Quality of Water and Chemistry of Bottom Sediment in the Rillito Creek Basin, Tucson, Arizona, 1992–93

By SAEID TADAYON

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CONVERSION FACTORS

Multiply	By	To obtain
inch (in)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06309	liter per second

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

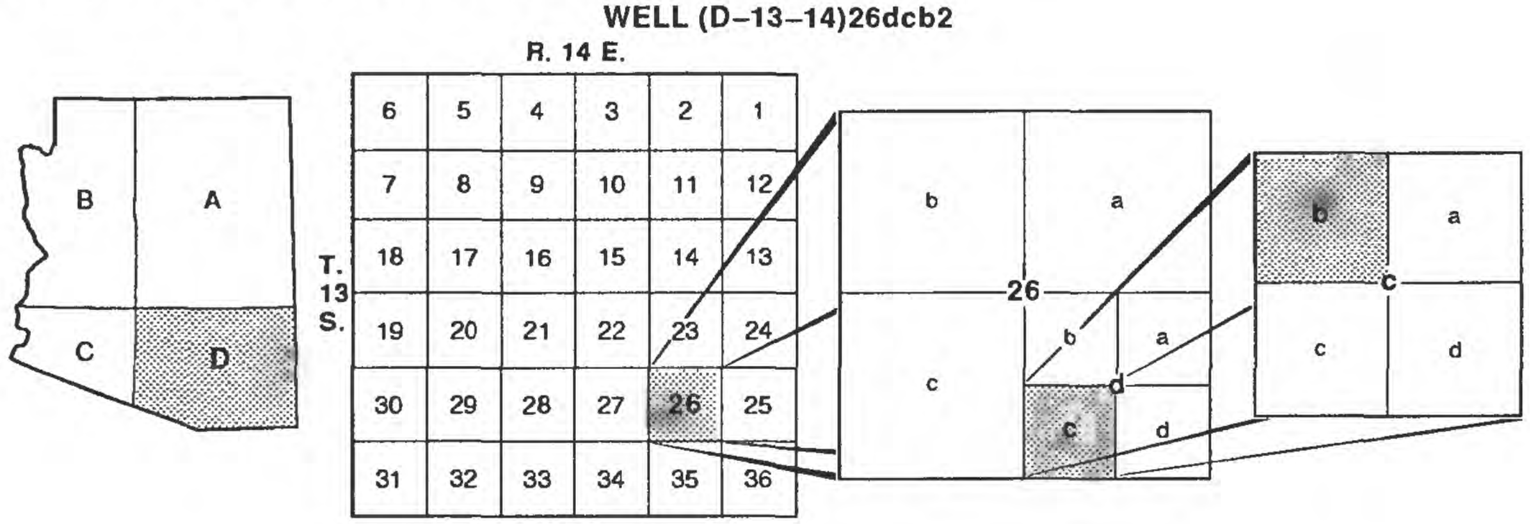
$$°C = (°F - 32)/1.8$$

ABBREVIATED UNITS FOR WATER-QUALITY AND BOTTOM-SEDIMENT CHEMISTRY

Chemical concentration and water temperature are given only in metric units. Chemical concentration in water is given in milligrams per liter (mg/L) or micrograms per liter (μg/L). Milligrams per liter is a unit expressing the solute mass per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million. Specific conductance is given in microsiemens per centimeter (μS/cm) at 25°C. Chemical concentration in bottom sediment is given in milligrams per kilogram (mg/kg), micrograms per gram (μg/g), micrograms per kilogram (μg/kg), or grams per kilogram (g/kg). Grams per kilogram is equal to parts per thousand (ppt). Milligrams per kilogram and micrograms per gram are equal to parts per million (ppm). Micrograms per kilogram is equal to parts per billion (ppb). Radioactivity is expressed in picocuries per gram (pCi/g), which is the amount of radioactive decay producing 2.2 disintegrations per minute in a unit mass (gram) of sediment.

WELL-NUMBERING AND NAMING SYSTEM

WELL (D–13–14)26dcb2



Quadrant D, Township 13 South, Range 14 East, section 26, quarter section d, quarter section c, quarter section b, second well inventoried in 10-acre tract

The well numbers used by the U.S. Geological Survey in Arizona are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the State into four quadrants and are designated by capital letters A, B, C, and D in a counterclockwise direction beginning in the northeast quarter. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters a, b, c, and d after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract and the third the 10-acre tract. These letters also are assigned in a counterclockwise direction beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. Where more than one well is within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes. In the example shown, well number (D–13–14)26dcb2 designates the well as being in the NW1/4, SW1/4, SE1/4, section 26, Township 13 South, and Range 14 East.

VERTICAL DATUM

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

Quality of Water and Chemistry of Bottom Sediment in the Rillito Creek Basin, Tucson, Arizona, 1992–93

By Saeid Tadayon

Abstract

Controlled artificial recharge of surface runoff is being considered as a water-management technique to address the problem of ground-water overdraft in the Tucson basin in southern Arizona. A proposed ground-water recharge project on Rillito Creek in the upper Santa Cruz River basin will utilize low-flow runoff in a 1-mile reach between Craycroft Road and Swan Road within the channel and overbank areas. The use of recharge facilities in urban areas has caused concern about the quality of urban runoff to be recharged and the potential for ground-water contamination. In order to identify possible effects on ground-water quality that the project might create, physical and chemical data were collected from four surface-water, six ground-water, and two bottom-sediment sites during 1992–93.

Concentrations of suspended sediment ranged from 21 to 18,000 milligrams per liter with a median value of 1,610 milligrams per liter for 16 surface-water samples. Specific conductance, hardness, alkalinity, and dissolved solids increased in surface water from December 1992 and January 1993 to August 1993 and increased in ground water from shallow wells from January 1993 to September 1993. These properties were mostly unchanged in ground water from deeper wells during the same period. The values of these constituents generally were higher in ground water than in surface water. The median values for hardness indicate that surface water (40 milligrams per liter as calcium carbonate) is soft and ground water (96 milligrams per liter) is moderately hard. The median concentrations of major dissolved ions, with the exception of potassium, were higher in ground water than in surface water. Calcium was the dominant cation and bicarbonate was the dominant anion in surface water and ground water.

Concentrations of dissolved nitrite and nitrite plus nitrate in surface water and ground water did not exceed the U.S. Environmental Protection Agency maximum contaminant levels of 1 and 10 milligrams per liter for drinking water, respectively. Concentrations of dissolved ammonia as nitrogen were higher in surface water than in ground water. Ammonium plus organic nitrogen in bottom sediment was detected at the highest concentration of any nitrogen species.

Low concentrations of dissolved cadmium, lead, mercury, molybdenum, and nickel were detected in one or more surface-water samples but were not detected in any of the ground-water samples. Dissolved trace elements in surface water and ground water did not exceed the U.S. Environmental Protection Agency maximum contaminant levels for drinking water. Trace-element concentrations in bottom sediment of Rillito Creek were similar to those reported for soils of the western conterminous United States.

Six organochlorine pesticides were detected in surface-water samples, and seven organochlorine pesticides were detected in bottom-sediment samples. Four priority pollutants were detected in surface water, and two priority pollutants were detected in bottom sediment. Chlordane and polychlorinated biphenyls were the only pesticides or priority pollutants detected that are included in quality standards for drinking water. Concentrations of chlordane and polychlorinated biphenyls were below the maximum contaminant levels for these constituents. Pesticides and priority pollutants were not detected in ground-water samples.

Concentrations of dissolved organic carbon were higher in surface water than in ground water and ranged from 6.8 to 180 milligrams per liter and 1.0 to 4.4 milligrams per liter, respectively. Concentrations of organic carbon plus inorganic carbon ranged from 0.7 to 12 grams per kilogram in bottom sediment. Lower concentrations of dissolved organic carbon in ground water may have resulted from sorption to sediment and microbial degradation.

INTRODUCTION

Controlled artificial recharge of surface runoff is being considered as a water-management technique to address the problem of ground-water overdraft in the Tucson basin in southern Arizona. The Bureau of Reclamation High Plains States Groundwater Demonstration Program suggested the Rillito Creek at Tucson, Arizona, as a site to study the feasibility of using stormwater runoff for artificial recharge. The Pima County Department of Transportation and Flood Control District (PCFCD) in cooperation with the Bureau of Reclamation is developing plans for the implementation of a ground-water recharge project in a 1-mile reach of the Rillito Creek between Craycroft Road and Swan Road in the north-central part of Tucson (fig. 1). The proposed Rillito Creek ground-water recharge project will utilize low-flow runoff entering a 1-mile reach of the Rillito Creek between Craycroft Road and Swan Road for infiltration and recharge purposes within the channel and excavated overbank areas. This proposed recharge would be accomplished by water spreading and detention using an inflatable rubber dam. In addition, urban runoff from Alamo Wash that enters the study area may be diverted to a separate recharge basin just west of Alamo Wash.

The use of recharge facilities in urban areas has caused concern about the quality of urban runoff to be recharged and the potential for ground-water contamination. Runoff from developed areas is exposed to a broad range of contaminant sources, and the presence of particular contaminants may depend on the type of land use. Little was known of the chemical quality of runoff from a southwestern urbanized environment and even less was known about the potential for contamination of ground water by recharge of urban runoff in the Tucson area. As part of the Rillito Creek ground-water recharge study, a monitoring plan was developed to collect physical and chemical data for surface water, ground water, and bottom sediment in the Rillito Creek basin from August 1986 through February 1992. During the first phase of the monitoring, about 50 percent of the surface-water samples were from discharges greater than 300 ft^3/s. As part of this study, ground water in the study area was sampled during abnormally dry periods. Because the project is designed to impound low-flow stormwater for infiltration and recharge purposes, 14 of 16 samples were collected for discharges that were less than 250 ft^3/s during the second phase of the project. In December 1992, the U.S. Geological Survey (USGS), in cooperation with PCFCD, began collecting additional data for surface water, ground water, and bottom sediment. Ground water was sampled from the monitoring wells in January and September of 1993 to determine if the recharge from surface water in December 1992 and January and August of 1993 had an immediate effect on ground-water quality.

Purpose and Scope

The purpose of this report is to (1) present the physical and chemical data from surface water, ground water, and bottom sediment collected from December 1992 through September 1993, (2) compare physical and chemical data for surface water and ground water collected in the winter with data collected in the summer, and (3) compare the quality of surface water with the quality of recharged ground water in the study area. The quality of surface water was determined at three inflow sites and one outflow site for the proposed recharge-project area. Surface-water samples were collected at four sites to determine the possible occurrence and concentrations of contaminants in streamflow. Samples were collected from six monitoring wells to determine the quality of recharged ground water in the study area. Bottom-sediment samples were collected at two surface-water sites and were analyzed to determine the occurrence and concentrations of potential contaminants.

Previous Reports on the Study

Tadayon and Smith (1994) documented the monitoring phase of the study that began in August 1986 and continued through February 1992. Their report contains physical and chemical data for 4 surface-water, 14 ground-water, and 4 bottom-sediment sites in the Rillito Creek basin. CH2M Hill (1988a, b) reported on the quality of source waters for artificial recharge and the quality

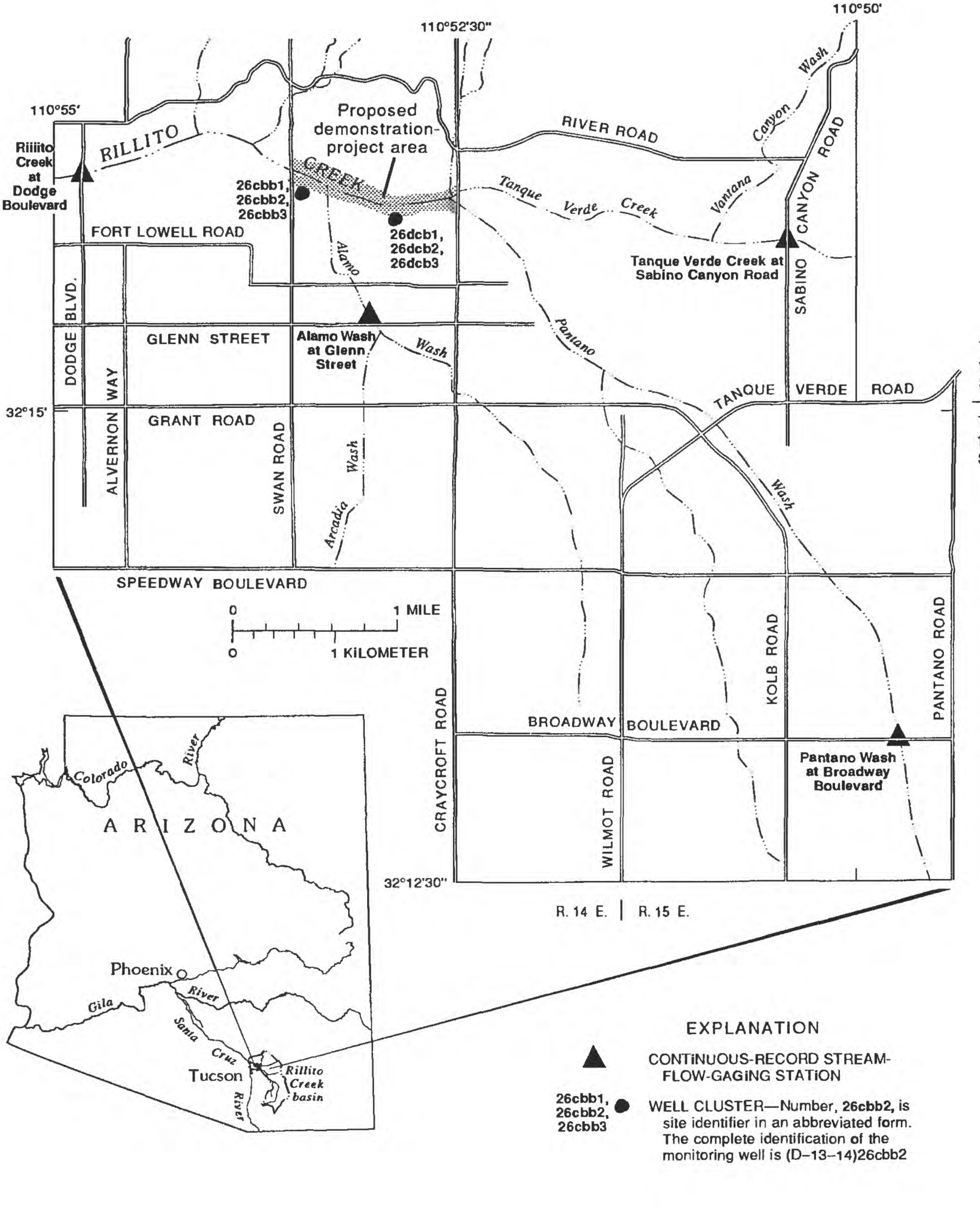


Figure 1. Location of study area and surface-water and ground-water data-collection sites, Rillito Creek basin.

of ground water in the Tucson basin. CH2M Hill (1992) then designed two alternatives for a multipurpose artificial-recharge facility along Rillito Creek between Swan and Craycroft Road. Camp Dresser and McKee, Inc. (1990) reported on the availability of water sources for recharge including floodwaters, reclaimed water, and water from the Central Arizona Project. They also assessed the quality of the water sources that might be recharged at the site and the consequential effect on ground-water quality. Barnes (1988) published ground-water quality data for 11 monitoring wells from August 1986 through 1987 in the Rillito Creek basin. A list of publications on previous studies in the area is given by Tadayon and Smith (1994).

DESCRIPTION OF THE STUDY AREA

The Tucson basin is a broad alluvial valley about 1,000-square-mile in area, which is in the upper Santa Cruz drainage basin in southern Arizona (Laney, 1972). The Tucson basin is bounded on the north by the Tortolita and Santa Catalina Mountains; on the east by the Rincon Mountains; on the south by the Santa Rita Mountains; and on the west by the Sierrita, Black, and Tucson Mountains (fig. 2). These mountains consist of igneous, metamorphic, and sedimentary rocks from Precambrian to late Tertiary age (Davidson, 1973).

The basin is underlain by several thousand feet of unconsolidated and semiconsolidated alluvial material (Burkham, 1970). The primary stratigraphic units of the Tucson basin are the Pantano Formation of Oligocene age, the Tinaja beds of Miocene and Pliocene age, and the Fort Lowell Formation of Pleistocene age (Davidson, 1973). The Pantano Formation consists of silty sandstone to gravel that is cemented by calcium carbonate (Davidson, 1973). The Pantano Formation contains a few interbedded volcanic flows and tuffs, and the formation is about 1,000 ft thick in the central part of the Tucson basin (Davidson, 1973; Anderson, 1987). The Tinaja beds unconformably overlie the Pantano Formation and are unconformably overlain by the Fort Lowell Formation. The Tinaja beds consist of clayey silt, mudstone, and gravel and are as much as 5,000 ft thick (Davidson, 1973). The Fort Lowell Formation overlies the Tinaja beds and is overlain by surficial deposits. The Fort Lowell Formation, which consists of silty gravel near the margin of the basin to a silty sand and clayey silt in the central part of the basin, is 300 to 400 ft thick in most of the basin and thins toward the mountains (Davidson, 1973). In some areas of the Tucson basin, the surficial deposits include alluvial-fan, sheetflow, and stream-channel deposits overlying the older sedimentary units and range from a thin veneer to tens of feet thick (Davidson, 1973). The unconfined aquifer that underlies the Tucson basin consists of these sedimentary units that are hydraulically interconnected. The aquifer is more than 2,000 ft thick and is composed mainly of loosely consolidated to moderately cemented silty sand to silty gravel (Davidson, 1973).

The climate of the Tucson basin is semiarid and is characterized by hot summers and mild winters. Temperatures at the University of Arizona in Tucson for 1986–92 ranged from a monthly mean of 53.9°F in January to 88.2°F in July (U.S. Department of Commerce, 1986–92). The average annual precipitation for 1986–92 was 10.85 in. at the University of Arizona in Tucson and about 30 in. in the surrounding mountains (U.S. Department of Commerce, 1986–92). The Tucson basin has two distinct rainfall seasons. About 50 percent of the annual precipitation occurs during the summer from intense, localized thunderstorms of short duration. Winter rainfall generally is less intense and longer in duration.

HYDROLOGY OF THE RILLITO CREEK BASIN

The Santa Cruz River and Rillito Creek are the major surface-water channels in the Tucson basin. The main tributaries to Rillito Creek include Tanque Verde Creek, Pantano Wash, and Alamo Wash. Rillito Creek flows about 12 mi west-northwestward from the confluence of Pantano Wash and Tanque Verde Creek to the Santa Cruz River (fig. 2). Rillito Creek at Dodge Boulevard drains 871 mi^2 of mountains, desert, and approximately 34 mi^2 of urban area and is, for the most part, unregulated. Tanque Verde Creek at Sabino Canyon Road drains 219 mi^2 of mainly rural

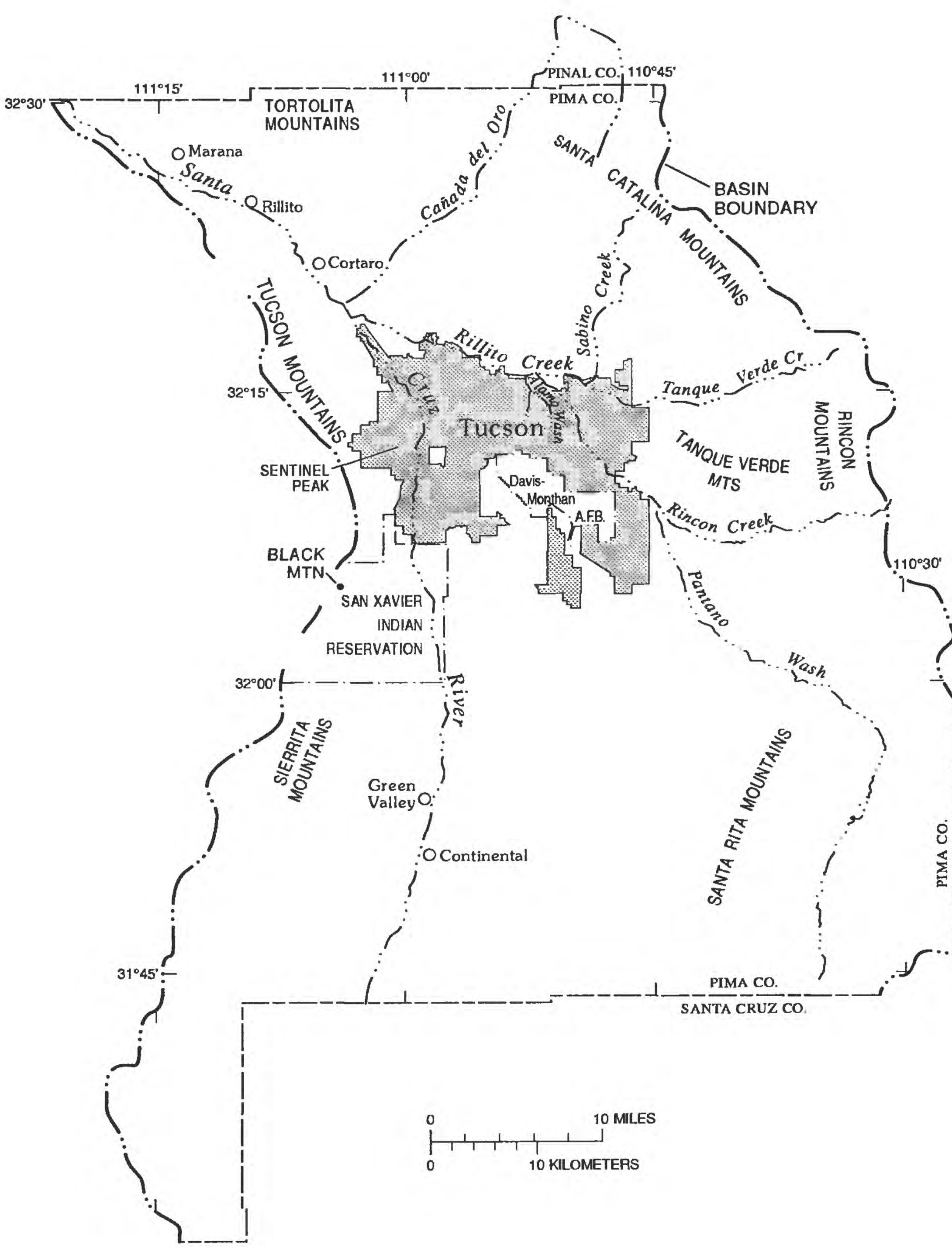


Figure 2. Location of Rillito Creek in the upper Santa Cruz drainage basin.

area, including mountainous areas in the northeastern part of the basin, and is dominated by winter flows. Pantano Wash at Broadway Boulevard drains 599 mi^2 of the valley area in the southern and southeastern parts of the basin and is dominated by summer flows. Alamo Wash at Glenn Street drains 9.58 mi^2 of urban area. Rillito Creek and its tributaries are ephemeral, which means that flow in the stream generally is in response to precipitation (Condes de la Torre, 1970).

Surface water.—Streamflow in Rillito Creek and its tributaries is affected by seasonal storms. Summer flows generally result from localized and intense thunderstorms. In addition, summer flows are sudden, short in duration, and have high peak discharges and suspended-sediment concentrations. Winter flows generally result from more widespread frontal storms, are longer in duration, and have lower peak discharges and suspended-sediment concentrations (Matlock, 1965).

Streamflow is produced from rainfall and snowmelt originating in the Tanque Verde Creek and Rillito Creek watersheds. Flow in the Pantano and Alamo Washes generally consists of rainfall runoff. Runoff from local rainfall may last for several hours; however, streamflow from snowmelt may last for several weeks or more. Davidson (1973) calculated mean annual streamflow within the Tucson basin as 68,000 acre-ft in 1936–63. The average annual discharge at the streamflow-gaging station, Rillito Creek near Tucson, was 11,660 acre-ft for 67 years of record for 1908–75 (U.S. Geological Survey, 1976).

Ground water.—According to Davidson (1973), recharge of the aquifer underlying the Tucson basin occurs primarily through streamflow along the main streams and the basin perimeter. The streamflow infiltration of runoff to the basin averages 51,000 acre-ft/yr; mountain-front recharge averages 31,000 acre-ft/yr; and subsurface inflow averages 17,000 acre-ft/yr. In the Tucson basin, other sources of recharge include return flows of water pumped for irrigation from drainage, public supply, and industrial use. Discharge from the basin occurs primarily through pumping for irrigation, municipal use, and industrial use as well as evapotranspiration and underflow from the basin (Davidson, 1973).

Two sets of three nested monitoring wells were constructed by Tucson Water in 1988 (fig. 1 and table 1). Nested wells are within 50 ft of each other at the two locations. The first set of nested wells is east of Swan Road, within 50 ft of the Rillito Creek, and includes wells (D-13-14)26cbb1, (D-13-14)26cbb2, and (D-13-14)26cbb3. The second set of nested wells is west of Craycroft Road, within 250 ft of the Rillito Creek, and includes wells (D-13-14)26dcb1, (D-13-14)26dcb2, and (D-13-14)26dcb3. Continuous water-level recorders were installed in all six monitoring wells. Streamflow data from the gaging station, Tanque Verde Creek at Tucson, and hydrographs from wells (D-13-14)26cbb2 and

Table 1. Well-construction information for monitoring wells in the Rillito Creek basin, 1992–93

Well identification (D-13-14)	Latitude	Longitude	Depth of well, in feet	Perforated zone, in feet		Diameter, in inches	Casing type	Pump
				From	To			
26cbb1	32°16'15"	110°53'30"	35	15	35	6	Steel	No
26cbb2	32°16'14"	110°53'30"	130	90	130	6	Steel	No
26cbb3	32°16'15"	110°53'29"	80	45	80	6	Steel	No
26dcb1	32°16'05"	110°52'57"	40	15	40	6	Steel	No
26dcb2	32°16'04"	110°52'56"	120	80	120	6	Steel	No
26dcb3	32°16'05"	110°52'55"	70	50	70	6	Steel	No

(D-13-14)26dcb2 about 3 mi downstream indicate that water levels in the wells respond to flow in the channel (fig. 3).

According to D.R. Pool (hydrologist, USGS, written commun., 1994), recharge to the aquifer underlying the Tucson basin from Craycroft Road to Dodge Boulevard and from River Road to Pima Street was estimated by temporal-gravity methods and was about 9,200 acre-ft from December 1992 through mid-May 1993. Water levels rise quickly when recharge occurs in Rillito Creek because of the high permeability of the sediments in the channel and the shallow depth to ground water (Camp Dresser and McKee, Inc., 1990). Ground-water levels in the basin fluctuate in response to high recharge in the stream channels, pumping activity in the area, and outflow from the basin (Camp Dresser and McKee Inc., 1990)

SAMPLE COLLECTION AND ANALYSIS

Surface water.—From December 1992 through August 1993, samples of surface water were collected at four sites—Tanque Verde Creek at Sabino Canyon Road; Pantano Wash at Broadway Boulevard; Alamo Wash at Fort Lowell Road; and Rillito Creek at Dodge Boulevard (fig. 1).

Winter sampling was done on December 29, 1992, and during early January and March 1993. Summer sampling was done during August and September 1993. Samples were collected according to procedures described by the USGS (1977) using equal-width-increment methods and were composited. Surface-water samples were collected for analysis of properties and constituents of major ions, nutrients, trace elements, organochlorine pesticides, priority pollutants, and organic carbon. Organochlorine pesticides and priority pollutants were analyzed only for Alamo Wash at Fort Lowell Road. Suspended-sediment samples were analyzed for sediment concentrations and particle-size distribution.

Samples for analyses of all dissolved inorganic constituents were filtered through 0.45-micrometer membrane filters using a peristaltic pump. A special stainless-steel-filter unit consisting of 0.45-micrometer silver-membrane filters, a small pressure cylinder of nitrogen gas, and a pressure regulator was used for filtering dissolved organic carbon. Samples for total constituents were discharged into sample bottles without being filtered. Water samples were processed in the field using methods described by the USGS (1977). Sample treatment and preservation were performed according to recommended methods of the USGS (1985). Nitric acid was added to water samples to lower the pH to less than 2 for the determination of most major ions and trace elements; potassium dichromate was added to samples for mercury analyses; and mercuric chloride was added to samples for nutrient analyses.

Inorganic constituents were analyzed by methods documented by Fishman and Friedman (1989). Organic constituents were analyzed according to methods documented by Wershaw and others (1987). Samples were analyzed for sediment concentration and particle-size distribution at the USGS sediment laboratory in Vancouver, Washington. All other analyses of water samples were done by the USGS National Water Quality Laboratory in Arvada, Colorado.

Ground water.—Samples of water were collected from six monitoring wells in January and September of 1993. The wells were sampled once in January after several weeks of high flows and again in September after several days of runoff in the Rillito Creek. Water levels in the monitoring wells in January and September 1993 ranged from 11.08 to 17.15 ft and from 23.32 to 29.75 ft below the land surface, respectively. The purpose of sampling in January and September of 1993 was to determine if the recharge from surface water had an immediate effect on ground-water quality. Monitoring wells—(D-13-14)26cbb2, (D-13-14)26cbb3, and (D-13-14)26dcb2—were sampled during a much drier period in March 1989, and the water level was about 80 ft below the land surface at the time of sampling.

Before samples were collected, the monitoring wells were purged with a portable submersible pump until a minimum of three casing volumes of water were removed. Specific conductance, pH, and temperature were continually monitored using a flow-through chamber until field measurements were stable and a representative sample was being

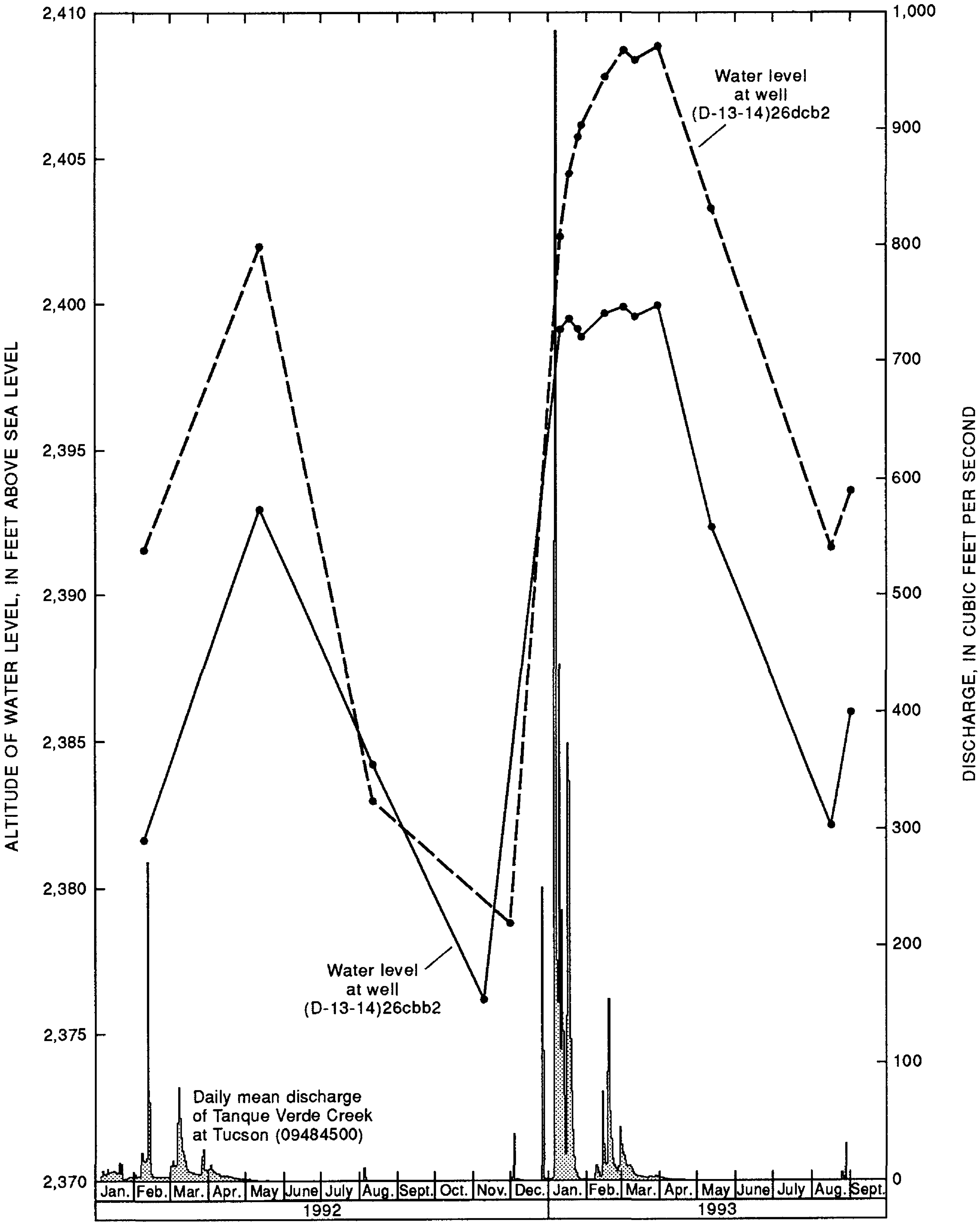


Figure 3. Flow in Tanque Verde Creek and water levels in observation wells (D-13-14)26cbb2 and (D-13-14)26dcb2, 1992–93.

collected. Ground-water samples were collected using a stainless-steel bailer.

Ground-water samples were collected for analysis of properties and constituents of major ions, nutrients, trace elements, organochlorine pesticides, priority pollutants, and organic carbon. Ground-water samples were sent to the USGS National Water Quality Laboratory in Arvada, Colorado. Ground-water samples were analyzed using the same procedures as those used for surface-water samples.

Bottom sediment.—Between January and August 1993, samples of bottom sediment were collected from Alamo Wash at Fort Lowell Road and Rillito Creek at Swan Road. Samples were collected shortly after recession of runoff from the upper 2 in. of sediment using materials that would not be sources of additional contamination. Plastic spoons and containers were used to collect samples for inorganic analyses, and stainless-steel spoons and containers were used to collect samples for organic analysis. Samples were collected in equal-width increments across the channel, composited and mixed into a single sample, passed through a 500-micrometer-size sieve, and split into several sample containers in the field.

Samples were analyzed for constituents of nutrients, trace elements, radionuclides, organochlorine pesticides, priority pollutants, and inorganic and organic carbon. Particle-size distributions were determined on unsieved sediment from each site. Samples for particle-size distribution were analyzed using a wet-sieve method by the USGS Sediment Laboratory in Vancouver, Washington. Plastic containers were used for storage and shipment of bottom-sediment samples for analysis of inorganic constituents. Samples collected for the determination of organic compounds were stored and shipped in glass bottles. Samples for analysis of nutrients and organics were preserved by immediately chilling to 4°C to retard any chemical or biological changes that may occur before analysis. Samples for analysis of trace elements and radionuclides required no preservation.

At the laboratory, samples for trace-elements analyses were air dried and then crushed and sieved through a 230-mesh (63-micrometer) screen. The fine materials that passed through the screen were retained and analyzed. Inorganic constituents were analyzed by methods documented by Fishman and Friedman (1989). Organic constituents were analyzed according to methods documented by Wershaw and others (1987). Analysis of bottom-sediment samples for radionuclides was performed by a private laboratory under contract to the USGS. Trace elements were analyzed by the USGS, Geologic Division in Lakewood, Colorado. All other analyses of bed-material samples were performed by the USGS Geochemistry Laboratory in Arvada, Colorado.

SURFACE-WATER QUALITY

A summary of the results was compiled for suspended-sediment concentrations, properties, and concentrations of major ions, nutrients, trace elements, organochlorine pesticides, priority pollutants, and organic carbon (table 2). A summary of the constituent groups, such as organochlorine pesticides and priority pollutants, was determined only for those constituents detected. Results of the analyses of all surface-water samples are presented in tables 6 and 7 in the "Basic Data" section at the end of the report. Some of the physical and chemical data collected for this study from December 1992 through August 1993 are compared with the previous data collected from February 1987 through March 1992 (Tadayon and Smith, 1994).

Suspended sediment.—Suspended-sediment movement in streams is an important factor in the transport of many inorganic, organic, and biological pollutants. Suspended sediment in Rillito Creek and its tributaries are highly variable. Variations in sediment concentrations and particle-size distribution probably occur because of differences in the intensity of precipitation and location of areas contributing runoff to streamflow in Rillito Creek and its tributaries. Suspended sediment may cause clogging of the channel bed during recharge, which reduces infiltration rates. Concentrations of suspended sediment ranged from 37 to 1,560 mg/L at Tanque Verde Creek, from 1,790 to 16,600 mg/L at Pantano Wash, from 480 to 2,830 mg/L at Alamo Wash, and from 21 to 18,000 mg/L at Rillito Creek. The median concentration of suspended sediment

Table 2. Summary of selected physical and chemical data for surface-water sites, Rillito Creek basin, December 1992 through August 1993

[mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; NTU, nephelometetric-turbidity units; °C, degrees Celsius; µg/L, micrograms per liter; <, less than; DDD, dichlorodiphenyldichloroethane; DDE, dichlorodiphenylethylene; DDT, dichlorodiphenyltrichloroethane; PCB, polychlorinated biphenyl; ND, not detected; -----, dashes indicate no data]

Constituent	Number of observations	Minimum	Maximum	Median
Suspended sediment:				
Suspended sediment (mg/L)	16	21	18,000	1,610
Properties:				
Specific conductance (µS/cm)	16	58	337	110
pH (units)	16	6.4	8.1	7.7
Turbidity (NTU)	14	47	2,800	620
Hardness as $CaCO_3$ (mg/L)	16	19	130	40
Alkalinity as $CaCO_3$ (mg/L)	16	19	49	36
Dissolved solids at 180°C (mg/L)	16	43	467	90.5
Major ions:				
Calcium, dissolved (mg/L)	16	6	48	14
Magnesium, dissolved (mg/L)	16	.82	3.5	1.4
Sodium, dissolved (mg/L)	16	1.9	15	4.9
Sodium adsorption ratio	16	.1	.9	.3
Potassium, dissolved (mg/L)	16	1.1	11	2.4
Bicarbonate as HCO_3 (mg/L)	16	23	60	39
Sulfate, dissolved (mg/L)	16	2.7	49	6.9
Chloride, dissolved (mg/L)	16	.8	15	2.8
Fluoride, dissolved (mg/L)	16	.1	1.3	.2
Silica, dissolved (mg/L)	16	1.9	17	8.4
Nutrients:				
Nitrogen, nitrite, dissolved as N (mg/L)	16	<.01	.07	.03
Nitrogen, nitrite plus nitrate, dissolved, as N (mg/L)	16	.14	2.70	.83
Nitrogen, ammonia, dissolved, as N (mg/L)	16	.01	3.50	.07
Orthophosphorus, dissolved as P (mg/L)	16	<.01	.79	.10
Trace elements, dissolved:				
Arsenic (µg/L)	16	<1	6	2

Table 2. Summary of selected physical and chemical data for surface-water sites, Rillito Creek basin, December 1992 through August 1993—Continued

Constituent	Number of observations	Minimum	Maximum	Median
Trace elements, dissolved:—Continued				
Barium (µg/L)	16	8	110	26.5
Boron (µg/L)	16	<10	60	20
Cadmium (µg/L)	16	<1	1	<1
Chromium (µg/L)	16	<1	9	<1
Copper (µg/L)	16	<10	80	<10
Iron (µg/L)	14	13	580	40
Lead (µg/L)	16	<1	7	<1
Manganese (µg/L)	14	3	280	9.5
Mercury (µg/L)	16	<.1	.2	<.1
Molybdenum (µg/L)	16	<1	6	<1
Nickel (µg/L)	16	<1	19	<1
Selenium (µg/L)	16	<1	1	<1
Silver (µg/L)	16	ND	ND	------
Vanadium (µg/L)	16	3	73	8.5
Zinc (µg/L)	16	<3	42,000	8
Organochlorine pesticides, total recoverable:				
Chlordane (µg/L)	5	<.1	.6	.4
DDD (µg/L)	5	<.01	.02	.02
DDE (µg/L)	5	<.01	.05	.02
DDT (µg/L)	5	<.01	.02	.02
Dieldrin (µg/L)	5	<.01	.10	.05
PCB (µg/L)	5	<.1	.1	<.1
Priority pollutants, total recoverable:				
Benzo-(b)-fluoranthene (µg/L)	5	<10	12	<10
Bis(2-ethylhexyl)phthalate (µg/L)	5	6	10	8
Fluoranthene (µg/L)	5	<5	14	7
Pyrene (µg/L)	5	<5	11	5
Organic carbon:				
Organic carbon, dissolved (mg/L)	16	6.8	180	14

was 1,610 mg/L for 16 samples collected at the four surface-water sites. Flow during summer months generally had a higher concentration of silt and clay than did flow during winter months. Particle-size distribution for silt and clay (less than 0.062 mm) and for sand (0.062 to 2 mm) ranged from 27 to 99 percent and 1 to 73 percent, respectively (table 6).

Concentrations of suspended sediment ranged from 22 to 36,700 mg/L with a median value of 4,730 mg/L for 40 samples collected from February 1987 through March 1992 (Tadayon and Smith, 1994). Higher concentrations of suspended sediment were found in samples from February 1987 through March 1992 than in samples from December 1992 through August 1993. The higher concentrations in the samples from February 1987 through March 1992 probably were due to variation in duration, location, intensity, and temporal distribution of precipitation within the watershed and the collection of more suspended-sediment samples at higher discharges in that period.

Properties.—pH is defined as the negative log of the hydrogen-ion activity in water. When pH is 7, the water is neutral; a pH of greater than 7 is alkaline, and a pH of less than 7 is acidic. Values of pH generally were higher in samples collected in summer months than in samples collected in winter months. The pH of water ranged from 6.4 to 8.1 and had a median value of 7.7 for 16 samples. The data indicate that the water generally is alkaline. The pH value of 6.4 from one sample collected at Alamo Wash in January 1993 was not within the secondary maximum contaminant level (SMCL) range of 6.5 to 8.5 set by the U.S. Environmental Protection Agency (USEPA) for drinking water (U.S. Environmental Protection Agency, 1993b).

Turbidity is an indicator of water quality that relates to the penetration of light. Turbidity ranged from 47 nephelometric-turbidity units (NTU) at Alamo Wash to 2,800 NTU at Pantano Wash and had a median value of 620 NTU for 14 samples. Turbidity generally increased as suspended sediment increased.

Specific conductance is the ability of water to conduct electrical current and is related to the concentrations of major ions in water. Values of specific conductance generally were higher during flows that occurred in summer than during flows that occurred in winter. Specific conductance ranged from 58 µS/cm in January 1993 at Tanque Verde Creek to 337 µS/cm in July 1993 at Alamo Wash and had a median value of 110 µS/cm for 16 samples.

Hardness is a measure of the relative amount of certain ions in water, mainly calcium and magnesium, that form insoluble precipitates with soap. According to Hem (1989), water with a hardness of less than 60 mg/L as calcium carbonate ($CaCO_3$) is soft, 61 to 120 mg/L is moderately hard, 121 to 180 mg/L is hard, and more than 180 mg/L is very hard. Hardness values were generally higher in samples collected during summer than in samples collected during winter. Hardness values generally ranged from 19 to 54 mg/L as $CaCO_3$ except in one sample collected from Alamo Wash (130 mg/L) in July 1993. The median value of hardness was 40 mg/L as $CaCO_3$ in 16 samples. The data indicate that the water in the study area generally is soft.

Alkalinity is a measure of the capacity of water to neutralize acid. Alkalinity of water primarily is due to bicarbonate, carbonate, and hydroxide ions. Alkalinity generally was higher in samples collected in summer than in samples collected in winter. Alkalinity for filtered samples ranged from 19 mg/L at Tanque Verde Creek to 49 mg/L as $CaCO_3$ at Pantano Wash. The median value of alkalinity was 36 mg/L for 16 samples.

Dissolved solids is a general term used to describe the mineral content of water. Dissolved solids consist primarily of calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, and nitrate. Dissolved-solids concentrations were generally higher in samples collected in summer than in samples collected in winter. Concentrations of dissolved solids ranged from 43 to 124 mg/L except in one sample at Alamo Wash (467 mg/L) in July 1993. The median concentration of dissolved solids was 90.5 mg/L in 16 samples. Concentrations of dissolved solids in all surface-water samples collected were below the SMCL of 500 mg/L for drinking water.

Median values for specific conductance (110 µS/cm), hardness (40 mg/L as $CaCO_3$), alkalinity (36 mg/L as $CaCO_3$), and dissolved solids (90.5 mg/L) for December 1992 through September 1993 were higher than the median values for specific conductance (79 µS/cm), hardness (35 mg/L as $CaCO_3$), alkalinity (31 mg/L as $CaCO_3$), and dissolved solids (85 mg/L) for August 1987 through February 1992 (Tadayon and Smith, 1994). pH, however, was lower in December 1992 through August 1993 (7.7) than for August 1987 through February 1992 (8.3).

Major ions.—Calcium, magnesium, and sodium are common constituents in most natural waters and result from the dissolution of rock minerals. Higher concentrations of dissolved calcium, magnesium, and potassium generally were detected in samples collected in summer months than in samples collected in winter months. The highest concentrations of calcium (48 mg/L), magnesium (3.5 mg/L), and potassium (11 mg/L) were detected in one sample at Alamo Wash in July 1993. Dissolved-sodium concentrations were elevated and ranged from 1.9 to 15 mg/L in samples collected in winter and ranged from 1.9 to 12 mg/L in samples collected in summer. Sodium-adsorption ratios, which are the proportion of sodium to calcium and magnesium, were low at all sites and ranged from 0.1 to 0.9. The median sodium-adsorption ratio was 0.3 for 16 samples.

The median concentrations of calcium, magnesium, sodium, and potassium were 14, 1.4, 4.9, and 2.4 mg/L, respectively, from December 1992 through August 1993. These median concentrations generally were similar to the median concentrations for the same constituents (11, 1.3, 4.5, and 2.1 mg/L, respectively) from August 1987 through February 1992 (Tadayon and Smith, 1994).

Bicarbonate concentrations as bicarbonate (HCO_3) ranged from 23 mg/L at Tanque Verde Creek to 60 mg/L at Pantano Wash. Concentrations of bicarbonate generally were higher in samples collected in summer than in samples collected in winter. The maximum concentrations of dissolved sulfate (49 mg/L), dissolved chloride (15 mg/L), and dissolved fluoride (1.3 mg/L) were detected at Alamo Wash in July 1993. Concentrations of sulfate and chloride were higher in samples collected from Tanque Verde Creek and Rillito Creek in March 1993 than in samples collected in August 1993. These constituents were detected in higher concentrations in samples collected in summer at Pantano Wash and Alamo Wash than in samples collected in winter at the same sites. The maximum concentrations of sulfate and chioride did not exceed the SMCL's of 250 mg/L. The maximum concentration of fluoride did not exceed the USEPA primary maximum contaminant level (MCL) of 4 mg/L for drinking water (U.S. Environmental Protection Agency, 1993a). The highest concentration of dissolved silica (17 mg/L) was detected in one sample at Rillito Creek in March 1993. In surface water, calcium was the dominant cation and bicarbonate was the dominant anion (fig. 4).

From December 1992 through August 1993, median concentrations of bicarbonate, sulfate, chloride, fluoride, and silica were 39, 6.9, 2.8, 0.2, and 8.4 mg/L, respectively, and generally were similar to the median concentrations for the same constituents (37, 7.2, 3.0, 0.1, and 8.2 mg/L, respectively) from February 1987 through March 1992 (Tadayon and Smith, 1994). Surface water also was primarily a calcium and bicarbonate type from August 1987 through February 1992 (Tadayon and Smith, 1994).

Nutrients.—Nitrogen compounds in surface water originate from both natural and anthropogenic sources (Marron and others, 1989; Moore, 1991). Natural sources of nitrogen are soil and biological material; anthropogenic sources include fertilizers, sewage, and animal wastes (Hem, 1989; Marron and others, 1989; Moore, 1991).

Nitrogen occurred predominantly in the form of nitrate ions in surface-water samples. Concentrations of dissolved nitrite, nitrite plus nitrate, and ammonia generally were low for all four surface-water sampling sites. Concentrations for these constituents were higher in samples collected in summer than in samples collected in winter. The highest concentrations of nitrite (0.07 mg/L) and nitrite plus nitrate (2.7 mg/L) were detected in one sample at Alamo Wash in July 1993 and were below the MCL's of 1 mg/L and 10 mg/L as nitrogen (N), respectively. Concentrations of dissolved ammonia as N ranged from 0.01 to 0.03 mg/L at Tanque Verde Creek, 0.05 to 0.31 mg/L at Pantano Wash, 0.18 to 3.5 mg/L at Alamo Wash, and 0.01 to 0.4 mg/L at Rillito Creek. Concentrations of orthophosphorus were higher in samples collected in summer than in samples collected in winter. Concentrations of dissolved orthophosphorus as phosphorus (P) ranged from 4 to 0.1 mg/L at Tanque Verde Creek, 0.04 to

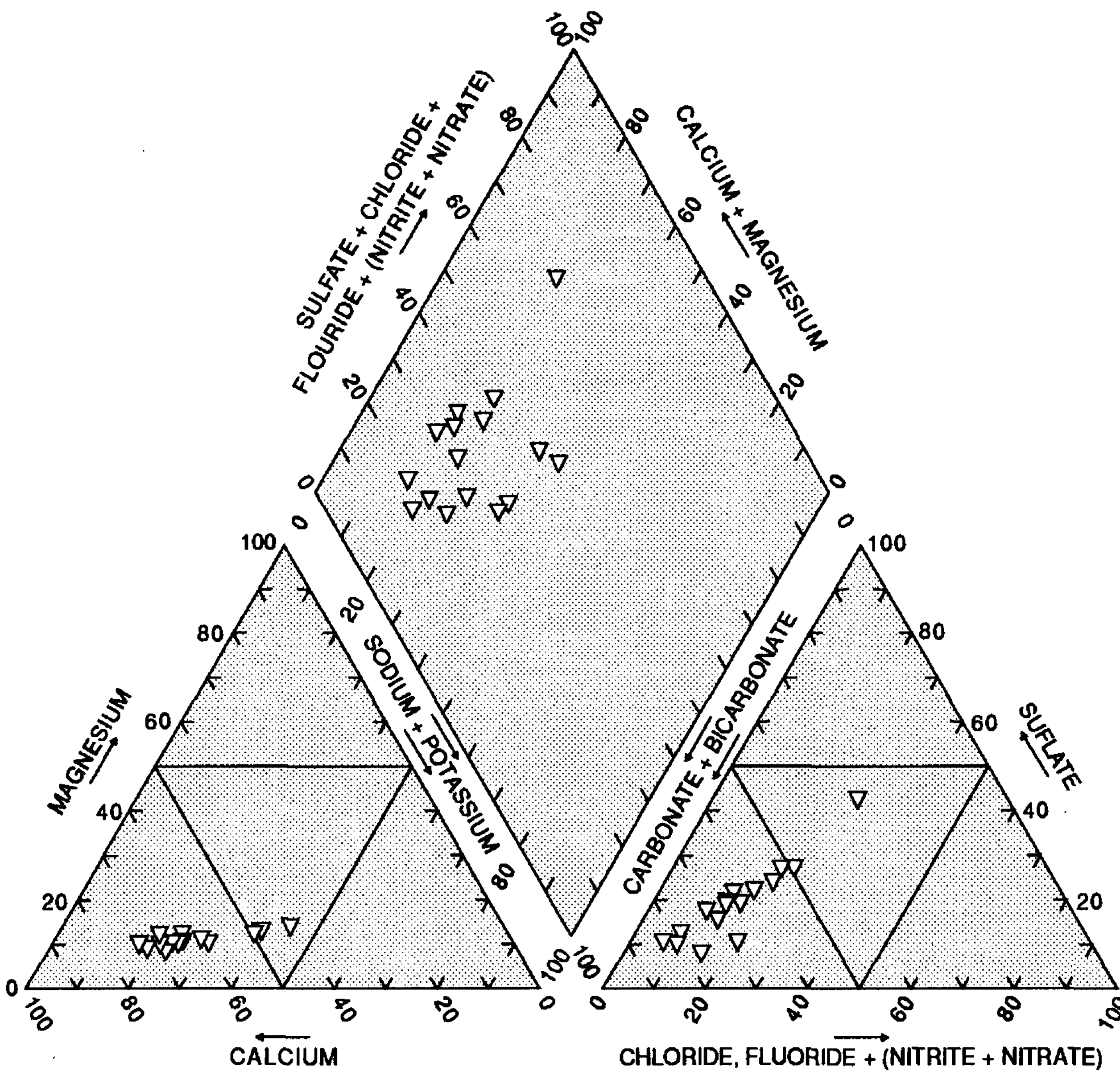


Figure 4. Compositions of surface water in the Rillito Creek basin, 1992–93.

0.2 mg/L at Pantano Wash, less than 0.01 to 0.79 mg/L at Alamo Wash, and 0.02 to 0.12 mg/L at Rillito Creek.

The median concentrations of dissolved nitrite, ammonia, and orthophosphorus (0.03, 0.07, and 0.10 mg/L, respectively) from December 1992 through August 1993 generally were similar to the median concentrations (0.02, 0.06, and 0.08 mg/L, respectively) from August 1987 through February 1992 (Tadayon and Smith, 1994). The median concentration of nitrite plus nitrate (0.83 mg/L) was higher for samples from December 1992 through September 1993 than the median concentration (0.27 mg/L) for samples collected in August 1987 through February 1992 (Tadayon and Smith, 1994).

Trace elements.—Sources of trace elements in the Rillito Creek basin may be attributed to the natural weathering or erosion of rocks and soils, urban stormwater runoff, and transportation.

Concentrations of dissolved trace elements generally were lower in samples collected in winter than in samples collected in summer. The highest concentrations of dissolved barium (110 µg/L), boron (60 µg/L), copper (80 µg/L), iron (580 µg/L), lead (7 µg/L), manganese (280 µg/L), nickel (19 µg/L), and vanadium (73 µg/L) were detected in samples collected in summer. Concentrations of dissolved zinc generally ranged from less than 3 to 330 µg/L. One sample from Pantano Wash had 42,000 µg/L of dissolved zinc, which probably resulted from field contamination and (or) laboratory error. Concentrations of lead ranged from 1 to 7 µg/L in 4 samples, and lead was not detected in 12 samples. The highest concentrations of dissolved trace elements, except for chromium, iron, and mercury were detected in one sample collected in July 1993 at Alamo Wash. Mercury (0.2 µg/L) was above the detection limit of 0.1 µg/L in one sample at Pantano Wash in August 1992. None of the dissolved trace elements in surface-water samples exceeded the MCL's for drinking water. Concentrations of manganese (280 µg/L) exceeded the SMCL of 50 µg/L in one sample at Alamo Wash in July 1993. Concentrations of iron (580 µg/L) exceeded the SMCL of 300 µg/L in one sample from Pantano Wash in August 1993. Cadmium, lead, mercury, molybdenum, nickel, and silver generally were below detection levels. The median concentrations of dissolved arsenic (6 µg/L), barium (26.5 µg/L), boron (20 µg/L), vanadium (8 µg/L), and zinc (8 µg/L) for samples from August 1987 through February 1992 (Tadayon and Smith, 1994) generally were similar to the median concentrations in samples collected from December 1992 through August 1993.

Organochlorine pesticides.—Multiple organochlorine pesticides were detected in samples at Alamo Wash. Pesticides that were detected in one or more samples include chlordane, dichlorodiphenyldichloroethane (DDD), dichlorodiphenylethylene (DDE), dichlorodiphenyltrichloroethane (DDT), dieldrin, and polychlorinated biphenyls (PCB's). The highest concentrations of chlordane, DDD, and dieldrin probably were related to an increase in suspended-sediment concentrations. These compounds tend to sorb to sediment and can be transported into the stream by sediment.

Concentrations of these chemicals generally were higher in samples collected in August 1993 than in a sample collected in January 1993. Concentrations of DDD were detected in two of five samples and ranged from less than 0.01 to less than 0.02 µg/L. DDT was detected in two of five samples and ranged from 0.01 to 0.02 µg/L. Concentrations of chlordane, DDE, and dieldrin were detected in four of five samples and were less than 0.1 to 0.6 µg/L, less than 0.01 to 0.05 µg/L, and less than 0.01 to 0.1 µg/L, respectively. The maximum concentration of chlordane (0.6 µg/L) did not exceed the MCL of 2 µg/L for drinking water. PCB's were detected in one of five samples (0.1 µg/L) and did not exceed the MCL of 0.5 µg/L for drinking water. Some of the pesticides in the water may have resulted from the frequent use of chemicals to control weeds and insects in urban areas.

Concentrations of chlordane, DDD, DDE, DDT, and dieldrin also were detected in samples from Alamo Wash from July 1987 through January 1992 (Tadayon and Smith, 1994). During January through August 1993, the median concentrations of chlordane, DDD, DDE, DDT, and dieldrin were 0.4, 0.02, 0.02, 0.02, and 0.05 µg/L, respectively. These concentrations were higher than the median concentrations (0.15, 0.01, less than 0.01, less than 0.01, and 0.01 µg/L, respectively) for July 1987 through January 1992 (Tadayon and Smith, 1994). Aldrin (0.02 µg/L) was detected in one sample at Alamo Wash in July 1987, and endrin (0.01 µg/L) was detected in July 1990 (Tadayon and Smith, 1994); however, aldrin and endrin were not detected at any of the samples collected during January through August 1993. Although PCB's were not detected in any samples collected from July 1987 through January 1992 (Tadayon and Smith, 1994), PCB's (0.1 µg/L) were detected in one sample in July 1993.

Priority pollutants.—Benzo-(b)-fluoranthene, bis(2-ethylhexyl)phthalate, fluoranthene, and pyrene were detected in samples from Alamo Wash. Concentrations of these chemicals were higher in samples collected in July and August 1993 than in a sample collected in January 1993. Benzo-(b)-fluoranthene was detected in one sample at a concentration of 12 µg/L. Bis(2-ethylhexyl)phthalate was detected in all five samples collected at Alamo Wash and ranged from 6 to 10 µg/L. Fluoranthene and pyrene were detected in three of five samples; fluoranthene concentrations ranged from less than 5 to 14 µg/L, and pyrene concentrations ranged from less than 5 to 11 µg/L. Some of the priority pollutants in water probably are the result of urbanization and type of land use in the Alamo Wash area.

Bis(2-ethylhexyl)phthalate, fluoranthene, and pyrene also were detected in samples at Alamo Wash from July 1987 through January 1992. Concentrations of bis(2-ethylhexyl)phthalate ranged from less than 5 to 10 µg/L; fluoranthene, less than 5 to 6 µg/L; and pyrene, less than 5 to 6 µg/L (Tadayon and Smith, 1994). Concentrations of these chemicals were slightly higher in samples from January through August 1993 than in samples from July 1987 through January 1992.

Organic carbon.—Organic carbon is derived from natural (soil and plant) and synthetic sources. Concentrations of dissolved organic carbon ranged from 6.8 to 26 mg/L except for one sample collected from Alamo Wash (180 mg/L). The reason for the significantly higher concentration of dissolved organic carbon is unknown. The median concentration of dissolved organic carbon (14 mg/L) for samples taken from December 1992 through August 1993 was slightly higher than the median concentration (11.5 mg/L) for samples collected from August 1987 through February 1992 (Tadayon and Smith, 1994).

GROUND-WATER QUALITY

A summary was compiled of the results for properties and concentrations of major ions, nutrients, trace elements, and organic carbon (table 3). Organochlorine pesticides and priority pollutants were not detected in the samples. Results of the analyses of all ground-water samples are presented in table 8 in the "Basic Data" section at the end of the report. Some of the physical and chemical data collected from monitoring wells in January and September 1993 are compared to data collected from the same wells in March 1989 (Tadayon and Smith, 1994).

Properties.—pH ranged from 6.2 to 7.2 and had a median value of 6.6 for 12 samples. Values of pH generally were similar for water from shallow and intermediate wells in January and September 1993. pH values for samples from deep wells were lower in January than in September 1993. The pH of water samples collected from wells (D-13-14)26dcb2 (6.2) and (D-13-14)26cbb2 (6.4) in January were not within the SMCL range of 6.5 to 8.5 for drinking water.

Turbidity generally ranged from 3.8 to 53 NTU; however, samples from well (D-13-14)26dcb3, (D-13-14)26cbb1, and (D-13-14)26cbb3 were 420, 130, and 390 NTU, respectively. Turbidity in ground water probably is due to well construction and well development.

Values for specific conductance, hardness, alkalinity, and dissolved solids were higher in samples from deep and intermediate depth wells than in samples from shallow wells in January but generally did not show the same trend in September. Specific conductance ranged from 127 to 326 µS/cm in January and from 206 to 323 µS/cm in September. Concentrations of hardness as $CaCO_3$ ranged from 47 to 130 mg/L in January and from 81 to 130 mg/L in September. The data indicate that the ground water is soft to very hard. Alkalinity for filtered samples ranged from 44 to 141 mg/L as $CaCO_3$ in January and from 56 to 134 mg/L in September. Dissolved-solids concentrations ranged from 83 to 218 mg/L in January and from 127 to 204 mg/L in September. Concentrations of dissolved solids in all ground-water samples were below the SMCL of 500 mg/L for drinking water.

In March 1989, the median values for pH (7.4), specific conductance (287 µS/cm), hardness (120 mg/L) as $CaCO_3$, alkalinity (111 mg/L) as $CaCO_3$, dissolved solids (187 mg/L) were determined from sample data from monitoring wells (D-13-14)26cbb2, (D-13-14)26dcb2, and (D-13-14)26dcb3 (Tadayon and Smith, 1994). Median values of these constituents were lower in January and September 1993 than in March 1989.

Major ions.—Concentrations of dissolved calcium, magnesium, and sodium generally were higher in water samples from deep wells than in water samples from intermediate and shallow wells in January and September. The maximum concentration of calcium (46 mg/L) was detected in wells (D-13-14)26dcb1 and (D-13-14)26cbb2. The concentration of magnesium (4.5 mg/L) was highest in samples from well (D-13-14)26dcb1, and the concentration of sodium (17 mg/L) was highest in samples from well (D-13-14)26cbb2. Concentrations of potassium generally were low and ranged from 1.0 mg/L at well (D-13-14)26dcb1 to 3.9 mg/L at well (D-13-14)26cbb2. Sodium-adsorption ratios ranged from 0.3 to 0.7 and had a median value of 0.4 for 12 samples.

Median concentrations of dissolved calcium, magnesium, and sodium (32.5, 2.9, and 7.6 mg/L, respectively) for January and September 1993 were slightly lower than the median values from March 1989 (44, 3.4, and 9.2 mg/L, respectively; Tadayon

Table 3. Summary of selected physical and chemical data for ground-water sites, Rillito Creek basin, January and September 1993

[µS/cm, microsiemens per centimeter at 25°C; NTU, nephelometetric-turbidity units; mg/L, milligrams per liter; °C, degrees Celsius; µg/L, micrograms per liter; <, less than; ND, not detected; -----, dashes indicate no data]

Constituent	Number of observations	Minimum	Maximum	Median
Properties:				
Specific conductance (µS/cm)	12	127	326	235
pH (units)	12	6.2	7.2	6.6
Turbidity (NTU)	12	3.8	420	17.5
Hardness as $CaCO_3$ (mg/L)	12	47	130	96
Alkalinity as $CaCO_3$ (mg/L)	12	44	141	79
Dissolved solids at 180°C (mg/L)	12	83	218	139.5
Major Ions:				
Calcium, dissolved (mg/L)	12	16	46	32.5
Magnesium, dissolved (mg/L)	12	1.6	4.5	2.9
Sodium, dissolved (mg/L)	12	5.4	17	7.6
Sodium-adsorption ratio	12	.3	.7	.4
Potassium, dissolved (mg/L)	12	1.0	3.9	1.9
Bicarbonate as HCO_3 (mg/L)	12	53	172	90.5
Sulfate, dissolved (mg/L)	12	9.6	36	21
Chloride, dissolved (mg/L)	12	3.1	13	4.5
Fluoride, dissolved (mg/L)	12	<.1	.2	.2
Silica, dissolved (mg/L)	12	7.9	34	19
Nutrients:				
Nitrogen, nitrite, dissolved as N (mg/L)	12	<.01	.03	.01
Nitrogen, nitrite plus nitrate, dissolved, as N (mg/L)	12	.29	3.0	1.4
Nitrogen, ammonia, dissolved, as N (mg/L)	12	<.01	.04	.03
Orthophosphorus, dissolved as P (mg/L)	12	<.01	.03	.01
Trace elements, dissolved:				
Arsenic (µg/L)	12	ND	ND	--------
Barium (µg/L)	12	7	68	33
Boron (µg/L)	12	<10	30	20
Cadmium (µg/L)	12	ND	ND	--------
Chromium (µg/L)	12	<1	20	<1
Copper (µg/L)	12	ND	ND	--------
Iron (µg/L)	12	14	240	36
Lead (µg/L)	12	ND	ND	--------
Manganese (µg/L)	12	18	97	47.5
Mercury (µg/L)	12	ND	ND	--------
Molybdenum (µg/L)	12	<1	2	<1
Nickel (µg/L)	12	<1	1	<1
Selenium (µg/L)	12	ND	ND	--------
Silver (µg/L)	12	ND	ND	--------
Vanadium (µg/L)	12	<1	3	<1
Zinc (µg/L)	12	<3	92	16.5
Organic carbon:				
Organic carbon, dissolved (mg/L)	12	1.0	4.4	2.1
Organic carbon, total (mg/L)	6	1.0	5.6	2.6

and Smith, 1994). The median concentration of potassium (1.9 mg/L) was higher in January and September 1993 than the median concentration (1.1 mg/L) in March 1989.

Concentrations of bicarbonate were lower in samples from shallow wells in January than in samples from shallow wells in September; however, the data did not show the same trend in samples from deep wells. Concentrations of bicarbonate, as $CaCO_3$, generally were lower in shallow wells than in deep wells and ranged from 53 mg/L at well (D-13-14)26dcb1 to 172 mg/L at well (D-13-14)26cbb2. Dissolved sulfate generally was higher in samples collected in September (19 to 36 mg/L) than in samples collected in January (9.6 to 26 mg/L). Concentrations of dissolved chloride ranged from 3.1 mg/L at well (D-13-14)26cbb2 to 13 mg/L at well (D-13-14)26dcb1. Concentrations of dissolved fluoride generally were low and ranged from less than 0.1 to 0.2 mg/L. Maximum concentrations of sulfate and chloride did not exceed the SMCL's of 250 mg/L for drinking water. Maximum concentrations of fluoride did not exceed the MCL of 4 mg/L for drinking water. Concentrations of dissolved silica generally were lower in shallow wells than in deep wells and ranged from 7.9 to 34 mg/L. In ground water, calcium was the dominant cation, and bicarbonate was the dominant anion (fig. 5).

Median concentrations of bicarbonate, sulfate, chloride, and silica (90.5, 21, 4.5, and 19 mg/L, respectively) in January and September generally were lower than the median concentrations for the same constituents in March 1989 (136, 25, 3.2, and 23 mg/L, respectively; Tadayon and Smith, 1994). Chloride was slightly higher in this study. The data indicate that the concentrations of most of the major ions from monitoring wells during higher recharge

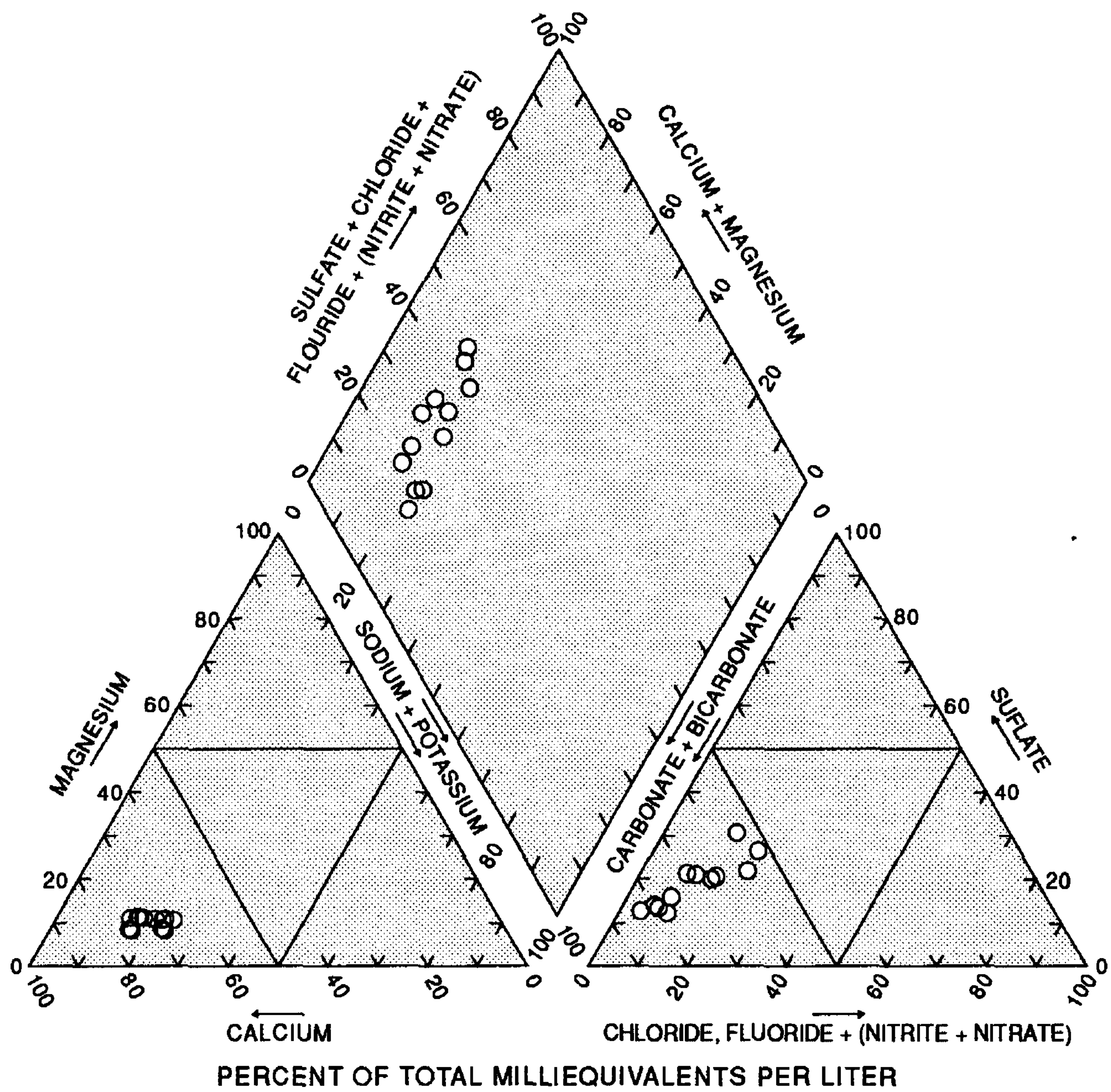


Figure 5. Compositions of ground water in the Rillito Creek basin, January and September 1993.

from Rillito Creek in January and September 1993 were slightly lower than concentrations of the major ions detected during the lower recharge of 1989.

Nutrients.—Nitrogen occurred in samples from the monitoring wells predominantly in the form of nitrate ions. Dissolved nitrite ranged from 0.01 to 0.03 mg/L as N in January 1993 but was not detected in any samples in September 1993. Concentrations of dissolved nitrite plus nitrate and ammonia were lower in samples collected in January than in samples collected in September. Concentrations of dissolved nitrite plus nitrate ranged from 0.29 to 1.5 mg/L as N, and concentrations of ammonia ranged from less than 0.01 to 0.04 mg/L as N. Concentrations of nitrite and nitrite plus nitrate were below the MCL's of 1 mg/L and 10 mg/L as N, respectively. Concentrations of dissolved orthophosphorus in ground-water samples ranged from less than 0.01 to 0.03 mg/L as P.

Median concentrations of dissolved ammonia (0.03 mg/L) and orthophosphorus (0.01 mg/L) in January and September 1993 were higher than the median concentrations of ammonia (less than 0.01 mg/L) and orthophosphorus (less than 0.01 mg/L) in March 1989 (Tadayon and Smith, 1994). The median concentration of dissolved nitrite plus nitrate (1.4 mg/L) was lower in January and September 1993 than the median concentration of nitrite plus nitrate (1.6 mg/L) in March 1989.

Trace elements.—The highest concentrations of dissolved barium, boron, chromium, iron, manganese, and zinc were 68, 30, 20, 240, 97, and 92 μg/L, respectively. Concentrations of these trace elements were varied in samples collected in January and September 1993. The highest concentrations of barium and iron were detected in samples collected from well (D-13-14)26dcbl in September. Trace elements that were not detected in ground-water samples were arsenic, cadmium, copper, lead, mercury, silver, and selenium. Dissolved trace elements did not exceed the MCL's for drinking water. Concentrations of manganese (71 to 97 μg/L) in 5 of 12 samples exceeded the SMCL of 50 μg/L. The wells were not constructed for water-quality monitoring, and construction materials could have contributed to increased concentrations of some metals such as iron and zinc.

Organochlorine pesticides.—Analysis of ground-water samples for organochlorine pesticides indicated no detectable concentrations. The detection limits ranged from 0.01 to 1 μg/L. Organochlorine pesticides were not detected in ground-water samples collected in March 1989 (Tadayon and Smith, 1994).

Priority pollutants.—Analysis of ground-water samples for priority pollutants in this study indicated no detectable concentrations. The detection limits were from 5 to 40 μg/L. Priority pollutants were not detected in ground-water samples collected in March 1989 (Tadayon and Smith, 1994).

Organic carbon.—Dissolved and total organic carbon were detected at all monitoring wells. Concentrations of dissolved organic carbon were higher in water samples from the shallow well than in water samples from the deep well at Swan Road; however, the concentration of dissolved organic carbon was higher in the deep well near Craycroft Road than in the shallow well. Concentrations of dissolved organic carbon ranged from 1.0 mg/L at well (D-13-14)26dcbl to 4.4 mg/L at well (D-13-14)26cbb1. Total organic carbon concentrations ranged from 1.0 mg/L at well (D-13-14)26cbb2 to 5.6 mg/L at well (D-13-14)26cbb1. Concentrations of total organic carbon were 0.7, 1.5, and 3.2 mg/L in three samples collected in March 1989 (Tadayon and Smith, 1994) and generally were similar to concentrations in samples collected in January and September 1993.

BOTTOM-SEDIMENT CHEMISTRY

A summary of the results was compiled for concentrations of nutrients, trace elements, radionuclides, organochlorine pesticides, priority pollutants, and inorganic and organic carbon (table 4). Results of the analyses of bottom-sediment samples are presented in tables 9 and 10 in the "Basic Data" section at the end of the report. Some of the data for bottom sediment collected from Alamo Wash at Fort Lowell Road and Rillito Creek at Swan Road in 1993 are compared with the data for bottom sediment collected from Alamo Wash at Glenn Street and

Table 4. Summary of selected chemical constituents for bottom-sediment sites, Rillito Creek basin, January 1993 through August 1993

[mg/kg, milligrams per kilogram; µg/g, micrograms per gram; ND, not detected; <, less than; pCi/g, picocuries per gram; µg/kg, micrograms per kilogram; g/kg, grams per kilograms; DDD, dichlorodiphenyldichloroethane; DDE, dichlorodiphenylethylene; DDT, dichlorodiphenyltrichloroethane; PCB, polychlorinated biphenyl; ----, dashes indicate no data]

Constituent	Number of observations	Minimum	Maximum	Median
Nutrients, total:				
Nitrogen, nitrite plus nitrate as N (mg/kg)	7	<2.0	37	9
Nitrogen, ammonium as N (mg/kg)	7	.8	35	2
Nitrogen, ammonium plus organics as N (mg/kg)	6	50	500	85
Phosphorus as P (mg/kg)	7	40	360	120
Trace elements:				
Aluminum, total recoverable (µg/g)	7	57,000	79,000	70,000
Arsenic, total (µg/g)	7	<10	11	<10
Barium, total recoverable (µg/g)	7	660	770	720
Beryllium, total recoverable (µg/g)	7	1	2	2
Bismuth, total recoverable (µg/g)	7	ND	ND	--------
Cadmium, total recoverable (µg/g)	7	ND	ND	--------
Calcium, total recoverable (µg/g)	7	20,000	55,000	28,000
Cerium, total recoverable (µg/g)	7	68	160	110
Chromium, total recoverable (µg/g)	7	12	41	26
Cobalt, total recoverable (µg/g)	7	5	9	7
Copper, total recoverable (µg/g)	7	12	35	24
Europium, total recoverable (µg/g)	7	ND	ND	--------
Gallium, total recoverable (µg/g)	7	13	21	15
Holmium, total recoverable (µg/g)	7	ND	ND	--------
Iron, total recoverable (µg/g)	7	16,000	74,000	27,000
Lanthanum, total recoverable (µg/g)	7	38	87	58
Lead, total recoverable (µg/g)	7	21	47	30
Lithium, total recoverable (µg/g)	7	18	48	24
Magnesium, total recoverable (µg/g)	7	3,700	10,000	5,400
Manganese, total recoverable (µg/g)	7	420	1,700	690
Molybdenum, total recoverable (µg/g)	7	ND	ND	--------
Neodymium, total recoverable (µg/g)	7	31	75	49
Nickel, total recoverable (µg/g)	7	6	15	11
Niobium, total recoverable (µg/g)	7	9	24	11
Phosphorus, total recoverable (µg/g)	7	600	800	700
Potassium, total recoverable (µg/g)	7	24,000	27,000	25,000
Scandium, total recoverable (µg/g)	7	5	10	7
Silver, total recoverable (µg/g)	7	ND	ND	--------
Sodium, total recoverable (µg/g)	7	14,000	25,000	21,000

Table 4. Summary of selected chemical constituents for bottom-sediment sites, Rillito Creek basin, January 1993 through August 1993—Continued

Constituent	Number of observations	Minimum	Maximum	Median
Trace elements—Continued:				
Strontium, total recoverable (μg/g)	7	230	280	270
Tantalum, total recoverable (μg/g)	7	ND	ND	-------
Thorium, total recoverable (μg/g)	7	10	32	22
Tin, total recoverable (μg/g)	7	<5	5	<5
Titanium, total recoverable (μg/g)	7	2,100	6,100	3,100
Uranium, total recoverable (μg/g)	7	ND	ND	-------
Vanadium, total recoverable (μg/g)	7	36	150	58
Yttrium, total recoverable (μg/g)	7	20	41	32
Ytterbium, total recoverable (μg/g)	7	2	5	3
Zinc, total recoverable (μg/g)	7	35	99	74
Radionuclides:				
Gross alpha, as U (μg/g)	7	.1	17	3.5
Gross alpha as Th-230 (pCi/g)	7	<6	17.6	2.0
Gross beta as Sr-90/Y-90 (pCi/g)	7	24.8	269	29.2
Gross beta, as Cs-137 (pCi/g)	7	32.5	364	37.8
Organochlorine pesticides, total recoverable:				
Chlordane (μg/kg)	7	1.0	20.0	8.0
DDD (μg/kg)	7	<.1	1.0	.4
DDE (μg/kg)	7	<.1	.9	.3
DDT (μg/kg)	7	<.1	.6	.1
Dieldrin (μg/kg)	7	.1	2.4	.8
Heptachlor epoxide (μg/kg)	7	<.1	.1	<.1
PCB (μg/kg)	7	<1.0	2	<1.0
Priority pollutants, total recoverable:				
Fluoranthene (μg/kg)	7	<200	380	<200
Pyrene (μg/kg)	7	<200	330	<200
Inorganic carbon and organic carbon plus inorganic carbon:				
Inorganic carbon, total (g/kg)	5	<.1	6.0	.6
Organic carbon plus inorganic carbon, total (g/kg)	7	.7	12	2.0

Rillito Creek at Dodge Boulevard in July 1987 and February 1992.

Particle-size distribution.—Five bottom-sediment samples were analyzed for particle-size distribution. Particles measured were from less than 0.0625 to 2.00 mm. The materials consisted mainly of sand-sized particles from 0.5 to 1.0 mm (table 9).

Nutrients.—Concentrations of nutrients were higher in samples at Rillito Creek than in samples at Alamo Wash in August 1993. Concentrations of nitrite plus nitrate as N and ammonium plus organic nitrogen as N were lower in samples at Rillito Creek during January and March 1993 than in samples from August 1993. Concentrations of nitrite plus nitrate as N ranged from less than 2.0 mg/kg at Alamo Wash to 37 mg/kg at Rillito Creek. The highest concentration of ammonium (35 mg/kg) was detected in one sample at Rillito Creek. Ammonium plus organic nitrogen as N in bottom sediment, which was detected at the highest concentration of any nitrogen species, ranged from 50 mg/kg at Alamo Wash to 500 mg/kg at Rillito Creek. Concentrations of phosphorus were higher in samples collected at Rillito Creek in August 1993 than in samples collected during January and March 1993. Phosphorus was detected at concentrations of 100 and 200 mg/kg at Alamo Wash and ranged from 40 to 360 mg/kg at Rillito Creek.

In 1993, median concentrations of ammonium, ammonium plus organic nitrogen, and phosphorus analyzed in samples collected at Alamo Wash at Fort Lowell Road and Rillito Creek at Swan Road (2, 85, and 20 mg/L, respectively) were lower than the median concentrations from Alamo Wash at Glenn Street and Rillito Creek at Dodge Boulevard collected during 1987–92 (3.5, 140, and 165 mg/L, respectively; Tadayon and Smith, 1994). The median concentration of nitrite plus nitrate was higher in 1993 (9 mg/L) than the median concentration in 1987–92 (less than 0.2 mg/L).

Trace elements.—The highest concentrations of total recoverable aluminum, barium, calcium, iron, magnesium, manganese, and potassium were 79,000, 770, 55,000, 74,000, 10,000, 1,700, and 27,000 μg/g, respectively. Concentrations of trace elements in bottom sediment at Alamo Wash and Rillito Creek generally were similar (table 10 in the "Basic Data" section at the end of the report). Bismuth, cadmium, europium, holmium, molybdenum, silver, tantalum, tin, and uranium were not detected in any of the samples. Arsenic (11 μg/g) was detected only in one sample collected at Rillito Creek. The median concentrations of trace elements from samples in 1993 generally were similar to the medians for samples collected during 1987–92 (Tadayon and Smith, 1994).

Trace-element concentrations for bottom sediments are not regulated; therefore, trace-element concentrations for bottom sediments were compared with geochemical baseline information from soils of the western United States (Shacklette and Boerngen, 1984). Table 5 has been modified from Shacklette and Boerngen to include only the constituent concentrations that were part of the chemical analyses for this study. Soil-sample data in table 5 consists of selected natural soils west of the 97th meridian within the conterminous United States. Samples were collected at a depth of about 8 in. below land surface and were collected at 50-mile intervals. The soil samples were oven dried and sifted through a 2-millimeter sieve before analysis. Analysis of bottom-sediment samples collected at Alamo Wash and Rillito Creek indicates that concentrations of trace elements were within the ranges for soils of the western United States (table 5).

Radionuclides.—Gross alpha activity as U ranged from 0.1 μg/g in bottom sediment from Rillito Creek to 17 μg/g in bottom sediment from Alamo Wash. Activity of gross alpha as thorium-230 (Th-230) ranged from less than 6 pCi/g at Rillito Creek to 17.6 pCi/g at Alamo Wash. The maximum activities of gross beta (269 pCi/g) as strontium-90/yttrium-90 (Sr-90/Y-90) and gross beta (364 pCi/g) as cesium-137 were detected in bottom sediment from Rillito Creek in March 1993.

Activities of gross beta ranged from 8.4 to 35 pCi/g as Sr-90/Y-90 and activities of gross alpha ranged from 10 to 17.1 pCi/g as Th-230 in samples from Alamo Wash at Glenn Street and Rillito Creek at Dodge Boulevard during 1987–92 (Tadayon and Smith, 1994). The median activities of gross beta as Sr-90/Y-90 and gross alpha as Th-230 (29.2 and 2.0 pCi/g, respectively) during January and August 1993 were lower than the median activities from July 1987 through February 1992 (31.4 and (15.8 pCi/g, respectively; Tadayon and Smith, 1994).

Organochlorine pesticides.—Several organochlorine pesticides were detected in bottom-sediment samples collected at Alamo Wash and Rillito Creek. Concentrations of chlordane and dieldrin were detected at all samples and ranged from 1 to 20 μg/kg and 0.1 to 2.4 μg/kg, respectively. Concentrations of DDD, DDE, and DDT were detected in five of seven samples and ranged from less than 0.1 to 1 μg/kg, less than 0.1 to

Table 5. Trace-element concentrations in bottom sediment of the Rillito Creek basin and in soils of the western conterminous United States

[Minimum, maximum, median, and mean are reported in micrograms per gram (μg/g); mean is geometric; >, greater than; <, less than; ND, not detected. Modified from Shacklette and Boergen (1984)]

Constituent	Bottom sediment, Rillito Creek basin		Soil of the western conterminous United States		Constituent	Bottom sediment, Rillito Creek basin		Soil of the western conterminous United States	
	Minimum	Maximum	Minimum	Maximum		Minimum	Maximum	Minimum	Maximum
Aluminum	57,000	79,000	5,000	100,000	Molybdenum	ND	ND	<3	7
Arsenic	<10	11	<0.10	97	Neodymium	31	75	<70	300
Barium	660	770	70	5,000	Nickel	6	15	<5	700
Beryllium	1	2	<1	15	Niobium	9	24	<10	100
Calcium	20,000	55,000	600	320,000	Potassium	24,000	27,000	1,900	630,000
Cerium	68	160	<150	300	Scandium	5	10	<5	50
Chromium	12	41	3	2,000	Sodium	14,000	25,000	500	100,000
Cobalt	5	9	<3	50	Strontium	230	280	10	3,000
Copper	12	35	2	300	Thorium	10	32	2.4	31
Gallium	13	21	<5	70	Tin	<5	5	<0.1	7.4
Iron	16,000	74,000	1,000	100,000	Titanium	2,100	6,100	500	20,000
Lanthanum	38	87	<30	200	Uranium	ND	ND	.68	7.9
Lead	21	47	<10	700	Vanadium	36	150	7	500
Lithium	18	48	5	130	Yttrium	20	41	<10	150
Magnesium	3,700	10,000	300	>100,000	Ytterbium	2	5	<1	20
Manganese	420	1,700	30	5,000	Zinc	35	99	10	2,100

0.9 μg/kg, less than 0.1 to 0.6 μg/kg, and less than 1 to 2 μg/kg, respectively. Concentrations of PCB were detected in three of seven samples and ranged from less than 1 to 2 μg/kg. Heptachlor epoxide (0.1 μg/kg) was detected only in one sample collected at Alamo Wash. Seven organochlorine pesticides were detected in samples from Alamo Wash at Glenn Street, and six pesticides were detected in samples from Rillito Creek at Dodge Boulevard during 1987–92 (Tadayon and Smith, 1994).

Priority pollutants.—Fluoranthene and pyrene were the only priority pollutants detected in bottom-sediment samples collected at Alamo Wash and Rillito Creek in August 1993. The maximum concentrations of fluoranthene (380 μg/kg) and pyrene (330 μg/kg) were detected at Alamo Wash. Eleven priority pollutants were detected in samples collected from Alamo Wash at Glenn Street, and none were detected in samples collected from Rillito Creek at Dodge Boulevard during 1987–92 (Tadayon and Smith, 1994).

Inorganic and organic carbon.—Concentrations of organic carbon were higher than concentrations of inorganic carbon in samples from Alamo Wash and Rillito Creek. Concentrations of inorganic carbon were 0.6 and 1.1 g/kg in two samples from Alamo Wash and ranged from less than 0.1 to 6 g/kg at Rillito Creek. Inorganic carbon plus organic carbon was 2.4 and 3.3 g/kg at Alamo Wash and ranged from 0.7 to 12 g/kg at Rillito Creek. The median concentrations of inorganic carbon (0.6 g/kg) and inorganic plus organic carbon (2.0 g/kg) from Alamo Wash at Fort Lowell Road and Rillito Creek at Swan Road in 1993 were lower than the median concentrations from Alamo Wash at Glenn Street and Rillito Creek at Dodge Boulevard during 1987–92 (1.9 and 2.7 g/kg, respectively; Tadayon and Smith, 1994).

COMPARISON OF SURFACE-WATER AND GROUND-WATER QUALITY

According to Hem (1989), the chemical composition of natural water is derived from many different sources of solutes including gases and aerosols from the atmosphere, weathering and erosion of rocks and soil, solution or precipitation reactions occurring below the land surface, and anthropogenic activities. The quality of surface water varies from storm to storm and seasonally because of variation in duration, location, intensity, and temporal distribution of precipitation within the watershed. The variability of these factors is high in the Rillito Creek basin, which receives runoff from the intense localized thunderstorms of short duration in the summer and from less intense, areally extensive frontal storms of longer duration in the winter.

The chemical composition of ground water in the study area is affected by streamflow recharge, underflow, geology, mineralogy, and internal and external drainage patterns (Anderson and others, 1992). Surface water that infiltrates the unsaturated zone may undergo many physical, chemical, and biological processes (Crites, 1985; Knorr and Cliett, 1985; MacKay and others, 1985; and Oaksford, 1985). Such processes may include dissolution; ion exchange; sorption; filtration; precipitation; volatilization; and physical, chemical, and microbial degradation (Miller and Blair, 1971; DeCook and Wilson, 1980; Mooradian, 1983; and Olson, 1987). Filtration and sorption are the most important purification processes, playing a vital part in quality improvement and in the attenuation of constituents in the unsaturated zone during infiltration (Miller and Blair, 1971; Crites, 1985; Huisman and Olsthhoorn, 1983; and Miller, 1990).

Properties.—In surface water, pH ranged from 6.4 to 8.1 and had a median value of 7.7. In ground water, pH ranged from 6.2 to 7.2 and had a median value of 6.6. Specific conductance, hardness, alkalinity, and dissolved solids increased in surface water from December 1992 and January 1993 to August 1993 and increased in ground water from shallow wells from January 1993 to September 1993. These constituents did not show the same trend in water samples in deep wells and generally were similar in January and September 1993. Specific conductance in surface-water samples ranged from 58 to 183 µS/cm—except for one sample at Alamo Wash (337 µS/cm) in July 1993—and had a median value of 110 µS/cm. Ground-water samples had a specific conductance that ranged from 127 to 326 µS/cm and had a median value of 235 µS/cm. Median values for hardness indicate that surface water (40 mg/L as $CaCO_3$) is soft, and ground water (96 mg/L as $CaCO_3$) is moderately hard. In surface-water samples, alkalinity ranged from 19 to 49 mg/L as $CaCO_3$ and had a median value of 36 mg/L. Alkalinity in ground-water samples ranged from 44 to 141 mg/L as $CaCO_3$ and had a median value of 79 mg/L. The higher concentrations of alkalinity in ground water probably are due to increased contributions of bicarbonate. In surface water, concentrations of dissolved solids ranged from 43 to 467 mg/L and had a median value of 90.5 mg/L. In ground water, concentrations of dissolved solids ranged from 83 to 218 mg/L and had a median value of 139.5 mg/L. Higher concentrations of dissolved solids in ground water probably are due to increased dissolution of minerals in the subsurface.

Major ions.—The median concentrations of all major ions analyzed, with the exception of potassium, were higher in ground water than in surface water (tables 2 and 3). The largest differences were in the concentrations of calcium, bicarbonate, sulfate, and silica. Lower concentrations of calcium, magnesium, sodium, potassium, bicarbonate, and silica in surface water in January 1993 than in August 1993 resulted in lower concentrations of these constituents in ground water from shallow wells in January 1993 than in September 1993. Concentrations of these constituents did not show the same trend for deep wells (tables 8 and 9). According to Hem (1952), the amount and kinds of dissolved matter contained in the ground water depend on the types of rocks through which the water moves and upon the length of time the water is in contact with the rocks. The ionic composition of water changes as water moves through sediments and interacts with minerals. Concentrations of dissolved silica commonly are considerably higher in ground water than in surface water because silica is a constituent of most igneous rocks and is found in some form in most other rocks and soils (Hem, 1989). In surface water and ground water in the study area, calcium was the dominant cation, and bicarbonate was the dominant anion.

Nutrients.—Concentrations of nitrite and ammonia were lower in ground water than in surface water. Concentrations of nitrite plus nitrate were higher in ground water than in surface water. Higher concentrations of dissolved nitrate in surface water in August 1993 may have caused an increase in the concentrations of nitrite plus nitrate in samples from wells in September 1993. Concentrations of nitrite plus nitrate and ammonium plus organic nitrogen were higher in bottom-sediment samples collected from Rillito Creek in August 1993 than in samples collected during January and March 1993. Concentrations of dissolved orthophosphorus as P were higher in surface water than in ground water; however, higher concentrations of orthophosphorus in surface water during July and August 1993 did not cause an increase in concentrations of orthophosphorus in ground-water samples collected in September 1993.

Trace elements.—Low concentrations of dissolved cadmium, lead, mercury, molybdenum, and nickel were detected in one or more surface-water samples but were not detected in any of the ground-water samples. The median values of barium, manganese, and zinc were higher in ground water than in surface water; however, the median values of iron and vanadium were greater in surface water than in ground water. Lower concentrations of dissolved trace elements in ground water probably are the result of sorption of trace elements to the sediments as the water moves through the unsaturated zone and (or) aquifer.

Organochlorine pesticides.—Six organochlorine pesticides were detected in surface-water samples, and seven organochlorine pesticides were detected in bottom-sediment samples. Pesticides were not detected in water samples collected from monitoring wells. All of the pesticides that were detected in surface water also were detected in bottom sediment. Heptachlor epoxide was the only pesticide detected in bottom sediment that was not detected in surface water. The highest concentrations of chlordane were detected in surface-water and bottom-sediment samples. Pesticides probably are removed by sorption to the sediments as the water moves through the unsaturated zone.

Priority pollutants.—Four priority pollutants were detected in surface-water samples, and two priority pollutants were detected in bottom-sediment samples. Priority pollutants were not detected in water samples collected from monitoring wells. Benzo-(b)-fluoranthene, bis(2-ethylhexyl)phthalate, fluoranthene, and pyrene were the only priority pollutants detected in surface-water samples. Fluoranthene and pyrene were the only priority pollutants detected in bottom-sediment samples. Priority pollutants probably are removed by sorption to the sediment as the water moves through the unsaturated zone.

Organic carbon.—Concentrations of dissolved organic carbon were higher in surface-water samples (6.8 to 180 mg/L) than in ground-water samples (1.0 to 4.4 mg/L). Organic carbon also was detected in bottom-sediment samples. Lower concentrations of dissolved organic carbon in ground water may have resulted from sorption to sediment as the water moves through the unsaturated zone and through microbial degradation.

SUMMARY

Controlled artificial recharge of surface runoff is being considered as a water-management technique to address the problem of ground-water overdraft in the Tucson basin in southern Arizona. The use of recharge facilities in urban areas has caused concern about the quality of urban runoff to be recharged and the potential for ground-water contamination. The proposed ground-water recharge in Rillito Creek will utilize low-flow runoff entering a 1-mile reach of the Rillito Creek between Craycroft Road and Swan Road for infiltration and recharge purposes within the channel and excavated overbank areas. Streamflow data from the gaging station, Tanque Verde Creek at Tucson, and hydrographs from well (D-13-14)26cbb2 and (D-13-14)26dcb2 about 3 mi downstream indicate that water levels in the wells respond to flow in the channel.

Physical and chemical data were collected from four surface-water, six ground-water, and two bottom-sediment sites during 1992–93. Surface-water samples were collected at four sites to determine the possible occurrence and concentrations of contaminants in streamflow. Samples were collected from six monitoring wells to determine the quality of recharged ground water in the study area. Bottom-sediment samples were collected at two surface-water sites and analyzed to determine concentrations of contaminants.

Concentrations of suspended sediment ranged from 21 to 18,000 mg/L and had a median value of 1,610 in 16 surface-water samples. Flow during the summer generally had a higher concentration of silt and clay than flow during the winter. In surface water, pH ranged from 6.4 to 8.1 and had a median value of 7.7. In ground water, pH ranged from 6.2 to 7.2 and had a median value of 6.6. Specific conductance, hardness, alkalinity, and dissolved solids increased in surface water from December 1992 and January 1993 to August 1993 and increased in ground water from shallow wells from January 1993 to September 1993. These properties were mostly unchanged in ground water from deeper wells during the same period. Specific conductance, hardness, alkalinity, and dissolved-solids concentrations generally were higher in ground water than in surface water. The median values for hardness indicate that surface water (40 mg/L as $CaCO_3$) is soft and that ground water (96 mg/L as $CaCO_3$) is moderately hard. In surface water, dissolved-solids concentrations ranged from 43 to 124 mg/L, except for one sample from Alamo Wash (467 mg/L). In ground water, dissolved-solids concentrations ranged from 83 to 218 mg/L. Higher concentrations of dissolved solids in ground water probably are due to increased dissolution of minerals in the subsurface.

The median concentrations of all dissolved major ions analyzed, with the exception of potassium, were higher in ground water than in surface water. The largest differences were in concentrations of calcium, bicarbonate, sulfate, and silica. Concentrations of calcium, magnesium, and sodium generally were higher in water samples collected from deep wells than in samples from intermediate and shallow wells in January and September 1993. In surface water and ground water, calcium was the dominant cation, and bicarbonate was the dominant anion.

Concentrations of dissolved nitrite ranged from less than 0.01 to 0.03 mg/L in surface water and in ground water and did not exceed the MCL of 1 mg/L as N for drinking water. Concentrations of dissolved nitrite plus nitrate ranged from 0.14 to 2.7 mg/L in surface water and ranged from 0.29 to 3.0 mg/L in ground water and did not exceed the MCL of 10 mg/L as N for drinking water. Dissolved ammonia as N was detected in greater concentrations in surface water than in ground water and ranged from 0.01 to 3.5 mg/L and less than 0.01 to 0.04 mg/L, respectively. Concentrations of dissolved orthophosphorus as P were higher in surface water than in ground water. Ammonium plus organic nitrogen in bottom sediment was detected at the highest concentration of any nitrogen species and ranged from 50 mg/kg at Alamo Wash to 500 mg/kg as N at Rillito Creek. Concentrations of nutrients were higher in bottom-sediment samples collected at Rillito Creek than in samples collected at Alamo Wash in August 1993.

Low concentrations of dissolved cadmium, lead, mercury, molybdenum, and nickel were detected in one or more surface-water samples but were not detected in any of the ground-water samples. None of the dissolved trace elements in surface water or ground water exceeded the MCL's for drinking water. In surface water, the maximum concentrations of iron (580 μg/L) and manganese (280 μg/L) exceeded the SMCL's of 50 and 300 μg/L, respectively. Concentrations of manganese (71 to 97 μg/L) in 5 of 12 samples in ground water exceeded the SMCL of 50 μg/L.

Analyses of bottom sediments for trace elements were compared with baseline geochemical information for soils of the western conterminous United States. Concentrations of trace elements in bottom sediment of Rillito Creek generally were similar to reported concentrations in soils of the western conterminous United States and do not suggest a significant accumulation of these elements. Lower concentrations of dissolved trace elements in ground water probably are the result of sorption of trace elements to the sediments as the water moves through the unsaturated zone and (or) aquifer.

The highest gross alpha activity as U and gross alpha as Th-230 were detected at Rillito Creek (17 μg/g and 17.6 pCi/g, respectively). The maximum activity of gross beta as Sr-90/Y-90 and gross beta as Cs-137 were detected at Rillito Creek and ranged from 24.8 to 269 pCi/g and 32.5 to 364 pCi/g, respectively.

Six organochlorine pesticides were detected in surface-water samples and seven were detected in bottom-sediment samples. Chlordane and PCB's were the only pesticides or priority pollutants detected that are included in quality standards for drinking water. The maximum concentration of chlordane in surface water was 0.6 μg/L, and the maximum concentration in bottom sediment was 20 μg/kg. The maximum concentration of PCB's in surface water was 0.1 μg/L. Concentrations of chlordane and PCB's were below the maximum contaminant levels for drinking water—2 and 0.5 μg/L, respectively. Some of the pesticides in surface water and bottom sediment probably are the result of frequent use of the chemicals to control weeds and insects in agricultural and urban areas. No pesticides were detected in samples from wells. Pesticides probably are removed by sorption to the sediment as the water moves through the unsaturated zone.

Four priority pollutants were detected in surface-water samples and two priority pollutants were detected in bottom-sediment samples. The priority pollutants that were detected in surface water are not included in water-quality standards. In surface water, concentrations of benzo-(b)-fluoranthene, bis(2-ethylhexyl)phthale, fluoranthene, and pyrene ranged from less than 10 to 12 μg/L, 6 to 10 μg/L, less than 5 to 14 μg/L, and less than 5 to 11 μg/L, respectively. The highest concentration of fluoranthene (380 μg/kg) and pyrene (330 μg/kg) were detected in one bottom-sediment sample at Alamo Wash. Priority pollutants in surface water and bottom sediment are attributed to a higher rate of urbanization and types of land use within the Alamo Wash and Rillito Creek watersheds. Priority pollutants were not detected in water samples from wells. Priority pollutants probably are removed by sorption to the sediment as the water moves through the unsaturated zone.

Concentrations of dissolved organic carbon were higher in surface water than in ground water and ranged from 6.8 to 180 mg/L and 1.0 to 4.4 mg/L, respectively. Concentrations of organic carbon plus inorganic carbon ranged from 0.7 to 12 g/kg in sediment. Lower concentrations of dissolved organic carbon in ground water may have resulted from sorption to sediment as the water moves through the unsaturated zone and through microbial degradation.

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(page 31 follows)

BASIC DATA

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Table 6. Suspended-sediment concentration and particle-size distribution of surface-water samples, Rillito Creek basin

[ft^3/s, cubic feet per second; mg/L, milligrams per liter; mm, millimeter; <, less than; ≥, equal to or greater than]

Date	Time	Discharge (ft^3/s)	Suspended-sediment concentration (mg/L)	Particle-size distribution, in percent	
				Silt and clay <0.062 mm	Sand ≥0.062–2 mm
Tanque Verde Creek at Sabino Canyon Road					
01–07–93	1200	3,250	1,560	34	66
03–10–93	1200	25	37	27	73
08–20–93	1600	116	352	87	13
Pantano Wash at Broadway Boulevard					
12–29–92	1045	35	1,790	99	1
01–07–93	1015	230	8,720	91	9
08–21–93	1915	30	2,530	30	70
08–30–93	1015	346	16,600	80	20
Alamo Wash at Fort Lowell Road					
01–06–93	1330	90	901	74	26
07–08–93	1945	14	480	95	5
08–03–93	2045	50	2,830	80	20
08–08–93	1900	130	874	83	17
08–21–93	1830	35	1,660	95	5
Rillito Creek at Dodge Boulevard					
01–07–93	1430	3,000	3,210	45	55
03–10–93	1455	20	21	66	34
08–08–93	1945	200	18,000	62	38
08–30–93	1645	60	554	95	5

Table 7. Analytical results of surface-water samples, Rillito Creek basin

Properties and major ions

[ft^3/s, cubic feet per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; NTU, nephelometric-turbidity units; ----, dashes indicate no data; <, less than; µg/L, micrograms per liter; DDD, dichlorodiphenyldichloroethane; DDE, dichlorodiphenylethylene; DDT, dichlorodiphenyltrichloroethane]

Date	Time	Discharge, instantaneous, (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Temperature, air (°C)	Temperature, water (°C)	Turbidity (NTU)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate, dissolved field (mg/L as $CaCO_3$)
Tanque Verde Creek at Sabino Canyon Road									
01–07–93	1200	3,250	58	6.6	14.0	11.0	100	19	0
03–10–93	1200	25	106	7.7	21.0	18.0	-------	29	5
08–20–93	1600	116	115	7.5	27.5	29	95	37	1
Pantano Wash at Broadway Boulevard									
12–29–92	1045	35	104	7.3	17.0	13.0	730	43	0
01–07–93	1015	230	98	6.6	13.0	11.0	2,800	40	1
08–21–93	1915	30	127	7.8	24.0	26.5	190	47	13
08–30–93	1015	346	119	7.7	30.0	23.0	1,600	54	4
Alamo Wash at Fort Lowell Road									
01–06–93	1330	90	68	6.4	------	------	200	28	5
07–08–93	1945	14	337	6.8	30.0	31.0	47	130	99
08–03–93	2045	50	114	7.7	25.0	27.0	180	40	14
08–08–93	1900	130	80	8.1	25.0	28.0	180	31	9
08–21–93	1830	35	105	7.8	24.0	30.0	720	41	11
Rillito Creek at Dodge Boulevard									
01–07–93	1430	3,000	73	6.8	14.0	12.0	520	28	0
03–10–93	1455	20	183	8.1	18.0	23.0	-------	54	10
08–08–93	1945	200	86	8.0	24.5	28.0	2,000	37	9
08–30–93	1645	60	135	7.7	27.0	28.0	210	50	3

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Properties and major ions—Continued

Date	Alkalinity, water, dissolved in field (mg/L as $CaCO_3$)	Solids, sum of constituents, dissolved (mg/L)	Solids, residue at 180°C, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium, in percent	Sodium adsorption ratio
Tanque Verde Creek at Sabino Canyon Road								
01–07–93	19	47	65	6.0	0.98	5.0	35	0.5
03–10–93	25	74	76	8.7	1.8	10	42	.8
08–20–93	37	81	104	12	1.8	9.1	33	.6
Pantano Wash at Broadway Boulevard								
12–29–92	45	67	95	15	1.3	4.0	16	.3
01–07–93	39	107	78	14	1.3	4.4	18	.3
08–21–93	34	74	110	16	1.6	5.4	19	.3
08–30–93	49	88	120	18	2.1	5.8	18	.3
Alamo Wash at Fort Lowell Road								
01–06–93	31	36	43	10	.82	1.9	12	.2
07–08–93	35	187	467	48	3.5	12	15	.5
08–03–93	26	63	93	14	1.3	3.9	16	.3
08–08–93	22	44	54	11	.83	2.1	12	.2
08–21–93	30	59	88	14	1.5	3.1	13	.2
Rillito Creek at Dodge Boulevard								
01–07–93	28	55	81	9.6	1.0	4.8	26	.4
03–10–93	44	115	124	17	2.8	15	37	.9
08–08–93	28	51	62	13	1.1	1.9	9	.1
08–30–93	48	86	108	17	1.9	7.4	23	.5

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Properties and major ions—Continued

Date	Potassium, dissolved (mg/L as K)	Bicarbonate, dissolved (mg/L as HCO_3)	Carbonate, dissolved (mg/L as CO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
Tanque Verde Creek at Sabino Canyon Road							
01–07–93	1.1	23	0	6.1	2.1	0.10	12
03–10–93	1.1	30	0	13	6.9	.10	15
08–20–93	2.6	45	0	10	3.1	.30	16
Pantano Wash at Broadway Boulevard							
12–29–92	2.2	55	0	5.4	2.0	.10	8.8
01–07–93	2.1	48	0	5.9	2.2	.20	10
08–21–93	3.0	41	0	12	4.2	.20	5.1
08–30–93	3.5	60	0	7.1	8.0	.20	7.9
Alamo Wash at Fort Lowell Road							
01–06–93	1.3	28	0	2.7	.80	.10	2.3
07–08–93	11	43	0	49	15	1.3	5.7
08–03–93	3.6	32	0	11	3.7	.20	2.8
08–08–93	2.1	27	0	6.4	1.9	.10	1.9
08–21–93	2.7	37	0	8.6	2.2	.20	3.7
Rillito Creek at Dodge Boulevard							
01–07–93	1.4	34	0	6.6	2.4	.10	11
03–10–93	1.8	54	0	22	12	.20	17
08–08–93	2.7	34	0	5.9	1.7	.10	2.6
08–30–93	3.0	58	0	4.6	3.0	.20	14

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Nutrients, organic carbon, and trace elements

Date	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Phosphorus ortho, dissolved (mg/L as P)	Carbon, organic, dissolved (mg/L as C)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)
Tanque Verde Creek at Sabino Canyon Road							
01–07–93	0.040	0.310	0.020	.100	15	<1	8
03–10–93	<.010	.500	.010	.040	8.6	<1	12
08–20–93	<.010	.810	.030	.090	14	1	13
Pantano Wash at Broadway Boulevard							
12–29–92	.020	.140	.050	.090	15	2	30
01–07–93	.030	.250	.070	.040	16	2	26
08–21–93	.050	1.10	.310	.160	17	6	34
08–30–93	.030	.930	.070	.200	12	3	36
Alamo Wash at Fort Lowell Road							
01–06–93	<.010	.370	.180	<.010	6.8	2	16
07–08–93	.070	2.70	3.50	.790	180	4	110
08–03–93	.030	1.20	.850	.210	26	4	27
08–08–93	.020	.840	.530	.100	13	4	17
08–21–93	.030	.860	.330	.130	17	5	24
Rillito Creek at Dodge Boulevard							
01–07–93	.030	.230	.050	.060	14	2	12
03–10–93	<.010	.200	.010	.020	8.3	<1	20
08–08–93	.040	.890	.400	.110	12	4	23
08–30–93	<.010	1.30	.030	.120	12	2	30

Date	Boron, dissolved (µg/L as B)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)
Tanque Verde Creek at Sabino Canyon Road							
01–07–93	10	<1.0	3	<10	110	<1	49
03–10–93	20	<1.0	<1	<10	91	<1	3
08–20–93	30	<1.0	<1	<10	34	<1	9
Pantano Wash at Broadway Boulevard							
12–29–92	<10	<1.0	<1	<10	130	1	21
01–07–93	10	<1.0	<1	<10	84	<1	4
08–21–93	40	<1.0	<1	10	33	<1	22
08–30–93	30	<1.0	9	10	580	2	32
Alamo Wash at Fort Lowell Road							
01–06–93	20	<1.0	4	<10	-----	<1	-----
07–08–93	60	1.0	4	80	270	7	280
08–03–93	50	<1.0	2	20	29	1	35
08–08–93	20	<1.0	<1	<10	13	<1	7
08–21–93	20	<1.0	<1	10	110	<1	3
Rillito Creek at Dodge Boulevard							
01–07–93	10	<1.0	5	<10	-----	<1	-----
03–10–93	20	<1.0	<1	<10	47	<1	5
08–08–93	20	<1.0	<1	<10	14	<1	5
08–30–93	30	<1.0	<1	<10	33	<1	10

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Nutrients, organic carbon, and trace elements—Continued

Date	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Silver, dissolved (µg/L as Ag)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Selenium, dissolved (µg/L as Se)
Tanque Verde Creek at Sabino Canyon Road							
01–07–93	<0.1	<1	1	<1.0	5	5	<1
03–10–93	<.1	<1	<1	<1.0	3	<3	<1
08–20–93	<.1	<1	<1	<1.0	9	4	<1
Pantano Wash at Broadway Boulevard							
12–29–92	<.1	<1	<1	<1.0	6	5	<1
01–07–93	<.1	<1	<1	<1.0	7	42,000	<1
08–21–93	<.1	<1	1	<1.0	11	3	<1
08–30–93	.2	<1	1	<1.0	19	9	<1
Alamo Wash at Fort Lowell Road							
01–06–93	<.1	<1	1	<1.0	4	5	<1
07–08–93	<.1	6	19	<1.0	73	330	1
08–03–93	<.1	3	2	<1.0	14	11	<1
08–08–93	<.1	2	<1	<1.0	8	4	<1
08–21–93	<.1	<1	1	<1.0	13	4	<1
Rillito Creek at Dodge Boulevard							
01–07–93	<.1	<1	1	<1.0	6	10	<1
03–10–93	<.1	<1	<1	<1.0	3	<3	<1
08–08–93	<.1	2	<1	<1.0	9	4	<1
08–30–93	<.1	1	<1	<1.0	10	7	<1

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Organochlorine pesticides

Date	Perthane, total (µg/L)	Endosulfate, total (µg/L)	Aldrin, total (µg/L)	Chlordane, total (µg/L)	DDD, total (µg/L)	DDE, total (µg/L)	DDT, total (µg/L)	Diel-drin, total (µg/L)
Alamo Wash at Fort Lowell Road								
01–06–93	<0.1	<0.010	<0.010	0.2	0.020	0.010	0.010	0.030
07–08–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
08–03–93	<.1	<.10	<.10	.6	<.10	.050	<.10	.10
08–08–93	<1.0	<.10	<.10	.4	<.10	.030	<.10	.050
08–21–93	<.1	<.010	<.010	.4	.020	.020	.020	.060

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Organochlorine pesticides—Continued

Date	Endrin, total (µg/L)	Hepta-chlor, total (µg/L)	Hepta-chlor epoxide, total (µg/L)	Lindane, total (µg/L)	Toxa-phene, total (µg/L)	Biphenyl, poly-chlor, total (µg/L)	Naph-thalene, poly-chlor, total (µg/L)	Meth-oxy-chlor, total (µg/L)	Mirex, total (µg/L)
Alamo Wash at Fort Lowell Road									
01–06–93	<.010	<.010	<.010	<.010	<1	<0.1	<.10	<.01	<.01
07–08–93	<.010	<.010	<.010	<.010	<1	<.1	<.10	<.01	<.01
08–03–93	<.10	<.10	<.10	<.10	<10	<1.0	<1.0	<.10	<.10
08–08–93	<.10	<.10	<.10	<.10	<10	<1.0	<1.0	<.10	<.10
08–21–93	<.010	<.010	<.010	<.010	<1	.1	<.10	<.01	<.01

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Priority pollutants

Date	Para-chloro-meta cresol, total (µg/L)	2-Chloro-phenol, total (µg/L)	2,4-Dichloro-phenol, total (µg/L)	2,4,6-Tri-chloro-phenol, total (µg/L)	2,4-Di-methyl-phenol, total (µg/L)	4,6-Di-nitro-ortho-cresol, total (µg/L)	2,4-Di-nitro-phenol, total (µg/L)
Alamo Wash at Fort Lowell Road							
01–06–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0
07–08–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0
08–03–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0
08–08–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0
08–21–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0

Date	2-Nitro-phenol, total (µg/L)	4-Nitro-phenol, total (µg/L)	Penta-chloro-phenol, total (µg/L)	Phenol, (C6h-50h) total (µg/L)	Ace-naph-thene, total (µg/L)	Ace-naph-thylene, total (µg/L)	Anthra-cene, total (µg/L)	Benzidine, total (µg/L)
Alamo Wash at Fort Lowell Road								
01–06–93	<5.0	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0
07–08–93	<5.0	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0
08–03–93	<5.0	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0
08–08–93	<5.0	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0
08–21–93	<5.0	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Priority pollutants—Continued

Date	Benzo-(a)-anthracene 1,2-benzan-thracene, total (µg/L)	Benzo-(b)-fluoranthene, total (µg/L)	Benzo-(k)-fluoranthene, total (µg/L)	Benzo-(a)-pyrene, total (µg/L)	Benzogh(i) perylene,1, 12-benzo-perylene, total (µg/L)	N-butyl-benzly-phthalate, total (µg/L)	Bis (2-chloro-ethoxy) methane, total (µg/L)
Alamo Wash at Fort Lowell Road							
01–06–93	<10.0	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0
07–08–93	<10.0	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0
08–03–93	<10.0	12.0	<10.0	<10.0	<10.0	<5.0	<5.0
08–08–93	<10.0	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0
08–21–93	<10.0	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0

Date	Bis (2-chloroethyl) ether, total (µg/L)	Bis(2-chloro-isopropyl) ether, total (µg/L)	4-Bromo-phenyl phenyl ether, total (µg/L)	2-Chloro-naphthalene, total (µg/L)	4-Chloro-phenyl phenyl ether, total (µg/L)	Chrysene, total (µg/L)	1,2,5,6 Dibenz-anthracene, total (µg/L)
Alamo Wash at Fort Lowell Road							
01–06–93	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0
07–08–93	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0
08–03–93	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0
08–08–93	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0
08–21–93	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<10.0

Date	Di-n-butyl phthalate, total (µg/L)	1,2-Chloro-benzene, total (µg/L)	1,3-Di-chloro-benzene, total (µg/L)	1,4-Di-chloro-benzene, total (µg/L)	3,3-Di-chloro-benzidine, total (µg/L)	Diethyl phthalate, total (µg/L)	Di-methyl-phthalate, total (µg/L)	2,4-Di-nitro-toluene, total (µg/L)
Alamo Wash at Fort Lowell Road								
01–06–93	<5.0	<5.0	<5.0	<5.0	<20.0	<5.0	<5.0	<5.0
07–08–93	<5.0	<5.0	<5.0	<5.0	<20.0	<5.0	<5.0	<5.0
08–03–93	<5.0	<5.0	<5.0	<5.0	<20.0	<5.0	<5.0	<5.0
08–08–93	<5.0	<5.0	<5.0	<5.0	<20.0	<5.0	<5.0	<5.0
08–21–93	<5.0	<5.0	<5.0	<5.0	<20.0	<5.0	<5.0	<5.0

Table 7. Analytical results of surface-water samples, Rillito Creek basin—Continued

Priority pollutants—Continued

Date	2,6-Di-nitro-toulene, total (µg/L)	Di-n-octyl phthalate, total (µg/L)	Bis (2-ethylhexyl) phthalate, total (µg/L)	Fluorene, total (µg/L)	Fluor-anthene, total (µg/L)	Hexachloro-benzene, total (µg/L)	Hexachloro-butadiene, total (µg/L)
Alamo Wash at Fort Lowell Road							
01–06–93	<5.0	<10.0	6.0	<5.0	<5.0	<5.0	<5.0
07–08–93	<5.0	<10.0	8.0	<5.0	7.0	<5.0	<5.0
08–03–93	<5.0	<10.0	10.0	<5.0	14.0	<5.0	<5.0
08–08–93	<5.0	<10.0	7.0	<5.0	7.0	<5.0	<5.0
08–21–93	<5.0	<10.0	9.0	<5.0	<5.0	<5.0	<5.0

Date	Hexachloro-cyclopenta-diene, total (µg/L)	Hexachloro-ethane, total (µg/L)	Indeno (1,2,3-cd) pyrene, total (µg/L)	Iso-phorone, total (µg/L)	Naphthalene, total (µg/L)	Nitroben-zene, total (µg/L)	N-nitro-sodimethyl-amine, total (µg/L)
Alamo Wash at Fort Lowell Road							
01–06–93	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0
07–08–93	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0
08–03–93	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0
08–08–93	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0
08–21–93	<5.0	<5.0	<10.0	<5.0	<5.0	<5.0	<5.0

Date	N-nitrosodi-phenylamine, total (µg/L)	N-nitrosodi-n-propylamine, total (µg/L)	Phenanthrene, total (µg/L)	Pyrene, total (µg/L)	1,2,4-Trichloro-benzene, total (µg/L)	1,2-Di-phenyl-hydrazine, total (µg/L)
Alamo Wash at Fort Lowell Road						
01–06–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
07–08–93	<5.0	<5.0	<5.0	5.0	<5.0	<5.0
08–03–93	<5.0	<5.0	<5.0	11.0	<5.0	<5.0
08–08–93	<5.0	<5.0	<5.0	6.0	<5.0	<5.0
08–21–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Table 8. Analytical results of ground-water samples, Rillito Creek basin

Properties and major ions

[°C, degrees Celsius; mm, millimeter; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; NTU, nephelometric-turbidity units; µg/L, micrograms per liter; ----, dashes indicate no data; <, less than; DDD, dichlorodiphenyldichloroethane; DDE, dichlorodiphenylethylene; DDT, dichlorodiphenyltrichloroethane]

Well identification (D-13-14)	Date	Time	Water level below land surface (feet)	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Turbidity (NTU)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate dissolved field (mg/L as $CaCO_3$)
26dcb1	01–28–93	1800	14.29	127	6.6	15.0	20	47	3
	09–02–93	1330	26.15	323	6.5	18.0	18	130	59
26dcb3	01–28–93	1715	15.92	156	6.6	17.5	17	58	0
	09–02–93	1430	27.75	310	6.7	17.0	420	81	24
26dcb2	01–28–93	1600	17.15	238	6.4	17.5	17	98	5
	09–02–93	1540	29.75	232	7.1	17.0	3.8	90	16
26cbb1	01–28–93	1430	11.60	179	6.5	16.5	53	69	21
	09–02–93	0845	23.32	237	6.7	20.0	130	100	19
26cbb3	01–28–93	1300	10.81	226	6.6	20.0	6.2	94	0
	09–02–93	1000	23.45	206	6.9	19.0	390	84	20
26cbb2	01–28–93	1145	11.08	326	6.2	20.0	4.7	130	0
	09–02–93	1115	24.00	312	7.2	20.0	7.5	130	0

Well identification (D-13-14)	Date	Alkalinity, water, dissolved in field (mg/L as $CaCO_3$)	Solids, sum of constituents, dissolved (mg/L)	Solids, residue at 180°C, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium, in percent	Sodium adsorption ratio
26dcb1	01–28–93	44	82	83	16	1.6	5.4	20	0.3
	09–02–93	111	190	204	46	4.5	11	15	.4
26dcb3	01–28–93	62	97	86	20	2.0	7.2	21	.4
	09–02–93	56	122	127	28	2.7	8.8	19	.4
26dcb2	01–28–93	93	149	151	34	3.2	8.1	15	.4
	09–02–93	74	148	146	31	3.0	8.0	16	.4
26cbb1	01–28–93	48	114	115	24	2.3	5.7	15	.3
	09–02–93	84	152	156	36	3.3	6.9	12	.3
26cbb3	01–28–93	96	147	133	34	2.3	6.9	13	.3
	09–02–93	64	130	128	30	2.1	6.1	13	.3
26cbb2	01–28–93	141	213	218	46	3.4	17	22	.7
	09–02–93	134	213	190	45	3.5	16	21	.6

Table 8. Analytical results of ground-water samples, Rillito Creek basin—Continued

Properties and major ions—Continued

Well identification (D-13-14)	Date	Potassium, dissolved (mg/L as K)	Bicarbonate, dissolved (mg/L as HCO_3)	Carbonate, dissolved (mg/L as CO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
26dcb1	01–28–93	1.0	53	0	13	3.6	0.20	13
	09–02–93	1.6	91	0	36	13	.20	19
26dcb3	01–28–93	1.9	76	0	9.6	3.6	.20	12
	09–02–93	2.4	69	0	21	11	.20	7.9
26dcb2	01–28–93	1.5	113	0	19	5.6	.20	19
	09–02–93	3.9	90	0	23	8.8	.20	19
26cbb1	01–28–93	1.8	59	0	26	4.9	.20	13
	09–02–93	2.4	103	0	25	3.6	.20	17
26cbb3	01–28–93	2.9	117	0	16	3.4	.20	19
	09–02–93	1.9	78	0	19	5.4	.20	19
26cbb2	01–28–93	1.4	172	0	21	4.0	<.10	34
	09–02–93	1.3	163	0	23	3.1	.20	33

Table 8. Analytical results of ground-water samples, Rillito Creek basin—Continued

Nutrients, organic carbon, and trace elements

Well identification (D-13-14)	Date	Nitrogen, nitrite, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Phosphorus ortho, dissolved (mg/L as P)	Carbon, organic, dissolved (mg/L as C)	Carbon, organic, total (mg/L as C)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)
26dcb1	01–28–93	0.020	0.450	0.010	0.020	1.0	----	<1	25
	09–02–93	<.010	3.00	.040	.010	2.0	2.5	<1	68
26dcb3	01–28–93	.020	.600	.030	<.010	1.8	----	<1	26
	09–02–93	<.010	1.40	.040	<.010	2.9	4.7	<1	11
26dcb2	01–28–93	.020	.670	<.010	.030	2.3	----	<1	68
	09–02–93	<.010	1.40	.040	.030	2.1	2.3	<1	62
26cbb1	01–28–93	.030	1.50	.010	.010	4.4	----	<1	44
	09–02–93	<.010	1.60	.030	<.010	2.7	5.6	<1	64
26cbb3	01–28–93	.010	1.00	<.010	.030	4.2	----	<1	38
	09–02–93	<.010	1.80	.030	<.010	1.5	2.7	<1	20
26cbb2	01–28–93	.020	.290	<.010	<.010	1.6	----	<1	8
	09–02–93	<.010	1.60	.030	<.010	1.1	1.0	<1	7

Table 8. Analytical results of ground-water samples, Rillito Creek basin—Continued

Nutrients, organic carbon, and trace elements—Continued

Well identification (D-13-14)	Date	Boron, dissolved (µg/L as B)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)
26dcb1	01–28–93	<10	<1.0	<1	<10	39	<1	18	<0.1
	09–02–93	20	<1.0	<1	<10	240	<1	89	<.1
26dcb3	01–28–93	10	<1.0	2	<10	93	<1	43	<.1
	09–02–93	10	<1.0	<1	<10	35	<1	97	<.1
26dcb2	01–28–93	20	<1.0	1	<10	37	<1	71	<.1
	09–02–93	20	<1.0	<1	<10	51	<1	45	<.1
26cbb1	01–28–93	20	<1.0	<1	<10	34	<1	47	<.1
	09–02–93	30	<1.0	20	<10	27	<1	94	<.1
26cbb3	01–28–93	30	<1.0	<1	<10	30	<1	19	<.1
	09–02–93	20	<1.0	<1	<10	18	<1	39	<.1
26cbb2	01–28–93	30	<1.0	5	<10	110	<1	48	<.1
	09–02–93	20	<1.0	<1	<10	14	<1	71	<.1

Well identification (D-13-14)	Date	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Silver, dissolved (µg/L as Ag)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Selenium, dissolved (µg/L as Se)
26dcb1	01–28–93	<1	<1	<1.0	<1	73	<1
	09–02–93	<1	<1	<1.0	<1	11	<1
26dcb3	01–28–93	<1	<1	<1.0	<1	92	<1
	09–02–93	<1	<1	<1.0	<1	8	<1
26dcb2	01–28–93	<1	<1	<1.0	<1	31	<1
	09–02–93	<1	1	<1.0	<1	14	<1
26cbb1	01–28–93	2	<1	<1.0	<1	92	<1
	09–02–93	1	1	<1.0	<1	3	<1
26cbb3	01–28–93	<1	<1	<1.0	1	17	<1
	09–02–93	<1	<1	<1.0	<1	<3	<1
26cbb2	01–28–93	<1	<1	<1.0	3	16	<1
	09–02–93	<1	<1	<1.0	2	36	<1

Table 8. Analytical results of ground-water samples, Rillito Creek basin—Continued

Organochlorine pesticides

Well identification (D-13-14)	Date	Perthane, total (µg/L)	Endoaulfate, total (µg/L)	Aldrin, total (µg/L)	Chlordane, total (µg/L)	DDD, total (µg/L)	DDE, total (µg/L)	DDT, total (µg/L)	Dieldrin, total (µg/L)
26dcb1	01–28–93	<0.1	<0.010	<0.010	<0.1	<0.010	<0.010	<0.010	<0.010
	09–02–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
26dcb3	01–28–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
	09–02–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
26dcb2	01–28–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
	09–02–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
26cbb1	01–28–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
	09–02–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
26cbb3	01–28–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
	09–02–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
26cbb2	01–28–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010
	09–02–93	<.1	<.010	<.010	<.1	<.010	<.010	<.010	<.010

Well identification (D-13-14)	Date	Endrin, total (µg/L)	Heptachlor, total (µg/L)	Heptachlor epoxide, total (µg/L)	Lindane, total (µg/L)	Toxaphene, total (µg/L)	Biphenyl, polychlor, total (µg/L)	Naphthalene, polychlor total (µg/L)	Methoxychlor, total (µg/L)	Mirex, total (µg/L)
26dcb1	01–28–93	<0.010	<0.010	<0.010	<0.010	<1	<0.1	<0.01	<0.01	<0.01
	09–02–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
26dcb3	01–28–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
	09–02–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
26dcb2	01–28–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
	09–02–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
26cbb1	01–28–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
	09–02–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
26cbb3	01–28–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
	09–02–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
26cbb2	01–28–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01
	09–02–93	<.010	<.010	<.010	<.010	<1	<.1	<.01	<.01	<.01

Table 8. Analytical results of ground-water samples, Rillito Creek basin—Continued

Priority pollutants

Well identification (D-13-14)	Date	Parachlorometa cresol, total (µg/L)	2-Chlorophenol, total (µg/L)	2,4-Dichlorophenol, total (µg/L)	2,4,6-Trichlorophenol, total (µg/L)	2,4-Dimethylphenol, total (µg/L)	4,6-Dinitro-ortho-cresol, total (µg/L)	2,4-Dinitrophenol, total (µg/L)	2-Nitrophenol, total (µg/L)
26dcb1	01–28–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
	09–02–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
26dcb3	01–28–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
	09–02–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
26dcb2	01–28–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
	09–02–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
26cbb1	01–28–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
	09–02–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
26cbb3	01–28–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
	09–02–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
26cbb2	01–28–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0
	09–02–93	<30.0	<5.0	<5.0	<20.0	<5.0	<30.0	<20.0	<5.0

Well identification (D-13-14)	Date	4-Nitrophenol, total (µg/L)	Pentachlorophenol, total (µg/L)	Phenol, (C6h-50h) total (µg/L)	Acenaphthene, total (µg/L)	Acenaphthylene, total (µg/L)	Anthracene, total (µg/L)	Benzidine, total (µg/L)	Benzo-(a)-anthracene 1,2-benzanthracene, total (µg/L)
26dcb1	01–28–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
	09–02–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
26dcb3	01–28–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
	09–02–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
26dcb2	01–28–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
	09–02–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
26cbb1	01–28–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
	09–02–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
26cbb3	01–28–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
	09–02–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
26cbb2	01–28–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0
	09–02–93	<30.0	<30.0	<5.0	<5.0	<5.0	<5.0	<40.0	<10.0

Table 8. Analytical results of ground-water samples, Rillito Creek basin—Continued

Priority pollutants—Continued

Well identification (D-13-14)	Date	Benzo-(b)-fluor-snthene, total (µg/L)	Benzo -(k)-fluor-anthene, total (µg/L)	Benzo -(a)-pyrene, total (µg/L)	Benzogh(i) perylene,1, 12-benzo-perylene, total (µg/L)	N-butyl-benzly-phthal ate, total (µg/L)	Bis (2-chloro-ethoxy) methane, total (µg/L)	Bis (2-chloro-ethyl) ether, total (µg/L)	Bis(2-chloro-iso-propyl) ether, total (µg/L)
26dcb1	01–28–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
26dcb3	01–28–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
26dcb2	01–28–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
26cbb1	01–28–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
26cbb3	01–28–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
26cbb2	01–28–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<10.0	<10.0	<10.0	<10.0	<5.0	<5.0	<5.0	<5.0

Well identification (D-13-14)	Date	4-Bromo-phenyl phenyl ether, total (µg/L)	2-Chloro-naph-tha-lene, total (µg/L)	4-Chloro-phenyl phenyl ether, total (µg/L)	Chry-sene, total (µg/L)	1,2,5,6 Dibenz-anthra-cene, total (µg/L)	Di-n-butyl phthal-ate, total (µg/L)	1,2-Chloro-benzene, total (µg/L)	1,3-Di-chloro-benzene, total (µg/L)
26dcb1	01–28–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
26dcb3	01–28–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
26dcb2	01–28–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
26cbb1	01–28–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
26cbb3	01–28–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
26cbb2	01–28–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<10.0	<10.0	<5.0	<5.0	<5.0

Table 8. Analytical results of ground-water samples, Rillito Creek basin—Continued

Priority pollutants—Continued

Well identification (D-13-14)	Date	1,4-Dichlorobenzene, total (µg/L)	3,3-Dichlorobenzidine, total (µg/L)	Diethyl phthalate, total (µg/L)	Dimethylphthalate, total (µg/L)	2,4-Dinitrotoluene, total (µg/L)	2,6-Dinitrotoluene, total (µg/L)	Di-n-octyl phthalate, total (µg/L)	Bis (2-ethylhexyl) phthalate, total (µg/L)
26dcb1	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26dcb3	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26dcb2	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26cbb1	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26cbb3	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26cbb2	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0

Well identification (D-13-14)	Date	Fluorene, total (µg/L)	Fluoranthene, total (µg/L)	Hexachlorobenzene, total (µg/L)	Hexachlorobutadiene, total (µg/L)	Hexachlorocyclopentadiene, total (µg/L)	Hexachloroethane, total (µg/L)	Indeno (1,2,3-cd) pyrene, total (µg/L)	Isophorone, total (µg/L)
26dcb1	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26dcb3	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26dcb2	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26cbb1	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26cbb3	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
26cbb2	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10.0	<5.0

Table 8. Analytical results of ground-water samples, Rillito Creek basin—Continued

Priority pollutants—Continued

Well identification (D-13-14)	Date	Naphthalene, total (µg/L)	Nitrobenzene, total (µg/L)	N-nitrosodimethylamine, total (µg/L)	N-nitrosodiphenylamine, total (µg/L)	N-nitrosodi-n-propylamine, total (µg/L)	Phenanthrene, total (µg/L)	Pyrene, total (µg/L)	1,2,4-Trichlorobenzene, total (µg/L)	1,2-Diphenylhydrazine, total (µg/L)
26dcb1	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
26dcb3	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
26dcb2	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
26cbb1	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
26cbb3	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
26cbb2	01–28–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
	09–02–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Table 9. Particle-size distribution of bottom-sediment samples, Rillito Creek basin

Date	Percent finer than indicated particle size, in millimeters						Date	Percent finer than indicated particle size, in millimeters					
	0.0625	0.125	0.250	0.500	1.00	2.00		0.0625	0.125	0.250	0.500	1.00	2.00
Alamo Wash at Fort Lowell Road							Rillito Creek at Swan Road						
08–22–93	0.1	0.3	1.5	16.4	53.1	90.7	08–09–93	0.6	0.7	2.4	16.7	49.2	84.0
08–31–93	.2	.7	3.3	19.8	56.2	89.9	08–23–93	12.7	15.3	19.6	31.0	55.0	85.7
							08–31–93	1.1	1.2	3.8	25.6	54.7	82.4

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin

Nutrients, organic carbon, and inorganic plus organic carbon

[mg/kg, milligram per kilogram; g/kg, gram per kilogram; µg/g, micrograms per gram; <, less than; ----, dashes indicate no data; µg/kg, micrograms per kilogram; pCi/g, picocuries per gram; DDD, dichlorodiphenyldichloroethane; DDE, dichlorodiphenylethylene; DDT, dichlorodiphenyltrichloroethane]

Date	Time	Nitrogen, NO_2+NO_3, total (mg/kg as N)	Nitrogen, NH_4, total (mg/kg as N)	Nitrogen, NH_4 plus organic, total (mg/kg as N)	Phosphorus, total (mg/kg as P)	Carbon, inorganic, total (g/kg as C)	Carbon, inorganic plus organic, total (g/kg as C)
Alamo Wash at Fort Lowell Road							
08-22-93	0930	<2.0	2.0	60	100	0.6	2.4
08-31-93	1500	9.0	.8	50	220	1.1	3.3
Rillito Creek at Swan Road							
01-26-93	1200	18	3.6	----	40	----	.7
03-11-93	1200	7.0	35	80	120	----	1.8
08-09-93	1130	15	1.5	130	92	.4	1.9
08-23-93	1000	37	3.0	500	260	6.0	12
08-31-93	1600	9.0	1.7	90	360	<.1	2.0

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Trace elements and radionuclides

Date	Aluminum, recoverable (µg/g as Al)	Arsenic, recoverable (µg/g as As)	Barium, recoverable (µg/g as Ba)	Beryllium, recoverable (µg/g as Be)	Bismuth, recoverable (µg/g as Bi)	Cadmium, recoverable (µg/g as Cd)	Calcium, recoverable (µg/g as Ca)
Alamo Wash at Fort Lowell Road							
08-22-93	57,000	<10	660	1	<10	<2	25,000
08-31-93	66,000	<10	700	2	<10	<2	31,000
Rillito Creek at Swan Road							
01-26-93	70,000	<10	720	2	<10	<2	25,000
03-11-93	74,000	<10	770	2	<10	<2	28,000
08-09-93	67,000	<10	730	2	<10	<2	33,000
08-23-93	72,000	11	710	2	<10	<2	55,000
08-31-93	79,000	<10	740	2	<10	<2	20,000

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Trace elements and radionuclides—Continued

Date	Cerium, recoverable (µg/g as Ce)	Chromium, recoverable (µg/g as Cr)	Cobalt, recoverable (µg/g as Co)	Copper, recoverable (µg/g as Cu)	Europium, recoverable (µg/g as Eu)	Gallium, recoverable (µg/g as Ga)	Holmium, recoverable (µg/g as Ho)
Alamo Wash at Fort Lowell Road							
08–22–93	150	36	8	23	<2	13	<4
08–31–93	110	25	7	30	<2	15	<4
Rillito Creek at Swan Road							
01–26–93	110	12	5	12	<2	16	<4
03–11–93	160	41	7	22	<2	18	<4
08–09–93	68	19	6	24	<2	14	<4
08–23–93	75	27	9	35	<2	15	<4
08–31–93	160	26	8	28	<2	21	<4

Date	Iron, recoverable (µg/g as Fe)	Lanthanum, recoverable (µg/g as La)	Lead, recoverable (µg/g as Pb)	Lithium, recoverable (µg/g as Li)	Magnesium, recoverable (µg/g as Mg)	Manganese, recoverable (µg/g as Mn)	Molybdenum, recoverable (µg/g as Mo)	Neodymium, recoverable (µg/g as Nd)
Alamo Wash at Fort Lowell Road								
08–22–93	74,000	80	47	18	3,800	1,700	<2	66
08–31–93	27,000	56	47	25	6,100	620	<2	46
Rillito Creek at Swan Road								
01–26–93	20,000	58	21	19	3,700	690	<2	49
03–11–93	30,000	87	26	22	5,400	680	<2	75
08–09–93	16,000	38	40	25	5,600	420	<2	31
08–23–93	25,000	40	30	48	10,000	730	<2	35
08–31–93	39,000	82	26	24	5,100	1,200	<2	73

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Trace elements and radionuclides—Continued

Date	Nickel, recoverable (µg/g as Ni)	Niobium, recoverable (µg/g as Nb)	Phosphorus, recoverable (µg/g as P)	Potassium, recoverable (µg/g as K)	Scandium, recoverable (µg/g as Sc)	Silver, recoverable (µg/g as Ag)	Sodium, recoverable (µg/g as Na)
			Alamo Wash at Fort Lowell Road				
08–22–93	9	24	600	24,000	7	<4	18,000
08–31–93	11	11	600	26,000	6	<4	19,000
			Rillito Creek at Swan Road				
01–26–93	6	9	800	24,000	6	<4	25,000
03–11–93	15	11	800	25,000	8	<4	23,000
08–09–93	9	10	600	26,000	5	<4	21,000
08–23–93	13	14	700	25,000	8	<4	14,000
08–31–93	11	15	800	27,000	10	<4	24,000

Date	Strontium, recoverable (µg/g as Sr)	Tantalum, recoverable (µg/g as Ta)	Thorium, recoverable (µg/g as Th)	Tin, recoverable (µg/g as Sn)	Titanium, recoverable (µg/g as Ti)	Uranium, recoverable (µg/g as U)	Vanadium, recoverable (µg/g as V)
			Alamo Wash at Fort Lowell Road				
08–22–93	230	<40	32	5	6,100	<100	150
08–31–93	260	<40	22	<5	3,100	<100	58
			Rillito Creek at Swan Road				
01–26–93	280	<40	15	<5	2,800	<100	39
03–11–93	270	<40	30	<5	3,400	<100	61
08–09–93	270	<40	10	<5	2,100	<100	36
08–23–93	280	<40	12	<5	3,000	<100	57
08–31–93	260	<40	14	<5	3,800	<100	63

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Trace elements and radionuclides—Continued

Date	Yttrium, recoverable (µg/g as Y)	Ytterbium, recoverable (µg/g as Yb)	Zinc, recoverable (µg/g as Zn)	Gross alpha (µg/g as U-Nat)	Gross beta, (pCi/g as Sr-90/Y-90)	Gross alpha (pCi/g as Th-230)	Gross beta (pCi/g as Cs-137)
Alamo Wash at Fort Lowell Road							
08–22–93	40	5	78	3.2	26.7	2.0	34.4
08–31–93	26	2	99	17	31.7	17.6	42.6
Rillito Creek at Swan Road							
01–26–93	32	3	35	.1	25.2	<6	32.5
03–11–93	37	3	58	2.6	269	<6	364
08–09–93	20	2	74	3.5	24.8	<6	33.4
08–23–93	23	2	82	12.5	29.2	9.7	37.8
08–31–93	41	4	65	11.9	44.6	11	58.9

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Organochlorine pesticides

Date	Perthane, total (µg/kg)	Endosulfate, total (µg/kg)	Aldrin, total (µg/kg)	Chlordane, total (µg/kg)	DDD, total (µg/kg)	DDE, total (µg/kg)	DDT, total (µg/kg)	Diel-drin, total (µg/kg)
Alamo Wash at Fort Lowell Road								
08–22–93	<1.00	<0.1	<0.1	13	0.6	0.4	0.2	1.2
08–31–93	<1.00	<3.0	<.1	11	.9	.6	.6	2.4
Rillito Creek at Swan Road								
01–26–93	<1.00	<.1	<.1	1.0	<.1	<.1	<.1	.1
03–11–93	<1.00	<.1	<.1	1.0	<.1	<.1	<.1	.4
08–09–93	<1.00	<.1	<.1	8.0	.4	.3	.1	.8
08–23–93	<1.00	<.1	<.1	20	1.0	.9	.4	1.7
08–31–93	<1.00	<.2	<.1	1.0	.1	.1	.1	.2

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Organochlorine pesticides—Continued

Date	Endrin, total (μg/kg)	Hepta-chlor, total (μg/kg)	Hepta-chlor epoxide, total (μg/kg)	Lindane, total (μg/kg)	Toxa-phene, total (μg/kg)	Biphenyl, polychlor, total (μg/kg)	Naph-thalene, polychlor, total (μg/kg)	Meth-oxy-chlor, total (μg/kg)	Mirex, total (μg/kg)
Alamo Wash at Fort Lowell Road									
08–22–93	<0.1	<0.1	<0.1	<0.1	<10	2	<1.0	<0.1	<0.1
08–31–93	<.1	<.1	.1	<.1	<10	<1	<1.0	<6.0	<.1
Rillito Creek at Swan Road									
01–26–93	<.1	<.1	<.1	<.1	<10	<1	<1.0	<.1	<.1
03–11–93	<.1	<.1	<.1	<.1	<10	<1	<1.0	<.1	<.1
08–09–93	<.1	<.1	<.1	<.1	<10	2	<1.0	<1.0	<.1
08–23–93	<.1	<.1	<.1	<.1	<10	2	<1.0	<.1	<.1
08–31–93	<.1	<.1	<.1	<.1	<10	<1	<1.0	<1.0	<.1

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Priority pollutants

Date	Para-chloro-meta cresol, total (μg/kg)	2-Chloro-phenol, total (μg/kg)	2,4-Di-chloro-phenol, total (μg/kg)	2,4-Di-phenol, total (μg/kg)	4,6-Di-nitro-ortho-cresol, total (μg/kg)	2,4-Di-nitro-phenol, total (μg/kg)	2-Nitro-phenol total (μg/kg)	4-Nitro-phenol total (μg/kg)
Alamo Wash at Fort Lowell Road								
08–22–93	<600	<200	<200	<200	<600	<600	<200	<600
08–31–93	<600	<200	<200	<200	<600	<600	<200	<600
Rillito Creek at Swan Road								
01–26–93	<600	<200	<200	<200	<600	<600	<200	<600
03–11–93	<600	<200	<200	<200	<600	<600	<200	<600
08–09–93	<600	<200	<200	<200	<600	<600	<200	<600
08–23–93	<600	<200	<200	<200	<600	<600	<200	<600
08–31–93	<600	<200	<200	<200	<600	<600	<200	<600

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Priority pollutants—Continued

Date	Phenol, (C6H5OH) total (µg/kg)	2,4,6-Tri-chloro-phenol total (µg/kg)	Ace-naph-thene, total (µg/kg)	Ace-naph-thylene, total (µg/kg)	Anthra-cene, total (µg/kg)	Benzo-(a)-anthracene 1,2-benz-anthracene, total (µg/kg)	Benzo-(b)-fluor-anthene, total (µg/kg)	Benzo-(k)-fluor-anthene, total (µg/kg)
Alamo Wash at Fort Lowell Road								
08–22–93	<200	<600	<200	<200	<200	<400	<400	<400
08–31–93	<200	<600	<200	<200	<200	<400	<400	<400
Rillito Creek at Swan Road								
01–26–93	<200	<600	<200	<200	<200	<400	<400	<400
03–11–93	<200	<600	<200	<200	<200	<400	<400	<400
08–09–93	<200	<600	<200	<200	<200	<400	<400	<400
08–23–93	<200	<600	<200	<200	<200	<400	<400	<400
08–31–93	<200	<600	<200	<200	<200	<400	<400	<400

Date	Benzo-(a)-pyrene, total (µg/kg)	Benzogh(i) perylene,1, 12-benzo-perylene, total (µg/kg)	N-butyl-benzly-phtha-late, total (µg/kg)	Bis (2-chloro-ethoxy) methane, total (µg/kg)	Bis (2-chloro-ethyl) ether, total (µg/kg)	4-Bromo-phenyl phenyl ether, total (µg/kg)	2-Chloro-naph-thalene, total (µg/kg)	4-Chloro-phenyl phenyl ether, total (µg/kg)
Alamo Wash at Fort Lowell Road								
08–22–93	<400	<400	<200	<200	<200	<200	<200	<200
08–31–93	<400	<400	<200	<200	<200	<200	<200	<200
Rillito Creek at Swan Road								
01–26–93	<400	<400	<200	<200	<200	<200	<200	<200
03–11–93	<400	<400	<200	<200	<200	<200	<200	<200
08–09–93	<400	<400	<200	<200	<200	<200	<200	<200
08–23–93	<400	<400	<200	<200	<200	<200	<200	<200
08–31–93	<400	<400	<200	<200	<200	<200	<200	<200

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Priority pollutants—Continued

Date	Chrysene, total (μg/kg)	1,2,5,6 Dibenz-anthra-cene, total (μg/kg)	Di-n-butyl phthalate, total (μg/kg)	1,2-Di-chloro-benzene, total (μg/kg)	1,3-Di-chloro-ben-zene, total (μg/kg)	1,4-Di-chloro-benzene, total (μg/kg)	Di-ethyl phtha-late, total (μg/kg)
Alamo Wash at Fort Lowell Road							
08–22–93	<400	<400	<200	<200	<200	<200	<200
08–31–93	<400	<400	<200	<200	<200	<200	<200
Rillito Creek at Swan Road							
01–26–93	<400	<400	<200	<200	<200	<200	<200
03–11–93	<400	<400	<200	<200	<200	<200	<200
08–09–93	<400	<400	<200	<200	<200	<200	<200
08–23–93	<400	<400	<200	<200	<200	<200	<200
08–31–93	<400	<400	<200	<200	<200	<200	<200

Date	2,4-Di-nitro-toluene, total (μg/kg)	2,6-Di-nitro-toluene, total (μg/kg)	Di-n-octyl phthalate, total (μg/kg)	Bis (2-ethyl-hexyl) phthalate, total (μg/kg)	Fluorene, total (μg/kg)	Fluor-anthene, total (μg/kg)	Hexachloro-benzene, total (μg/kg)
Alamo Wash at Fort Lowell Road							
08–22–93	<200	<200	<400	<200	<200	<200	<200
08–31–93	<200	<200	<400	<200	<200	380	<200
Rillito Creek at Swan Road							
01–26–93	<200	<200	<400	<200	<200	<200	<200
03–11–93	<200	<200	<400	<200	<200	<200	<200
08–09–93	<200	<200	<400	<200	<200	<200	<200
08–23–93	<200	<200	<400	<200	<200	240	<200
08–31–93	<200	<200	<400	<200	<200	<200	<200

Table 10. Analytical results of bottom-sediment samples, Rillito Creek basin—Continued

Priority pollutants—Continued

Date	Hexachloro-butadiene, total (µg/kg)	Hexachloro-cyclopenta-diene, total (µg/kg)	Hexachloro-ethane, total (µg/kg)	Indeno (1,2,3-cd) pyrene, total (µg/kg)	Iso-phorone, total (µg/kg)	Naphthalene, total (µg/kg)	Nitroben-zene, total (µg/kg)
Alamo Wash at Fort Lowell Road							
08–22–93	<200	<200	<200	<400	<200	<200	<200
08–31–93	<200	<200	<200	<400	<200	<200	<200
Rillito Creek at Swan Road							
01–26–93	<200	<200	<200	<400	<200	<200	<200
03–11–93	<200	<200	<200	<400	<200	<200	<200
08–09–93	<200	<200	<200	<400	<200	<200	<200
08–23–93	<200	<200	<200	<400	<200	<200	<200
08–31–93	<200	<200	<200	<400	<200	<200	<200

Date	N-nitro-sodimethyl-amine, total (µg/kg)	N-nitrosodi-phenylamine, total (µg/kg)	N-nitrosodi-n-propylamine, total (µg/kg)	Phenanthrene, total (µg/kg)	Pyrene, total (µg/kg)	1,2,4-Trichloro-benzene, total (µg/kg)
Alamo Wash at Fort Lowell Road						
08–22–93	<200	<200	<200	<200	<200	<200
08–31–93	<200	<200	<200	<200	330	<200
Rillito Creek at Swan Road						
01–26–93	<200	<200	<200	<200	<200	<200
03–11–93	<200	<200	<200	<200	<200	<200
08–09–93	<200	<200	<200	<200	<200	<200
08–23–93	<200	<200	<200	<200	200	<200
08–31–93	<200	<200	<200	<200	<200	<200