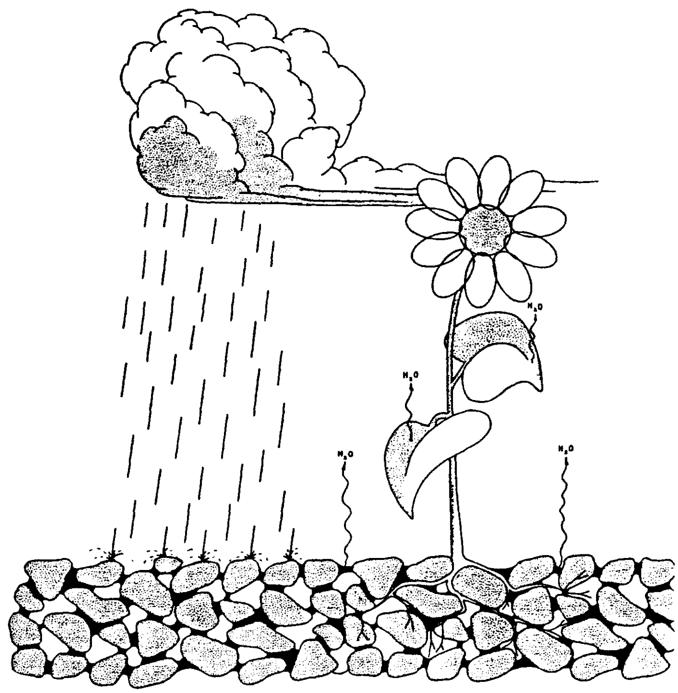
INFILTRATION AND EVAPOTRANSPIRATION WITHIN THE ALBUQUERQUE, NEW MEXICO, AREA WITH A SECTION ON HISTORICAL WATER-RESOURCE TRENDS DURING THE 1954-80'S PERIOD OF URBAN GROWTH

By Carole L. Goetz and Shareen G. Shelton



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CONVERSION FACTORS

In this report, most measurements are given in inch-pound units. The following table contains factors for converting to metric units. To convert millimeters (mm) to inches, multiply by 0.03937. To convert kilopascal to pounds per square inch, multiply by 0.1450.

Multiply inch-pound unit	By	To obtain metric unit
inch	2.540	centimeter
foot	0.3048	meter
mile	1.609	kilometer
square foot	0.09290	square meter
cubic foot	0.02832	cubic meter
square mile	2.590	square kilometer
gallon	3.785	liter
cubic foot	28.32	liter
acre-foot	1,233,619	liter
acre-foot per year	0.0391	liter per second
cubic foot per second	28.32	liter per second

Temperatures can be converted by the equations:

$$°F = (1.8 \times °C) + 32$$

$$°C = (°F - 32)/1.8$$

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

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ABSTRACT

Neutron logs collected over a period of 3 years and 2 months to reveal infiltration at 17 sites showed the greatest moisture changes occurring in the upper 3 feet of soil. Following rainfall, an increase in neutron counts to depths of 1.5 to 3 feet indicated infiltration to those depths; the wetting front infrequently advanced an additional 1.5 feet. A subsequent decrease in neutron counts in the upper few feet of soil indicated drying, probably due to evapotranspiration. Neutron-count increases beneath the arroyo bed were greater than those beneath the banks, indicating that infiltration per unit area is greater through the bed. The sandy and gravelly soils, the lack of transpiration-promoting vegetation, and the flow of water within arroyos promote infiltration. The mean infiltration at Grant Line Arroyo in northeast Albuquerque was 2,158 cubic feet, or 0.05 acre-foot per mile of arroyo.

Irrigation on golf-course rough areas increased the evapotranspiration rate two to three times over nonirrigated golf-course rough; lush, irrigated lawn had an evapotranspiration rate three to five times that of native vegetation. In the 31 years between 1956 and 1987, residential land use has more than tripled in the Albuquerque metropolitan area. With continued growth in residential land cover, an increase in evaporative water use can be expected.

Annual ground-water withdrawal from the Albuquerque metropolitan area more than tripled in 26 years from 31,000 acre-feet in 1954 to 105,000 acre-feet in 1980. During that same time period, annual precipitation had no systematic change. Water levels declined 0.53 foot to 1.28 feet per year in wells within the city of Albuquerque over the period of record evaluated. Water levels rose 0.04 to 0.19 foot per year in shallow wells, 75 to 123 feet deep, close to the Rio Grande between Albuquerque and Bernardo. From 1955 to 1984 streamflow losses on the Rio Grande between San Felipe and Bernardo decreased by 3,528 acre-feet per year. The Albuquerque metropolitan area, located between these stations, may have contributed to this trend of reduced losses through increased runoff to the Rio Grande as a result of land-surface paving and concrete lining of arroyos and through increased wastewater flow to the Rio Grande from the city's wastewater-treatment plant.

INTRODUCTION

Since 1950, the city of Albuquerque, New Mexico, has more than tripled in population, growing from 96,815 inhabitants in 1950 (U.S. Department of Commerce, Bureau of the Census, 1952) to 350,575 inhabitants in 1984 (City of Albuquerque Planning Division, 1986). The City of Albuquerque Planning Division (1986) compiled statistics projecting population growth for Albuquerque and the surrounding metropolitan area, citing a population of 404,079 in 1980, with a projected population of 506,000 by 1990. Managers and planners need current and historical information on water resources in order to efficiently use these resources for a rapidly expanding population. To provide the types of planning information needed, the U.S. Geological Survey, in cooperation with the New Mexico State Engineer Office and the Public Works Department of the City of Albuquerque, in 1983 began a study of precipitation, infiltration, and evapotranspiration characteristics in the Albuquerque metropolitan area. The study included an evaluation of the historical changes in water resources during the 1954-80's period of urban growth. This report describes and quantifies the processes of infiltration and evapotranspiration in the Albuquerque metropolitan area. The report also describes and quantifies historical changes in precipitation, ground-water withdrawals, water levels in wells, and stream discharge.

City of Albuquerque officials and private residents have graciously allowed access to their property for installation of scientific measurement equipment and for monitoring and maintenance of this equipment. Their help and cooperation are gratefully acknowledged.

DESCRIPTION OF THE STUDY AREA

The main area of focus for the study was the Albuquerque metropolitan area (fig. 1). The Albuquerque metropolitan area extends westward from the foothills of the Sandia Mountains across the Rio Grande flood plain past the West Mesa and southward from southern Sandoval County to about 5 miles north of Valencia County. Historical streamflow data, water-level data, and evapotranspiration data were cited from as far north as San Felipe (fig. 1) and as far south as Bernardo (fig. 1). Data were sometimes cited for the City of Albuquerque or Bernalillo County because most data-collection agencies operate within these political boundaries.

The Rio Grande flows from north to south through the area (fig. 1). Land-surface altitudes range from 4,900 at the Rio Grande to 6,500 feet above sea level in the foothills.

The City of Albuquerque Planning Division (1986) compiled the following statistics describing the population, size, and water consumption in Albuquerque. Ranked as the 44th most populous city in the United States, Albuquerque covered an area of 128 square miles on July 1, 1984. Per capita water consumption in Albuquerque in 1981 was 240 gallons per day. Ground water is the source of the municipal water supply.

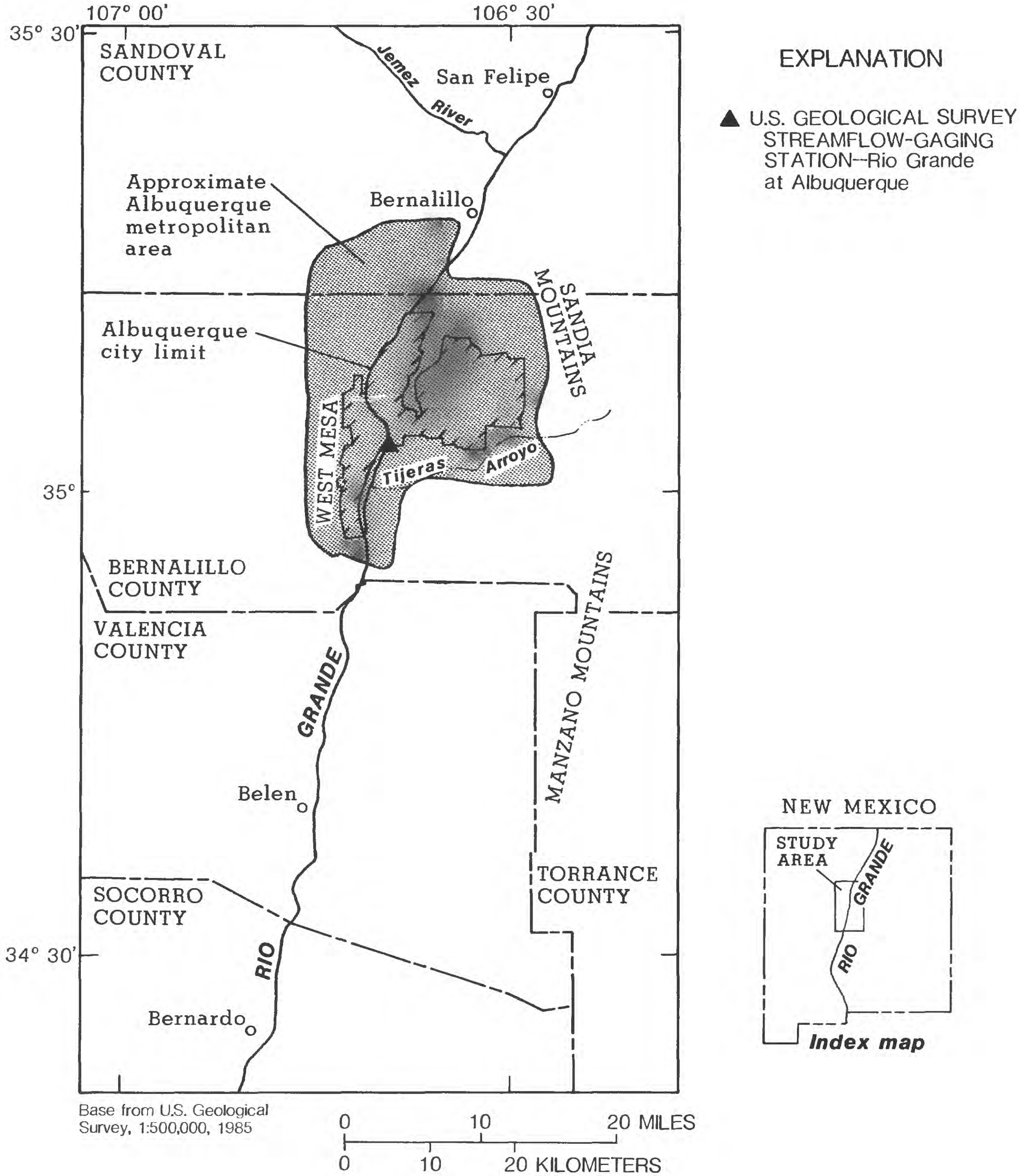


Figure 1.--Location of the study area.

Climate

Albuquerque has abundant sunshine, low relative humidity, scant precipitation, and a wide seasonal range of temperatures. The mean-annual precipitation in Albuquerque during 1956-85 was 8.4 inches per year (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1985). The mean-daily temperature during 1956-85 was 56 degrees Fahrenheit, ranging from a mean-daily low of 35 degrees Fahrenheit in January to a mean-daily high of 79 degrees Fahrenheit in July (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1985).

Surface-Water System

The Rio Grande is the only perennial stream within the Albuquerque metropolitan area. Flow in the Rio Grande has been regulated since November 1973 by Cochiti Dam located about 50 miles upstream from Albuquerque. The average discharge at the Albuquerque streamflow-gaging station (fig. 1) for the 12 years since completion of Cochiti Dam, water years 1974-85, is 1,352 cubic feet per second or 978,800 acre-feet per year (U.S. Geological Survey, 1985). Water is diverted for irrigation from the Rio Grande and is distributed through a system of canals and laterals.

Drainage of the eastern and western uplands is through arroyos, which carry runoff during and after precipitation. Most arroyos that drain from the east either lose their discharge by infiltration into their beds or empty into one of two large concrete-lined diversion channels that flow to the Rio Grande. A few arroyos empty into canals and drains that parallel the Rio Grande. Arroyos that drain from the west either lose their discharge by infiltration into their beds or empty into canals and drains that parallel the Rio Grande. During the last 10 to 20 years, the City of Albuquerque lined many arroyos with concrete for the purpose of channel and erosion control where they pass through developing areas. Concrete lining of arroyos prevents infiltration of water into the arroyo bed and increases storm runoff to the river, drains, and canals.

Ground-Water System

Basin-fill sediments constitute the aquifer from which Albuquerque derives its water supply. Composed of unconsolidated to loosely consolidated gravel, sand, silt, and clay, with some interbedded volcanic rocks, alluvial-fan deposits, and valley alluvium, these sediments underlie the metropolitan area to a mean depth of about 5,000 feet (Kernodle and Scott, 1986, p. 17). According to Kernodle and Scott, ground water moves diagonally downvalley in a southwestward direction from the base of the Sandia and Manzano Mountains. Near the mountains, the hydraulic gradient has a large vertical component directed downward. Ground water near the Rio Grande on the east and extending west about 8 miles flows southward and downgradient, paralleling the river valley. Kernodle and Scott (1986) believed that recharge to the alluvium along the base of the Sandia and Manzano Mountains on the east side of Albuquerque creates a water-level mound that must dissipate horizontally and vertically into lower zones in the basin fill. Local deflections of ground-water flow are caused by differences in hydraulic conductivity of the basin fill, evapotranspiration, withdrawal from wells, recharge from irrigation water, and arroyo runoff.

DATA COLLECTION

U.S. Geological Survey personnel collected data at 17 sites within the Albuquerque metropolitan area. The 17 sites selected for data collection (fig. 2) included a variety of typical land covers (table 1; all tables are in the back of the report in "Supplemental Information"). The types of data collected included: lithologic log, neutron log, net radiation, air temperature, soil temperature, relative humidity, vapor pressure, soil moisture, soil-heat flux, hydraulic head, water level, precipitation, streamflow, and evapotranspiration rate. Table 2 contains a summary of the frequency and period of record for data collected at each site. Sites are numbered from 1 to 21. Sites 5, 16, 18, and 19 had to be abandoned due to various problems, leaving a total of 17 sites. Data are available on computer tapes from the U.S. Geological Survey Office in Albuquerque.

INFILTRATION AND EVAPOTRANSPIRATION

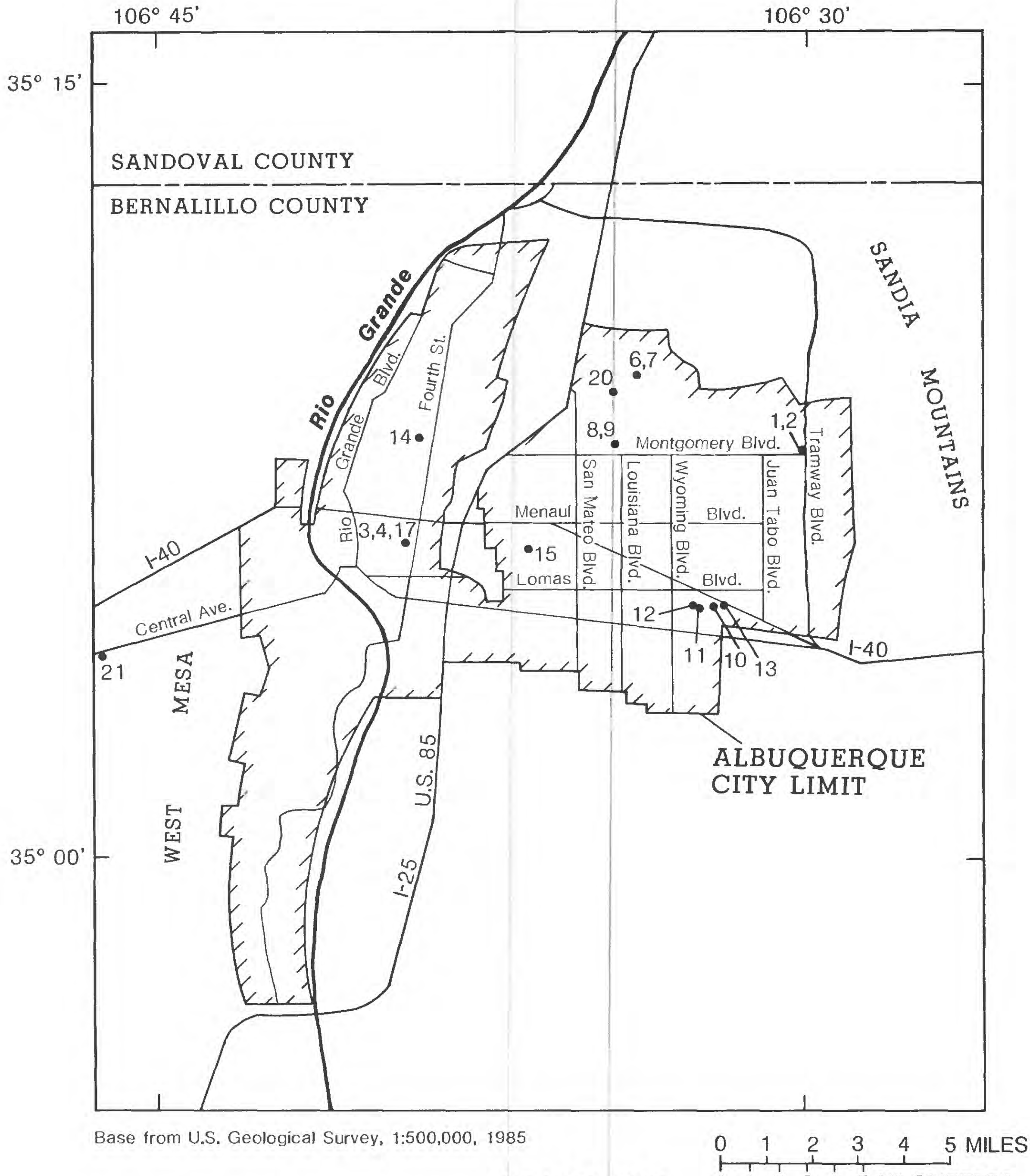
An understanding of infiltration and evapotranspiration and the ability to estimate them are important to disciplines such as watershed management, and land and water resource planning. Water is taken into bare soil or soil supporting vegetation through the process of infiltration. Water is lost from bare soil, reservoirs, lakes, crops, lawns, and forests through the processes of evaporation and transpiration, or undifferentiated, evapotranspiration.

Infiltration is the passing of water into the soil through its pore spaces. Water passed into the soil is generally applied as irrigation or precipitation.

Evaporation is the process by which molecules of water at a water surface or moist soil surface acquire enough energy from heated air or from sun radiation to escape the liquid and pass into the gaseous state. Transpiration is the process by which plants lose water to the atmosphere by converting water molecules to the gaseous state at the leaf surface. In many instances the amount of evaporation cannot be measured separately from transpiration, hence the two processes are considered together as evapotranspiration (Davis and DeWiest, 1966, p. 18-19).

Neutron-log data provided insight into the processes of infiltration and evapotranspiration. Correlation of return counts from a neutron source with moisture at a point in the soil column aided in the interpretation of vertical movement of moisture through soil profiles and changes in soil-moisture content over time.

Analysis of net-radiation, air-temperature, soil-temperature, relative-humidity, vapor-pressure, and soil-heat-flux data provided estimates of evapotranspiration rates using the Bowen-ratio, energy-balance method (Linsley and others, 1982, p. 160). Direct measurements of evapotranspiration rates also were made using a portable chamber. Tensiometers measured hydraulic head, which determined the direction of water flow within the unsaturated zone.



EXPLANATION

6 • DATA-COLLECTION SITE AND NUMBER--See tables 1 and 2

Figure 2.--Location of data-collection sites in the Albuquerque area.

Qualitative Implications of Neutron Logs

Counts recorded on the neutron log by the neutron tool relate to the quantity of hydrogen atoms within a surrounding volume of adjacent soil. Because water molecules are two hydrogen atoms and one oxygen atom, increases or decreases of water molecules within a volume of soil cause the neutron counts to increase or decrease. Neutron-count increases or decreases from one time period to the next indicate periods of soil-water recharge or discharge. Neutron-count increases or decreases that were not greater than or less than 10 percent were considered to be within the experimental error for the operation of the instrument (Hillel, 1980, p. 128-132).

Correlation of the neutron count with soil-moisture content can be made through calibration of the neutron tool instrument. Calibration involves concurrent gravimetric measurement of the soil-moisture content from soil samples collected during drilling and neutron-count measurement (Hillel, 1980, p. 128-132).

U.S. Geological Survey personnel drilled holes to allow access to the soil column with a 2-inch-diameter, stainless-steel tool, 11 inches long, closed on one end and toothed on the other end. Drilling, whenever possible, by pressing instead of rotating the tool avoided heating the soil, which could affect gravimetric moisture measurements. U.S. Geological Survey personnel removed soil samples from the tool and used them to prepare a lithologic log (table 3) and to measure gravimetric, soil-moisture content. The depth of the drilled hole was about 20 feet. Aluminum tubing sealed at the bottom and pressed into the hole provided the casing. Polyurethane foam hand mixed onsite, poured into the annular space, and allowed to harden prevented preferential movement of air and water through the void spaces (fig. 3). The neutron cross section of the foam is highly dependent on its hydrogen atom content, but in its expanded state is only 2 percent that of water, volume for volume, and is therefore considered insignificant (Black, 1977).

On many plots of soil-moisture content against neutron count, the points scattered and failed to yield a significant regression equation (fig. 4). Many soil samples were heterogeneous, each having a unique mixture of gravel, sand, silt, and clay. The heterogeneity may have caused the failure in the calibration procedure. Quantitative soil-moisture contents were not determined from neutron counts because none of the holes were calibrated.

Readings taken while lowering the portable neutron probe by 0.5-foot intervals yielded a neutron log. The authors collected neutron logs at 17 sites (fig. 2) in the Albuquerque metropolitan area from August 1983 through September 1986. Logs collected once a month at each site, and before and after rainfall at selected sites, tracked the movement of moisture within the soil column.

Figure 3.--Polyurethane foam sealing the void space between the casing and the drilled hole.

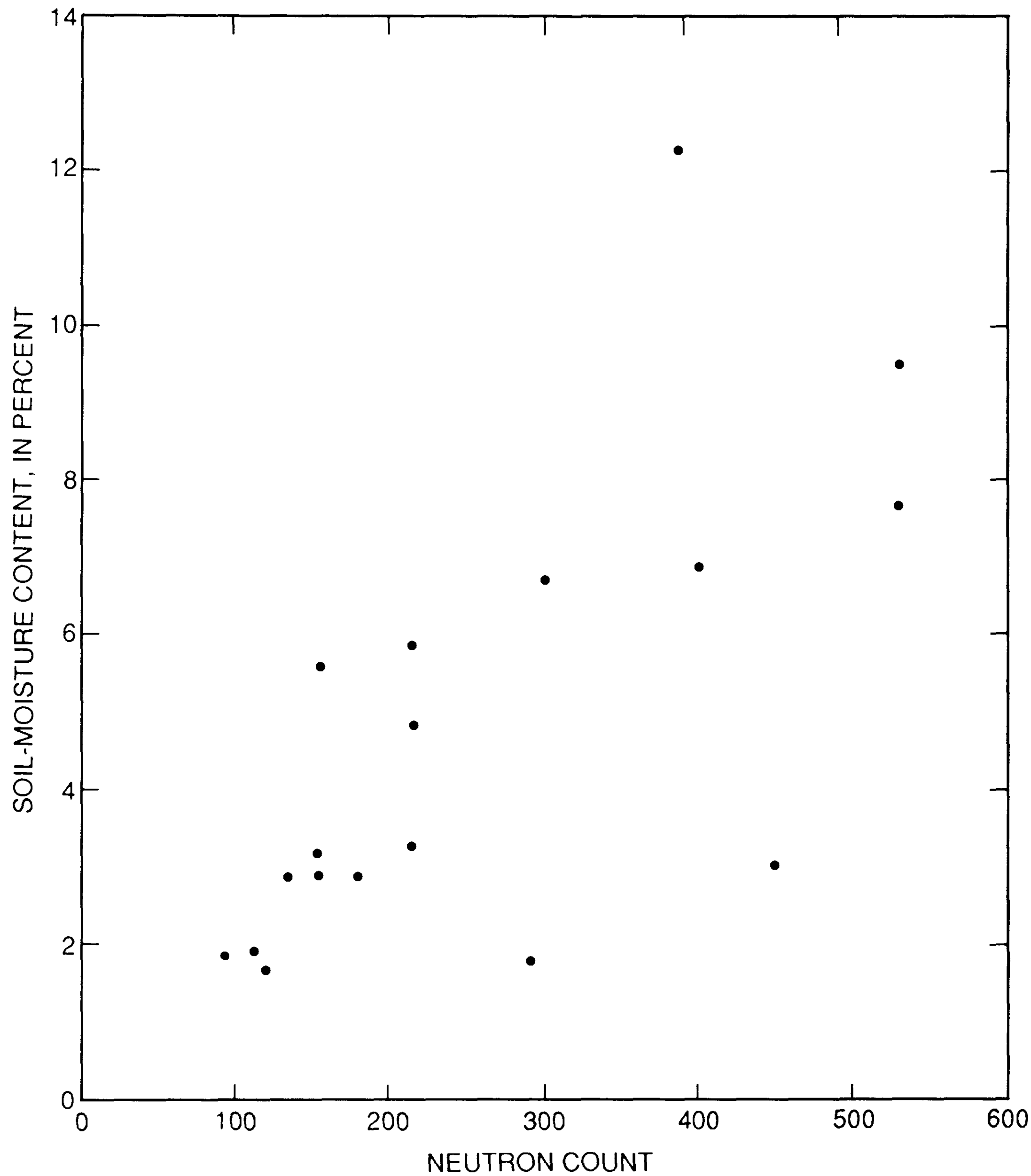


Figure 4.--Soil-moisture content and neutron count at site 9.

All sites showed the greatest changes in moisture in the upper 3 feet of soil. An increase in moisture content indicated by an increase in neutron count, called wetting in this report, followed rainfall or irrigation. A decrease in neutron counts, called drying in this report, followed the wetting when no further rainfall or irrigation occurred. At the irrigated residential and golf-course sites (sites 1, 6, 13, 14, and 15, fig. 2), the effects of rainfall could not be separated from irrigation effects unless rainfall occurred when there had not been any irrigation.

Vegetation growing adjacent to the neutron-access tube at site 4 increased soil-moisture content after a rainfall (fig. 5). The neutron logs are shown in figure 5 for sites 3, 4, and 17, measured on September 20, 1984, and on October 18, 1984. These sites are within 100 feet of each other, in unlandscaped ground adjacent to a government warehouse. On October 15, 1984, 1.25 inches of rain fell at the weather station at the Albuquerque International Airport about 5 miles from the sites. Three days after the rain, sites 3 and 17 showed little increase in neutron count within the first foot of the soil horizon, whereas site 4 showed a large increase. Site 4 had weeds growing adjacent to the neutron-access tube. Sites 3 and 17 had no vegetation nearby. The weeds at site 4 seemed to enhance the capture of moisture during rainfall, probably because plant roots have a larger percentage of moisture than barren soils.

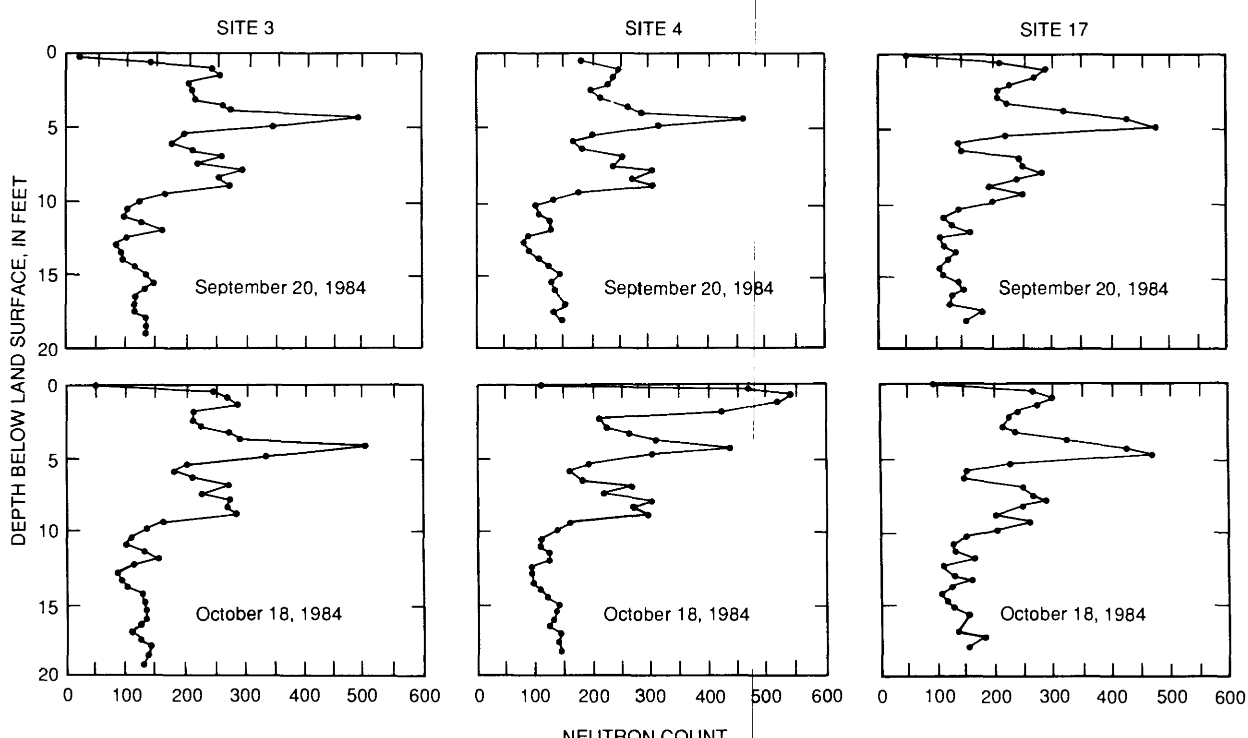


Figure 5.--Neutron counts at sites 3, 4, and 17 on September 20, 1984, and October 18, 1984.

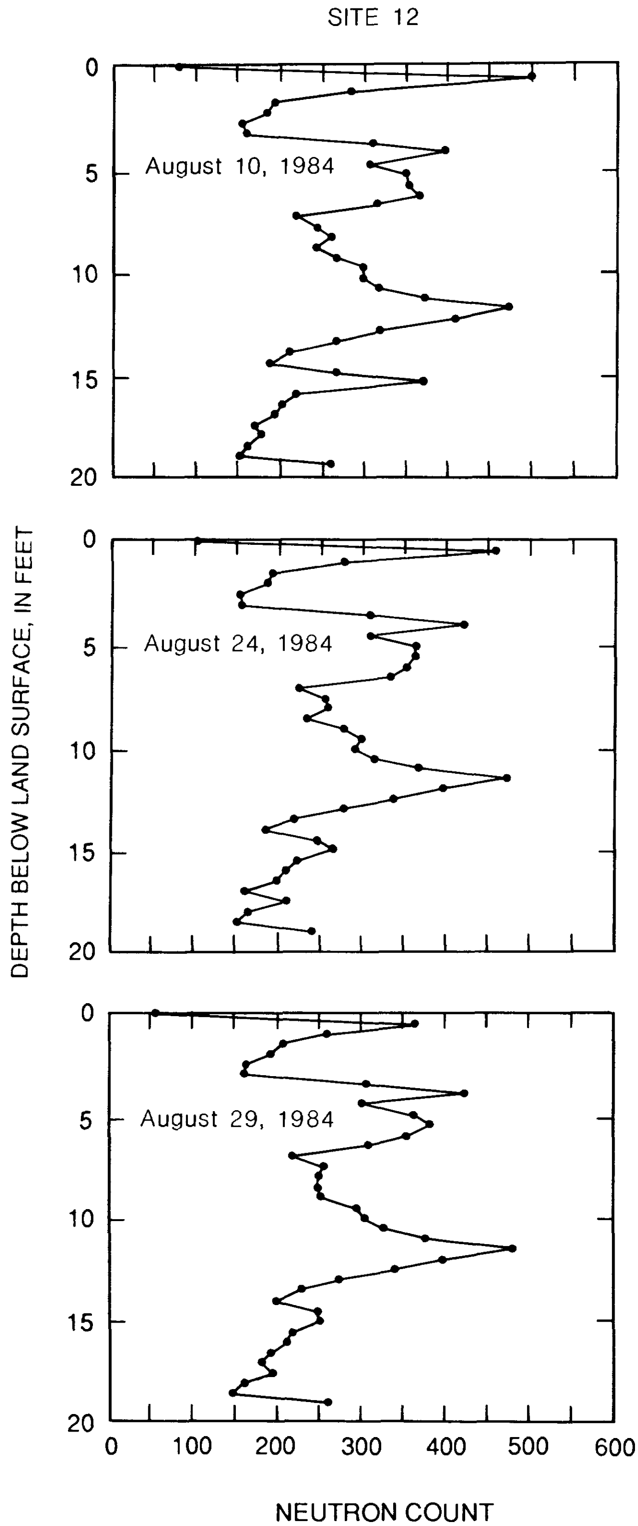


Figure 7.--Neutron counts at site 12 on August 10, 24, and 29, 1984.

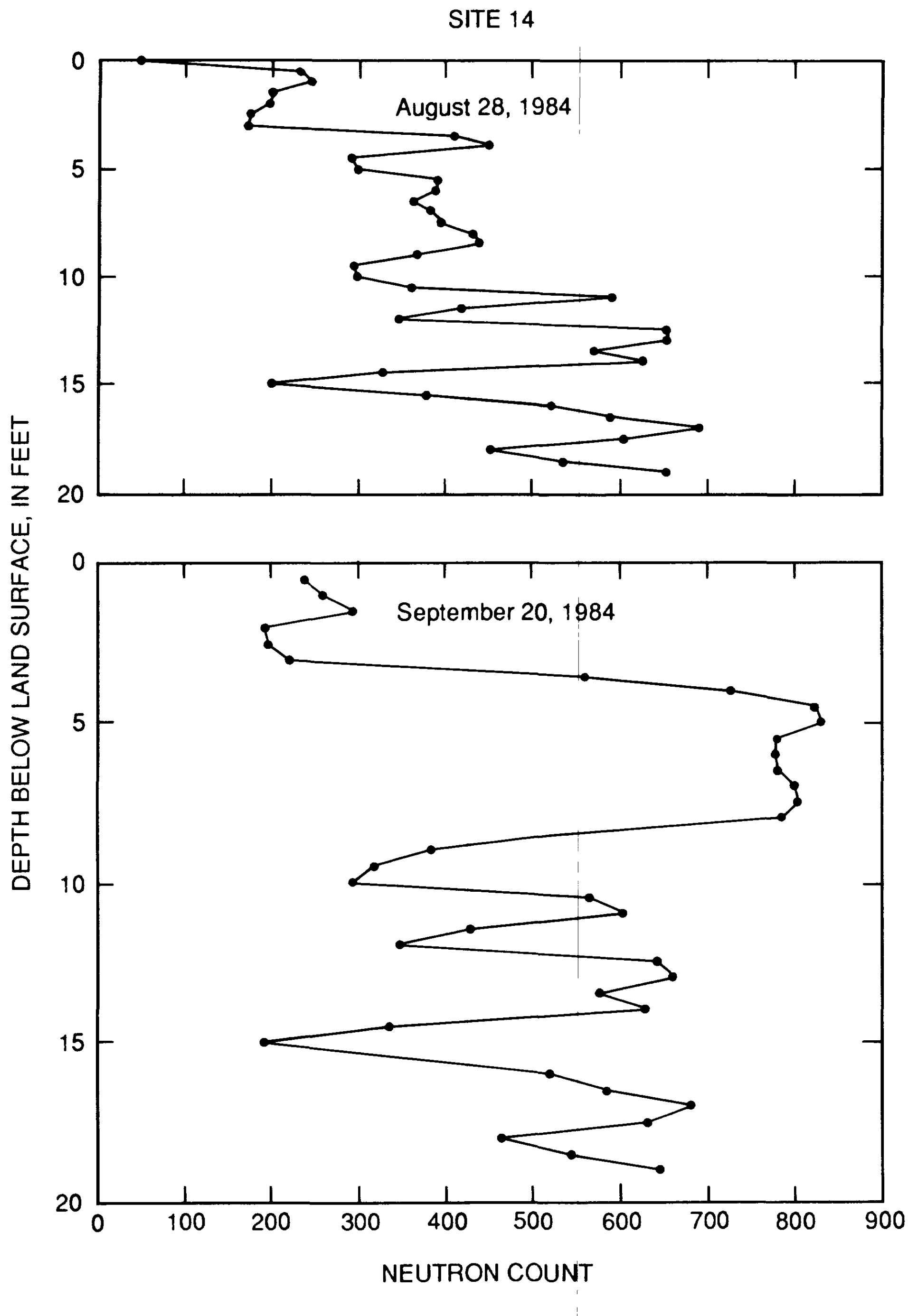


Figure 8.--Neutron counts at site 14 on August 28, 1984, and September 20, 1984.

Site 21 is located in sandy soil on Albuquerque's West Mesa, an undeveloped area with sand sage and other native plants. After rainfall on October 15, 1984, neutron counts, measured on October 17, 1984, increased in the first 1.5 feet of soil when compared with the October 4, 1984, counts (fig. 6). Neutron counts measured on October 29, 1984, indicate that on October 29, 1984, wetting advanced to about 3 feet. Another neutron log on November 21, 1984, indicates no further advance of wetting, and that the soil in the first 1.5 feet dried after October 17, 1984. This was typical at the majority of the 17 sites. Rainfall appeared to cause a wetting front in the first 1.5 to 3 feet, which occasionally moved down a small distance of about 1.5 feet. Neutron counts from the soil in the lower half of the hole did not increase noticeably. A decrease in neutron counts in the upper few feet of the soil with no concurrent increase in the neutron counts for the soil below typically occurred at the sites. This would seem to indicate that drying was due to evapotranspiration rather than advancement of the wetting front. Site 12 on August 10, 24, and 29, 1984, after rainfall on August 7, 22, and 23 of 0.97, 0.15, and 0.48 inch, respectively, illustrates this situation. This site had drying in the upper 3 feet of soil without advancement of the wetting front down the soil column (fig. 7).

At site 14 (fig. 8), between August 28, 1984, and September 20, 1984, the neutron counts between depths of 4 and 8.5 feet increased substantially. As shown in the lithologic log of site 14 (table 3), this zone is primarily clay. Several other sites also demonstrated large increases in moisture content at clay zones within the first 10 feet. When a wetting front reaches a clay layer, it primarily is retained by the clay or is transmitted horizontally along the upper surface of the clay layer through more permeable soil.

At one of three residential sites, an increase in neutron counts occurred at depth in 2 of a total of 41 neutron logs. Wetting occurred from a depth of about 3 feet to about 17 feet at site 6 (fig. 9). This wetting could be due to springtime irrigation to promote lawn growth. Because the large majority of the neutron logs did not indicate an increase in neutron counts at depth, it appears that water that is applied to the land surface as an irrigation or rainfall pulse begins infiltrating as a distinct wetting front, but quickly loses its definition. Changes in neutron counts become smaller with depth, and eventually the changes may be undetectable even though some infiltration may be occurring. Recharge to the water table from urban irrigation, although not observed as distinct wetting through the soil profile, probably occurs at least during the occasional times when wetting at depth occurs.

Nonirrigated sites had seasonal variation. At these sites the first 3 feet of soil became wetter during winter months and drier during summer months. The seasonal wetting and drying were particularly noticeable at residential sites that were covered by rockscaping, which consists of plastic laid directly over soil and covered by gravel. The plastic develops holes due to traffic and weathering. The wetting and drying are related to the summer and winter changes in evapotranspiration, which is a function of net radiation and water availability.

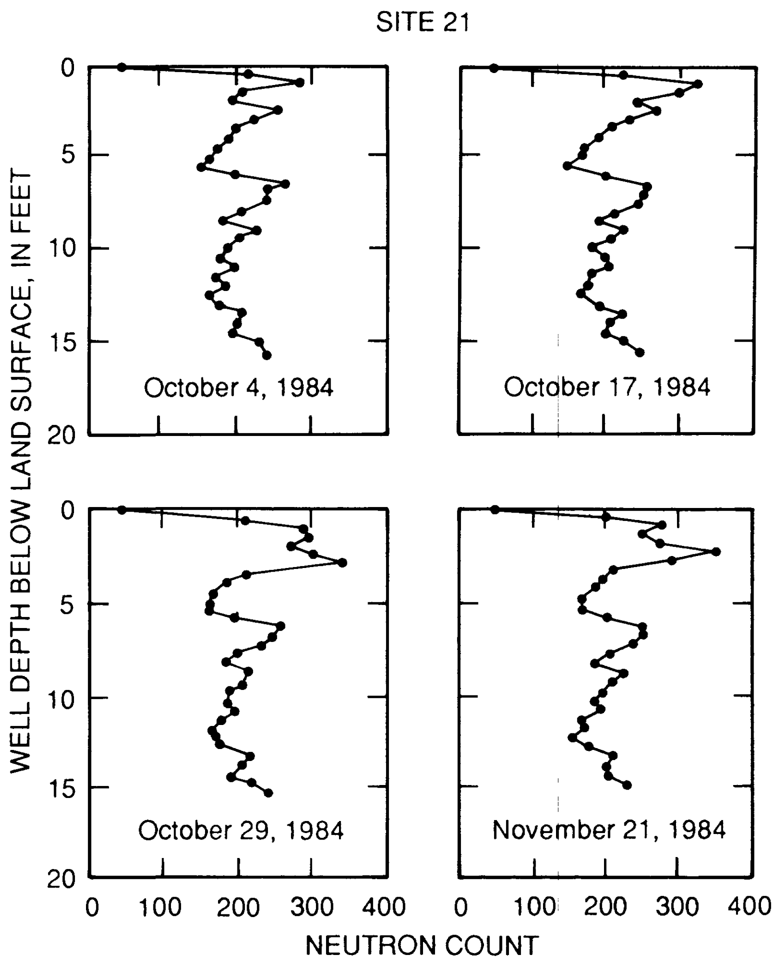


Figure 6.--Neutron counts at site 21 on October 4, 17, and 29, 1984, and November 21, 1984.

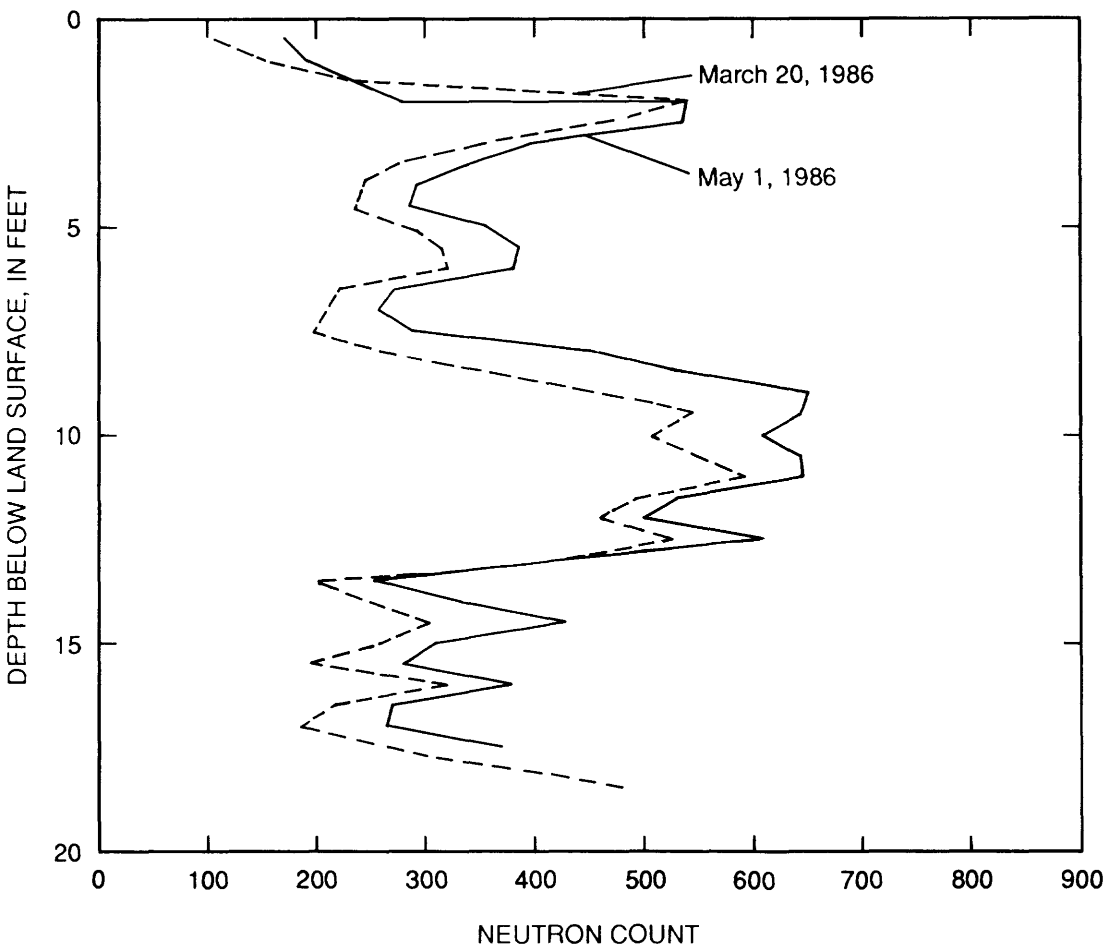


Figure 9.--Neutron counts at site 6 on March 20, 1986, and May 1, 1986.

Neutron-log site 8, in the bed of an unlined arroyo, was used to determine if infiltration occurred in the arroyo after runoff. Neutron-log site 9 was about 15 feet away on the arroyo bank. After significant rainfall and runoff neutron logs at site 8 showed wetting of the soil column followed by drying. The site 8 hole is about 12 feet deep. The soil column primarily is gravel and sand with one small silt layer (table 3). Following the rainfall and runoff of September 15-18, 1985 (table 4), the log of the neutron count with depth on September 18, 1985, at 4 p.m. (fig. 10) increased about 100 to 120 counts in the first 5 feet and about 45 to 65 counts in the bottom 4.5 feet compared with the log of August 12, 1985. Although the arroyo bed was still wet to the touch when this logging took place, it is possible that counts would have been even greater while water was flowing in the arroyo and that the largest part of the wetting front was missed. Also, because a log was not available immediately prior to September 15, 1985, and there were rainfall and runoff events between August 12, 1985, and September 15, 1985 (table 4), the increase in wetting due to a single rainfall and runoff was not isolated. However, it is clear that significant changes in soil moisture occur rather quickly after rainfall and runoff, as is shown by the neutron logs of September 18 and September 19, 1985. A log taken almost 18 hours after that taken on September 18, 1985, shows drying in the first 5 feet and some additional wetting in the bottom 4.5 feet. Drying could be due to drainage or evaporation, or both. Neither wetting nor drying was uniform with depth. A log taken 27 days later on October 15, 1985, shows that drying had taken place along the entire soil column even though there had been additional intervening rainfall and runoff (table 4). Site 9, located on the arroyo bank, did not show any wetting following the September rainfall and runoff (fig. 11). Site 9 (fig. 11) compared with site 8 (fig. 10) shows that most of the wetting and drying, and therefore potential recharge, are taking place in the arroyo bed rather than on the arroyo bank.

The sandy and gravelly soil in the arroyo bed, the lack of transpiration-promoting vegetation, and the flow of water within arroyos promote infiltration. However, concrete lining of arroyos, which is part of the urbanization process in Albuquerque, blocks infiltration through the bed.

Infiltration Measured in Grant Line Arroyo

The portion of Grant Line Arroyo (fig. 12) located between Louisiana Boulevard and San Pedro Boulevard (east of San Mateo Boulevard) and about 0.25 mile north of Montgomery Boulevard (fig. 2) served as an infiltration-measurement site. This portion of Grant Line Arroyo is an unlined sand channel without any tributary inflows or diversions and has a drainage area of 0.052 square mile. Broken concrete blocks and concrete sills stabilize the arroyo to prevent erosion in small areas along the length of the channel.

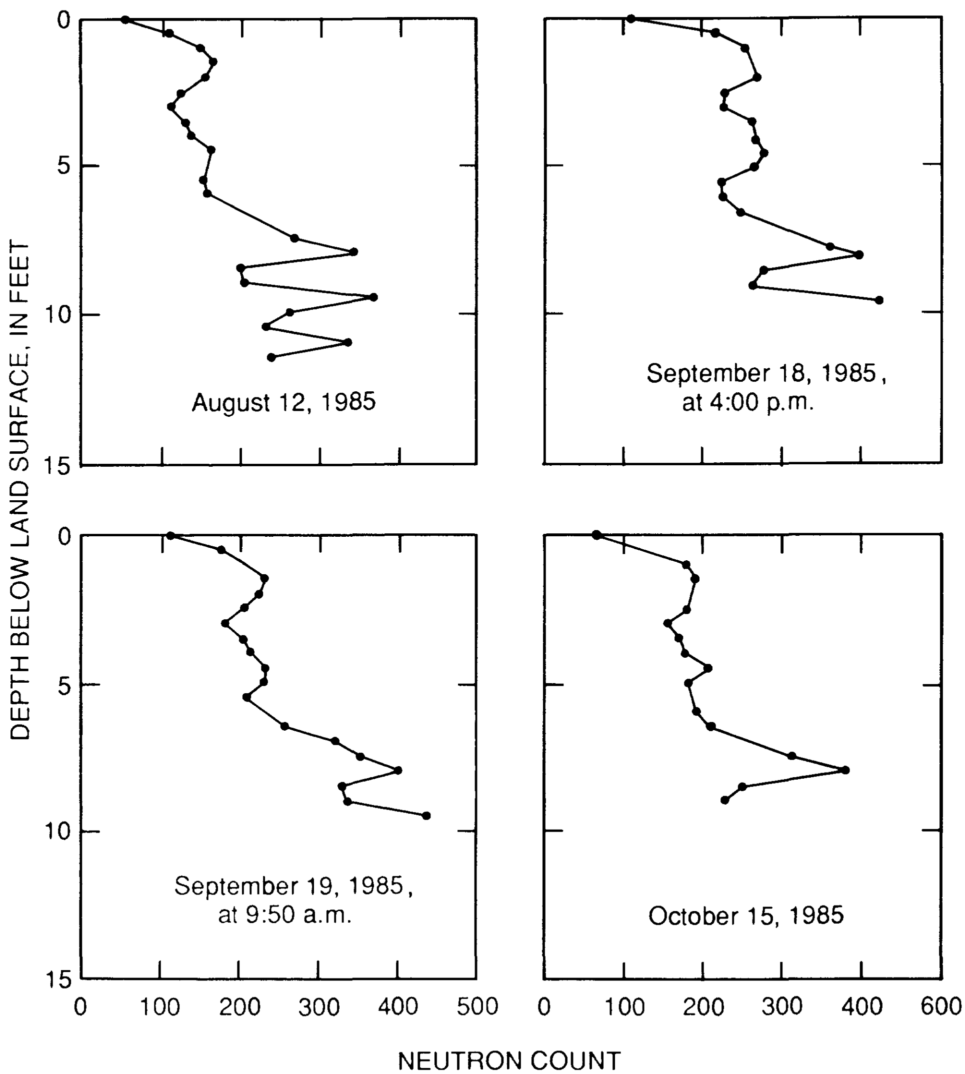


Figure 10.--Neutron counts at site 8 on August 12, 1985, September 18 and 19, 1985, and October 15, 1985.

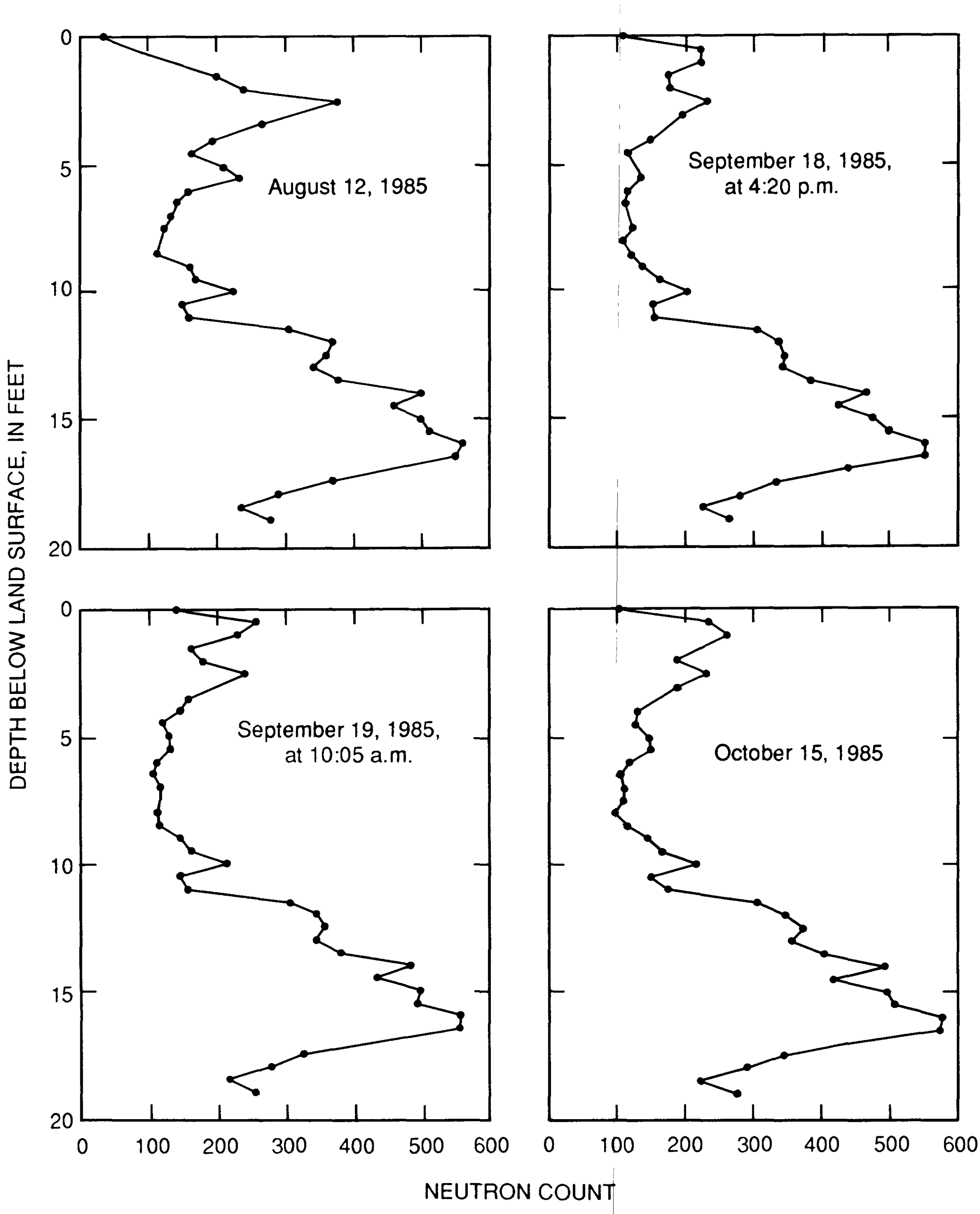


Figure 11.--Neutron counts at site 9 on August 12, 1985, September 18 and 19, 1985, and October 15, 1985.

Figure 12.--Grant Line Arroyo showing unlined sand channel with flow.

Two gages about 0.5 mile apart along the arroyo channel measure streamflow. The authors calculated infiltration (the movement of water through the soil surface into the soil) from the discharge measured at the upstream gage when no discharge passed the downstream gage. The upstream gage (fig. 13), station 08329860, consists of an arced sill, which provides a good control for accurate measurement of discharge into the arroyo. The downstream gage (fig. 14), station 08329865, is at a point where poor control conditions preclude accurate measurement of discharge. Therefore, the function of the downstream gage was to record whether or not water that passed the upstream gage reached the downstream gage. When water did not reach the downstream gage, all the discharge that passed the upstream gage infiltrated between the two gages, and the discharge passing the upstream gage was the amount of infiltration.

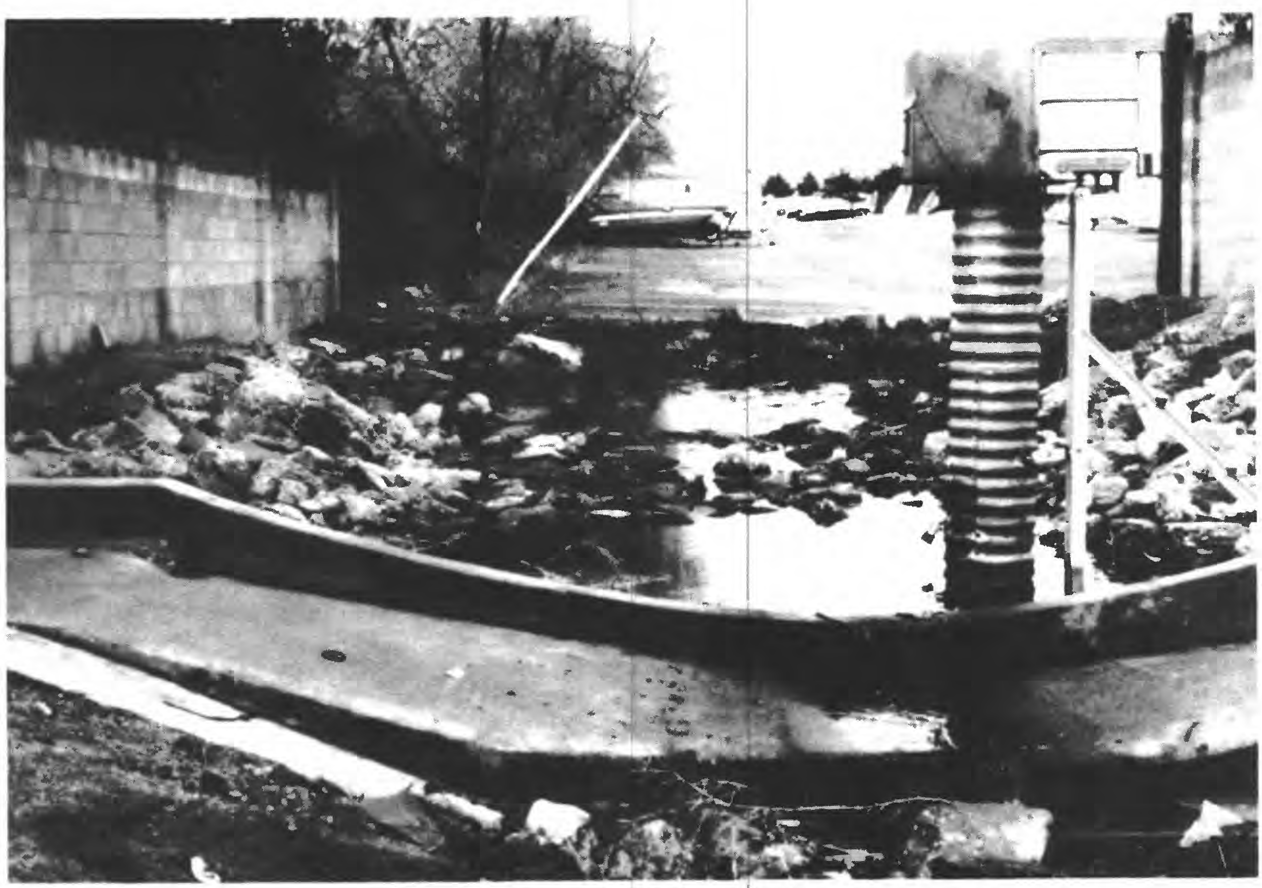


Figure 13.--Upstream gage and sill at Grant Line Arroyo showing small flow over sill from paved parking area.

Figure 14.--Downstream gage at Grant Line Arroyo showing flow through concrete control.

On March 31, 1984, April 14, 1984, September 24, 1984, and other dates, 0.00 inch of rainfall resulted in measurable infiltration. This is because rainfall sometimes occurs over part rather than all of a drainage basin, missing the rain gage. This results in flow in the arroyo even though no rainfall is recorded at the rain gage. On August 20, 1984, and other dates, rainfall and flow were measured but there was no infiltration measured. In this case, the duration of the rainfall was so short as to result in a daily-mean flow of 0.00 which results in an infiltration of 0.

Between March 26, 1984, and December 31, 1984, 62 flows occurred in Grant Line Arroyo (table 4). Infiltration could be calculated for 21 of those flows. Infiltration ranged between 0 and 4,320 cubic feet with a mean infiltration of 1,275 cubic feet (about 0.03 acre-foot) for an event. The sum of the infiltration for the 21 flows was 26,784 cubic feet (about 0.61 acre-foot). Expressed as a percentage of the precipitation on the drainage area, infiltration was about 13.7 percent of precipitation.

Between January 1, 1985, and December 31, 1985, 85 flows occurred in the arroyo (table 4). Infiltration could be calculated for 56 of those flows. Infiltration ranged between 0 and 3,456 cubic feet with a mean infiltration of 710 cubic feet or about 0.02 acre-foot. The sum of the infiltration for the 56 measurable flows was 39,744 cubic feet or about 0.91 acre-foot. Expressed as a percentage of the precipitation on the drainage area, infiltration was about 14.4 percent of precipitation.

Between January 1, 1986, and October 1, 1986, 51 flows occurred (table 4). Infiltration could be calculated for 35 of those flows. Infiltration ranged between 0 and 6,048 cubic feet with a mean infiltration of 1,382 cubic feet or about 0.03 acre-foot. The sum of the infiltration for the 35 measurable flows was 48,383 cubic feet or about 1.11 acre-feet. Expressed as a percentage of the precipitation on the drainage area, infiltration was about 13 percent of precipitation. Infiltration could not be calculated for a large number of flows because flows that reached the downstream gage were not considered; therefore, these calculations underestimate the sum of the infiltration for each year. The actual amount of infiltration is not known, and the degree of underestimation cannot be calculated.

The length of the studied reach of the Grant Line Arroyo, estimated from 7½-minute U.S. Geological Survey maps, is about 2,510 feet or 0.475 mile. During the period of study, 112 measurable events occurred, accounting for 114,910 cubic feet or 2.64 acre-feet of infiltration. The mean infiltration per event is 1,026 cubic feet or about 0.02 acre-foot. Assuming infiltration took place along the total length between the two gages, the mean infiltration per mile of arroyo is 2,158 cubic feet or about 0.05 acre-foot. The mean infiltration was 13.7 percent of rainfall.

The measurement of infiltration during some rainfall events in Grant Line Arroyo was successfully accomplished using streamflow gages. Upgrading the downstream gage, station 08329865, by improving the channel control would increase the number of infiltration measurements listed in table 4. Even with increased infiltration measurements, there is still the question of how much infiltration evaporates and how much reaches the water table. If a proper neutron calibration could be conducted, soil-moisture content could be determined from the neutron logs. An unsaturated flow model, requiring soil-moisture-content measurements, evapotranspiration measurements, and soil-moisture-characteristic curves, could be used to estimate how much infiltration evaporates and how much reaches the water table.

Neutron-log sites 8 and 9 were in the bed and on the bank of Grant Line Arroyo. Neutron counts indicate that infiltration is taking place at site 8 within the arroyo bed. This is confirmed by streamflow losses measured between the upstream and downstream Grant Line Arroyo streamflow gages. However, no quantitative comparisons can be made between the two methods because the neutron logs yielded only qualitative results.

Evapotranspiration Rates

As the city of Albuquerque grows, lawns, golf courses, parks, buildings, and streets replace native plants and shrubs. This change in land cover may influence various components of the city's water resources, including evapotranspiration. Evapotranspiration measurements made over various land covers within the city determined how different land cover affects evapotranspiration rate.

The authors measured evapotranspiration rate at 10 sites (table 2) in the Albuquerque metropolitan area from August 1985 to October 1986. Two methods of measurement were used: the Bowen-ratio technique (Linsley and others, 1982, p. 160) and the portable field-chamber technique (Stannard, 1988).

The authors computed Bowen-ratio, evapotranspiration rates from measurements of the following climatic factors: (1) net radiation, (2) soil-heat flux, (3) air-temperature difference between two levels above a field plot, and (4) vapor-density difference between the same two levels as air temperature (fig. 15). Vapor pressure measurements by a water-vapor-sensitive probe allowed computation of the vapor density (Campbell, 1977, p. 22). The Bowen ratio, computed each hour (Campbell, 1977, p. 136), assumed the vapor and heat-transfer resistances between the two levels above the field plot were equal. Computation of the evapotranspiration rate was in units of water depth per day by the energy-balance equation given in Linsley and others (1982, p. 160). Daily evapotranspiration rates averaged for the month determined the monthly evapotranspiration rate (tables 5-6). No monthly evapotranspiration rate was determined for months with less than six daily rates.

On the basis of the criteria discussed by Ohmura (1982), the authors rejected the hourly Bowen-ratio value when it was between -1.3 and -0.7 and set the evapotranspiration rate to zero. Rejection of the Bowen-ratio value and an evapotranspiration rate set equal to zero also resulted when the vapor-density gradient indicated an illogical situation compared to the sign of the evapotranspiration rate. These changes resulted in many sunrise and sunset values of evapotranspiration rate that were set to zero.

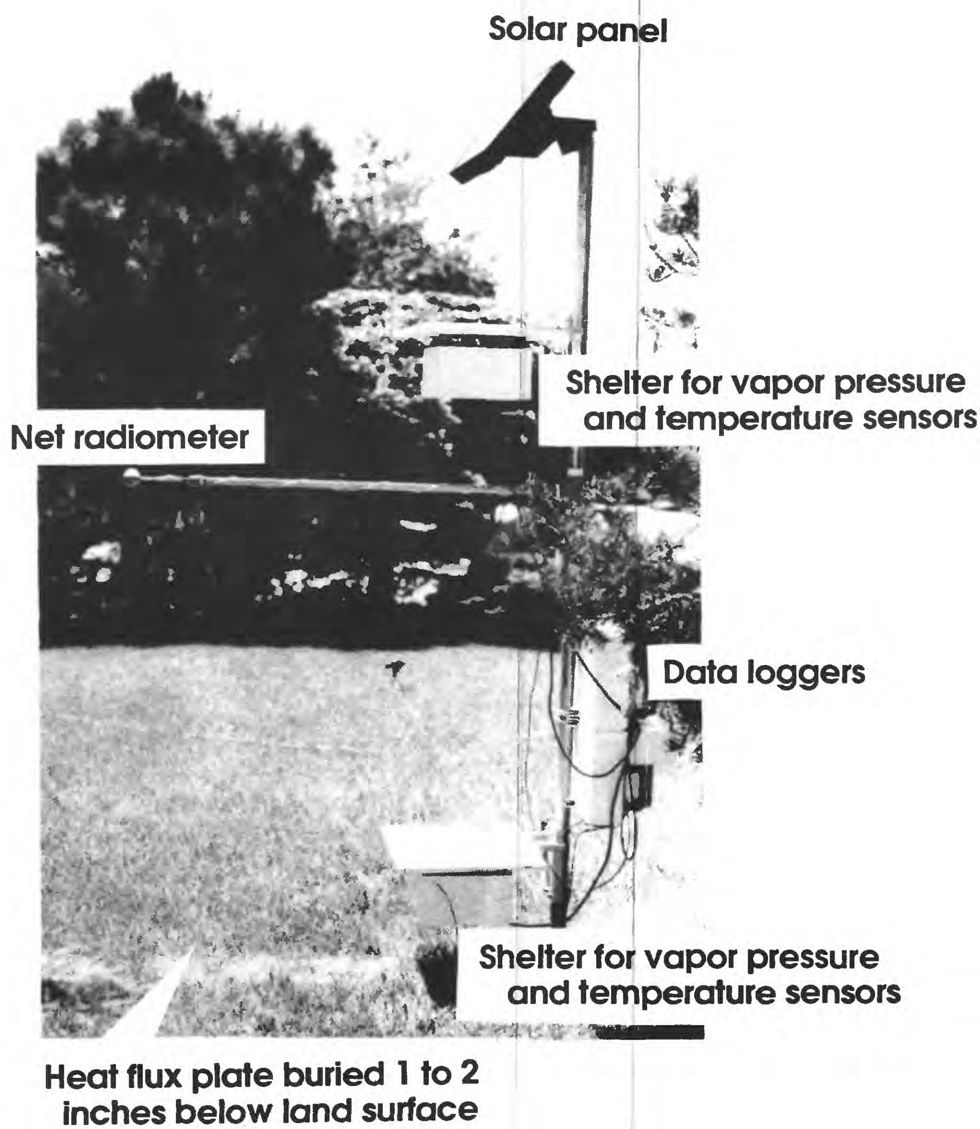


Figure 15.--Instruments for measuring Bowen-ratio, energy-balance evapotranspiration rate at site 1.

Two illogical situations occasionally occurred with the hourly midday evapotranspiration rates. Adjustment of the hourly Bowen-ratio values by Ohmura's (1982) criteria sometimes resulted in midday rates equal to zero. Negative hourly rates at midday also occurred at residential site 1. These illogical rates may relate to the asphalt road and cement sidewalks and driveway in close proximity to the lawn. Heated air masses from these surfaces may move by advection over the lawn area and anomalously affect the temperature and vapor-density gradient. When either of these two illogical situations occurred, the evapotranspiration rate was set to missing.

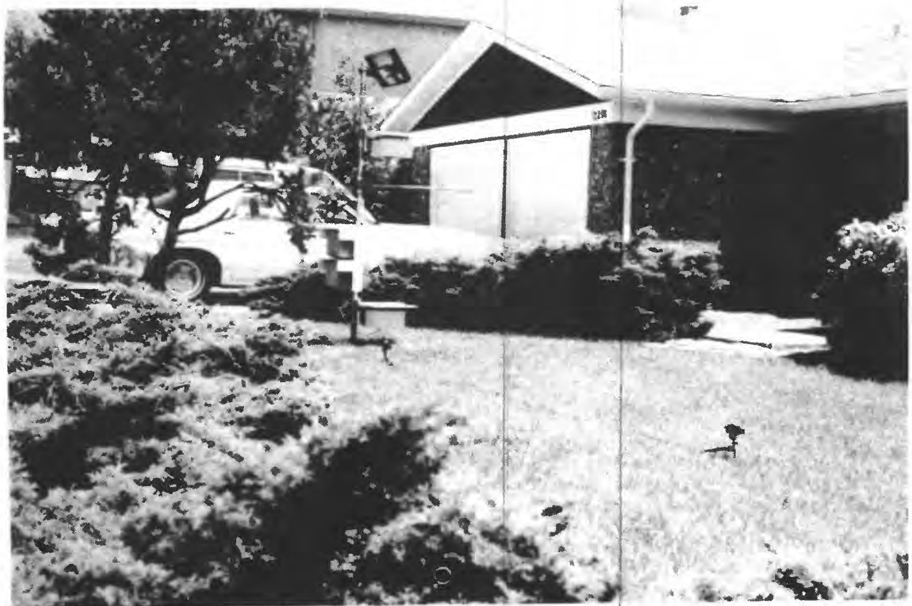
The Bowen-ratio technique requires a fetch, or length of uniform surface upwind of the instruments, of 100 times the height of the higher temperature and vapor-pressure probe. In this case, the required fetch was 600 feet. Equipment placement over residential lawns and rockscaping did not meet the fetch requirement. Although the prevailing wind direction at the weather station in Albuquerque is from the southeast (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, 1985, p. 3), the fetch is important in all directions at these sites because the turbulence caused by buildings and by uneven heating from the diverse land cover causes the wind direction to shift.

The Bowen-ratio instruments at site 1 are in the center of a lawn that extends about 25 feet in all directions (fig. 16). Adjacent to the lawn are shrubs, gravel, cement sidewalks and driveways, an asphalt road, and houses. The Bowen-ratio instruments at site 2 are in the center of residential rockscaping that extends about 15 feet in all directions (fig. 16). Adjacent to the rockscaping are shrubs, lawn, sidewalks, an asphalt road, houses, and a garage.

The fetch at site 14 was more uniform than at sites 1 and 2. At site 14, the clover and weeds extend about 100 feet to the east and west of the Bowen-ratio instruments and about 50 feet to the north and south (fig. 17). Adjacent to the clover and weeds are dirt driveways, lawn, buildings, pasture, and trees. The bare ground area at site 14 extended about 50 feet in all directions, with trees, pasture, weeds, and buildings adjacent to it (fig. 17).

An alternative method of evapotranspiration measurement that does not require a fetch is the portable field-chamber technique. The portable field chamber isolates a small area and measures vapor-density changes in the air above the isolated surface.

Site 1



Site 2

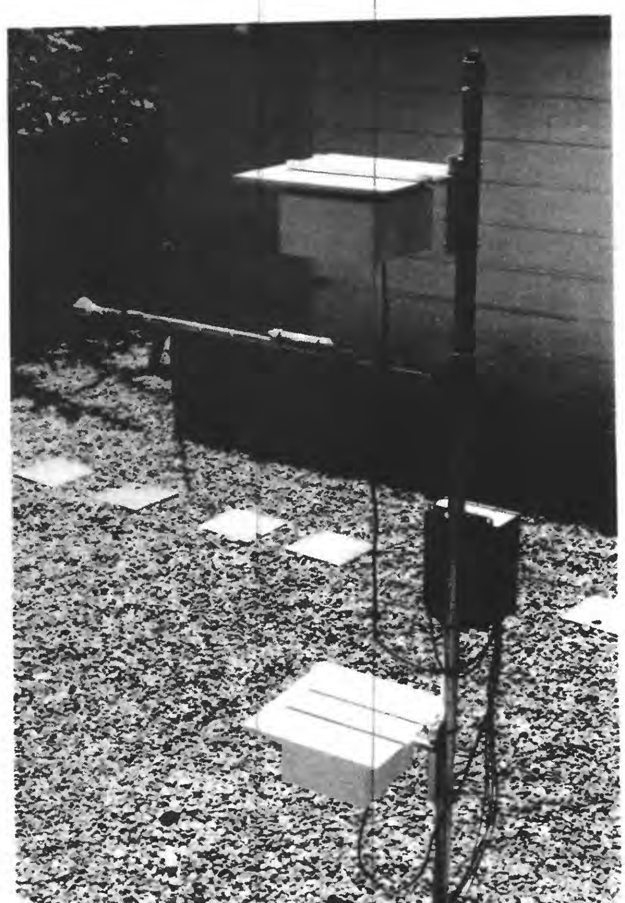
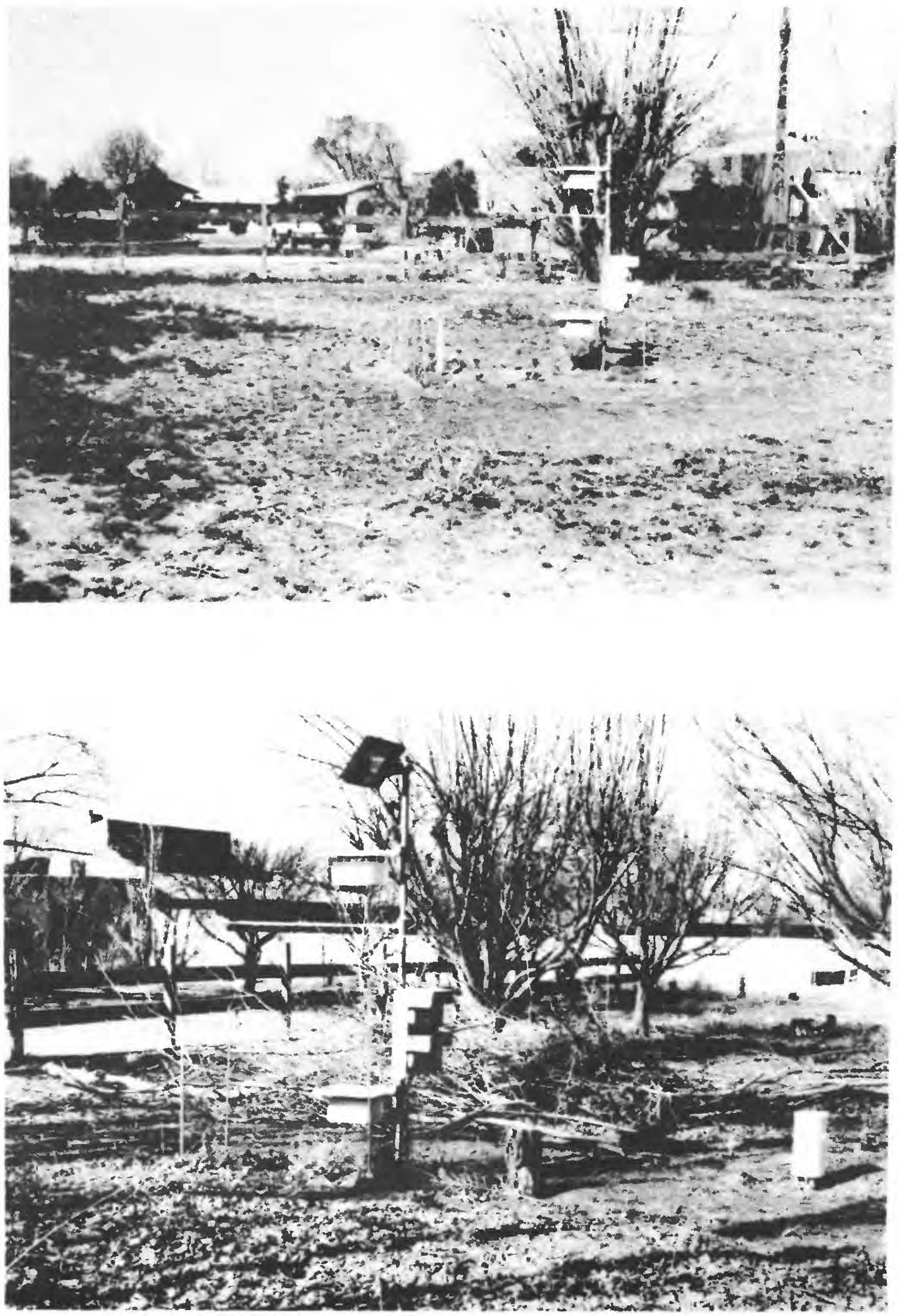


Figure 16.--Sites 1 and 2 showing the land cover within the fetch areas.



A

B

Figure 17.--Site 14 showing the fetch area during April 1986 (A) clover and weeds before irrigation and growth of the clover; and (B) bare ground.

The portable field chamber (fig. 18) is a device made of acrylic plastic in the shape of a hemisphere (Stannard, 1988). It isolates a surface area of about 9.7 square feet. To compute evapotranspiration by the portable field-chamber technique, vapor density was measured during a 1- to 4-minute period within an area isolated by the portable chamber. Computation of vapor density by the equations given in Campbell (1977, p. 22-24) was from wet-bulb and dry-bulb temperatures measured by a psychrometer mounted within the chamber. The slope of the vapor-density time series, inside the chamber before saturation occurred, determined an instantaneous evapotranspiration rate after accounting for the chamber volume, area, and calibration factor (Stannard, 1988, p. 4-12). The instantaneous evapotranspiration rate, measured for 12 to 14 times during daylight hours and integrated over a 24-hour period with an assumed rate of zero between sunset and sunrise, determined a daily evapotranspiration rate in inches per day. The evapotranspiration time series (fig. 19) compared for one of the largest daily evapotranspiration rates and one of the smallest daily evapotranspiration rates shows a peak near midday for the large rate and rises only slightly above zero during daylight for the small rate.

Simultaneous measurements using the Bowen-ratio and portable-chamber technique were made at sites 1 and 14. The Bowen-ratio data compared with the portable-chamber data show that evapotranspiration rates differ by a magnitude as great as two at site 1, whereas good agreement is found between the two methods at site 14:

Site	Date	Portable-chamber evapotranspiration rate, in inches per day	Bowen-ratio evapotranspiration rate, in inches per day
1	July 31, 1986	0.21	0.34
1	September 25, 1986	.08	.18
14	June 18, 1986	.11	.15
14	July 30, 1986	.17	.18
14	August 27, 1986	.10	.09

The unfavorable fetch at site 1 (fig. 16) probably causes the poor comparison between methods. Because of the poor comparison between methods at site 1 only the evapotranspiration data from the portable-chamber technique are presented in this report for the residential sites 1, 2, 6, and 7 (tables 7-8). At site 14 evapotranspiration data from the portable-chamber technique (tables 7-8) and the Bowen-ratio technique (tables 5-6) are reported because of the good agreement between methods.

The Bowen-ratio data are important because they were collected over 24-hour periods through all seasons of the year when portable-chamber data were not available. This allowed calculation of monthly and annual evapotranspiration rates.

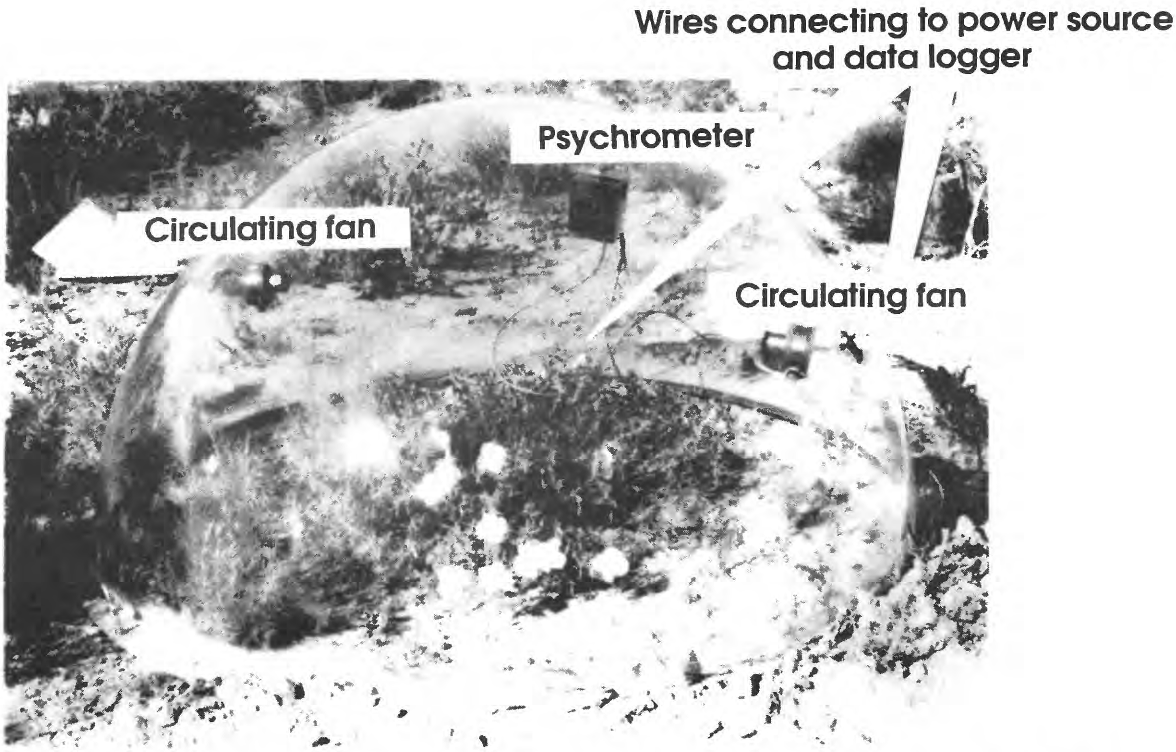


Figure 18.--Portable dome and instrumentation for measuring evapotranspiration rate at site 21.

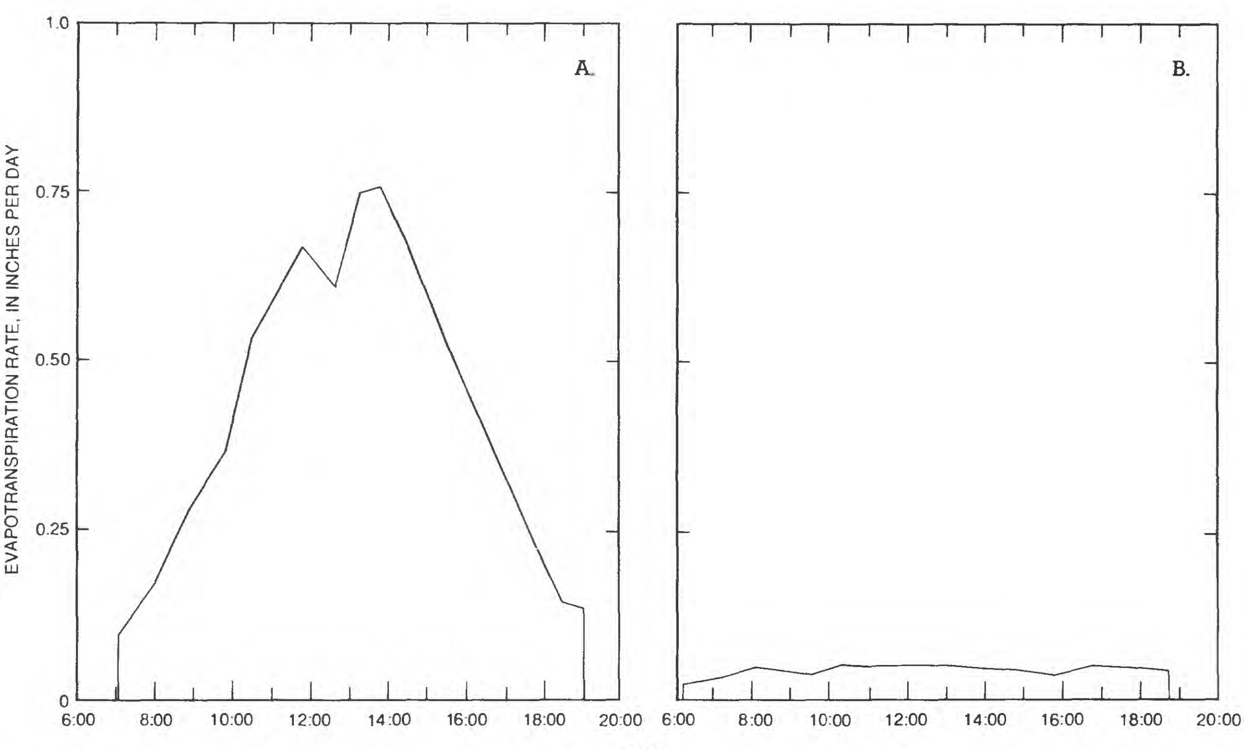


Figure 19.--Instantaneous evapotranspiration rates at site 1 (A) over grass on July 31, 1986; and (B) over gravel on September 25, 1986.

Evapotranspiration rates vary seasonally. Evapotranspiration rates were largest during May through August and smallest during October through February (tables 5-6). At site 14, the mean evapotranspiration rate estimated using the Bowen-ratio method for May through August 1986 over clover and weeds was seven times as great as the mean evapotranspiration rate for October 1985 through February 1986 (table 6, using an estimated rate of 0.41 inch for December 1985). The annual evapotranspiration rate at site 14 over clover and weeds for October 1, 1985, to October 1, 1986 (using an evapotranspiration rate of 4.33 inches for the month of April), was 33.9 inches (table 6).

The average portable-chamber evapotranspiration rates (table 8) show that evapotranspiration rates are largest over golf-course green, grass, and clover; and smallest over nonirrigated golf-course rough, gravel, soil with sparse vegetation, and bushes. The largest evapotranspiration rates (from 0.06 to 0.24 inch per day) over golf-course green, residential grass, and clover occur at irrigated sites. The smallest evapotranspiration rates (from 0.01 to 0.05 inch per day) over nonirrigated golf-course rough, gravel, soil with sparse vegetation, and bushes occur at nonirrigated sites. The lava rock at site 7 is within a sprinkler irrigation pattern and thus is not representative of evapotranspiration rates for rocks. Comparing the irrigated golf-course rough with the nonirrigated golf-course rough shows that irrigation increased the evapotranspiration rate two to three times during August through September 1986. Lush vegetation, such as that on the golf-course green, had an evapotranspiration rate that was three to four times that of nonirrigated rough during August through September 1986. Irrigated clover at site 14 had an evapotranspiration rate 1.3 to 1.5 times that of irrigated wild grass. Irrigated grass at site 1 had an evapotranspiration rate 3.3 to 5.3 times greater than nonirrigated gravel rockscaping at site 2 during July through September 1986. Although not measured on the same day, sand sage and snakeweed at site 21 on Albuquerque's West Mesa had an evapotranspiration rate three to five times less than irrigated lawn or golf-course green during July through September 1986. The change in land use from native vegetation to irrigated-land uses that accompany urban growth could increase evapotranspiration rates by a factor of three to five during the summer months.

A land-use survey of the Albuquerque metropolitan area (City of Albuquerque Planning Department, written commun., 1987) reports that 316,925,000 square feet of land was in residential use in 1956. The City of Albuquerque Planning Department (written commun., 1987) reports a residential-land use of 699,109,000 square feet in February 1987 with 65.3 percent of the Albuquerque metropolitan area surveyed. If the surveyed metropolitan area is representative of the entire metropolitan area, residential-land use was 1,070,620,000 square feet in February 1987. In the 31 years since 1956, residential-land use has more than tripled. Land is classified as residential if it contains single-family, multifamily, or mobile homes. No consideration for the amount of landscaped or irrigated surface is made. Because irrigated cover types had evapotranspiration rates two to five times greater than nonirrigated cover types, the tripled residential land significantly increases the demand for water.

Infiltration Potential and Evapotranspiration Potential Measured by the Tensiometers

The tensiometer, which consists of a porous cup of ceramic material connected through a vertical tube to a vacuum gage, measures hydraulic head. The hydraulic head is the sum of two components: the elevation of the point of measurement, or elevation head, and the pressure head. The elevation head is the drop in pressure due to the drop in elevation between the vacuum gage and the measurement point at the porous cup. The pressure head is the drop in pressure due to the suction of the soil water. The cup is placed in the soil at the point of measurement. Water from a plastic reservoir feeds down the tensiometer, comes into hydraulic contact, and equilibrates with soil water through the pores in the ceramic walls of the cup. Upon initial placement in the soil, the water contained in the tensiometer is at atmospheric pressure. Soil water generally exerts a pressure that is subatmospheric, causing a suction that draws out a certain amount of water from the rigid, airtight tensiometer, causing a drop in hydrostatic pressure. The vacuum gage indicates the hydrostatic pressure drop and the pressure drop due to the decrease in elevation between the gage and the measurement point at the porous cup.

A tensiometer left in the soil for a long period of time tends to follow the changes in the soil-water suction. As soil moisture is depleted by drainage or plant uptake, or as it is replenished by rainfall or irrigation, corresponding readings on the tensiometer occur.

Between December 14, 1984, and September 24, 1986, the authors made 194 measurements of hydraulic head for a group of six tensiometers at site 14. Site 14 is in an irrigated field of clover and weeds. Data from measurements made during all months of the year and at the depths of 0.5, 1, 2, 3, 4, and 5 feet showed that the hydraulic head (equal to zero at atmospheric pressure) from 0.5 foot to 5 feet either continuously decreased or was noncontinuous with depth. No data showed a continuous increase in hydraulic head with depth. The following table shows the hydraulic gradients measured on 4 days at site 14:

Tensiometer depth below LSD[1], in feet	Hydraulic head of water, in feet, and flow direction on: April 15, 1985, at 1:30 p.m.	June 5, 1985, at 11 a.m.	March 23, 1985, at 6 p.m.	June 18, 1986, at 11:30 a.m.
0.5	-2.8	-6.4 ↑	-2.4 ↓	-6.9 ↑
1	-3.8	-2.1	-6.4 ↑	-1.8
2	-5.1	-3.6	-5.1	-3.6 ↓
3	-5.8	-5.1	-6.4 ↓	-5.1 ↑
4	-9.1	-8.1	-9.1 ↑	-3.1
5	-10.5 ↓	-9.5 ↓	-6.8	-5.3 ↓

[1]LSD, land-surface datum

Observations made on April 15, 1985, show a potential downward soil-water flow from 0 to 5 feet. This is an infiltration profile. This type of profile occurred in 42 percent of the 194 observations. It occurred during the months of November through May but not during June through October. The infiltration type of profile was typical for the cooler months and seemed to be particularly associated with the cooler, overcast, or rainy days during those months.

Observations made on June 5, 1985, show a potential upward soil-water flow in the upper part of the profile and a potential downward soil-water flow in the lower part of the profile. This profile suggests that evapotranspiration is occurring. It occurred in 34 percent of the 194 observations during May through November but not during December through April. The evapotranspiration type of profile was typical for the warmer months.

The observations made on March 23, 1985, and June 18, 1986, show several reversals in the potential soil-water flow, indicating that flow may be into or out of various horizons in the soil column depending on their particular composition and moisture content. This type of profile occurred in 24 percent of the 194 observations during all months of the year except August and November. There were only four observations made during November.

The potential for infiltration is greatest during November through May when 38 percent of the annual precipitation occurs (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, 1985, p. 3). The potential for evapotranspiration is greatest during June through October.

HISTORICAL WATER-RESOURCE TRENDS

Historical data affected by a process that has continued through time, such as urbanization, for example, may show successive increases or decreases in values over time. In this report the authors refer to these successive increases or decreases in values over time as a trend. The presence of a trend indicates the existence of an effect and the magnitude of that effect. This effect may be due to one or many factors.

The "seasonal Kendall test and slope estimator for trend magnitude" (Crawford and others, 1983) determines the existence and magnitude of trend in data. The test also eliminates the influence of seasonality in hydrologic data. When the data being considered are annual values, the test automatically defaults to a nonseasonal test. This test was applied to hydrologic data and a trend was judged to exist if the test was significant at the 5-percent probability level. The hypothesis tested was that there is no trend over the selected time period. The hypothesis was declared true, that is, a trend does not exist, if the calculated probability exceeded 0.05 (5 percent). The hypothesis was declared false, that is, a trend exists, if the calculated probability was less than 0.05. Using the 5-percent level of significance, data from a site or station will, on average, appear to have trend, when it truly does not have trend, once in 20 trials. Therefore, in using the 5-percent level of significance, an error will occur once in 20 trials on average.

Precipitation

Annual precipitation at the Albuquerque station (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1954-82) ranged from a low of about 4 inches to a high of about 11 inches during 1954-82 (fig. 20). Annual precipitation showed no apparent trend for the period. The probability level for this test was 0.138 with a trend magnitude of 0.08 inch per year. The probability level greater than 0.05 indicates that annual precipitation rates have not changed significantly during the period tested.

Precipitation affects evapotranspiration, and indirectly affects water levels in wells through the hydrologic recharge process. It also directly affects stream discharge. A trend in precipitation could cause a concurrent trend in evapotranspiration, ground-water levels, and stream discharge.

Ground-Water Withdrawals

In the 27 years from 1954 to 1980 (inclusive) ground-water withdrawal more than tripled, increasing from about 31,000 to about 105,000 acre-feet per year (fig. 21). The seasonal Kendall test for trend indicates an increasing trend in ground-water pumpage of about 2,900 acre-feet per year. Demand for water has grown along with the growth in population. Between the census years 1950-80, population in Bernalillo County, which includes most of the Albuquerque metropolitan area, almost tripled, rising from 145,700 to 420,300 (U.S. Department of Commerce, Bureau of the Census, 1952-82).

Ground-water withdrawal lowers water levels in wells. The cone of depression associated with ground-water withdrawals can also create a gradient near the Rio Grande, which acts to capture water that would ordinarily have been a part of the stream discharge.

U.S. Geological Survey personnel compiled ground-water withdrawal information for the Albuquerque metropolitan area from the files of the New Mexico State Engineer Office, District 1, Albuquerque. Data on ground-water withdrawals for 1959-79 consisted of metered discharges with occasional periods of missing record. Data prior to 1959 and for 1980 were incomplete. Estimates for the missing and incomplete records were provided by the State Engineer Office personnel, calculated by interpolation between periods of known withdrawal, or calculated from the users-allowed diversion.

Water Levels in Wells

The authors searched the U.S. Geological Survey Ground-Water Site-Inventory (GWSI) files to obtain ground-water level data for the city of Albuquerque and the area along the Rio Grande valley as far north as Bernalillo and as far south as Bernardo. Data outside the city of Albuquerque metropolitan area were analyzed so that any trends that might be found within the city could be compared with regional trends.

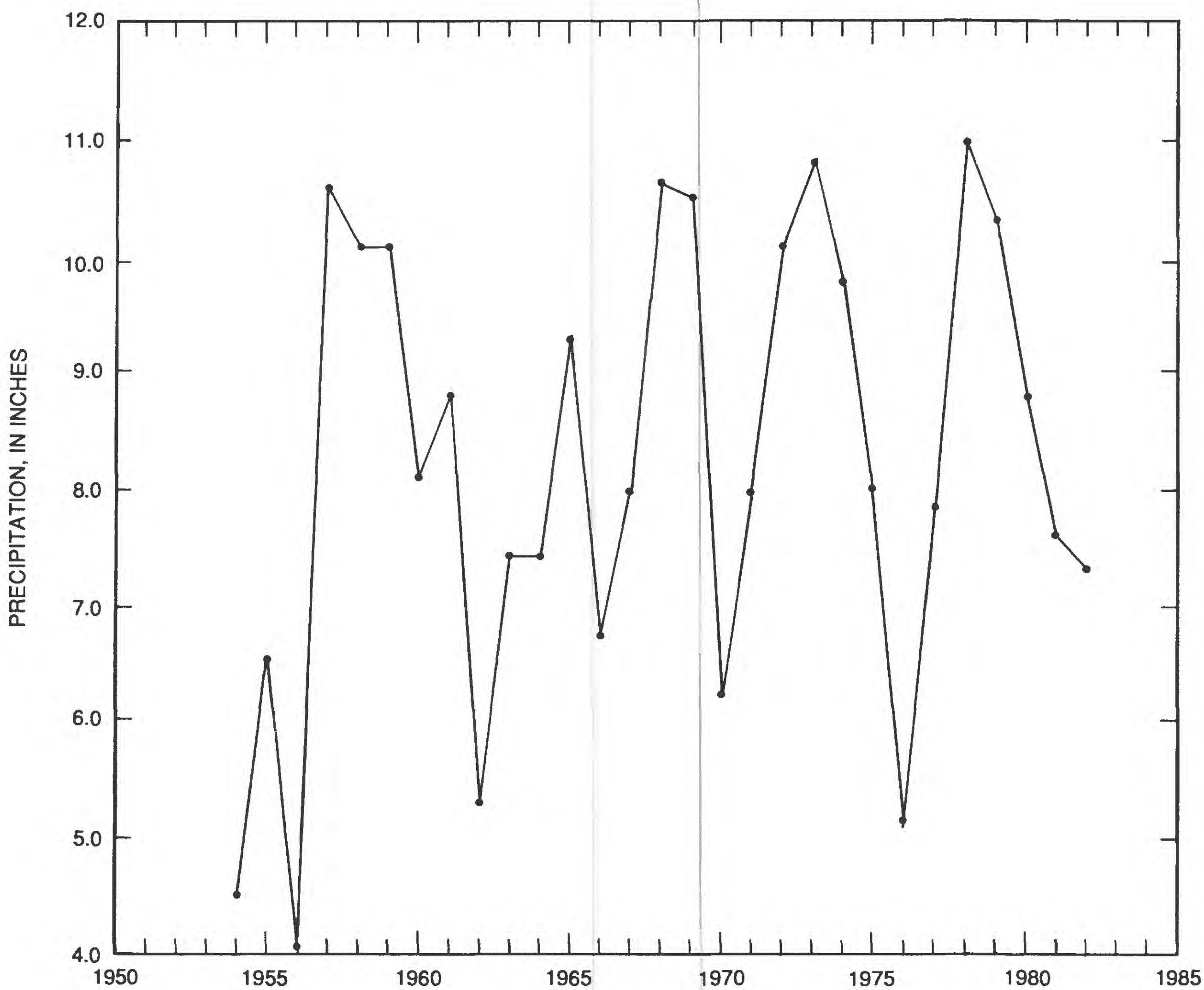


Figure 20.--Annual precipitation at Albuquerque, 1954-82 (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1954-82).

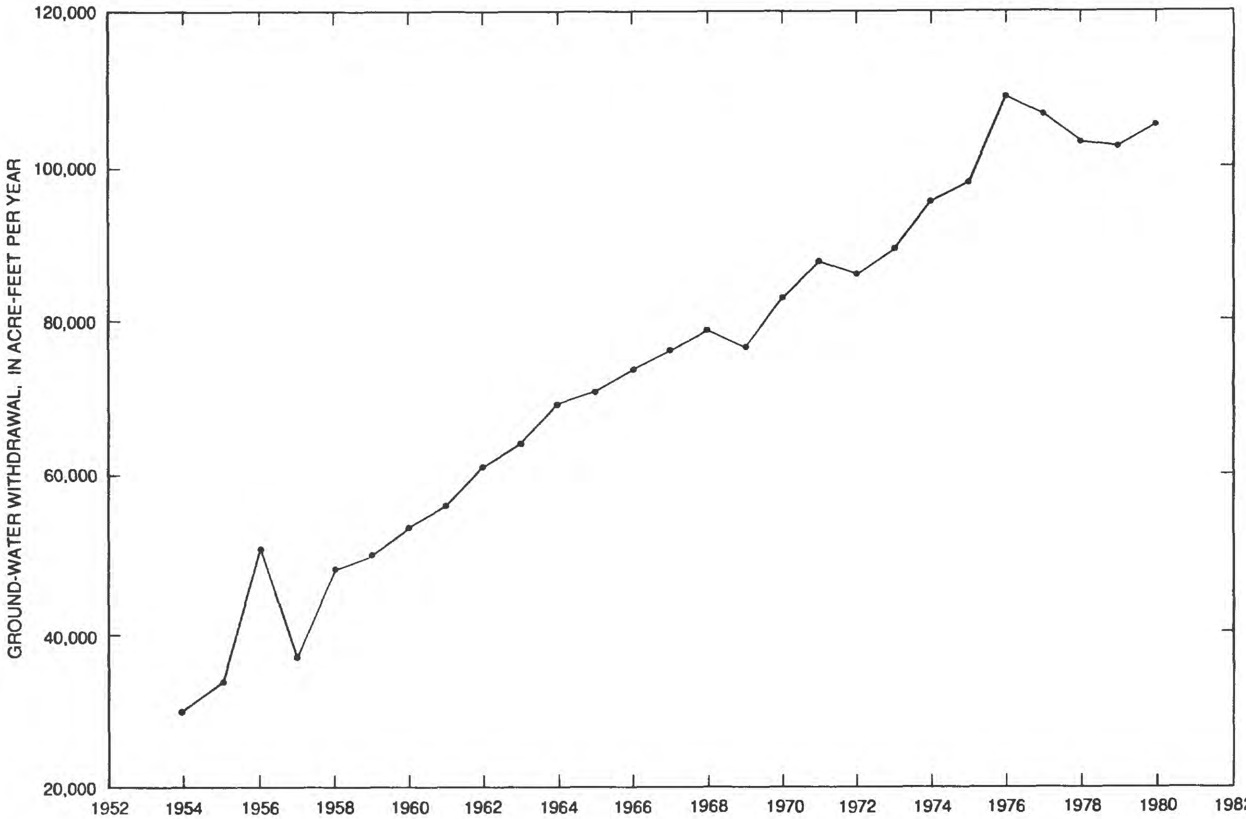


Figure 21.--Annual ground-water withdrawal from the Albuquerque-Belen Basin, 1954-80.

The GWSI file contained no water-level data prior to 1956. The objectives for the various data-collection programs dictated the frequency and period of record for data collection. Therefore, the frequency and period of record for data collection varied for these wells. Wells selected for trend analysis were those with the largest number of measurements and the longest periods of record within the years, 1954-1980's. The purpose of this trend test is to determine whether there is trend in historical water-level data and to quantify that trend if it exists.

Water levels in selected wells within the Albuquerque metropolitan area and in selected wells south of Albuquerque had trend in most cases (fig. 22). This indicates that the depth to water changed significantly over time, rather than remaining static. The seasonal Kendall trend test detected both declining water-level trends and rising water-level trends.

Of the six wells within the Albuquerque city limit (sites 3, 4, 5, 6, 7, and 8, fig. 22) three had a declining water-level trend, and three had no trend. The declining trends ranged from 0.53 to 1.28 feet per year. Well 6 (fig. 22) within the Albuquerque city limit had no trend but had a 5-foot step decrease in water level between 1970 and 1982, as shown by a Wilcoxon rank sum test (Helwig and Council, 1979, p. 331-334). Declining water levels probably are due to centers of heavy pumping within and near the metropolitan area.

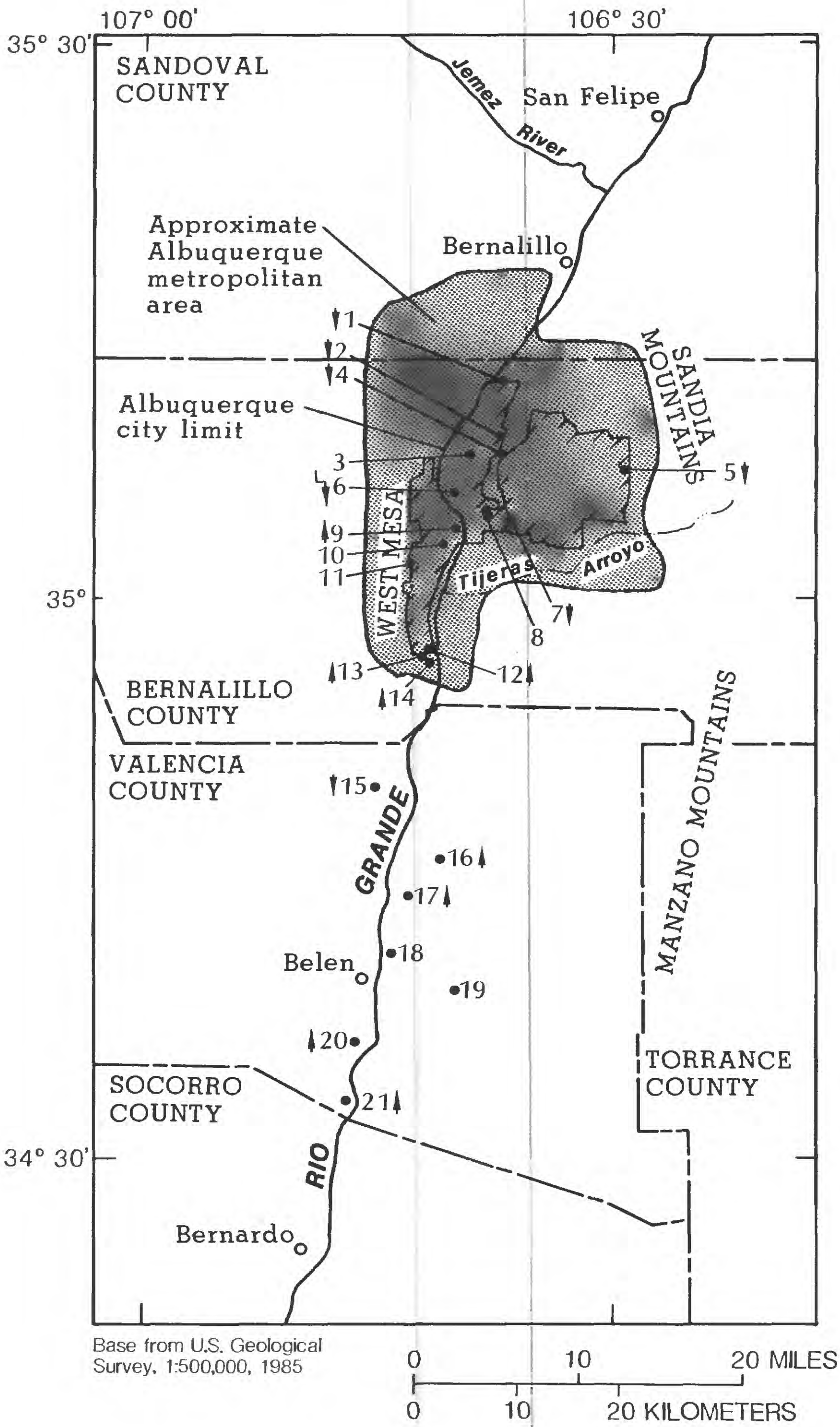


Figure 22.--Water-level trends at selected wells from Bernalillo to Bernardo.

EXPLANATION

↑1• WATER WELL AND NUMBER--Direction of arrow indicates rising water-level trend (↓); declining water-level trend (↑); step decrease (↴). Absence of arrow indicates no trend in water levels

Well number	Latitude-longitude number	Period of record	Depth, in feet	Water-level trend, in feet per year
1	351245106374501	1956-78	55	0.08 ↓
2	350900106373001	1956-62	170	0.63 ↓
3	350837106393801	1970-81	152	None
4	350824106375301	1967-78	150	1.28 ↓
5	350730106303001	1956-68	277	0.53 ↓
6	350646106403601	1970-82	150	Step decrease of 5 feet ↴
7	350548106383901	1970-81	148	1.04 ↓
8	350515106383001	1956-72	32	None
9	350415106403001	1956-78	Unknown	0.14 ↑
10	350330106410501	1956-66	46	None
11	350210106432501	1956-78	92	None
12	345752106423001	1956-72	87	0.04 ↑
13	345722106421001	1956-64	Unknown	0.19 ↑
14	345722106423001	1956-78	78	0.15 ↑
15	345009106454801	1956-70	388	0.04 ↓
16	344640106412701	1956-66	75	0.16 ↑
17	344443106435301	1956-76	90	0.06 ↑
18	344132106442101	1956-78	80	None
19	343910106395501	1956-81	260	None
20	343635106463001	1956-78	102	0.11 ↑
21	343304106465001	1956-78	123	0.10 ↑

Figure 22.--Water-level trends at selected wells from Bernalillo to Bernardo--Continued.

South of Albuquerque, most shallow wells, 75 to 123 feet deep, had rising water-level trends (sites 12, 13, 14, 16, 17, 20, and 21, fig. 22). The rising water-level trends south of Albuquerque, 0.04 to 0.19 foot per year, generally were smaller than the water-level declines within Albuquerque, 0.53 to 1.28 feet per year. Two shallow wells south of Albuquerque, 46 and 92 feet deep (sites 10 and 11, fig. 23), had no water-level trend. Well 15 south of Albuquerque (fig. 22), 388 feet deep, had a declining water-level trend of 0.04 foot per year.

Stream Discharge

The Rio Grande flows through the Albuquerque metropolitan area for about 17 miles along its course. The U.S. Geological Survey streamflow-gaging stations at San Felipe and at Rio Grande Floodway near Bernardo, are upstream and downstream, respectively, of the metropolitan area (fig. 23). The Rio Grande at Albuquerque streamflow-gaging station is within the city limit (fig. 23). Temporal changes in inflow from and withdrawals within the metropolitan area could generate or influence trends in discharge and in discharge losses or gains measured between gaging stations.

Runoff from precipitation and snowmelt and changing release rates from upstream reservoirs make discharge highly variable at streamflow-gaging stations. A less variable parameter over time is the discharge loss or gain measured between any two gaging stations. Unless discharge is equal, either a loss or gain will be measured between stations that reflects the effects of evapotranspiration, discharges to and withdrawals from the stream, and flow through the streambank and streambed between the stream and surrounding ground-water reservoir.

Between the San Felipe and Bernardo stations, the Rio Grande loses water; that is, stream discharge is largest at the upstream station and flow diminishes downstream. Since water year 1974, the mean-annual discharge, including flow in riverside drains and canals at the gaging stations at San Felipe, Albuquerque, and Bernardo, respectively, is 1,075,000; 979,500; and 955,600 acre-feet (U.S. Geological Survey, 1986).

In order to test for changes taking place between discharge-measurement stations along the Rio Grande the authors computed stream-discharge losses between stations and tested the losses for trend (table 9). Calculation of mean-daily stream discharge at each station included the mean-daily discharge in riverside drains, ditches, and canals to give the total mean-daily discharge at each valley cross section. The mean-daily stream discharge at San Felipe plus the discharge from the Jemez River, minus the mean-daily stream discharge at Bernardo, yielded the stream-discharge loss or gain between San Felipe and Bernardo. The adjustment to the mean-daily-discharge data for travel time between San Felipe and Bernardo was 2 days. The 2-day time of travel is for a mode flow (the most frequently occurring flow) of 700 cubic feet per second at San Felipe with a velocity of 2.5 feet per second for a distance of 83 miles between the two stations.

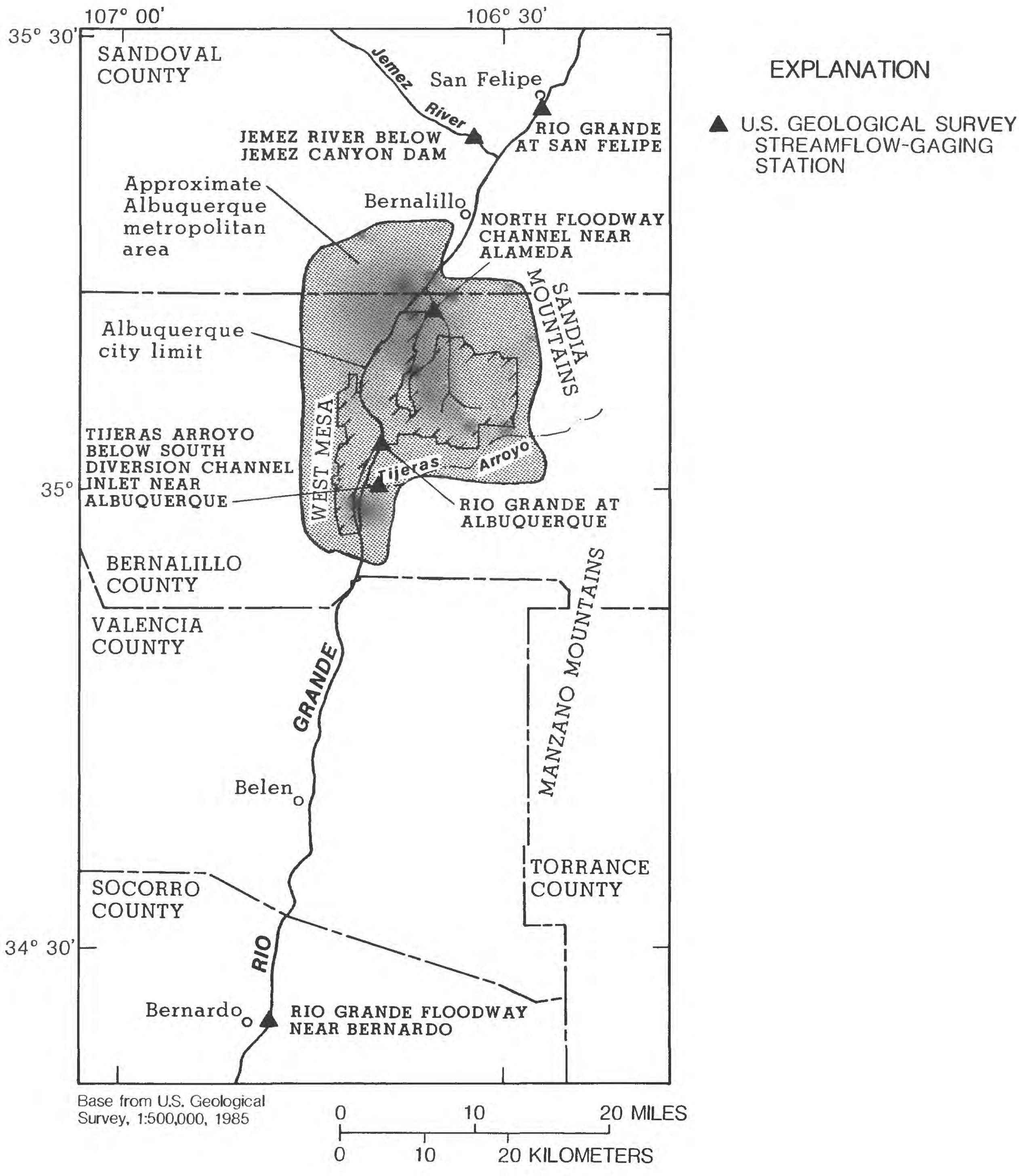


Figure 23.--Location of the Albuquerque metropolitan area, the Rio Grande, and selected streamflow-gaging stations.

A summary of significant trend results for 10-year and 30-year analysis periods shown in the table below indicates that changes are consistently a trend of less losses over time between the discharge stations. That is, either there is more inflow between the stations with time or there is less outflow between the stations with time. The time period with the greatest trend of less losses was 1964-73 with a trend of 8,520 acre-feet per year less losses. The time period with the least trend of less losses was 1955-84 with a trend of 3,528 acre-feet per year less losses. Because the Albuquerque metropolitan area is developed along the Rio Grande and lies between the two discharge-measurement stations, it may have a major effect on streamflow. Some possible causes for the trends that would result from a growing metropolitan area are also listed in the table. Increased runoff to the Rio Grande caused by increasing flow in large concrete-lined drainage channels (fig. 24) and increased wastewater flow to the Rio Grande from the city's wastewater-treatment plant (fig. 25) are factors that would increase flow in the Rio Grande. Changes in irrigation withdrawals and return flows along the reach between San Felipe and Bernardo also could account for the trend of less losses. The precipitation rate for 1954-82 showed no trend, indicating that the trend of less losses between 1955-84 is not correlated with precipitation.

Reach	Water years	Trend	Possible causes
San Felipe to Bernardo	1955-84	3,528 acre-feet per year less losses	Increased runoff, increase wastewater discharge
Do.	1957-66	6,000 acre-feet per year less losses	Do.
Do.	1959-68	4,604 acre-feet per year less losses	Do.
Do.	1960-69	4,816 acre-feet per year less losses	Do.
Do.	1962-71	5,077 acre-feet per year less losses	Do.
Do.	1963-72	6,877 acre-feet per year less losses	Do.
Do.	1964-73	8,520 acre-feet per year less losses	Do.
Do.	1965-74	7,725 acre-feet per year less losses	Do.
Do.	1966-75	7,631 acre-feet per year less losses	Do.
Do.	1967-76	6,255 acre-feet per year less losses	Do.
Do.	1968-77	5,476 acre-feet per year less losses	Do.

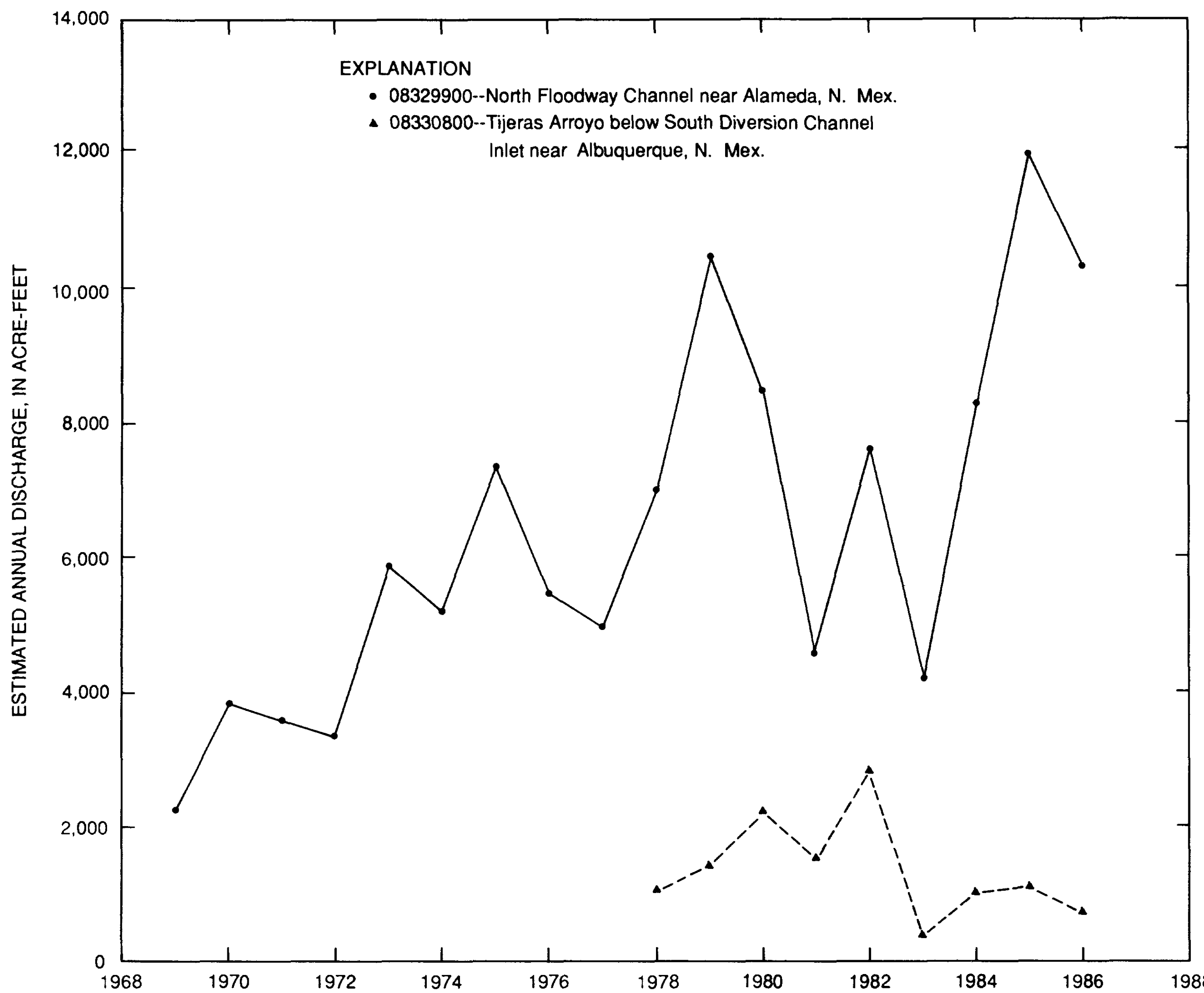


Figure 24.--Estimated annual discharge from the North and South Diversion Channels, 1969-86 (U.S. Geological Survey, 1970-86).

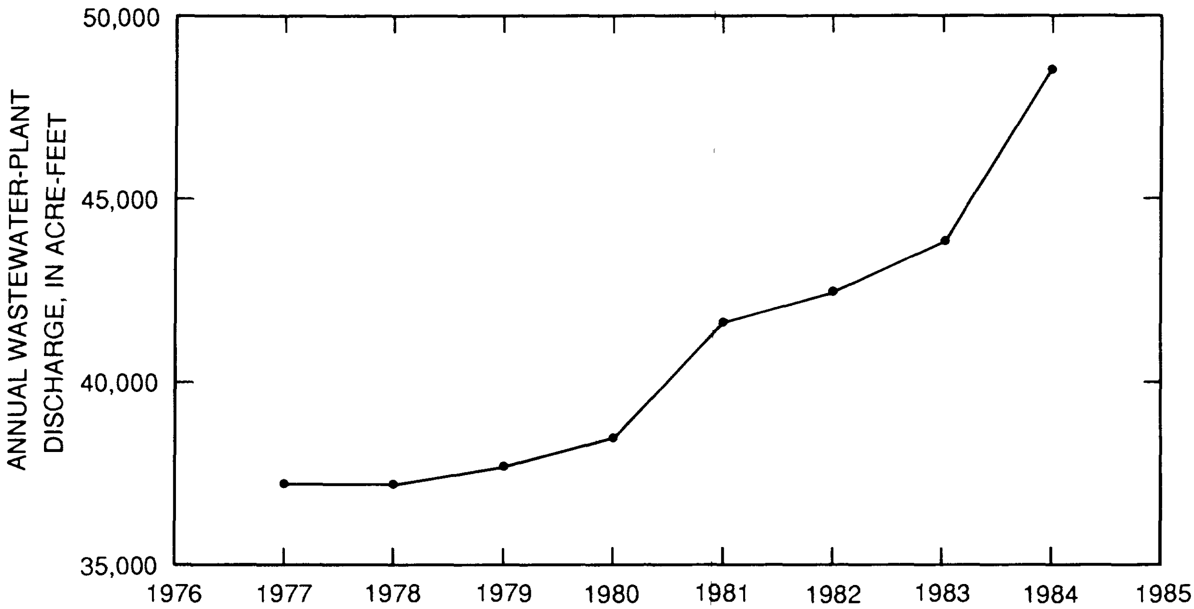


Figure 25.--Annual discharge from the City of Albuquerque Southside Water Reclamation Plant, 1977-84.

The City of Albuquerque's North Diversion Channel, a large concrete-lined channel designed to collect runoff from many small arroyos, was completed in 1969. Runoff from this channel, measured at station 08329900, North Floodway Channel near Alameda (figs. 23 and 24), enters the Rio Grande upstream from the streamflow-gaging station at Albuquerque. Runoff from station 08330800, Tijeras Arroyo below South Diversion Channel Inlet near Albuquerque (figs. 23 and 24), enters the Rio Grande downstream from the Albuquerque gaging station. Annual discharges reported at stations 08329900 and 08330800 are estimated from spring, summer, and fall discharge records (U.S. Geological Survey, 1970-75, 1976-86) because winter records have not been collected since 1973. Annual discharge from the North Diversion Channel has increased from less than 4,000 acre-feet before 1973 to more than 10,000 acre-feet for water years 1985 and 1986. This runoff adds to the discharge of the Rio Grande between San Felipe and Bernardo.

Effluent from the City of Albuquerque's wastewater-treatment plant (City of Albuquerque Southside Water Reclamation Plant, written commun., 1985) increased between 1977 and 1984 (fig. 25). The effluent increased from about 37,500 acre-feet in 1977 and 1978 to about 48,750 acre-feet in 1984. The wastewater enters the Rio Grande downstream from the streamflow-gaging station at Albuquerque and adds to the discharge of the Rio Grande between San Felipe and Bernardo.

SUMMARY AND CONCLUSIONS

Urban development affects water resources by altering the natural land cover, which changes the natural runoff, infiltration, and evapotranspiration rates. Urban development and its associated population growth also create a demand for water for various uses.

Neutron logs collected over a period of 3 years and 2 months (August 1983 through September 1986) to reveal infiltration at 17 sites showed the greatest moisture changes in the upper 3 feet of soil. Following rainfall, an increase in neutron counts to depths of 1.5 to 3 feet indicated infiltration to those depths; the wetting front infrequently advanced an additional 1.5 feet. A subsequent decrease in neutron counts in the upper few feet of soil indicated drying, probably due to evapotranspiration. Percolation of moisture to depths depends, in part, on the type of soil through which the water moves. Clay is hygroscopic and retains moisture. Several sites demonstrated large increases in moisture content at clay zones. Neutron-count increases beneath the arroyo bed were greater than those beneath the banks, indicating that infiltration per unit area is greater through the bed. The sandy and gravelly soil in the arroyo bed, the lack of transpiration-promoting vegetation, and the flow of water within arroyos promote infiltration. However, concrete lining of arroyos, which is part of the urbanization process in Albuquerque, blocks infiltration through the bed.

Infiltration in an unlined sand channel, Grant Line Arroyo, in northeast Albuquerque was measured for 112 events between March 1984 and October 1986. The mean infiltration per mile of arroyo was 2,158 cubic feet or about 0.05 acre-foot.

Evapotranspiration measured at 10 sites in the Albuquerque metropolitan area from August 1985 to October 1986 by the Bowen-ratio technique and the portable field-chamber technique showed that irrigation on golf-course rough increased evapotranspiration rate two to three times over nonirrigated golf-course rough; and lush, irrigated lawn had an evapotranspiration rate three to five times that of native sand sage and snakeweed bushes. In the 31 years between 1956 and 1987, residential land use has more than tripled in the Albuquerque metropolitan area. This causes a significant increase in evaporative water use during the summer, increasing the demand for water.

At site 14, 194 measurements of hydraulic head were made for a group of six tensiometers at depths of 0.5, 1, 2, 3, 4, and 5 feet between December 14, 1984, and September 24, 1986. An infiltration type of soil-water profile occurred in 42 percent of the observations during November through May, but not during June through October. An evapotranspiration type of soil-water profile occurred in 34 percent of the observations during May through November, but not during December through April. In the remaining 24 percent of the observations, a mixed profile suggesting that flow may be into or out of various horizons in the soil column occurred during all months except August and November.

Annual ground-water withdrawal from the Albuquerque metropolitan area more than tripled in 26 years from 31,000 acre-feet in 1954 to 105,000 acre-feet in 1980. During the same time period, annual precipitation had no systematic change.

Water levels in wells within the city of Albuquerque declined 0.53 to 1.28 feet per year over the period of record, which started as early as 1956 at 17 wells and included data as recent as 1981-82 at 4 wells. Declining water levels probably are due to heavy pumping within and near the metropolitan area. Water levels in shallow wells 75 to 123 feet deep, close to the Rio Grande between Albuquerque and Bernardo, rose 0.04 to 0.19 foot per year.

From 1955 to 1984 streamflow losses on the Rio Grande between San Felipe and Bernardo decreased by 3,528 acre-feet per year. Reduced losses indicate that there must be increased inflow or less withdrawal between San Felipe and Bernardo. Water-related activities within the Albuquerque metropolitan area, located between these stations, may have contributed to the trend of reduced losses. Increased runoff to the Rio Grande caused by increasing flow in large concrete-lined channels and increased wastewater flow to the Rio Grande from the city's wastewater-treatment plant are factors that would increase flow in the Rio Grande. For the most recent 10-year period of record, water years 1975-84, there was no systematic change in stream-discharge losses between San Felipe and Bernardo.

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SUPPLEMENTAL INFORMATION

Table 1.--Land cover at data-collection sites

[Sites 5, 16, 18, and 19 were abandoned]

Site number and location	Description of land cover
1 - 12200 Vienna Dr. N.E.	Residential grass lawn
2 - 12200 Vienna Dr. N.E.	Residential rockscaping
3 - 1800 12th St. N.W.	Federal warehouse and yard, no landscaping, mostly bare ground with some weeds
4 - 1800 12th St. N.W.	Federal warehouse and yard, no landscaping, weeds growing adjacent to neutron-access tube
6 - 7016 Vivian Dr. N.E.	Residential grass lawn
7 - 7016 Vivian Dr. N.E.	Residential rockscaping
8 - Grant Line Arroyo N.E.	Arroyo bed
9 - Grant Line Arroyo N.E.	Arroyo bank
10 - Southeast corner of Los Altos Golf Course	Weeds
11 - Southwest corner of Los Altos Golf Course	Weeds
12 - Southwest corner of Los Altos Golf Course	Weeds and grass
13 - Southeast corner of Los Altos Golf Course	Grass fairway
14 - 705 Camino Español N.W.	Clover, weeds, and bare ground
15 - 1527 Princeton Dr. N.E.	Residential grass lawn
17 - 1800 12th St. N.W.	Federal warehouse and yard, no landscaping, mostly bare ground with some weeds
20 - Burlison Dr. and Harper Dr. N.E.	Right of way between road and concrete-lined arroyo, bare ground, some weeds
21 - Central Avenue west of 98th Street	Sand sage, snakeweed, and other native plants

Table 2.—**Frequency and period of record for data collected at data-collection sites**

[°C, degrees Celsius; do., ditto; LSD, land-surface datum; sites 5, 16, 18, and 19 were abandoned]

Site	Data collected	Measurement unit of data	Frequency	Period of record	Date drilled	Depth, in feet
1	Lithologic log	-	Once	8-23-83	8-23-83	18
	Neutron log	Neutron counts	Monthly plus storms	8-23-83 to 10-1-86		
	Net radiation	Watts per square meter	Hourly	4-3-86 to 10-1-86		
	Air temperature at 6 feet	°C	do.	do.		
	Air temperature at 1.5 feet	°C	do.	do.		
	Relative humidity at 6 feet	Percent	do.	do.		
	Relative humidity at 1.5 feet	Percent	do.	do.		
	Vapor pressure at 6 feet	Kilopascal	do.	do.		
	Vapor pressure at 1.5 feet	Kilopascal	do.	do.		
	Soil-moisture tension at 3 feet below LSD	Bar	do.	do.		
	Soil-moisture tension at 5 feet below LSD	Bar	do.	do.		
	Soil-moisture tension at 7 feet below LSD	Bar	do.	do.		
	Soil-heat flux	Watts per square meter	do.	do.		
	Portable dome evapotrans-piration rate	Millimeters	Daily	7-31-86, 9-25-86		

Table 2.—Frequency and period of record for data collected at data-collection sites—Continued

Site	Data collected	Measurement unit of data	Frequency	Period of record	Date drilled	Depth, in feet
2	Lithologic log	-	Once	8-23-83	8-23-83	14
	Neutron log	Neutron counts	Monthly plus storms	8-25-83 to 10-1-86		
	Net radiation	Watts per square meter	Hourly	5-2-84 to 10-1-86		
	Air temperature at 6 feet	°C	do.	8-21-85 to 10-1-86		
	Air temperature at 1.5 feet	°C	do.	do.		
	Relative humidity at 6 feet	Percent	do.	do.		
	Relative humidity at 1.5 feet	Percent	do.	do.		
	Vapor pressure at 6 feet	Kilopascal	do.	do.		
	Vapor pressure at 1.5 feet	Kilopascal	do.	do.		
	Soil temperature at 2 inches below LSD	°C	do.	5-2-84 to 10-22-85		
	Soil temperature at 4 inches below LSD	°C	do.	5-2-84 to 10-22-85		
	Soil-heat flux	Watts per square meter		10-22-85 to 10-1-86		
	Precipitation	Inches		5-2-84 to 10-1-86		
	Portable dome evapotrans-piration rate	Millimeters	Daily	7-31-86, 9-25-86		
3	Lithologic log	-	Once	-	8-24-83	20
	Neutron log	Neutron counts	Monthly plus storms	8-24-83 to 6-11-85		

Table 2.—Frequency and period of record for data collected at data-collection sites—Continued

Site	Data collected	Measurement unit of data	Frequency	Period of record	Date drilled	Depth, in feet
4	Lithologic log	-	Once		8-24-83	17
	Neutron log	Neutron counts	Monthly plus storms	8-24-83 to 10-1-86		
6	Lithologic log	-	Once	-	8-30-83	19
	Neutron log	Neutron counts	Monthly plus storms	8-30-83 to 10-1-86		
	Net radiation	Watts per square meter	Hourly	2-16-84 to 4-14-85		
	Soil-moisture tension at 3 feet below LSD	Bar	do.	3-1-84 to 4-23-85		
	Soil-moisture tension at 5 feet below LSD	Bar	do.	3-1-84 to 4-23-85		
	Soil temperature at 2 inches below LSD	°C	do.	2-18-84 to 2-12-85		
	Soil temperature at 4 inches below LSD	°C	do.	2-18-84 to 2-12-85		
	Soil-heat flux	Watts per square meter	do.	2-12-85 to 4-23-85		
	Portable dome evapotrans-piration rate	Millimeters	Daily	6-19-86, 8-28-86		
7	Lithologic log	-	Once	8-31-83	8-31-83	14
	Neutron log	Neutron counts	Monthly plus storms	8-31-83 to 10-1-86		
	Net radiation	Watts per square meter	Hourly	2-16-84 to 4-15-85		
	Soil-moisture tension at 3 feet below LSD	Bar	do.	3-1-84 to 4-23-85		

Table 2.—Frequency and period of record for data collected at data-collection sites—Continued

Site	Data collected	Measurement unit of data	Frequency	Period of record	Date drilled	Depth, in feet
7	Soil-moisture tension at 5 feet below LSD	Bar	do.	3-1-84 to 4-23-85		
	Soil temperature at 2 inches below LSD	°C	do.	3-1-84 to 2-12-85		
	Soil temperature at 4 inches below LSD	°C	do.	3-1-84 to 2-12-85		
	Soil-heat flux	Watts per square meter	do.	2-12-85 to 4-23-85		
	Precipitation	Inches	Daily	3-5-84 to 4-24-85		
	Portable dome evapotrans-piration rate	Millimeters	Daily	6-19-86, 8-28-86		
8	Lithologic log	-	Once	9-15-83	9-15-83	13
	Neutron log	Neutron counts	Monthly plus storms	9-16-83 to 10-1-86		
	Portable dome evapotrans-piration rate	Millimeters	Daily	7-29-86, 8-26-86, 9-23-86		
	Streamflow	Cubic feet per second	Daily	3-26-84 to 10-1-86		
	Precipitation	Inches	Daily	3-26-84 to 10-1-86		
9	Lithologic log	-	Once	9-16-83	9-16-83	20
	Neutron log	Neutron counts	Monthly plus storms	9-16-83 to 8-19-86		
	Portable dome evapotrans-piration rate	Millimeters	Daily	7-29-86, 8-26-86, 9-23-86		
10	Lithologic log	-	Once	10-3-83	10-3-83	20
	Neutron log	Neutron counts	Monthly plus storms	10-3-83 to 10-1-86		

Table 2.—Frequency and period of record for data collected at data-collection sites—Continued

Site	Data collected	Measurement unit of data	Frequency	Period of record	Date drilled	Depth, in feet
11	Lithologic log	-	Once	10-4-83	10-4-83	19
	Neutron log	Neutron counts	Monthly	10-4-83 to 10-1-86		
	Portable dome evapotrans- piration rate	Millimeters	Daily	6-20-86, 8-1-86, 8-29-86, 9-26-86		
12	Lithologic log	-	Once	10-5-83	10-5-83	20
	Neutron log	Neutron counts	Monthly	10-5-83 to 10-1-86		
	Portable dome evapotrans- piration rate	Millimeters	Daily	6-20-86, 8-1-86, 8-29-86, 9-26-86		
13	Lithologic log	-	Once	10-6-83	10-6-83	20
	Neutron log	Neutron counts	Monthly plus storms	10-6-83 to 10-1-86		
14	Lithologic log	-	Once	10-11-83	10-11-83	6.1
	Neutron log	Neutron counts	Monthly plus storms	10-11-83 to 10-1-86		
	Net radiation	Watts per square meter	Hourly	5-8-85 to 10-1-86		
	Air temperature at 6 feet	°C	do.	8-21-85 to 10-1-86		
	Air temperature at 1.5 feet	°C	do.	do.		
	Relative humidity at 6 feet	Percent	do.	do.		
	Relative humidity at 1.5 feet	Percent	do.	do.		
	Vapor pressure at 6.0 feet	Kilopascal	do.	do.		
	Vapor pressure at 1.5 feet	Kilopascal	do.	do.		

Table 2.—**Frequency and period of record for data collected at data-collection sites—Concluded**

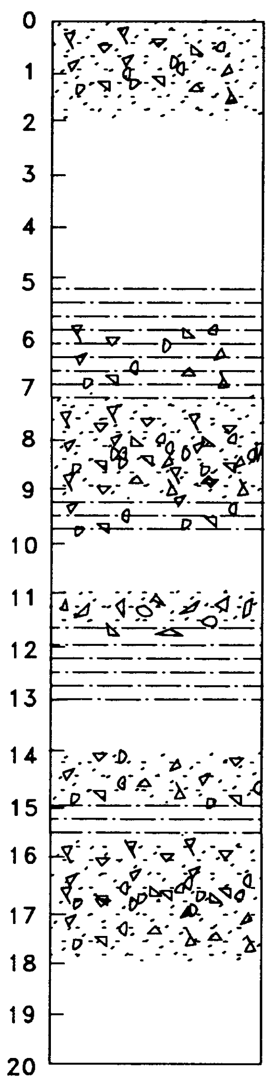
Site	Data collected	Measurement unit of data	Frequency	Period of record	Date drilled	Depth, in feet
14	Soil-moisture tension at 3.0 feet below LSD	Bar	do.	4-25-85 to 10-1-86		
	Soil-moisture tension at 5 feet below LSD	Bar	do.	4-25-85 to 10-1-86		
	Soil-moisture tension at 7 feet below LSD	Bar	do.	4-25-85 to 10-1-86		
	Soil-heat flux	Watts per square meter	do.	4-25-85 to 10-1-86		
	Precipitation	Inches	Daily	5-9-85 to 10-1-86		
	Water level	Feet	Monthly	10-4-84 to 10-1-86		
	Hydraulic head	Centibar	Daily	12-17-84 to 9-24-86		
	Portable dome evapotrans-piration rate	Millimeters	Daily	6-18-86, 7-30-86, 8-27-86, 9-24-86		
15	Lithologic log	-	Once	10-12-83	10-12-83	20
	Neutron log	Neutron counts	Monthly	10-12-83 to 10-1-86		
17	Lithologic log	-	Once	10-19-83	10-19-83	19
	Neutron log	Neutron counts	Monthly plus storms	10-19-83 to 2-19-86		
20	Lithologic log	-	Once	8-13-84	8-13-84	20
	Neutron log	Neutron counts	Monthly plus storms	8-13-84 to 2-21-86		
21	Lithologic log	-	Once	10-13-83	10-13-83	16
	Neutron log	Neutron counts	Monthly plus storms	10-13-83 to 10-1-86		
	Portable dome evapotrans-piration rate	Millimeters	Daily	7-28-86, 8-25-86, 9-22-86		

Table 3.--Lithologic description of soil-moisture test holes

[mm, millimeters; cm, centimeters; %, percent; <, less than]

Soil-Moisture Hole #1

Depth interval below land surface (feet)	Lithologic description



Predominantly fine- to medium-grained sand: 70% quartz, 30% mica grains, poorly sorted, subangular to subrounded; gravelly, silty.

30-40% sand; gravel, silt, clay, very poorly sorted.

40% silt, 10-20% clay, sand, gravel.

40-50% silt, 20-30% sand, clay, gravel, very poorly sorted, subangular to subrounded; 50% quartz, 20-30% mica, rest feldspar.

20-30% sand, 20-30% gravel, silt, clay, angular to round; 30-40% quartz, 30-40% mica, rest feldspar, etc.

40-50% gravel, sand, silt, very poorly sorted, angular to subrounded.

Silt, clay, sand, very poorly sorted, angular to subrounded.

Silt, clay, sand, gravel, very poorly sorted, angular to subrounded.

50-60% gravel, 20-30% silt and clay, very poorly sorted.

30-35% silt, 20-30% sand, 10-20% clay, gravel, very poorly sorted.

30-40% silt, 10-20% sand, 10-20% clay, gravel, very poorly sorted, subangular to subrounded.

50-60% sand, 10-15% silt, 20-30% gravel, poorly to moderately sorted, angular to subangular.

70% silt, 15-20% sand, 5% clay; 30-40% mica, 30-40% quartz, moderately to well sorted.

40-50% sand, 20-30% silt, 20-30% gravel, subangular to subrounded.

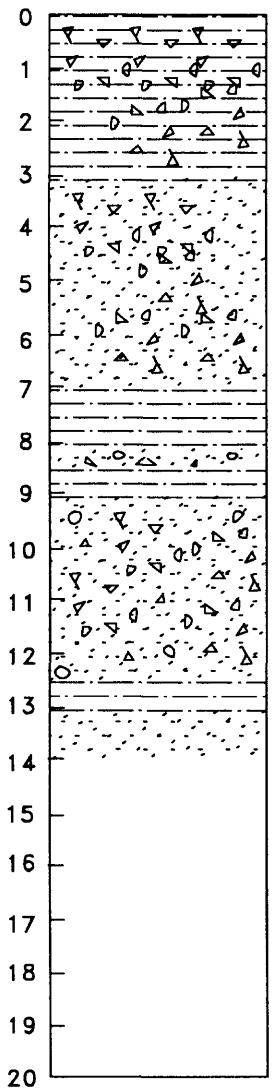
40% sand, 20-30% silt, 25% gravel, very poorly sorted.

40% sand, 30% silt, 25% gravel, very poorly sorted, subangular to subrounded.

Table 3.--Lithological description of soil-moisture test holes--Continued

Soil-Moisture Hole #2

Depth interval below land surface (feet)	Lithologic description



30-40% silt, 20-30% sand, 20-30% gravel, 10-20% clay; very poorly sorted, subangular to subrounded.

30-40% silt; same as above.

60% silt, 20-30% clay, 10-20% sand, 5-10% gravel; poorly to moderately sorted.

40% sand, 30% silt, 20-30% gravel, 10% clay; very poorly sorted.

Sand; same as above.

50% sand, 40% gravel, 10% silt and clay.

40% sand, 30% silt, 20% gravel, 10% clay; very poorly sorted.

60-70% silt, 10-15% clay, 10-15% sand, very fine to very coarse grained.

Sand, silty, clayey, gravelly, high percentage of quartz fragments.

Silt, sandy, clayey, poorly sorted.

40-50% sand, 30-40% silt, 10-20% clay, 10-20% gravel; poorly sorted.

40-50% sand, 30-40% gravel, 20-30% silt; poorly to moderately sorted.

40% sand, 30% silt, 30% gravel; poorly sorted.

50-60% sand, 20-30% gravel, 20-25% silt; poorly sorted.

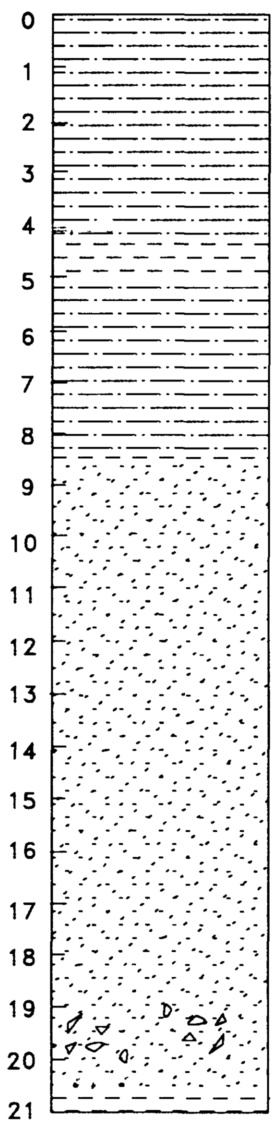
60% silt, 20-30% clay, 10-20% sand, 10% gravel.

40-50% sand, 30% silt, clay, gravel, very poorly sorted.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #3

Depth interval below land surface (feet)	Lithologic description



Silt, clayey, slightly sandy.

Silt, clayey, slightly sandy, scattered caliche.

Silt, clayey, slightly sandy, scattered caliche.

Silt, clayey, slightly sandy; mottled white caliche blobs, light tan.

Clay, silty, scattered caliche; consolidated; clay, dark brown.

Silt, clayey, sandy; light tan.

Silt, sandy, clayey, some scattered caliche fragments; light tan; moderately indurated.

Silt, clayey, slightly sandy, scattered caliche, moderately consolidated; light tan.

Silt, caliche fragments, light-tan.

Clay.

Sand.

Sand, slightly silty, very fine to fine-grained, well-sorted, moderately well rounded.

Sand, slightly silty, fine-grained, moderately rounded, well-sorted; 80-90% quartz grains.

Sand, very fine to fine-grained, well-sorted, moderately to well-rounded; scattered clay balls throughout sample, one silty place.

Sand, very fine to fine-grained, well-sorted.

Sand, fine-grained, well-sorted; some iron-stained zones.

Sand, fine-grained, well-sorted, moderately to well-rounded.

Sand, fine-grained, well-sorted, well-rounded.

Sand, very fine to fine-grained, well-sorted, well-rounded.

Sand, fine- to coarse-grained, moderately to poorly sorted; 80-90% quartz.

Sand, very fine to medium-grained, moderately well sorted.

Sand, scattered gravel, fine- to very coarse grained, poorly sorted, moderately to well-rounded.

Sand.

Clay.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #6

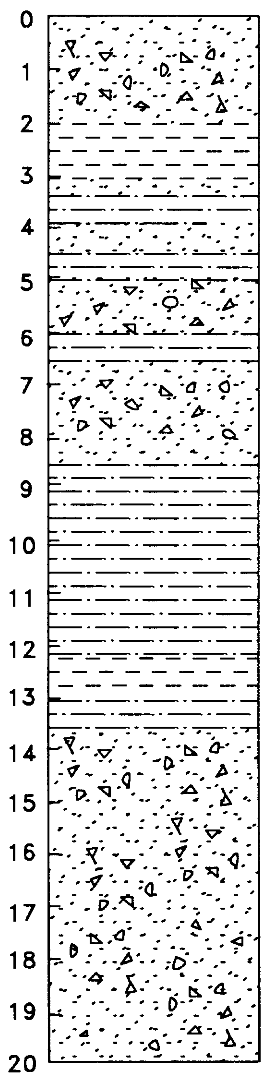
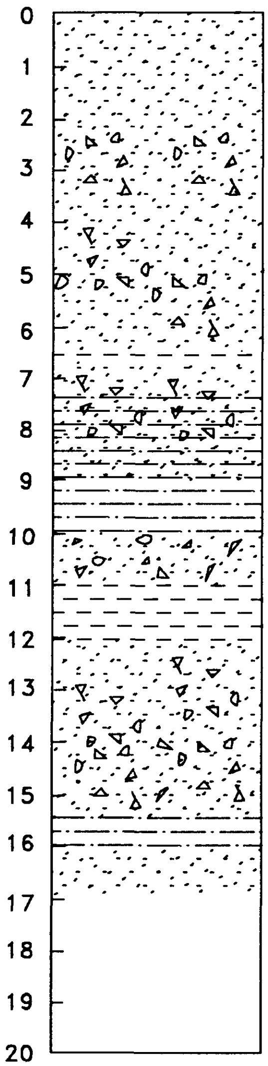
Depth interval below land surface (feet)	Lithologic description
	70-80% sand, silt, gravel, clay, very poorly sorted. 75% sand, 10-20% gravel, silt, very poorly sorted. 50-60% clay, 30% silt, sand; very plastic. Sand, very silty. Silt, very sandy. Sand, very silty. Silt, very sandy. 60-70% sand, medium- to coarse-grained; 20% gravel, fine grained; 20% silt; poorly sorted, "slope wash." 60-70% silt, sandy, clayey, gravelly. 60-70% sand, 20-30% silt, very poorly sorted. 70-80% sand, 20-30% gravel, 10-20% silt; poorly sorted. 60-70% sand, silty, slightly gravelly; very poorly sorted. Silt, sandy; sand, fine grained. Silt, sandy; sand, fine grained; silt, moderately plastic (probably contains 5-10% clay), moderately well sorted. 50-60% silt, 30-40% clay, 10-20% sand; moist. 50-60% silt, 20-30% clay, 20-30% sand; plastic; moist. 50-60% clay, 40-50% silt; appears to be "slope wash" material, as opposed to above-river-deposit material. 60-70% silt, 30% clay, 5-10% sand; wet; "slope wash." 70% sand, 10-20% silt; sand, medium- to coarse-grained; "slope wash." 60% sand, 20% gravel, 20% silt; poorly sorted; "slope wash." 50-60% sand, 30-40% silt, 10% gravel; very poorly sorted; "slope wash." 60-70% sand, 20-30% gravel, silty, poorly sorted; may be river deposit. 60% sand, 20-30% gravel, 10% silt, poorly sorted; may be river deposit. 60-70% sand, 10-20% silt, 10-20% gravel; sand, coarse grained; gravel, fine grained; very poorly sorted. 50-60% sand, 30-40% silt, 20-30% gravel; poorly sorted; "slope wash." 60% sand, 20% gravel, 10-20% silt; poorly sorted.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #7

Depth interval below land surface (feet)	Lithologic description



50-60% sand, 20-30% clay, silty, gravelly; sand, coarse to very coarse grained, very poorly sorted.

50-60% sand, 20-30% clay, silty, gravelly; sand, coarse to very coarse grained, very poorly sorted.

50-60% sand, 10-20% gravel, 10-20% clay; sand, coarse to very coarse grained, very poorly sorted.

50-60% sand, 10-20% gravel, 10-20% clay; sand, coarse to very coarse grained; very poorly sorted; 0-46 inches appear to be "slope wash."

60% sand, 20-30% gravel, slightly silty; moderately sorted; river deposit.

60% sand, 20-30% gravel, silty; moderately sorted; river deposit.

Sand, gravelly, slightly silty, approximately 80 inches of clayey silt; river deposit.

Sand, gravelly, 1/4-inch-thick silt layers; river deposit.

50% sand, 30% gravel, 10-20% silt, layers of silt; river deposit.

70% silt, 30% clay, well-sorted.

50% sand, 20-30% gravel, 20-30% silt, very poorly sorted.

60% clay, 20-30% sand, 10-20% silt, <10% gravel; slope wash or bank material.

50-60% sand, 20% gravel, 20% silt; very poorly sorted.

60-70% sand, 20-30% gravel, slightly silty; moderately sorted; river deposit.

50% sand, 20-30% silt, 20% gravel; poorly sorted.

Sand, gravelly, slightly silty; moderately sorted.

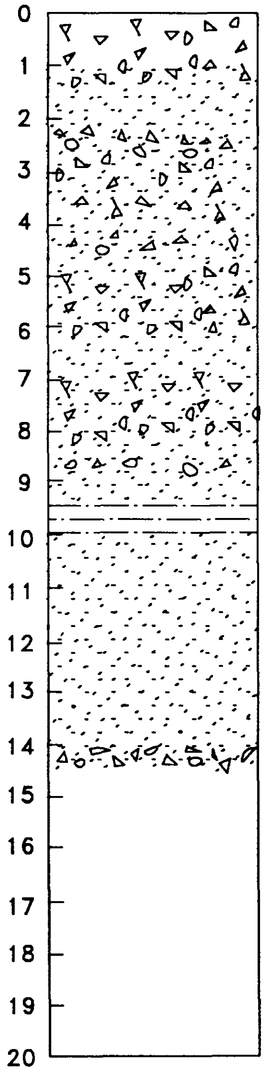
50% silt, 40% sand, 10% gravel; very poorly sorted.

50-60% sand, 20-30% silt, 10-20% gravel; moderately to very poorly sorted.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #8

Depth interval below land surface (feet)	Lithologic description



Gravel, sandy, silty; gravel, very fine to fine grained; sand, coarse to very coarse grained; very poorly sorted.

Sand, slightly gravelly, sand, coarse-grained; poorly sorted.

Gravel, sandy, slightly silty; gravel, fine grained, sand, coarse grained; poorly sorted.

Sand, gravelly; sand, coarse grained; gravel, fine grained; poorly sorted.

Gravel, sandy, silty; gravel, fine grained; poorly sorted.

Sand, gravelly, silty; poorly sorted; sand, coarse grained; gravel, fine grained.

Gravel, sandy, silty; very poorly sorted; sand, medium grained; gravel, fine grained.

Gravel, sandy, slightly silty; very poorly sorted.

Sand, gravelly, silty; sand, coarse grained; gravel, fine grained.

Gravel, sandy, silty; gravel, fine grained; sand, coarse grained; very poorly sorted.

Sand, gravelly, silty; sand, coarse to fine grained; very poorly sorted.

Sand, gravelly, silty, very poorly sorted, some silt layers.

Sand, silty, gravelly, very poorly sorted.

Silt, clayey, sandy, slightly gravelly.

Sand, silty, gravelly; sand, medium grained; very poorly sorted.

Sand, silty, gravelly; very poorly sorted.

Sand, silty, gravelly; poorly sorted; sand, fine to medium grained.

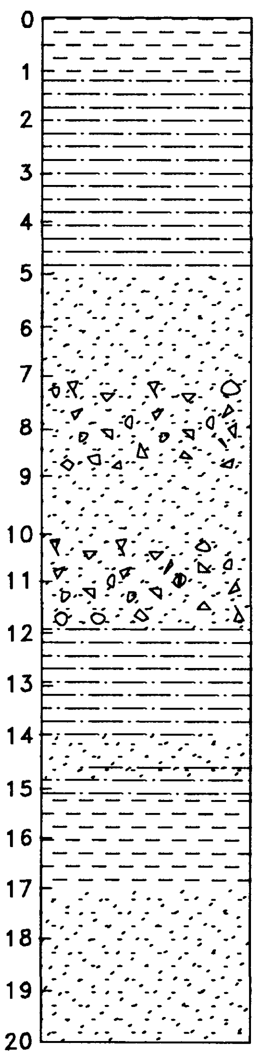
Sand, silty, gravelly; sand, medium grained; very poorly sorted.

Sand, gravelly, slightly silty; very poorly sorted.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #9

Depth interval below land surface (feet)	Lithologic description



Clay, silty, sandy, slighty gravelly, moderately compacted; very poorly sorted.

Silt, sandy, gravelly.

Silt, sandy, gravelly.

Silt, slightly clayey, very slightly sandy.

Silt, slightly clayey, very slightly sandy.

Silt, clayey, sandy.

Sand, very silty and clayey; sand, coarse grained; very poorly sorted.

Sand, silty, gravelly; sand, coarse grained; gravel, fine grained.

40% sand, 40% gravel, silty; very poorly sorted.

Sand, gravelly, silty; sand, coarse grained; gravel, fine grained.

Sand, silty, gravelly; sand, coarse grained; gravel, fine grained.

Sand, gravelly, silty; sand, coarse grained; gravel, fine grained.

Sand, gravelly, silty; sand, coarse grained; gravel, fine grained.

Silt, clayey, sandy.

Silt, clayey, sandy.

Sand, silty, gravelly; sand, coarse grained; very poorly sorted.

Silt, slightly clayey.

Clay, silty, slightly sandy; small live rootlets.

Clay, silty, sand; light tan.

Sand, very clayey and silty, gravelly; sand, medium to coarse grained; very poorly sorted.

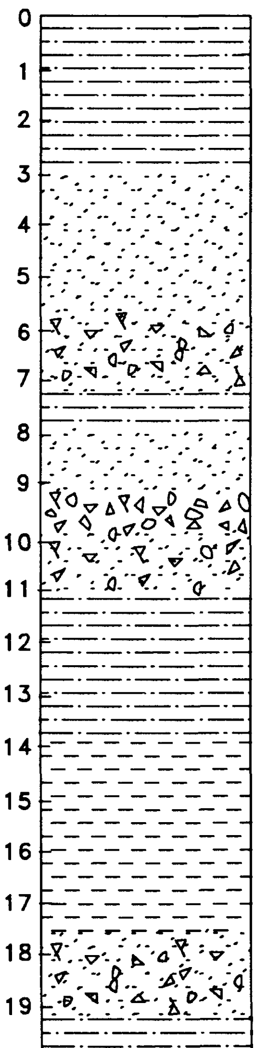
Sand, silty, clayey, gravelly; sand, coarse grained; very poorly sorted.

Sand, silty, clayey, gravelly; sand, medium to coarse grained; very poorly sorted.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #10

Depth interval below land surface (feet)	Lithologic description



Silt, clayey, slighty sandy, scattered caliche zones amount to approximately 10%.

Silt, clayey, sandy, 20% caliche.

Silt, clayey, sandy, slightly gravelly; scattered caliche.

Sand, very silty, gravelly; very poorly sorted.

Sand, very silty, gravelly, scattered caliche; very poorly sorted.

Sand, gravelly, slightly silty; sand, coarse grained; very poorly sorted.

Sand, gravelly, slightly silty.

Silt, clayey.

Sand, silty, gravelly; sand, coarse grained; very poorly sorted.

Gravel, sandy, silty; very poorly sorted.

Sand, gravelly, silty; sand, coarse grained; very poorly sorted.

Silt, clayey, sandy, gravelly.

Silt, sandy, clayey; sand, very fine to fine grained.

Silt, clayey, sandy, gravelly, scattered caliche fragments.

Clay, silty, sandy, gravelly; 30-40% mottled light- and dark-tan caliche.

Clay, silty, sandy, gravelly, scattered light-tan caliche.

Clay, silty, sandy, gravelly, scattered mottled light- tan and dark-tan caliche.

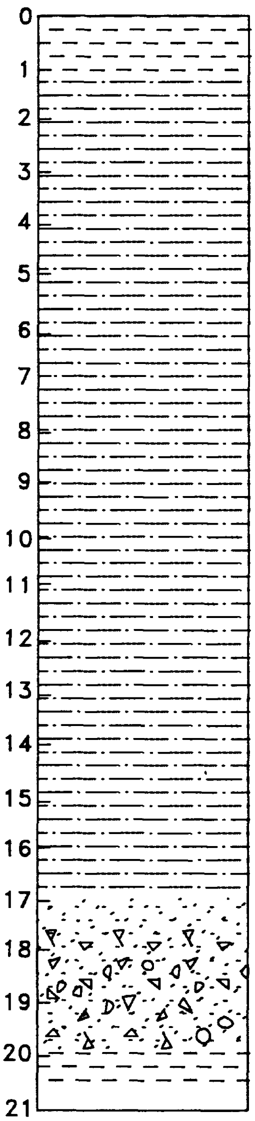
Sand, gravelly, silty; sand, fine to medium grained; gravel, fine grained; very poorly sorted.

Silt, clayey, sandy; dark brown.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #11

Depth interval below land surface (feet)	Lithologic description



Clay, slightly sandy, slightly silty, some mottled light-tan caliche zones; clay, dark brown and stiff.

Silt, sandy, scattered gravel, caliche; light tan.

Silt, sandy, scattered gravel, caliche; mottled light and dark tan.

Silt, same as above.

Silt, sandy, scattered gravel, caliche; reddish brown.

Silt, same as above.

Silt, sandy, abundant caliche; sand, very fine grained; mottled light and dark brown.

Silt, same as above.

Silt, very sandy, slightly calcareous, scattered caliche zones; dark tan.

Silt, very sandy, scattered gravel.

Silt, very sandy, scattered gravel, abundant caliche; light tan.

Silt, very sandy, gravelly, abundant caliche; light tan.

Silt, sandy, gravelly, abundant caliche; dark reddish brown.

Silt, sandy, gravelly, abundant caliche; very poorly sorted, dark reddish brown.

Silt, very sandy, very gravelly, abundant calcium carbonate; very poorly sorted, reddish brown.

Silt, sandy, clayey, scattered gravel, caliche; reddish brown.

Sand, very gravelly; sand, coarse grained; gravel, fine grained; very poorly sorted; calcium carbonate in sample.

Sand, same as above.

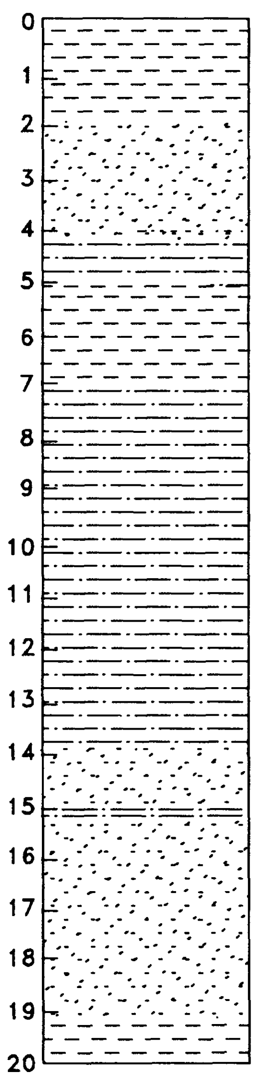
Sand, gravelly; sand, fine to medium grained; gravel, fine grained; very poorly sorted.

Clay, silty, slightly sandy, slight caliche; dark reddish brown.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #12

Depth interval below land surface (feet) — Lithologic description



Clay, silty, slightly sandy; reddish brown.

Clay, silty, caliche; calcareous; light tan.

Sand, clayey, silty, gravelly, abundant caliche; very poorly sorted; light tan.

Sand, same as above.

Silt, sandy, clayey, calcareous; dark red.

Clay, silty, sandy, caliche, calcareous; dark red.

Clay, silty, slightly sandy, abundant caliche; dark red.

Silt, slightly sandy, clayey, calcareous; dark red.

Silt, very sandy, clayey, calcareous; dark red.

Silt, very sandy, clayey, calcareous; sand, fine grained; dark red.

Silt, sandy, clayey, gravelly, abundant caliche; caliche, light tan; gravel, dark red.

Silt, clayey, slightly sandy, abundant caliche; light tan.

Silt, clayey, slightly sandy; light reddish brown, mottled tan caliche zones.

Silt, clayey, slightly sandy, abundant caliche; sample is reddish brown.

Sand, clayey, silty, gravelly, sand, very fine to fine-grained; gravel, very fine grained; very poorly sorted.

Silt, clayey, sandy, slightly calcareous; reddish brown.

Sand, silty, clayey, moderately calcareous; red brown.

Sand, silty, gravelly, sand, fine- to medium-grained; gravel, very fine to fine grained, red brown; calcareous.

Sand, same as above.

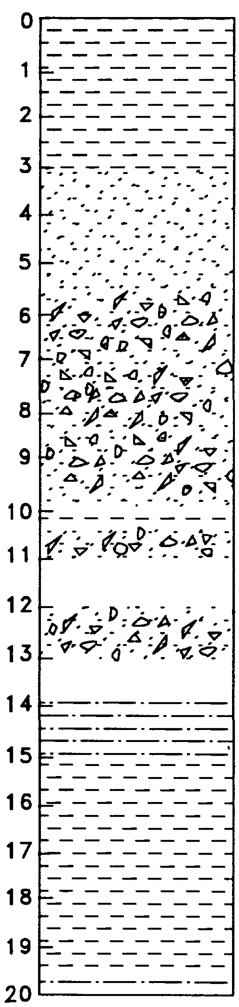
Sand, silty, gravelly; moderately calcareous; very poorly sorted; sand, medium grained; gravel, very fine grained.

Clay, slightly sandy, slightly gravelly; strongly calcareous; very sticky; red brown.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #13

Depth interval below land surface (feet)	Lithologic description



Clay, silty, sandy, slightly gravelly; sand, very fine to medium grained; gravel, very fine to fine grained; dark brown.

Clay, silty, sandy, strongly calcareous; light tan.

Clay, silty, sandy, strongly calcareous; sand, very fine grained; light tan.

Sand, very silty, slightly clayey; sand, very fine to fine grained; tan.

Sand, very silty, very clayey, scattered gravel; very poorly sorted.

Sand, gravelly, slightly calcareous; sand, coarse grained; very poorly sorted.

Gravel, sandy, slightly calcareous; gravel, very fine grained, very poorly sorted.

Gravel, same as above.

Gravel, sandy, slightly silty, moderately calcareous; gravel, fine grained; sand, medium to coarse grained; very poorly sorted.

Gravel, same as above.

Clay, slightly silty, slightly sandy, strongly calcareous; dark reddish brown.

Gravel, sandy, silty, strongly calcareous; gravel, fine grained; very poorly sorted.

Gravel, sandy, silty, clayey.

Silt, sandy, clayey, a few scattered gravels, strongly calcareous; dark reddish brown.

Clay, sandy, silty, strongly calcareous; clay, light tan to mottled light tan.

Clay, gravelly, sandy, moderately calcareous.

Clay, sandy, silty, gravelly, strongly calcareous; clay, mottled light tan.

Clay, sandy, gravelly, silty; moderately calcareous; gravel, fine grained; clay, dark reddish brown.

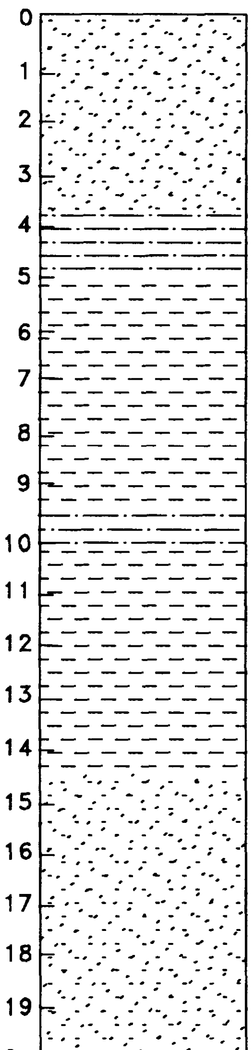
Clay, sandy, gravelly, silty, moderately calcareous; dark reddish brown.

Silt, sandy, slightly gravelly; moderately calcareous; reddish brown.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #14

Depth interval below land surface (feet)	Lithologic description



Sand, silty, strongly calcareous; sand, fine grained; moderately sorted; dark brown.

Sand, same as above.

Sand, very slightly silty; sand, fine grained; moderately to well sorted; light tan.

Sand, same as above.

Sand, as above but with scattered silt lenses.

Silt, sandy, moderately calcareous; moderately indurated; dark brown.

Clay, slightly silty, slightly calcareous; mottled light and dark tan; compact.

Clay, silty; moderately calcareous; dark brown with white specks throughout.

Clay, silty; moderately calcareous; mottled light and dark tan; compact.

Clay, silty, moderately to strongly calcareous; dark brown with numerous light-brown to white fragments.

Clay, silty, slightly sandy, strongly calcareous, dark-brown.

Silt, clayey, slightly sandy; strongly calcareous; mottled light and dark tan.

Clay, slightly silty; moderately calcareous; dark brown to brown black; plastic.

Clay, same as above.

Clay, silty; moderately calcareous; dark brown with white caliche specks; very plastic.

Clay, very silty, strongly calcareous; scattered caliche; clay, dark brown; compact.

Sand, silty; sand, very fine grained; moderately to well sorted.

Sand, clayey, silty, dark-brown; sand, very fine to fine grained.

Sand, same as above.

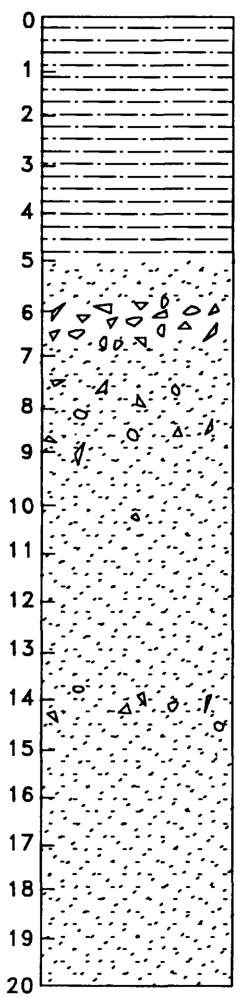
Sand, silty, with silty clay zones about 1/4 inch thick; sand, fine grained; yellowish orange.

Sand, slightly silty; sand, fine grained; moderately well sorted; scattered iron-stained zone.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #15

Depth interval below land surface (feet)	Lithologic description



Silt, clayey, sandy, scattered fine-grained gravel, strongly calcareous; brown; roots from lawn present.

Silt, same as above.

Silt, sandy, clayey, scattered very fine grained gravels, strongly calcareous; sand, very fine; light brown.

Silt, same as above.

Silt, same as above but with scattered caliche zones.

Sand, silty, clayey, strongly calcareous; sand, medium grained; very poorly sorted; light brown.

Gravel, sandy, slightly silty, gravel, fine-grained; very poorly sorted.

Sand, gravelly, silty, moderately calcareous; sand, medium to coarse-grained; gravel, fine grained; very poorly sorted.

Sand, gravelly, silty, clayey, slightly calcareous.

Sand, gravelly, moderately calcareous; sand, medium grained; very poorly sorted.

Sand, silty, sand, very fine grained, well-sorted.

Sand, same as above.

Sand, same as above.

Sand, silty, slightly clayey, slightly calcareous; sand, very fine grained; well sorted.

Sand, same as above but with scattered caliche.

Sand, gravelly, silty, clayey, strongly calcareous; sand, medium to coarse grained; very poorly sorted.

Sand, silty, slightly gravelly; slightly calcareous.

Sand, silty, scattered gravel; sand, very fine grained, well sorted.

Sand, silty, some clayey lenses; sand, very fine grained, moderately well sorted; slightly calcareous.

Sand, same as above.

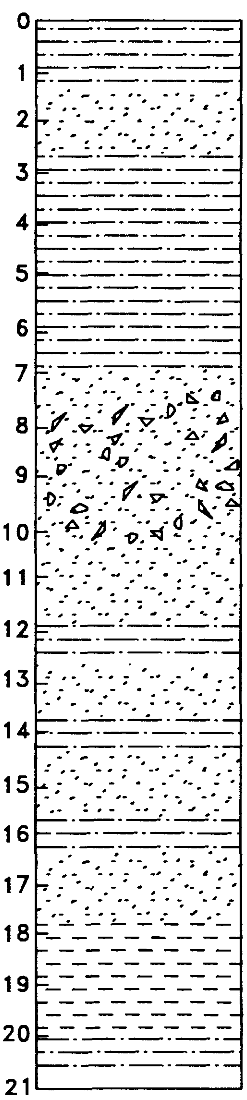
Sand, silty, scattered gravel; sand, very fine grained; well sorted.

Sand, silty, slightly gravelly; sand, very fine grained; moderately sorted; slightly calcareous.

Table 3.--Lithologic description of soil-moisture test holes--Continued

Soil-Moisture Hole #20

Depth interval below land surface (feet)	Lithologic description



Silt, clayey, sandy, gravelly, very poorly sorted; scattered gravel to 15 mm.

Sand, clayey, silty, gravelly, maximum gravel size is 20 mm, very poorly sorted.

Silt, clayey, sandy, scattered gravels to 20 mm, very poorly sorted.

Silt, clayey, slightly sandy, slightly gravelly, maximum gravel 1.0 mm, mottled and speckled white, very poorly sorted.

Silt, slightly clayey, scattered sand grains, coarse- to very coarse grained.

Silt, same as above.

Silt, slightly clayey, scattered sand grains to coarse-grained.

Sand, clayey, slightly silty, very poorly sorted.

Sand, gravelly, silty, sand, very fine to very coarse grained; gravel to 15 mm, very poorly sorted.

Sand, gravelly, silty, clayey, sand, very fine to very coarse grained; gravel, very fine to medium grained, maximum 15 mm, very poorly sorted.

Sand, silty, gravelly, sand, very fine to very coarse grained, very fine to medium-grained, very poorly sorted.

Sand, same as above.

Silt, sandy, slightly clayey, sand, very fine grained.

Sand, silty, clayey, slightly gravelly, sand, very fine to very coarse grained, gravel, very fine to fine-grained, very poorly sorted. Scattered rootlets in sample.

Silt, very clayey.

Sand, silty, clayey, slightly gravelly, very poorly sorted.

Silt, sandy, clayey, slightly gravelly, very poorly sorted.

Sand, silty, gravelly, very poorly sorted.

Sand, silty, gravelly, sand, very fine to very coarse grained, gravel, very fine to medium-grained, very poorly sorted.

Clay, silty, clayey, compacts easily.

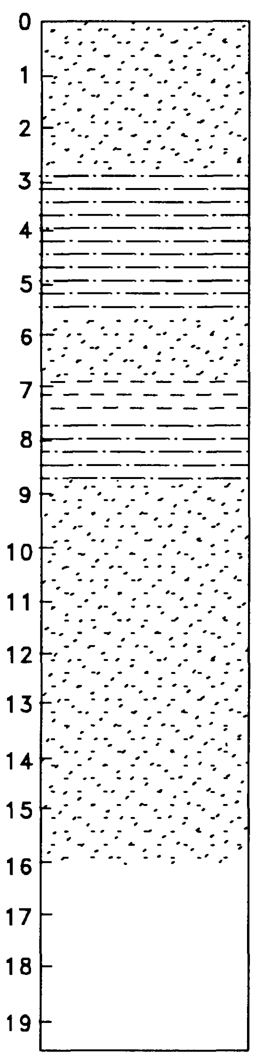
Clay, silty, very plastic.

Silt, clayey, sand, some scattered, very coarse grained.

Table 3.--Lithologic description of soil-moisture test holes --Concluded

Soil-Moisture Hole #21

Depth interval below land surface (feet) — Lithologic description



Sand, very silty, few scattered very fine gravels, sand, very fine to coarse-grained, predominantly very fine, very poorly sorted, strongly calcareous.

Sand, same as above.

Silt, sandy, sand, very fine to medium-grained, predominantly very fine grained, abundant caliche streaks and stringers throughout, strongly calcareous.

Silt, sandy, sand, very fine to very coarse grained, predominantly very fine to fine-grained few scattered very fine to fine-grained gravels, caliche streaks, strongly calcareous.

Silt, same as above.

Sand, gravelly, silty, sand, very fine to very coarse grained, predominantly fine-grained gravel, very fine to very coarse grained, predominantly fine- to medium-grained approximately 30-40% gravel, strongly calcareous.

Clay, silty, slightly sandy, well-indurated, drills slowly, strongly calcareous.

Silt, clayey, indurated, blobs and streaks of caliche throughout, strongly calcareous.

Sand, very silty, slightly clayey, very fine to medium-grained, predominantly very fine to fine-grained, poorly sorted, abundant caliche, strongly calcareous.

Sand, same as above, except slightly coarser grained and indurated.

Sand, same as above, except less indurated and has a few scattered gravels.

Sand, very silty, slightly clayey, sand, very fine to very coarse grained, predominantly fine-grained, nonindurated, few scattered gravels, abundant caliche.

Sand, same as above, except strongly calcareous.

Sand, same as above.

Sand, same as above.

Sand, same as above, except poorly sorted with scattered gravel fragments to 20 mm.

Table 4.--Infiltration at Grant Line Arroyo between Louisiana Boulevard and San Pedro Boulevard, Albuquerque, New Mexico

[UTC, unable to calculate; MR, missing record]

Date	Flow at upstream station 08329860, in cubic feet per second		Flow or no flow recorded at downstream station 08329865	Daily rainfall at upstream station 08329860, in inches	Infiltration between stations, in cubic feet
	Daily maximum	Daily mean			
3-26-84	0.82	0.17	Flow	0.41	UTC
3-27-84	.41	.05	Flow	.20	UTC
3-31-84	.06	.02	No flow	.00	1,728
4-14-84	.06	.02	No flow	.00	1,728
4-26-84	.32	.05	No flow	.31	4,320
4-28-84	.74	.01	No flow	.08	864
4-29-84	.32	.02	Flow	.09	UTC
5-23-84	14	.17	Flow	.44	UTC
6-1-84	9.7	.08	Flow	.52	UTC
6-2-84	.53	.01	No flow	.10	864
6-5-84	.16	.01	No flow	.10	864
6-19-84	4.2	.19	Flow	.65	UTC
6-26-84	MR	MR	No flow	.06	UTC
7-3-84	MR	MR	Flow	.26	UTC
7-10-84	MR	MR	No flow	.04	UTC
7-11-84	MR	MR	No flow	.03	UTC
7-16-84	MR	MR	No flow	.16	UTC
7-17-84	MR	MR	No flow	.07	UTC
7-21-84	MR	MR	Flow	.11	UTC
8-1-84	MR	MR	No flow	0.11	UTC
8-2-84	MR	MR	No flow	.20	UTC
8-4-84	MR	MR	Flow	.32	UTC
8-6-84	1.1	0.03	Flow	.31	UTC
8-7-84	5.2	.17	Flow	.55	UTC
8-8-84	.32	.02	Flow	.01	UTC
8-20-84	.07	.00	No flow	.04	0
8-22-84	12	.27	Flow	.85	UTC
8-23-84	10	.23	Flow	.53	UTC
8-24-84	.04	.01	Flow	.02	UTC
8-26-84	1.7	.03	Flow	.16	UTC

Table 4.—Infiltration at Grant Line Arroyo between Louisiana Boulevard and San Pedro Boulevard, Albuquerque, New Mexico—Continued

Date	Flow at upstream station 08329860, in cubic feet per second: Daily maximum	Flow at upstream station 08329860, in cubic feet per second: Daily mean	Flow or no flow recorded at downstream station 08329865	Daily rainfall at upstream station 08329860, in inches	Infiltration between stations, in cubic feet
9-7-84	0.07	0.00	No flow	0.00	0
9-14-84	1.8	.09	Flow	.41	UTC
9-15-84	.04	.01	No flow	.02	864
9-20-84	.01	.00	No flow	.00	0
9-23-84	.16	.01	No flow	.03	864
9-25-84	.67	.05	No flow	.25	4,320
9-26-84	2.1	.23	Flow	.79	UTC
9-27-84	.04	.01	Flow	.00	UTC
9-28-84	.03	.01	No flow	.00	864
10-1-84	.47	.02	No flow	.09	1,728
10-2-84	.67	.02	Flow	.11	UTC
10-3-84	3.7	.19	Flow	.59	UTC
10-4-84	.08	.02	No flow	.06	1,728
10-12-84	.09	.01	No flow	.04	864
10-15-84	2.1	.26	Flow	1.3	UTC
10-19-84	.18	.01	No flow	.08	864
10-20-84	1.1	.07	Flow	.26	UTC
10-21-84	1.0	.04	Flow	.10	UTC
10-22-84	.16	.02	Flow	.07	UTC
10-24-84	.32	.05	Flow	.21	UTC
10-25-84	.03	.01	Flow	.00	UTC
10-26-84	1.1	.04	Flow	.12	UTC
10-27-84	.04	.01	Flow	.00	UTC
11-17-84	.82	.07	Flow	.45	UTC
11-18-84	.12	.01	No flow	.08	864
11-24-84	.36	.02	No flow	.17	1,728
11-25-84	.09	.01	No flow	.04	864
12-4-84	.14	.01	No flow	.12	864
12-12-84	MR	MR	Flow	MR	UTC
12-13-84	MR	MR	Flow	MR	UTC

Table 4.—**Infiltration at Grant Line Arroyo between Louisiana Boulevard and San Pedro Boulevard, Albuquerque, New Mexico**—Continued

Date	Flow at upstream station 08329860, in cubic feet per second		Flow or no flow recorded at downstream station 08329865	Daily rainfall at upstream station 08329860, in inches	Infiltration between stations, in cubic feet
	Daily maximum	Daily mean			
12-15-84	MR	MR	Flow	MR	UTC
12-28-84	MR	MR	Flow	MR	UTC
1-8-85	MR	MR	Flow	MR	UTC
2-22-85	0.91	0.04	Flow	MR	UTC
2-23-85	.12	.01	No flow	MR	864
2-28-85	.47	.03	No flow	MR	2,592
3-12-85	.82	.17	Flow	0.69	UTC
3-19-85	.32	.04	Flow	.17	UTC
3-20-85	.03	.00	No flow	.00	0
3-25-85	.06	.00	No flow	.00	0
3-26-85	.08	.03	No flow	.00	2,592
3-29-85	.09	.01	No flow	.04	864
4-18-85	3.5	.07	Flow	.32	UTC
4-21-85	.14	.01	No flow	.07	864
4-22-85	1.8	.08	Flow	.29	UTC
4-25-85	.10	.00	No flow	.02	0
4-26-85	.32	.04	No flow	.13	3,456
4-28-85	2.6	.31	Flow	1.2	UTC
4-29-85	.10	.02	Flow	.05	UTC
5-1-85	1.7	.05	Flow	.22	UTC
5-4-85	.07	.00	No flow	.03	0
5-12-85	.67	.02	Flow	.15	UTC
5-17-85	1.3	.03	Flow	.10	UTC
5-18-85	.03	.00	Flow	.02	UTC
5-21-85	1.7	.06	Flow	.23	UTC
5-22-85	.02	.00	No flow	.00	0
5-28-85	.12	.00	No flow	.00	0
6-4-85	.16	.01	No flow	.03	864
6-5-85	.03	.00	No flow	.00	0
6-6-85	.03	.00	No flow	.00	0

Table 4.—Infiltration at Grant Line Arroyo between Louisiana Boulevard and San Pedro Boulevard, Albuquerque, New Mexico—Continued

Date	Flow at upstream station 08329860, in cubic feet per second		Flow or no flow recorded at downstream station 08329865	Daily rainfall at upstream station 08329860, in inches	Infiltration between stations, in cubic feet
	Daily maximum	Daily mean			
6-9-85	0.08	0.00	No flow	0.02	0
6-20-85	.16	.00	No flow	.04	0
6-24-85	3.5	.10	Flow	.40	UTC
6-25-85	.08	.01	Flow	.00	UTC
6-26-85	.03	.00	No flow	.00	0
7-2-85	.41	.01	No flow	.05	864
7-12-85	.07	.00	No flow	.00	0
7-15-85	.18	.01	No flow	.06	864
7-16-85	.02	.00	No flow	.02	0
7-19-85	.08	.00	No flow	.04	0
7-21-85	.06	.00	No flow	.00	0
7-22-85	1.3	.02	No flow	.02	1,728
7-23-85	.20	.01	No flow	.06	864
7-26-85	.04	.01	No flow	.00	864
7-27-85	.02	.00	No flow	.00	0
7-28-85	.16	.01	No flow	.07	864
7-29-85	.59	.03	No flow	.14	2,592
8-1-85	.91	.04	No flow	.18	3,456
8-2-85	1.5	.07	Flow	.15	UTC
8-3-85	.02	.00	No flow	.09	0
8-7-85	.24	.01	No flow	.05	864
8-8-85	.09	.01	No flow	.00	864
8-10-85	4.4	.06	Flow	.26	UTC
8-11-85	.16	.01	No flow	.05	864
8-20-85	1.4	.04	No flow	.17	3,456
8-21-85	.02	.00	No flow	.00	0
8-23-85	.09	.01	No flow	.00	864
8-24-85	.03	.00	No flow	.00	0
8-26-85	.08	.01	No flow	.00	0
8-28-85	3.5	.05	Flow	.21	UTC

Table 4.—Infiltration at Grant Line Arroyo between Louisiana Boulevard and San Pedro Boulevard, Albuquerque, New Mexico—Continued

Date	Flow at upstream station 08329860, in cubic feet per second: Daily maximum	Daily mean	Flow or no flow recorded at downstream station 08329865	Daily rainfall at upstream station 08329860, in inches	Infiltration between stations, in cubic feet
8-29-85	0.04	0.00	No flow	0.00	0
8-31-85	.06	.00	No flow	.00	0
9-3-85	.91	.02	No flow	.09	1,728
9-12-85	2.2	.03	Flow	.00	UTC
9-15-85	.53	.03	Flow	.18	UTC
9-16-85	6.0	.15	Flow	.53	UTC
9-17-85	.74	.02	Flow	.10	UTC
9-18-85	2.4	.08	Flow	.32	UTC
9-19-85	1.3	.05	Flow	.21	UTC
9-20-85	1.3	.11	Flow	.52	UTC
9-21-85	.01	.00	No flow	.01	0
9-28-85	.04	.00	No flow	.03	0
9-29-85	.32	.01	No flow	.08	864
10-7-85	.47	.02	No flow	.13	1,728
10-9-85	2.4	.06	Flow	.22	UTC
10-10-85	3.7	.20	Flow	.83	UTC
10-11-85	1.1	.04	Flow	.08	UTC
10-13-85	.07	.01	No flow	.03	864
10-14-85	.01	.00	No flow	.01	0
10-16-85	1.2	.11	Flow	.47	UTC
10-17-85	1.0	.07	Flow	.24	UTC
10-31-85	.09	.01	No flow	.09	864
11-1-85	.05	.01	No flow	.04	864
11-14-85	.07	.00	No flow	.08	0
11-30-85	.08	.00	No flow	.05	0
12-10-85	.27	.01	No flow	MR	864
12-31-85	.12	.01	No flow	MR	864
1-7-86	.24	.04	No flow	MR	3,456
2-10-86	MR	MR	Flow	MR	UTC
3-10-86	.05	.00	No flow	.05	0

Table 4.--Infiltration at Grant Line Arroyo between Louisiana Boulevard and San Pedro Boulevard, Albuquerque, New Mexico--Continued

Date	Flow at upstream station 08329860, in cubic feet per second		Flow or no flow recorded at downstream station 08329865	Daily rainfall at upstream station 08329860, in inches	Infiltration between stations, in cubic feet
	Daily maximum	Daily mean			
3-11-86	0.20	0.01	No flow	0.01	864
3-18-86	.03	.00	No flow	.04	0
3-28-86	.07	.01	No flow	.00	864
4-1-86	1.8	.05	No flow	.25	4,320
4-23-86	.04	.00	No flow	.02	0
4-24-86	.20	.01	No flow	.08	864
4-25-86	2.4	.04	Flow	.17	UTC
5-3-86	1.2	.05	Flow	.27	UTC
5-4-86	.02	.00	No flow	.02	0
5-16-86	1.2	.08	Flow	.43	UTC
5-17-86	2.1	.10	Flow	.34	UTC
5-29-86	.18	.01	No flow	.07	864
5-30-86	.07	.01	No flow	.06	864
6-17-86	2.6	.06	No flow	.44	5,184
6-18-86	.53	.02	No flow	.08	1,728
6-19-86	.24	.01	No flow	.04	864
6-24-86	.67	.06	Flow	.41	UTC
6-25-86	.36	.07	Flow	.30	UTC
6-26-86	.06	.01	No flow	.04	864
6-27-86	6.3	.15	Flow	MR	UTC
6-29-86	.36	.01	No flow	MR	864
6-30-86	3.5	.08	Flow	MR	UTC
7-1-86	.05	.00	No flow	.02	0
7-4-86	1.5	.05	Flow	.25	UTC
7-7-86	1.4	.07	No flow	.37	6,048
7-8-86	.74	.02	Flow	.06	UTC
7-9-86	.59	.03	No flow	.16	2,592
7-13-86	1.3	.02	No flow	.08	1,728
7-16-86	4.9	.10	Flow	.35	UTC
7-19-86	.10	.00	No flow	.05	0

Table 4.--Infiltration at Grant Line Arroyo between Louisiana Boulevard and San Pedro Boulevard, Albuquerque, New Mexico--Concluded

Date	Flow at upstream station 08329860, in cubic feet per second: Daily maximum	Flow at upstream station 08329860, in cubic feet per second: Daily mean	Flow or no flow recorded at downstream station 08329865	Daily rainfall at upstream station 08329860, in inches	Infiltration between stations, in cubic feet
7-20-86	0.32	0.02	No flow	0.12	1,728
7-22-86	24	.33	Flow	.84	UTC
8-3-86	.01	.00	No flow	.02	0
8-4-86	.06	.00	No flow	.00	0
8-5-86	.08	.02	No flow	.00	1,728
8-10-86	2.7	.06	Flow	.22	UTC
8-13-86	.12	.01	No flow	.08	864
8-14-86	.01	.00	No flow	.00	0
8-21-86	.08	.00	No flow	.02	0
8-22-86	.01	.00	No flow	.04	0
8-23-86	1.4	.06	Flow	.31	UTC
8-25-86	7.5	.11	Flow	.36	UTC
9-2-86	.08	.00	No flow	.02	0
9-4-86	.24	.01	No flow	.10	864
9-13-86	3.7	.05	No flow	.20	4,320
9-16-86	.20	.01	No flow	.08	864
9-23-86	.06	.00	No flow	.09	0
9-24-86	2.9	.07	No flow	.26	6,048

Table 5.--Bowen-ratio, evapotranspiration rates at site 14, over bare ground and sparse weeds, Albuquerque, New Mexico

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
September 3, 1985	0.14	
September 10, 1985	.03	
September 13, 1985	.07	
September 19, 1985	.06	
September 23, 1985	.10	
September 28, 1985	.05	
September 1-30, 1985		2.25
October 11, 1985	.09	
October 14, 1985	.11	
October 20, 1985	.07	
October 21, 1985	.03	
October 24, 1985	.08	
October 27, 1985	.05	
October 29, 1985	.04	
October 30, 1985	.03	
October 1-31, 1985		1.94
November 1, 1985	.05	
November 2, 1985	.05	
November 3, 1985	.03	
November 6, 1985	.04	
November 7, 1985	.03	
November 8, 1985	.04	
November 9, 1985	.03	
November 10, 1985	.02	
November 11, 1985	.09	
November 12, 1985	.03	
November 13, 1985	.03	
November 17, 1985	.04	
November 19, 1985	.02	
November 20, 1985	.02	
November 23, 1985	.02	
November 24, 1985	.02	
November 27, 1985	.04	
November 28, 1985	.02	
November 29, 1985	.03	

Table 5.--Bowen-ratio, evapotranspiration rates at site 14, over bare ground and sparse weeds, Albuquerque, New Mexico--Continued

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
November 30, 1985	0.05	
November 1-30, 1985		1.05
December 1, 1985	.03	
December 2, 1985	.03	
December 3, 1985	.02	
December 4, 1985	.02	
December 5, 1985	.03	
December 6, 1985	.03	
December 7, 1985	.02	
December 8, 1985	.02	
December 10, 1985	.02	
December 11, 1985	.01	
December 12, 1985	.02	
December 13, 1985	.03	
December 14, 1985	.03	
December 15, 1985	.02	
December 21, 1985	.02	
December 22, 1985	.02	
December 23, 1985	.02	
December 25, 1985	.01	
December 27, 1985	.02	
December 31, 1985	.03	
December 1-31, 1985		0.70
January 2, 1986	.02	
January 3, 1986	.02	
January 4, 1986	.02	
January 5, 1986	.02	
January 6, 1986	.02	
January 7, 1986	.03	
January 8, 1986	.02	
January 9, 1986	.02	
January 10, 1986	.02	
January 11, 1986	.01	
January 12, 1986	.02	
January 19, 1986	.01	

Table 5.--**Bowen-ratio, evapotranspiration rates at site 14, over bare ground and sparse weeds, Albuquerque, New Mexico**--Continued

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
January 21, 1986	0.02	
January 22, 1986	.02	
January 23, 1986	.02	
January 25, 1986	.01	
January 26, 1986	.02	
January 27, 1986	.02	
January 28, 1986	.02	
January 29, 1986	.02	
January 30, 1986	.02	
January 1-31, 1986		0.59
February 1, 1986	.01	
February 4, 1986	.01	
February 5, 1986	.01	
February 6, 1986	.02	
February 15, 1986	.03	
February 16, 1986	.06	
February 17, 1986	.04	
February 18, 1986	.06	
February 23, 1986	.04	
February 25, 1986	.04	
February 27, 1986	.02	
February 28, 1986	.02	
February 1-28, 1986		0.84
March 1, 1986	.04	
March 2, 1986	.04	
March 3, 1986	.02	
March 4, 1986	.04	
March 5, 1986	.04	
March 6, 1986	.04	
March 7, 1986	.05	
March 8, 1986	.04	
March 9, 1986	.05	
March 10, 1986	.03	
March 11, 1986	.06	
March 12, 1986	.04	

Table 5.--Bowen-ratio, evapotranspiration rates at site 14, over bare ground and sparse weeds, Albuquerque, New Mexico--Concluded

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
March 13, 1986	0.05	
March 15, 1986	.04	
March 16, 1986	.03	
March 17, 1986	.03	
March 21, 1986	.05	
March 22, 1986	.04	
March 23, 1986	.04	
March 27, 1986	.06	
March 28, 1986	.06	
March 29, 1986	.06	
March 1-31, 1986		1.33

Table 6.--Bowen-ratio, evapotranspiration rates at site 14, over clover and weeds, Albuquerque, New Mexico

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
August 21, 1985	0.13	
August 25, 1985	.12	
August 26, 1985	.11	
August 27, 1985	.08	
August 28, 1985	.10	
September 1, 1985	.06	
September 2, 1985	.10	
September 3, 1985	.07	
September 4, 1985	.04	
September 9, 1985	.07	
September 10, 1985	.07	
September 15, 1985	.08	
September 19, 1985	.05	
September 21, 1985	.08	
September 22, 1985	.10	
September 23, 1985	.07	
September 24, 1985	.06	
September 25, 1985	.05	
September 27, 1985	.04	
September 28, 1985	.04	
September 29, 1985	.05	
September 1-30, 1985		1.93
October 3, 1985	.02	
October 4, 1985	.02	
October 7, 1985	.04	
October 9, 1985	.02	
October 10, 1985	.04	
October 11, 1985	.06	
October 14, 1985	.05	
October 15, 1985	.03	
October 19, 1985	.02	
October 29, 1985	.03	
October 1-31, 1985		1.02
November 6, 1985	.02	
November 7, 1985	.02	

Table 6.--Bowen-ratio, evapotranspiration rates at site 14, over clover and weeds, Albuquerque, New Mexico--Continued

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
November 8, 1985	0.04	
November 9, 1985	.02	
November 12, 1985	.03	
November 19, 1985	.02	
November 20, 1985	.02	
November 21, 1985	.04	
November 23, 1985	.01	
November 30, 1985	.06	
November 1-30, 1985		0.84
December 12, 1985	.02	
December 13, 1985	.01	
December 31, 1985	.01	
January 7, 1986	.03	
January 24, 1986	.01	
January 25, 1986	.01	
January 26, 1986	.01	
January 27, 1986	.01	
January 29, 1986	.01	
January 1-31, 1986		0.41
February 4, 1986	.05	
February 5, 1986	.03	
February 6, 1986	.03	
February 15, 1986	.02	
February 16, 1986	.06	
February 17, 1986	.06	
February 18, 1986	.04	
February 1-28, 1986		1.16
March 7, 1986	.02	
March 9, 1986	.09	
March 12, 1986	.06	
March 13, 1986	.07	
March 14, 1986	.04	
March 15, 1986	.04	
March 16, 1986	.04	
March 17, 1986	.03	

Table 6.--Bowen-ratio, evapotranspiration rates at site 14, over clover and weeds, Albuquerque, New Mexico--Continued

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
March 23, 1986	0.11	
March 24, 1986	.10	
March 25, 1986	.07	
March 26, 1986	.13	
March 27, 1986	.09	
March 28, 1986	.14	
March 29, 1986	.11	
March 30, 1986	.11	
March 1-31, 1986		2.42
May 3, 1986	.18	
May 6, 1986	.18	
May 7, 1986	.23	
May 8, 1986	.13	
May 9, 1986	.17	
May 10, 1986	.17	
May 11, 1986	.20	
May 20, 1986	.25	
May 21, 1986	.26	
May 23, 1986	.24	
May 24, 1986	.20	
May 25, 1986	.22	
May 27, 1986	.18	
May 1-31, 1986		6.22
June 4, 1986	.22	
June 6, 1986	.22	
June 7, 1986	.24	
June 8, 1986	.20	
June 10, 1986	.17	
June 12, 1986	.22	
June 13, 1986	.22	
June 14, 1986	.22	
June 15, 1986	.24	
June 16, 1986	.22	
June 17, 1986	.20	
June 18, 1986	.15	

Table 6.--Bowen-ratio, evapotranspiration rates at site 14, over clover and weeds, Albuquerque, New Mexico--Continued

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
June 22, 1986	0.20	
June 24, 1986	.07	
June 25, 1986	.08	
June 26, 1986	.15	
June 27, 1986	.22	
June 29, 1986	.21	
June 30, 1986	.17	
June 1-30, 1986		5.72
July 1, 1986	.18	
July 2, 1986	.26	
July 3, 1986	.23	
July 7, 1986	.16	
July 10, 1986	.12	
July 11, 1986	.19	
July 12, 1986	.19	
July 13, 1986	.19	
July 15, 1986	.15	
July 19, 1986	.10	
July 20, 1986	.14	
July 27, 1986	.13	
July 28, 1986	.18	
July 29, 1986	.18	
July 30, 1986	.18	
July 31, 1986	.18	
July 1-31, 1986		5.35
August 1, 1986	.19	
August 2, 1986	.20	
August 3, 1986	.15	
August 4, 1986	.17	
August 5, 1986	.18	
August 6, 1986	.15	
August 7, 1986	.20	
August 8, 1986	.16	
August 9, 1986	.15	
August 10, 1986	.13	

Table 6.--Bowen-ratio, evapotranspiration rates at site 14, over clover and weeds, Albuquerque, New Mexico--Continued

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
August 11, 1986	0.11	
August 12, 1986	.11	
August 13, 1986	.13	
August 14, 1986	.15	
August 15, 1986	.17	
August 16, 1986	.18	
August 17, 1986	.17	
August 21, 1986	.15	
August 22, 1986	.11	
August 23, 1986	.06	
August 24, 1986	.09	
August 25, 1986	.08	
August 26, 1986	.06	
August 27, 1986	.09	
August 28, 1986	.11	
August 29, 1986	.08	
August 30, 1986	.08	
August 31, 1986	.11	
August 1-31, 1986		4.12
September 1, 1986	.10	
September 2, 1986	.10	
September 3, 1986	.09	
September 4, 1986	.11	
September 5, 1986	.08	
September 6, 1986	.05	
September 9, 1986	.05	
September 10, 1986	.06	
September 11, 1986	.04	
September 13, 1986	.07	
September 14, 1986	.06	
September 18, 1986	.08	
September 19, 1986	.07	
September 20, 1986	.10	
September 21, 1986	.08	
September 22, 1986	.06	

Table 6.--Bowen-ratio, evapotranspiration rates at site 14, over clover and weeds, Albuquerque, New Mexico--Concluded

Date	Evapotranspiration rate, in inches per day	Evapotranspiration rate, in inches per month
September 23, 1986	0.00	
September 25, 1986	.03	
September 27, 1986	.04	
September 29, 1986	.04	
September 30, 1986	.03	
September 1-30, 1986		1.91

Table 7.--Evapotranspiration rates measured by the portable chamber at selected sites in Albuquerque, New Mexico

Subsite	Date	Evapotranspiration rate, in inches per day
	Site 1, 12200 Vienna Dr. N.E.	
Grass at north of lawn	July 31, 1986	0.18
	September 25, 1986	.08
Grass at center of lawn	July 31, 1986	.22
	September 25, 1986	.08
Grass at west of lawn	July 31, 1986	.23
	September 25, 1986	.07
	Site 2, 12200 Vienna Dr. N.E.	
Gravel at north of lawn	July 31, 1986	0.06
	September 25, 1986	.02
Gravel at east of driveway	July 31, 1986	.04
	September 25, 1986	.02
Gravel at east of lawn	July 31, 1986	.03
	September 25, 1986	.02
	Site 6, 7016 Vivian Dr. N.E.	
Grass	June 19, 1986	0.12
Grass at north of lawn	August 28, 1986	.08
Grass at center of lawn	August 28, 1986	.08
Grass at east of lawn	August 28, 1986	.06
	Site 7, 7016 Vivian Dr. N.E.	
Lava rock	June 19, 1986	0.12
Lava rock at north of lawn	August 28, 1986	.05
Lava rock at northeast of lawn	August 28, 1986	.04
Lava rock at east of lawn	August 28, 1986	.04

Table 7.--Evapotranspiration rates measured by the portable chamber at selected sites in Albuquerque, New Mexico--Continued

Subsite	Date	Evapotranspiration rate, in inches per day
	Site 8, Grant Line Arroyo N.E.	
Arroyo bed soil upstream from neutron-access tube	July 29, 1986	0.02
	August 26, 1986	.07
	September 23, 1986	.04
Arroyo bed soil with sparse weeds downstream from neutron-access tube	July 29, 1986	.04
	August 26, 1986	.09
	September 23, 1986	.04
Arroyo bed soil downstream from neutron-access tube	July 29, 1986	.02
	August 26, 1986	.06
	September 23, 1986	.04
	Site 9, Grant Line Arroyo N.E.	
Arroyo bank in weeds	July 29, 1986	0.04
	August 26, 1986	.06
	September 23, 1986	.03
Arroyo bank in wild grass downstream from neutron-access tube	July 29, 1986	.04
	August 26, 1986	.06
	September 23, 1986	.06
Arroyo bank in wild grass upstream from neutron-access tube	July 29, 1986	.04
	August 26, 1986	.06
	September 23, 1986	.03
	Site 11, Southwest corner of Los Altos Golf Course	
Weeds in rough	June 20, 1986	0.13
	August 1, 1986	.14
Grass and weeds in rough within irrigation pattern	August 1, 1986	.13
	August 29, 1986	.09
	September 26, 1986	.06
Grass and weeds in rough outside of irrigation pattern	August 29, 1986	.03
	September 26, 1986	.04
Sparse grass and weeds in rough outside of irrigation pattern	August 1, 1986	.04
	August 29, 1986	.04
	September 26, 1986	.02

Table 7.--Evapotranspiration rates measured by the portable chamber at selected sites in Albuquerque, New Mexico—Continued

Subsite	Date	Evapotranspiration rate, in inches per day
Site 12, Southwest corner of Los Altos Golf Course		
Grass on green	June 20, 1986	0.24
Grass on side slope of green	August 1, 1986	.18
	August 29, 1986	.07
	September 26, 1986	.11
Grass at west side of green	August 1, 1986	.17
	August 29, 1986	.09
	September 26, 1986	.11
Grass at center of green	August 1, 1986	.17
	August 29, 1986	.13
	September 26, 1986	.11
Site 14, 705 Camino Español N.W.		
Clover	June 18, 1986	0.13
Wild grass and weeds	June 18, 1986	.10
Clover at east of field	July 30, 1986	.22
	August 27, 1986	.12
	September 24, 1986	.08
Clover at center of field	July 30, 1986	.20
	August 27, 1986	.12
	September 24, 1986	.07
Clover at west of field	August 27, 1986	.13
Wild grass at center of field	July 30, 1986	.10
	September 24, 1986	.05
Wild grass and weed at center of field	July 30, 1986	.15
	August 27, 1986	.06
	September 24, 1986	.05
Wild grass and weed at south of field	July 30, 1986	.16
	August 27, 1986	.11
	September 24, 1986	.05

Table 7.--Evapotranspiration rates measured by the portable chamber at selected sites in Albuquerque, New Mexico--Concluded

Subsite	Date	Evapotranspiration rate, in inches per day
Site 21, Central Avenue west of 98th Street		
Soil with sparse vegetation near dirt road	July 28, 1986	0.03
	August 25, 1986	.02
	September 22, 1986	.01
Soil with sparse vegetation uphill from dirt road	July 28, 1986	.02
	August 25, 1986	.02
	September 22, 1986	.01
Medium-sized sand sage (*Artemisia filifolia*)	August 25, 1986	.02
	September 22, 1986	.02
Large-sized sand sage near dirt road	July 28, 1986	.05
	August 25, 1986	.03
	September 22, 1986	.02
Large-sized sand sage uphill from dirt road	July 28, 1986	.04
	August 25, 1986	.02
	September 22, 1986	.02
Medium-sized snakeweed (*Gutierrezia sarothrae*)	July 28, 1986	.06
	August 25, 1986	.03
	September 22, 1986	.02

Table 8.—Average evapotranspiration rates and evapotranspiration-rate ratios over different land covers as measured by the portable chamber at selected sites in Albuquerque, New Mexico

[irr., irrigated; nonirr., nonirrigated]

Site	Land cover	Date	Average evapotranspiration rate, in inches per day	Average evapotranspiration-rate ratio
1	Grass	July 31, 1986	0.21	$\frac{\text{Grass}}{\text{Gravel}} = \frac{0.21}{0.04} = 5.2$
1	Grass	September 25, 1986	.08	$\frac{\text{Grass}}{\text{Gravel}} = \frac{0.08}{0.02} = 4.0$
2	Gravel	July 31, 1986	.04	
2	Gravel	September 25, 1986	.02	
6	Grass	June 19, 1986	.12	$\frac{\text{Grass}}{\text{Lava rock}} = \frac{0.12}{0.12} = 1.0$
6	Grass	August 18, 1986	.07	$\frac{\text{Grass}}{\text{Lava rock}} = \frac{0.07}{0.04} = 1.8$
7	Lava rock	June 19, 1986	.12	
7	Lava rock	August 28, 1986	.04	
8	Arroyo bed	July 29, 1986	.03	$\frac{\text{Arroyo bed}}{\text{Arroyo bank}} = \frac{0.03}{0.04} = 0.8$
8	Arroyo bed	August 26, 1986	.08	$\frac{\text{Arroyo bed}}{\text{Arroyo bank}} = \frac{0.08}{0.06} = 1.3$
8	Arroyo bed	September 23, 1986	.04	$\frac{\text{Arroyo bed}}{\text{Arroyo bank}} = \frac{0.04}{0.04} = 1.0$
9	Arroyo bank	July 29, 1986	.04	
9	Arroyo bank	August 26, 1986	.06	
9	Arroyo bank	September 23, 1986	.04	
11	Nonirrigated golf-course rough	August 1, 1986	.04	
11	Nonirrigated golf-course rough	August 29, 1986	.03	

Table 8.—Average evapotranspiration rates and evapotranspiration-rate ratios over different land covers as measured by the portable chamber at selected sites in Albuquerque, New Mexico—Continued

Site	Land cover	Date	Average evapotranspiration rate, in inches per day	Average evapotranspiration-rate ratio
11	Nonirrigated golf-course rough	September 26, 1986	0.03	
11	Irrigated golf-course rough	August 1, 1986	.13	$\frac{\text{Irr. rough}}{\text{Nonirr. rough}} = \frac{0.13}{0.04} = 3.2$
11	Irrigated golf-course rough	August 29, 1986	.09	$\frac{\text{Irr. rough}}{\text{Nonirr. rough}} = \frac{0.09}{0.03} = 3.0$
11	Irrigated golf-course rough	September 26, 1986	.06	$\frac{\text{Irr. rough}}{\text{Nonirr. rough}} = \frac{0.06}{0.03} = 2.0$
12	Golf-course green	June 20, 1986	.24	
12	Golf-course green	August 1, 1986	.17	$\frac{\text{Green}}{\text{Nonirr. rough}} = \frac{0.17}{0.04} = 4.2$
12	Golf-course green	August 29, 1986	.10	$\frac{\text{Green}}{\text{Nonirr. rough}} = \frac{0.10}{0.03} = 3.3$
12	Golf-course green	September 26, 1986	.11	$\frac{\text{Green}}{\text{Nonirr. rough}} = \frac{0.11}{0.03} = 3.7$
14	Clover	June 18, 1986	.13	$\frac{\text{Clover}}{\text{Wild grass}} = \frac{0.13}{0.10} = 1.3$
14	Clover	July 30, 1986	.21	$\frac{\text{Clover}}{\text{Wild grass}} = \frac{0.21}{0.14} = 1.5$
14	Clover	August 27, 1986	.13	$\frac{\text{Clover}}{\text{Wild grass}} = \frac{0.13}{0.08} = 1.6$

Table 8.—Average evapotranspiration rates and evapotranspiration-rate ratios over different land covers as measured by the portable chamber at selected sites in Albuquerque, New Mexico—Concluded

Site	Land cover	Date	Average evapotrans-piration rate, in inches per day	Average evapotrans-piration-rate ratio
14	Clover	September 24, 1986	0.07	$\frac{\text{Clover}}{\text{Wild grass}} = \frac{0.07}{0.05} = 1.4$
14	Wild grass	June 18, 1986	.10	
14	Wild grass	July 30, 1986	.14	
14	Wild grass	August 27, 1986	.08	
14	Wild grass	September 24, 1986	.05	
21	Soil with sparse vegetation	July 28, 1986	.02	
21	Soil with sparse vegetation	August 25, 1986	.02	
21	Soil with sparse vegetation	September 22, 1986	.01	
21	Sand sage and snakeweed bushes	July 28, 1986	.05	$\frac{\text{Bushes}}{\text{Soil}} = \frac{0.05}{0.02} = 2.5$
21	Sand sage and snakeweed bushes	August 25, 1986	.02	$\frac{\text{Bushes}}{\text{Soil}} = \frac{0.02}{0.02} = 1.0$
21	Sand sage and snakeweed bushes	September 22, 1986	.02	$\frac{\text{Bushes}}{\text{Soil}} = \frac{0.02}{0.01} = 2.0$

Table 9.--Results of seasonal Kendall test and slope estimator for trend magnitude with monthly seasonality

[Rio Grande at San Felipe plus Jemez River minus Rio Grande near Bernardo; 2-day time of travel considered; the hypothesis was rejected when the computed probability was less than 0.05]

Period analyzed	Number of monthly values	Probability level	Kendall slope estimator, in acre-feet per year	Result
1955-59	60	0.525	-1,569	No trend
1956-60	60	.289	9,954	No trend
1957-61	60	.671	-724.0	No trend
1958-62	60	.202	8,630	No trend
1959-63	60	.478	-1,257	No trend
1960-64	60	.257	-6,396	No trend
1961-65	60	.321	-5,368	No trend
1962-66	60	.047	-16,090	Trend of less losses
1963-67	60	1.00	-844.9	No trend
1964-68	60	.179	-8,086	No trend
1965-69	60	.832	3,855	No trend
1966-70	60	.138	7,825	No trend
1967-71	60	.321	-9,622	No trend
1968-72	60	.119	-15,170	No trend
1969-73	60	.016	-17,380	Trend of less losses
1970-74	60	.119	-7,421	No trend
1971-75	60	.832	-2,232	No trend
1972-76	60	.179	9,939	No trend
1973-77	60	.437	3,170	No trend
1974-78	60	.229	8,137	No trend
1975-79	60	.621	-1,427	No trend
1976-80	60	.040	-18,770	Trend of less losses
1977-81	60	.229	-9,622	No trend
1978-82	59	.942	-2,092	No trend
1979-83	59	.017	24,280	Trend of more losses
1980-84	59	.427	14,720	No trend
1955-61	84	.664	1,388	No trend
1956-62	84	.259	4,821	No trend
1957-63	84	.193	-1,738	No trend
1958-64	84	.862	1,200	No trend

Table 9.--**Results of seasonal Kendall test and slope estimator for trend magnitude with monthly seasonality**--Continued

Period analyzed	Number of monthly values	Probability level	Kendall slope estimator, in acre-feet per year	Result
1959-65	84	0.278	-1,448	No trend
1960-66	84	.002	-11,640	Trend of less losses
1961-67	84	.140	-7,398	No trend
1962-68	84	.140	-4,995	No trend
1963-69	84	.728	-1,122	No trend
1964-70	84	.516	-1,478	No trend
1965-71	84	.224	-4,834	No trend
1966-72	84	.259	-5,483	No trend
1967-73	84	.012	-14,030	Trend of less losses
1968-74	84	.015	-11,660	Trend of less losses
1969-75	84	.004	-10,860	Trend of less losses
1970-76	84	.862	-1,291	No trend
1971-77	84	.363	3,395	No trend
1972-78	84	.109	6,276	No trend
1973-79	84	.897	724.0	No trend
1974-80	84	.633	-1,427	No trend
1975-81	84	.209	-7,362	No trend
1976-82	83	.355	-4,471	No trend
1977-83	83	.235	7,362	No trend
1978-84	83	.895	360.2	No trend
1955-64	120	.757	-299.9	No trend
1956-65	120	.816	-181.0	No trend
1957-66	120	.004	-6,000	Trend of less losses
1958-67	120	.188	-1,629	No trend
1959-68	120	.019	-4,604	Trend of less losses
1960-69	120	.011	-4,816	Trend of less losses
1961-70	120	.071	-3,300	No trend
1962-71	120	.019	-5,077	Trend of less losses
1963-72	120	.011	-6,877	Trend of less losses
1964-73	120	.001	-8,520	Trend of less losses
1965-74	120	.002	-7,725	Trend of less losses
1966-75	120	.005	-7,631	Trend of less losses
1967-76	120	.026	-6,255	Trend of less losses
1968-77	120	.039	-5,476	Trend of less losses
1969-78	120	.352	-2,493	No trend

Table 9.—Results of seasonal Kendall test and slope estimator for trend magnitude with monthly seasonality—Concluded

Period analyzed	Number of monthly values	Probability level	Kendall slope estimator, in acre-feet per year	Result
1970-79	120	0.535	-1,347	No trend
1971-80	120	.897	736.2	No trend
1972-81	120	.661	-1,068	No trend
1973-82	119	.754	747.7	No trend
1974-83	119	.676	1,376	No trend
1975-84	119	.917	205.1	No trend
1955-69	180	.065	-1,689	No trend
1956-70	180	.100	-1,496	No trend
1957-71	180	.000	-4,180	Trend of less losses
1958-72	180	.000	-3,791	Trend of less losses
1959-73	180	.000	-5,938	Trend of less losses
1960-74	180	.000	-6,963	Trend of less losses
1961-75	180	.000	-7,193	Trend of less losses
1962-76	180	.000	-5,522	Trend of less losses
1963-77	180	.000	-5,409	Trend of less losses
1964-78	180	.003	-4,530	Trend of less losses
1965-79	180	.001	-4,783	Trend of less losses
1966-80	180	.005	-4,676	Trend of less losses
1967-81	180	.000	-6,186	Trend of less losses
1968-82	179	.025	-3,755	Trend of less losses
1969-83	179	.185	-2,283	No trend
1970-84	179	.751	-672.1	No trend
1955-84	359	.000	-3,528	Trend of less losses