35bab- 1	07-16-62	15.0	282	7.3	120	0	36	7.1	--	--	14	--
	10-24-67	14.0	260	7.5	110	0	35	4.9	--	--	13	--
	03-06-68	13.0	263	7.3	110	0	32	7.8	--	--	15	--
	03-09-70	13.0	248	7.9	97	0	26	7.8	--	--	15	--
	08-27-80	14.0	315	7.0	120	0	35	7.4	11	4.1	--	--
	08-29-83	14.5	300	7.6	120	--	35	7.8	12	4.1	--	117
	08-13-86	17.0	310	7.9	120	--	35	7.9	12	4.2	--	118
(C-33- 5) 4ddd- 1	04-01-55	--	--	--	240	0	54	25	--	--	62	--
	08-31-88	16.0	720 L	7.6	220	--	56	20	84	4.2	--	342
(C-33- 5)32aad- 1	09-28-88	11.5	510	7.7	220	--	61	16	24	2.7	--	230
(C-33- 5)34bdc- 1	04-12-89	11.0	520	7.7	200	--	49	18	41	2.3	--	280
(C-34- 5) 4cdc-S1	08-30-89	18.5	720 L	--	380	--	60	56	21	3.3	--	407
(C-34- 5) 4cdc-S2	08-03-88	13.0	720	7.2	330	--	70	38	36	3.5	--	392
(C-34- 5) 5dac- 1	04-11-89	10.0	390	7.9	160	--	45	12	21	1.3	--	183
(C-34- 5)10cac- 1	09-28-88	10.0	530	7.6	250	--	60	25	18	2.4	--	244
(C-34- 5)27cad-S1	08-30-89	13.0	480 L	--	240	--	58	24	8.4	2.0	--	211
(C-34- 5)32dcd- 1	08-31-88	13.0	390 L	7.7	140	--	35	12	20	6.0	--	108
(C-35- 5)12dac-S1	06-07-89	12.0	465 L	--	200	--	34	29	20	4.3	--	212
(C-35- 5)25bbc- 3	08-31-88	12.0	430	7.7	200	--	45	22	8.3	5.0	--	208
(C-35- 5)35dad- 1	06-21-89	12.0	750 L	7.1	360	--	70	46	17	4.8	--	404
(C-36- 5)29dcd- 1	04-10-48	--	--	--	150	1	45	8.1	--	--	6.9	--
	06-07-49	--	335	--	170	9	50	10	--	--	6.1	--
	01-26-50	--	--	8.3	160	4	47	10	--	--	4.4	--
	05-03-62	13.0	345	7.9	170	10	57	7.3	--	--	6.1	--
	09-01-88	12.0	340	7.9	160	--	47	10	6.4	3.2	--	164
(C-36- 7)31dac-S1	07-14-54	4.5	150	7.3	70	0	--	--	--	--	--	--
	08-06-54	4.5	150	7.9	69	0	20	4.7	--	--	6.4	--
	09-28-68	6.0	160	7.5	82	0	19	8.3	3.4	1.0	--	--
	06-17-89	5.0	170	7.2	76	--	21	5.8	3.2	1.1	--	80
(C-37- 5)19cad- 1	08-31-88	9.5	720	7.4	360	--	68	47	12	3.3	--	307
(C-37- 5)32abb-S1	07-25-81	8.5	455 L	7.6	250	--	50	30	3.8	1.0	--	180
	05-25-82	8.0	475	7.3	250	7	51	29	3.7	0.90	--	239
	06-07-89	12.0	460 L	--	240	--	49	29	4.0	0.70	--	236

from selected sites in the upper Sevier River basin

--, data were not collected or information was not available; <, less than]

laboratory value.

Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Fluo-ride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)	Solids, sum of consti-tuents, dis-solved (mg/L)	Phos-phorous, ortho, dis-solved (mg/L as P)	Nitro-gen, ammonia, dis-solved (mg/L as N)	Nitro-gen, nitrite, dis-solved (mg/L as N)	Nitro-gen, NO_2+NO_3, dis-solved (mg/L as N)	Boron, dis-solved (µg/L as B)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Sele-nium, dis-solved (µg/L as Se)
						Sevier River drainage area						
51	9.0	--	51	291 R	--	--	--	--	6	--	--	--
6.0	4.0	0.20	44	203	0.040	<0.010	<0.010	0.250	30	68	3	<1
11	9.1	0.10	30	473	0.020	0.040	<0.010	3.20	70	5	1	<1
120	9.0	0.20	53	359	0.030	<0.010	<0.010	0.630	40	<3	<1	<1
1.9	2.5	--	35	86 R	--	--	--	--	--	--	--	--
3.1	1.1	0.10	35	85	0.060	<0.010	<0.010	0.220	<10	14	2	<1
21	10	0.20	46	389	0.050	<0.010	<0.010	2.30	80	5	<1	<1
40	11	--	--	--	--	--	--	--	--	--	--	--
8.0	8.0	--	25	185 R	--	--	--	--	4	--	--	--
5.1	7.2	0.20	51	195	0.010	<0.010	<0.010	0.620	40	10	3	<1
10	12	--	46	351 R	--	--	--	--	6	--	--	--
7.0	12	0.20	52	248	0.010	<0.010	<0.010	0.260	50	42	8	<1
4.5	8.5	0.50	48	197	--	--	--	--	--	--	--	--
3.8	9.5	--	47	184 R	--	--	--	--	--	--	--	--
13	12	--	--	178 R	--	--	--	--	--	--	--	--
5.8	8.4	--	--	190 R	--	--	--	--	--	--	--	--
7.0	15	0.20	51	206	--	--	--	0.830	10	20	2	--
8.5	15	0.20	50	207	--	--	--	0.860	30	6	2	--
12	18	0.20	49	213	--	--	--	0.930	30	7	<1	--
10	22	1.1	40	429 R	--	--	--	--	--	20	--	--
26	24	1.2	35	457	0.040	<0.010	<0.010	0.240	190	12	2	<1
20	11	0.10	38	322	0.030	0.030	<0.010	2.50	110	10	4	1
6.0	2.8	0.20	38	327	0.010	0.030	<0.010	0.430	50	8	<1	<1
3.0	4.1	0.50	48	440	0.030	0.020	<0.010	<0.100	70	24	16	<1
7.5	3.8	0.20	31	428	0.030	0.010	<0.010	0.550	50	42	5	<1
7.0	6.3	0.20	32	240	0.040	0.030	<0.010	1.20	50	4	<1	<1
21	17	0.30	32	328	0.030	0.030	<0.010	1.20	60	7	<1	<1
8.0	6.0	0.30	30	265	<0.010	<0.010	<0.010	0.350	30	30	3	<1
21	42	0.30	34	240	0.010	0.030	<0.010	0.930	30	380	78	1
16	7.9	0.30	40	279	0.020	<0.010	<0.010	0.160	40	13	5	<1
10	5.4	0.20	37	258	0.010	<0.010	<0.010	<0.100	40	51	47	<1
12	8.2	0.20	31	448	0.030	<0.010	<0.010	3.80	60	15	1	1
6.2	7.0	0.10	36	211 R	--	--	--	--	--	0	--	--
8.6	7.0	0.10	44	224 R	--	--	--	--	0	--	--	--
5.2	6.7	0.20	39	226 R	--	--	--	--	--	30	--	--
8.6	7.5	0.10	45	216 R	--	--	--	--	2	0	--	--
4.4	5.5	0.10	41	220	0.030	<0.010	<0.010	0.800	20	11	3	<1
--	2.5	--	--	--	--	--	--	--	--	--	--	--
3.6	2.5	--	20	103	--	--	--	--	--	--	--	--
3.5	1.1	0.30	18	104	--	--	--	--	0	--	--	--
1.0	0.70	0.20	19	101	0.040	<0.010	<0.010	0.250	30	10	<1	<1
23	9.2	0.10	21	368	0.010	<0.010	<0.010	<0.100	40	52	36	<1
<5.0	4.5	0.10	12	80	--	--	--	0.790	10	<10	<1	--
5.0	4.2	0.20	12	252	--	--	--	0.430	--	<9	5	--
7.0	5.2	0.20	12	251	0.010	<0.010	<0.010	0.610	<10	10	3	<1

Table 8.—*Results of chemical analysis of ground water*

Location	Date	Water temperature (°C)	Specific conductance (µS/cm)	pH (standard units)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sodium+potassium, dissolved (mg/L as Na)	Alkalinity, lab (mg/L as $CaCO_3$)
(C-37- 6)32dac-S1	07-13-54	8.0	410	7.5	220	0	--	--	--	--	--	--
	08-03-54	9.0	410	7.6	230	2	54	22	--	--	3.7	--
	08-11-54	8.0	405	8.3	220	1	52	23	--	--	3.0	--
	10-01-68	8.0	385	7.6	220	4	42	28	1.3	0.50	--	--
(C-37- 6)33bc -S1	10-01-68	8.0	400	7.6	230	11	47	27	1.4	0.20	--	--
(C-38- 9)12bdb-S1	07-15-81	4.0	400 L	7.2	210	--	63	13	1.2	0.40	--	200
East Fork Sevier River drainage area												
(C-26- 1)12dbc- 1	09-01-88	12.0	375 L	7.2	180	--	47	15	9.4	2.0	--	181
(C-26- 1)23ddb- 2	05-13-59	12.0	180	7.4	73	0	24	3.2	--	--	10	--
	05-11-60	12.0	190	7.8	76	0	24	3.9	--	--	14	--
	05-23-61	12.0	190	7.5	77	0	26	2.9	10	2.4	--	--
	09-23-63	12.0	185	7.4	76	0	--	--	--	--	13	--
	03-18-65	11.0	175	7.8	70	0	28	0.0	11	--	--	--
	05-25-72	11.5	175	7.7	66	0	21	3.2	8.0	2.5	--	--
	07-23-73	11.5	175	8.0	68	0	22	3.2	8.4	2.4	--	--
	05-24-74	12.0	180	7.7	62	0	20	2.9	7.8	2.4	--	--
	08-28-80	12.0	230	7.7	69	0	22	3.3	8.3	4.9	--	--
	08-10-83	12.0	195 L	7.6	74	--	23	3.9	10	2.8	--	83
	07-11-84	12.0	195 L	7.6	78	--	25	3.7	9.1	2.9	--	78
	07-27-88	13.0	200 L	8.2	75	--	24	3.6	9.2	4.5	--	81
(C-26- 1)35dcb- 2	08-15-62	12.0	205	7.2	88	0	25	6.1	--	--	9.5	--
(C-27- 1)10dab- 1	08-10-88	12.0	235 L	--	97	--	30	5.3	8.6	2.2	--	91
(C-27- 1)27abc- 2	07-05-62	10.0	240	7.5	97	0	30	5.4	--	--	14	--
(C-27- 1)35cad-S1	06-20-89	12.0	270	6.9	100	--	27	8.5	13	3.1	--	115
(C-29- 2)35bad- 1	07-05-62	11.5	485	7.5	210	37	61	14	--	--	18	--
	09-13-65	11.0	485	7.3	210	34	58	16	15	--	--	--
	06-08-66	10.5	480	7.5	210	33	58	16	16	6.0	--	--
	08-23-67	12.5	490	7.4	210	31	59	16	--	--	21	--
	05-25-72	13.5	510	7.3	220	25	61	16	15	6.0	--	--
	07-25-73	16.0	500	7.6	220	33	62	16	15	5.6	--	--
	08-28-80	13.0	500	7.4	220	18	61	16	14	6.0	--	--
	07-08-82	17.0	485 L	--	200	--	57	15	14	5.9	--	188
	07-11-84	15.5	460	7.0	200	--	55	15	15	6.2	--	183
	07-27-88	15.0	460 L	7.6	200	--	54	15	14	8.5	--	182
(C-30- 2)28bdc- 1	07-08-82	18.5	445 L	--	180	--	49	15	19	5.1	--	195
	06-28-85	14.0	465 L	8.1	200	--	54	15	21	5.2	--	201
	08-19-87	12.5	430	--	190	--	53	15	22	5.3	--	205
(C-32- 2)13bdd-S1	07-19-89	12.0	205	7.2	90	--	27	5.5	5.6	2.0	--	94
(C-34- 3)27ddc-S1	07-31-62	10.0	410	7.8	190	0	53	14	--	--	18	--
	09-25-74	--	445	--	210	0	50	21	17	2.1	--	--
	06-08-89	10.0	375	--	170	--	41	17	15	1.3	--	192
(C-36- 3) 6dba- 1	07-11-52	--	--	8.1	150	4	24	23	--	--	9.1	--
	05-28-62	12.0	440	8.1	220	11	54	21	--	--	13	--
	09-24-63	15.0	425	7.7	220	9	--	--	--	--	11	--
	08-30-88	10.0	415	7.6	230	--	48	27	7.7	2.0	--	211

from selected sites in the upper Sevier River basin--Continued

Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Fluo-ride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)	Solids, sum of consti-tuents, dis-solved (mg/L)	Phos-phorous, ortho, dis-solved (mg/L as P)	Nitro-gen, ammonia, dis-solved (mg/L as N)	Nitro-gen, nitrite, dis-solved (mg/L as N)	Nitro-gen, NO_2+NO_3, dis-solved (mg/L as N)	Boron, dis-solved (µg/L as B)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Sele-nium, dis-solved (µg/L as Se)
3.0	--	--	--	--	--	--	--	--	--	--	--	--
7.4	20	--	9.0	210	--	--	--	--	--	--	--	--
4.0	2.5	--	--	227	--	--	--	--	--	--	--	--
3.8	1.5	0.30	6.1	214	--	--	--	--	0	--	--	--
4.0	1.4	0.20	6.8	219	--	--	--	--	10	--	--	--
<1.0	1.0	0.10	5.4	205	--	--	--	0.150	--	20	2	--
					East Fork Sevier River drainage area							
4.1	7.3	0.20	39	240	0.040	<0.010	<0.010	1.70	20	6	2	<1
1.9	7.0	--	46	142 R	--	--	--	--	--	--	--	--
9.9	9.0	--	46	156 R	--	--	--	--	--	--	--	--
11	6.0	0.20	41	140 R	--	--	--	--	--	--	--	--
5.1	9.0	--	--	138 R	--	--	--	--	--	--	--	--
4.3	6.0	--	39	138	--	--	--	--	--	--	--	--
5.7	4.7	--	41	132	--	--	--	--	--	--	--	--
4.0	6.4	--	41	133	--	--	--	--	--	--	--	--
3.5	5.6	--	38	126	--	--	--	--	--	--	--	--
0.90	8.1	0.20	42	141	--	--	--	0.190	20	30	2	--
4.0	8.7	0.30	41	145	--	--	--	0.300	30	<3	<1	--
4.1	8.8	0.30	42	144	--	--	--	0.310	30	<3	<1	--
5.1	10	0.20	41	148	--	--	--	0.320	30	9	<1	--
6.6	7.0	0.30	34	146 R	--	--	--	--	6	--	--	--
14	9.4	0.30	47	172	0.020	<0.010	<0.010	0.190	50	27	4	<1
5.8	7.0	0.40	53	189 R	--	--	--	--	5	1	--	--
4.0	9.0	0.30	45	182	<0.010	<0.010	<0.010	0.640	40	<3	<1	<1
24	35	0.20	43	301	--	--	--	--	--	--	--	--
22	31	--	38	212	--	--	--	--	--	--	--	--
24	30	0.40	40	296	--	--	--	--	--	--	--	--
24	36	--	33	298	--	--	--	--	--	--	--	--
24	27	--	45	310	--	--	--	--	--	--	--	--
24	32	--	46	313	--	--	--	--	--	--	--	--
24	30	0.20	46	320	--	--	--	0.760	10	<10	1	--
21	24	0.20	45	298	--	--	--	0.750	30	8	2	--
20	24	0.20	46	294	--	--	--	0.740	30	11	3	--
19	22	0.20	45	290	--	--	--	0.630	30	52	3	--
21	12	0.30	32	272	--	--	--	0.400	60	8	2	--
19	14	0.30	36	286	--	--	--	0.100	70	4	2	--
23	13	0.30	40	296	--	--	--	0.210	80	7	1	--
5.0	4.2	0.20	32	139	0.030	<0.010	<0.010	0.140	30	<3	<1	<1
17	6.0	0.20	30	246 R	--	--	--	--	4	--	--	--
11	7.7	0.30	27	270	0.060	--	--	0.370	100	20	<10	--
9.0	4.8	0.30	29	233	0.080	<0.010	<0.010	0.150	30	8	<1	<1
12	4.8	0.10	12	168 R	--	--	--	--	--	160	--	--
21	12	--	8.8	238 R	--	--	--	--	--	99	--	--
13	13	--	--	226 R	--	--	--	--	--	30	--	--
18	12	0.10	9.0	251	<0.010	0.070	<0.010	<0.100	60	580	25	<1

Table 9.—*Results of chemical analysis of surface water*

[mg/L, milligrams per liter; µg/L, micrograms per liter; --, data were not

Site name and location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Discharge: ft^3/s, cubic feet per second.
Water temperature: °C, degrees Celsius.
Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius.

Site name and location	Date	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (µS/cm)	pH (standard units)	Hardness, total (mg/L as $CaCO_3$)	Solids, sum of constituents, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
Sevier River drainage area										
Sevier River near Hatch, gaging station 10174500	08-18-88	79.0	17.0	322	8.5	170	185	40	17	3.2
Sevier River at Highway 12 bridge	08-18-88	75.2	20.0	370	8.5	180	196	41	19	3.9
Casto Wash near confluence with Sevier River	08-18-88	--	27.0	510	8.6	190 200	308	28	30	33
Sevier River at Roller Mill Hill Bridge	08-18-88	28.6	25.0	395	8.5	360	215	43	22	4.5
Inflow to Sevier River from west at (C-34-5)17dac	08-18-88	0.05	20.0	735	8.1	240	419	54	55	17
Sevier River above McEwen Canal diversion at (C-34-5)9bba	08-18-88	65.2	17.5	525	8.2	240	299	55	24	14
Sevier River at (C-33-5)3aaa	08-18-88	75.4	15.0	545	8.4	318	56	24	26	3.3
Sevier River near Circleville, gaging station 10180000	08-18-88	81.3	12.0	480	8.5	210	288	50	21	26
East Fork Sevier River drainage area										
East Fork Sevier River below confluence with Deer Creek	08-17-88	23.0	17.0	520	8.6	260	288	45	35	12
Inflow to East Fork Sevier River below Osiris at (C-32-2)13bcd	08-17-88	0.49	14.0	235	7.9	100	148	30	6.2	6.1
East Fork Sevier River above Antimony, at (C-32-2)2cbb	08-17-88	140	20.0	425	8.6	200	247	37	27	11
East Fork Sevier River near Kingston, gaging station 10189000	08-17-88	125	20.5	430	8.7	170	242	36	20	21

from selected sites in the upper Sevier River basin

collected or information was not available; <, less than]

Potassium, dissolved (mg/L as K)	Alkalinity, total (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Phosphorus, ortho, dissolved (mg/L as P)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Boron, dissolved (µg/L as B)	Iron, dissolved (µg/L as Fe)	Manganese, dissolved (µg/L as Mn)	Selenium, dissolved (µg/L as Se)
						Sevier River drainage area						
1.1	175	4.1	1.9	0.20	12	0.20	<0.01	<0.10	10	22	10	<1
1.4	180	5.5	2.7	0.30	14	0.10	0.01	<0.10	20	14	4	<1
	245	360	50	0.10		<0.10	0.02	<0.10	80	<3	1	<1
4.8	199	5.5	3.6	0.20	31	--	0.02	<0.10	20	12	9	<1
1.6	393	8.8	4.4	1.4	15	--	0.03	<0.10	60	70	2	<1
6.9	267	6.7	5.5	0.20	36	0.20	<0.01	0.45	40	17	17	<1
3.1	271	8.0	6.5	0.20	28 30	<0.01	0.01	0.27	50	8	8	<1
3.5	229	8.8	7.4	0.20	33	<0.01	<0.01	0.19	50	15	3	<1
						East Fork Sevier River drainage area						
1.7	239	17	11	0.30	21	0.04	0.01	0.45	50	14	8	1
1.9	99	6.6	5.0	0.30	32	0.04	<0.01	0.15	40	29	2	<1
2.0	203	14	9.5	0.20	24	0.02	<0.01	0.14	40	<3	4	<1
4.8	184	20	13	0.30	16	0.18	<0.01	<0.10	130	17	6	<1

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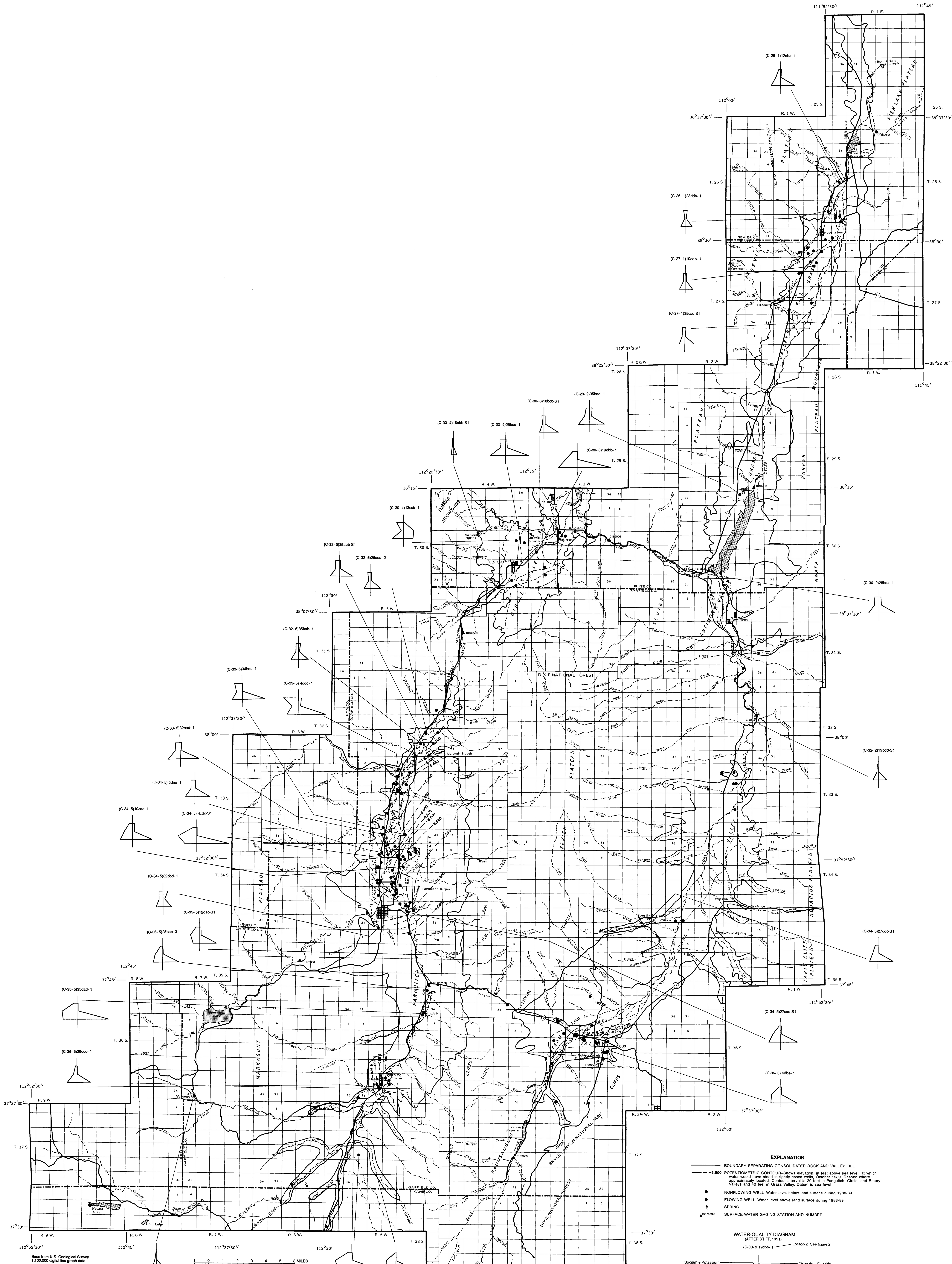

MAP SHOWING ELEVATION OF THE POTENTIOMETRIC SURFACE FOR THE VALLEY FILL AT SELECTED WELLS IN OCTOBER 1989, LOCATION OF HYDROLOGIC-DATA SITES, AND WATER-QUALITY DIAGRAMS FOR GROUND WATER IN THE UPPER SEVIER RIVER BASIN, UTAH