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Flow and Water-Quality Characteristics of Perennial Reaches in Pajarito Canyon and Cañon de Valle, Los Alamos National Laboratory

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FOREWORD

The mission of the New Mexico Environment Department DOE Oversight Bureau is to assure that activities at DOE facilities are protective of the public health and safety and the environment. The Bureau's activities are funded through a grant from the U.S. Department of Energy in accordance with the provisions set forth in the *Agreement-in-Principle between the State of New Mexico and the U.S. Department of Energy*. One of the primary objectives of the agreement is the development and implementation of a program of independent monitoring and oversight.

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ABSTRACT

Surface-water flow and quality were investigated in selected reaches of Pajarito Canyon and Cañon de Valle, which are located along the western edge of the Los Alamos National Laboratory. From 1995 to 1997, streamflow in these canyons was periodically measured, field water-quality parameters were obtained, and water samples were analyzed for chemical and radiological constituents.

Flow-measurement data for the study reaches in both canyons indicate that perennial flow exists and varies seasonally in response to precipitation. Flow rates ranged from 0.049 to 0.395 cfs in Pajarito Canyon and from 0.023 to 0.179 cfs in Cañon de Valle. The majority of flow is apparently supported by several springs that discharge from the upper units of the Bandelier Tuff. Samples collected in Pajarito Canyon did not show evidence of man-made or anthropogenic constituents. Water samples collected in Cañon de Valle contained high-explosive compounds, as well as levels of barium, manganese, and nitrate plus nitrite as nitrogen that are elevated relative to those for water in Pajarito Canyon, a minimally impacted stream. In Cañon de Valle, the concentrations of dissolved barium and the high-explosive compound RDX exceeded the Environmental Protection Agency's Region IX screening action levels for water.

The study shows that baseflow from perched saturated zones in the upper Bandelier Tuff supplies sufficient water to sustain perennial flow in two canyon reaches along the western portion of the Laboratory and that Laboratory-derived contaminants are present in Cañon de Valle surface water.

INTRODUCTION

Los Alamos National Laboratory (LANL) is located west of the Rio Grande in Los Alamos County, 40 mi northwest of Santa Fe, New Mexico. Since the late 1940s, several Technical Areas (TAs) in the western portion of LANL have released both hazardous and radioactive materials to some of the major drainage features of the Pajarito Plateau. Therefore, the New Mexico Environment Department's (NMED) Department of Energy Oversight Bureau (DOE OB) expanded its oversight activities into that area, particularly upper Pajarito Canyon and Cañon de Valle (Figure 1).

Perennial (continuously flowing) reaches at LANL have previously been described in Pajarito, Water, Ancho and Chaquehui Canyons (December 6, 1996, draft of LANL's Hydrogeologic Workplan). Recent work by NMED DOE OB documents the existence of a previously unrecognized perennial reach in Cañon de Valle, and shows that the reach in Pajarito Canyon is longer than previously reported. More specifically, several reconnaissance excursions in late 1994 in these canyons revealed an abundance of surface water. Consequently, in early 1995, DOE OB

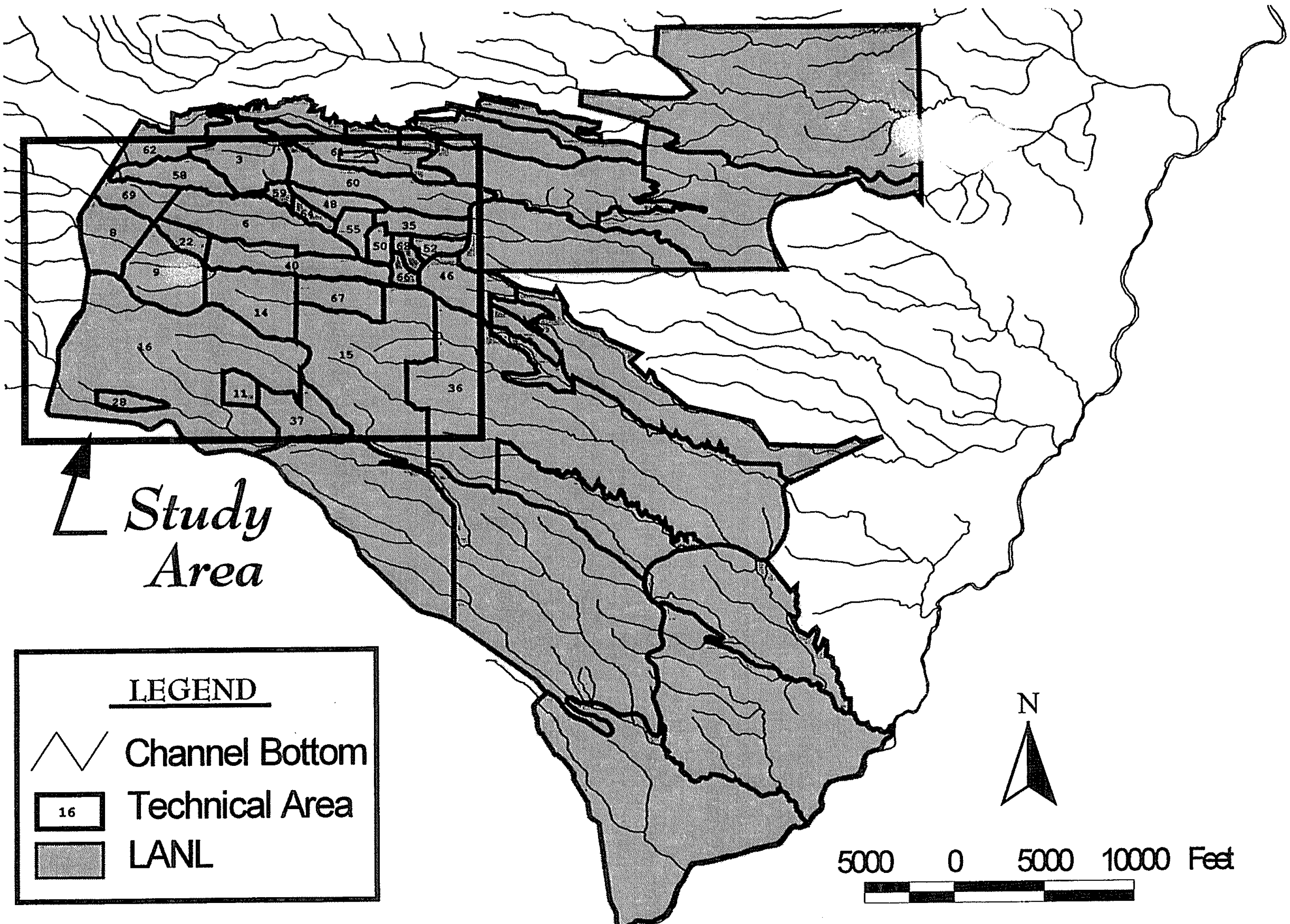

Figure 1. Generalized location map showing Los Alamos National Laboratory, technical areas, and study area.

personnel began collecting discharge data to determine whether perennial conditions exist in these western reaches; field observations and periodic-flow measurements were made from 1994 to early 1997. Surface-water samples were collected in both reaches in early 1997 to assess water quality.

The purpose of this report is to present the findings of this study. Results enhance the conceptual hydrogeologic model for these canyon systems. As noted by Stone (1996),

> "understanding the movement of perched water at LANL is important not only for conceptualizing the hydrogeologic system, but also for predicting the fate of water-borne contaminants. Such contaminants may reach the perched waters by recharge from contaminated surface waters, especially in the canyons. Leakage from perched-water zones may permit contamination of the regional aquifer".

These baseline data will also provide significant information for ecological and human health risk analyses/investigations.

GENERAL SETTING OF THE STUDY AREA

The study area is located within the boundaries of TAs 9, 16 and 22, in the western portion of LANL. This investigation was restricted to the upper reaches of Pajarito Canyon and Cañon de Valle (Figure 1). Within this area of the Laboratory, facility-operational areas are restricted to the mesa tops, and contain buildings, roads, utilities, storm-drains, active and inactive outfalls (e.g., NPDES outfalls), waste-disposal areas, etc.

Vegetation within this region of the Pajarito Plateau varies from the mesa tops to the canyon bottoms. Mesa-top vegetation is dominated by ponderosa pine, while the canyon bottoms contain a variety of flora, including ponderosa pine, white fir, Douglas fir, Gambel Oak, and aspen. A recent investigation by Ford-Schmid (1996) indicated that Pajarito Canyon at the study area has optimum habitat (consisting of gravel/rubble riffles, plunge pools, stable-vegetated undercut banks, healthy riparian vegetation) and a diverse, well-balanced, moderately tolerant, benthic macroinvertebrate community.

Based on LANL's historical climatological data, collected from 1961 through 1990, the average low and high temperatures in July were 13°C and 27°C respectively; the average low and high temperatures in January were -8° and 4°C respectively (Cross, 1996).

Precipitation data within the region have been collected by LANL at TA-16 (Figure 2) from January 1, 1977 to the present (with the exception of 1978). The average yearly rainfall from 1979 through 1997 was about 21 inches with the most occurring in August and the least occurring in January. Total rainfall amounts for 1994, 1995 and 1996, were 24.7, 23.3 and 24.0 inches respectively, with an average monthly rainfall of approximately 2 inches. As shown on Figure 3, the driest October-to-May period on record for the TA-16 station is that for October 1995 through May 1996. The

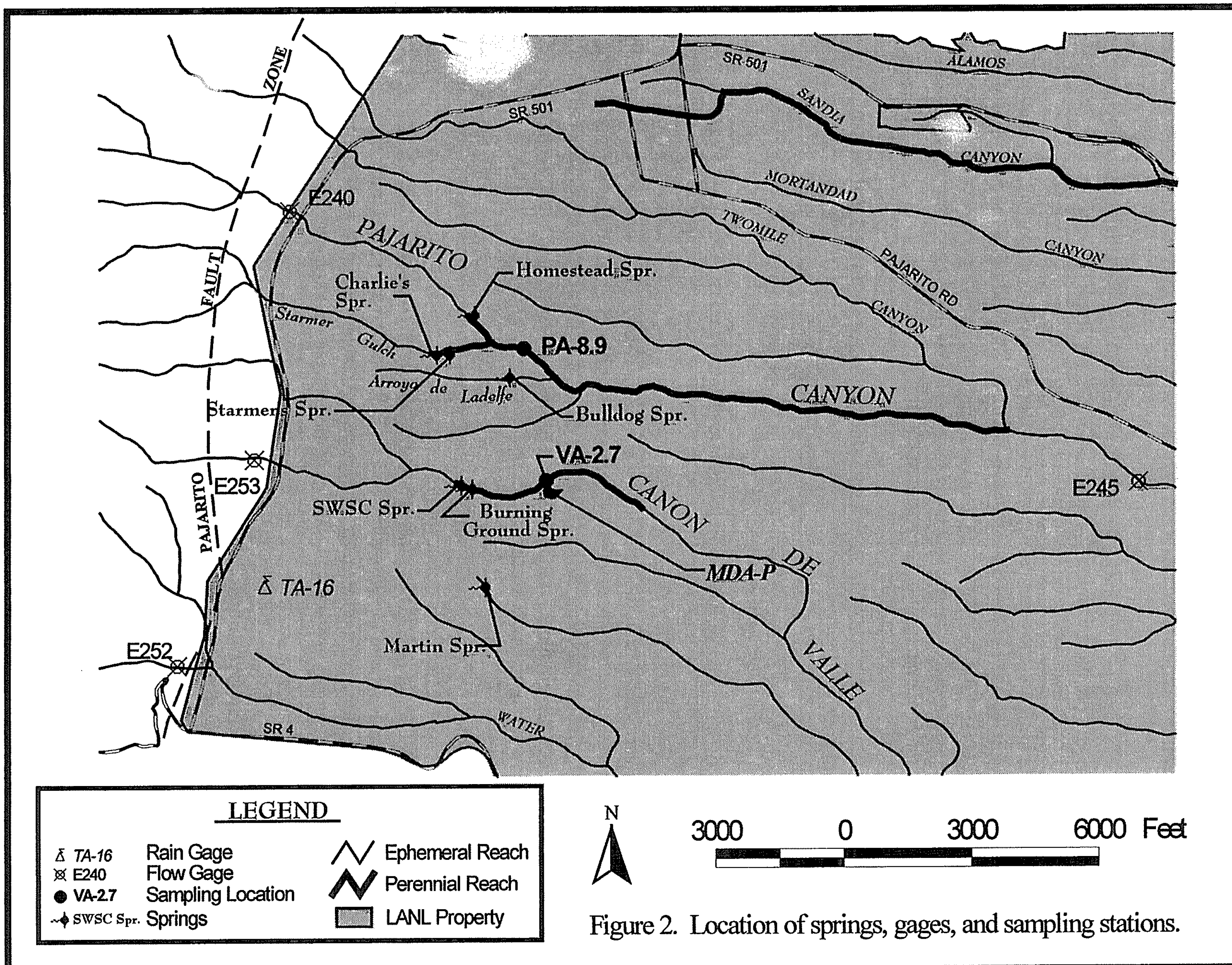

Figure 2. Location of springs, gages, and sampling stations.

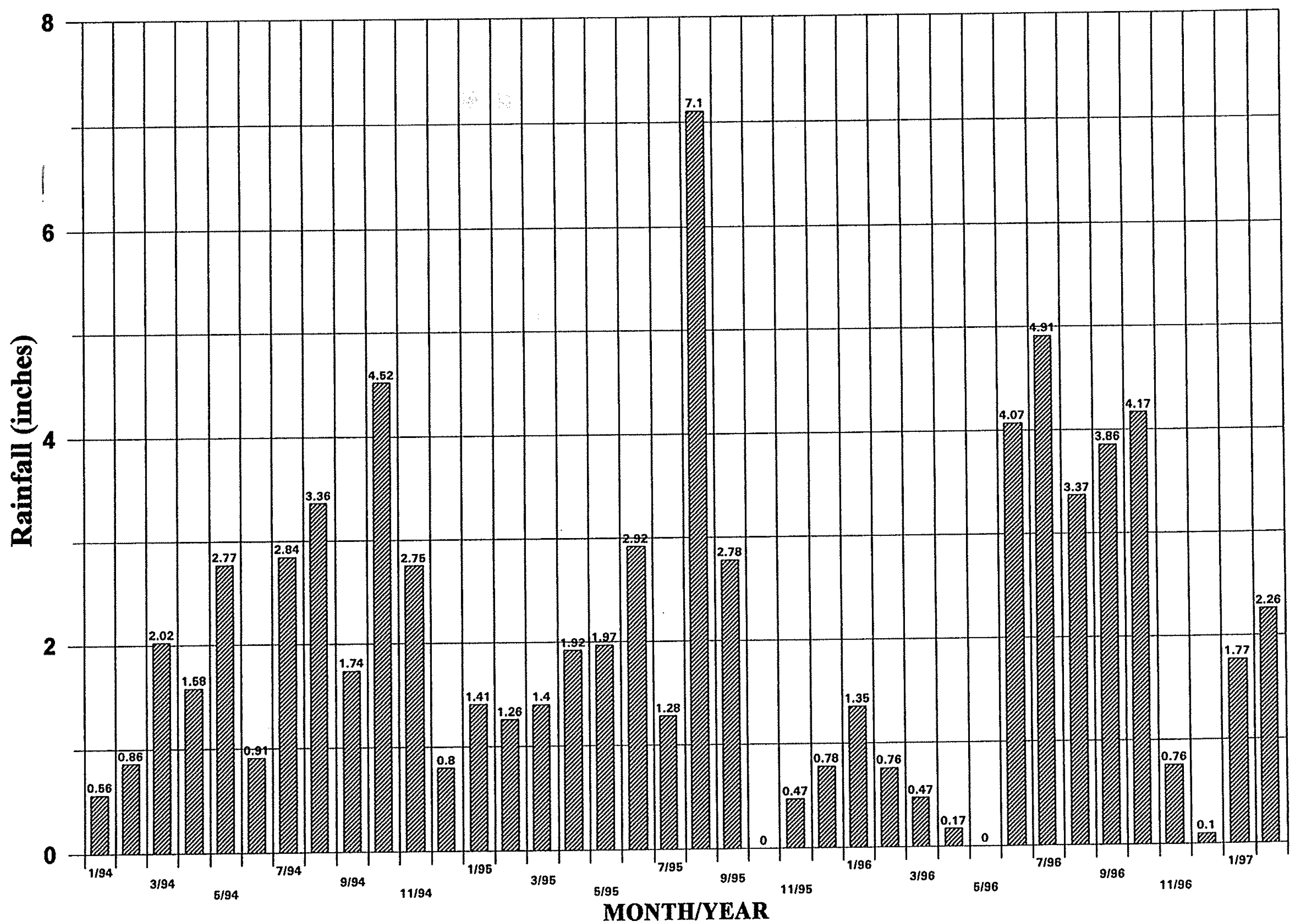

Figure 3. Monthly precipitation for the study area from January 1994 through February 1997 based on LANL's Technical Area 16 Meteorological Station (Source: LANL, ESH-17).

total precipitation for this period was approximately 4 inches, or an average of 0.5 inches per month. This is about one-third of the average (1.7 inches) for the October-to-May period between 1979 through 1997. Precipitation data were obtained by DOE OB via LANL's Environment, Safety and Health Division's Air Quality Group Home Page on the Internet.

GEOLOGY

Geologically, LANL sits on the Pajarito Plateau, an area of deeply dissected Quaternary-aged volcanic deposits and Tertiary fill of the Espanola Basin. The volcanics belong to the Bandelier Tuff, largely rhyolitic ash flows and pumice falls that were derived from the Valles Caldera in the Jemez Mountains to the west (Purtymun, 1984). The basin fill is represented by the Puye Formation (fanglomerate, lake clays, basalt flows, ash and river gravels) and the Tesuque Formation (mostly poorly consolidated sand and gravel).

The canyon bottom within the study area is covered by a thin deposit of Quaternary alluvium. The average alluvium thickness is currently unknown, but observations indicate that it probably ranges from about 2 ft to approximately 10 ft. A recent study by Broxton et al. (1996) showed that the hillsides in the portion of Cañon de Valle investigated are composed of units 3 and 4 of the Tshirege Member of the Bandelier Tuff; the same units form the canyon walls near the reaches studied in upper Pajarito Canyon. These tuff units are moderately welded, and show abundant vertical and horizontal fractures as well as abundant parting surfaces between beds.

HYDROLOGY

The Pajarito Plateau is drained by perennial, ephemeral and intermittent streams that flow easterly to the Rio Grande, lying some 1,450 ft below the plateau. Seepage from these streams and mesa tops supports perched saturated zones within the Bandelier Tuff, canyon-bottom alluvium, as well as basalts and fine grained sedimentary units in the Puye Formation. The regional water table lies at considerable depth in units making up the so-called 'main aquifer" (Tesuque Formation and lower part of the overlying and intertonguing Tschicoma Formation in the western parts of the plateau; Tesuque Formation and overlying Puye Formation in the central and eastern parts of the plateau). The water supply for LANL and the town of Los Alamos is derived from this source.

Pajarito Canyon and Cañon de Valle are incised into the Pajarito Plateau, draining from west to east (Figure 1). Pajarito Canyon extends from the Sierra de los Valles to the Rio Grande. Cañon de Valle also heads in the Sierra de los Valles and flows into Water Canyon approximately 4 mi east of the western Laboratory boundary. The surface of adjacent mesas rises to the west. Data-collection points in Pajarito Canyon and Cañon de Valle are about 150 ft below the surrounding mesa tops and are located within the canyon bottom at approximate elevations of 7,360 ft and 7,350 ft respectively. Active channels are approximately 2 to 5 ft wide and 1 to 3 ft deep. Waterfalls are present in areas where resilient bedrock crops out and/or where large boulders have dammed the active channel. Surface-water flow within these reaches is supplied by regional and localized snowmelt, storm-water runoff, as well as perennial and ephemeral springs located near ($\approx$0.5 mi) the study areas. Runoff contributions from canyon walls or hillsides are restricted to localized storm water and snowmelt.

Several springs located west and east of data-collection station PA-8.9 contribute to surface-water flow in Pajarito Canyon (Figure 2). These source springs are located in Pajarito Canyon and two southern tributaries, informally named Starmer Gulch and Arroyo De Ladelfe. Starmer's Spring, which is located in Starmer Gulch, supplies the majority of flow observed at PA-8.9. Homestead Spring, located in Pajarito Canyon about 0.25 mi west of the confluence with Starmer Gulch, supplies a smaller portion of the total flow observed in this reach. Observations made throughout the study period show that flow is ephemeral west (upstream) of Starmer's Spring. Flow upstream of Homestead Spring is ephemeral to approximately 0.5 mi west of State Route 501 (SR 501). It is not certain how far east of PA-8.9 flow extends, however continuous flow to at least the confluence with Twomile Canyon has been documented (Figure 2; Ford-Schmid, 1996). Flow east of PA-8.9 is recorded at LANL's gaging station E245 (Figure 2), and average daily discharge rates are shown in Figure 4.

Another potentially perennial reach appears to be present in Pajarito Canyon west of LANL. This reach is located approximately 0.5 mi west of SR 501 and is supported by PC Spring. LANL's gaging station E240, which is located in Pajarito Canyon at SR 501, recorded 239 and 123 days of recorded flow during the 1995 and 1996 Water Years respectively (Figure 4; Shaull et al., 1996a, b). Surface-water flow in this reach is relatively constant to a point about 0.25 mi west of SR 501, where high transmission loss or infiltration appears to be occurring. This area of infiltration coincides within the intersection of Pajarito Canyon and the Pajarito Fault zone (Figure 2). This zone may be acting as a ground-water-recharge conduit. Further study concerning this possibility is warranted.

Perennial flow in Cañon de Valle is observed to be supplied predominantly by springs located west (upstream) of the study area (VA-2.7). Multiple field observations made between 1994 and 1997 showed that flow extends 1.5 to 2.0 mi east of the source springs (Figure 2). Surface-water flow west of the source springs to about 1 mi west of SR 501 is ephemeral; no-flow conditions were recorded during the 1995 and 1996 Water Years at LANL's gaging station E253, which is located in Cañon de Valle at SR 501 at the western boundary of the Laboratory (Shaull et al., 1996a, b). Another perennial reach may also exist in Cañon de Valle approximately 1 mi west of E253 (SR 501); continuous flow in this reach was observed during this investigation. Further work is needed to determine if this reach is perennial.

The U.S. Fish and Wildlife Service studied some of the same stream segments during this period using Hydrolab water-quality monitors (Russ MacRae, U.S. Fish and Wildlife Service, personal communication):

> "...units were placed in ... Pajarito Canyon (at the confluence of Pajarito and Starmer's, below TA-22), and [Cañon] de Valle (below MDA-P and the Burning Ground). [These] were placed in small pools. Date, time, temperature, pH, [specific conductance], and dissolved oxygen were measured hourly from 12/13/96 through 11/17/97. There are a few data gaps in the first few months of operation due to technical and/or access problems, and

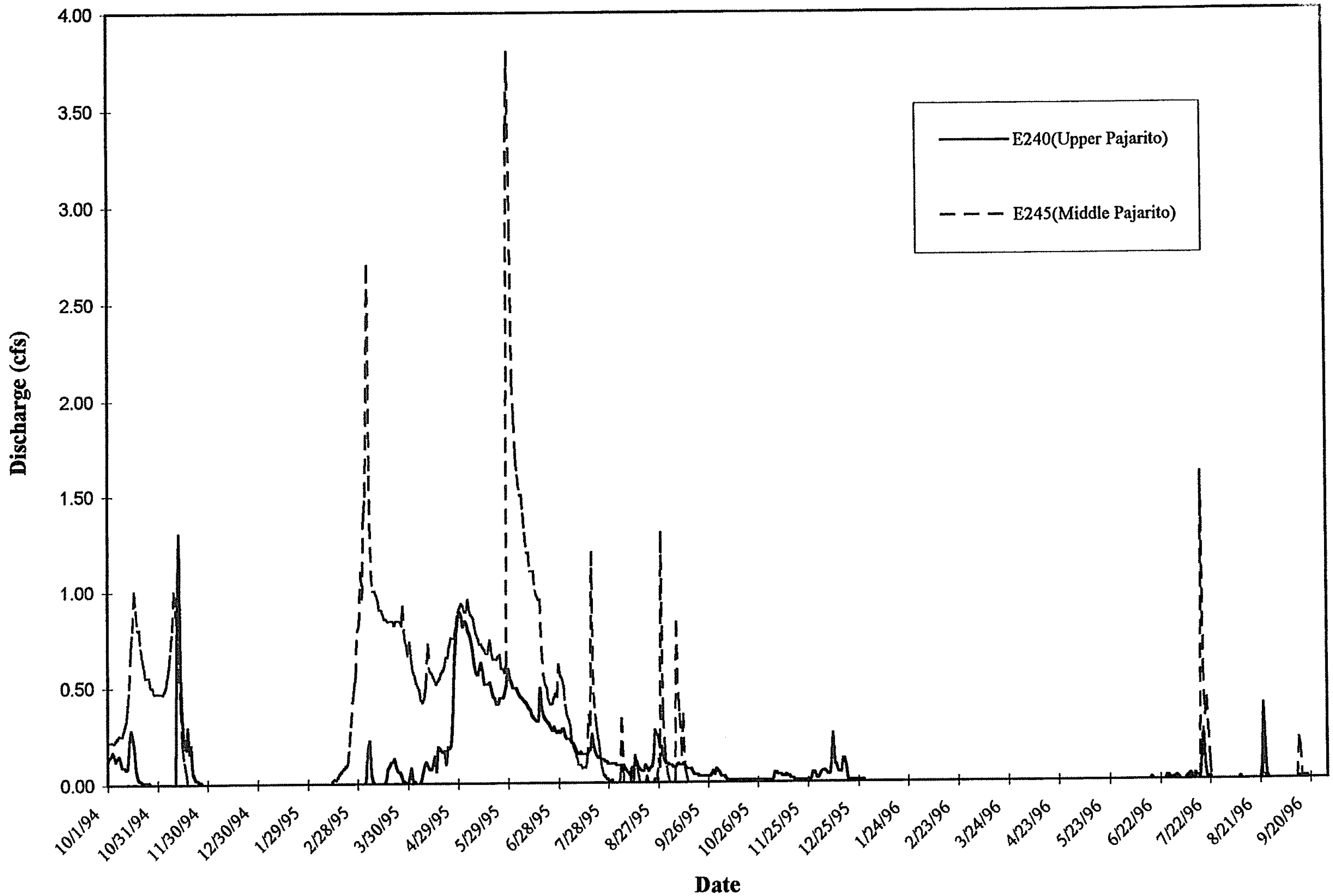

Figure 4. Average daily discharge for LANL's Pajarito Canyon gaging stations E240 and E245 (Source: Shaull, et al., 1996a, b).

~2 week gaps in late summer 1997 data for Sandia and Pajarito (units were washed out during floods).

So far, [no evidence has been seen] that the pools the units were placed in ever went stagnant. For instance, if the pools were not receiving renewed flows, [one] would expect temperatures to increase and DO to drop significantly. ...this sort of sudden and drastic change in these parameters [was never seen]. Therefore, at least in the immediate vicinity of the Hydrolabs, these canyons flowed continuously from December 1996 to November 1997."

These observations parallel those of the DOE OB.

Perennial and ephemeral springs apparently supply the bulk of the observed flow at PA-8.9 and VA-2.7. These springs discharge from fractures and contacts or parting surfaces between tuff beds within unit D (Rogers, 1995) or 3 (Broxton and Reneau, 1995) of the Tshirege Member of the Bandelier Tuff. Continuous flow from several of these springs was observed throughout the study period, and it is assumed that they are perennial. Pajarito Canyon and Cañon de Valle probably contain perched water in the canyon-floor alluvium that is recharged via surface-water and ground-water sources in the study area. The interconnection (e.g., return flow) between these possible perched-water zones and streamflow and ground-water seepage beneath the alluvium are not well understood.

FLOW MEASUREMENTS

Measurements of flow rate for both ground water (springs) and surface water were determined by the volumetric method (bucket and stop watch). Multiple measurements were made at each flow station in order to acquire a mean flow rate. All measurements were made during non-flood conditions. Flow data are presented in Table 1.

PAJARITO CANYON (PA-8.9)

As mentioned above, baseflow at station PA-8.9 appears to be supplied predominantly by several perennial springs located west (upstream) in Pajarito Canyon and Starmer Gulch (Figure 2). Estimated flow rates at these springs range from approximately 5 to 35 gpm. Observations showed that flow at PA-8.9 varies with discharge at the source springs. Other contributions to streamflow at this location may include interflow, underflow, throughflow, direct precipitation, etc. Streamflow within the active channels directly upstream of the source-spring discharge points was nonexistent throughout the investigation. That is, the flowing reach at PA-8.9 only extended down from the source springs. Streamflow loss between these springs and PA-8.9 was not calculated due to the lack of direct discharge data for each spring. The full distance that flow extends downstream from PA-8.9 was not determined; however, on July 22, 1994, continuous flow was observed to

Table 1. NMED surface- and ground-water flow measurements , upper Pajarito Canyon and Cañon de Valle, Los Alamos National Laboratory, New Mexico (see Figure 2 for flow-measurement locations).

Station	Date	Number of Measurements	Mean Flow (cfs)[1]	SD[2]
		CANYON		
Pajarito Canyon[3]	2/10/95	3	0.147	0.0057
	2/25/95	3	0.279	0.0270
	6/20/95	3	0.395	0.0417
	8/9/95	4	0.213	0.0161
	10/27/95	4	0.092	0.0050
	11/16/95	5	0.082	0.0012
	4/11/96	10	0.070	0.0030
	5/15/96	10	0.049	0.0013
	7/31/96	15	0.075	0.0035
	10/18/96	5	0.064	0.0005
	2/7/97	10	0.088	0.0053
Cañon de Valle[4]	3/17/95	3	0.154	0.0089
	3/22/95	3	0.159	0.0007
	3/30/95	3	0.169	0.0106
	5/5/95	3	0.179	0.0113
	6/16/95	3	0.103	0.0051
	8/31/95	3	0.088	0.0060
	11/16/95	3	0.034	0.0008
	12/15/95	9	0.039	0.0011
	3/29/96	9	0.039	0.0008
	4/11/96	10	0.034	0.0013
	5/24/96	11	0.023	0.0004
	10/18/96	7	0.036	0.0005
	11/22/96	7	0.042	0.0008
	1/24/97	10	0.026	0.0005
	2/7/97	10	0.027	0.0010
		CAÑON DE VALLE SPRINGS		
SWSC	10/18/96	10	0.003 (1.3 gpm)	0.00001
Burning Ground	10/18/96	10	0.028 (12.4 gpm)	0.0014

1 - average of multiple measurements by volumetric method (bucket and stop watch)
2 - sample standard deviation (the square root of the sample variance)
3 - made at PA-8.9
4 - made at VA-2.7
cfs - cubic feet per second
gpm - gallons per minute

extend from PA-8.9 to at least the confluence with Twomile Canyon (Figure 2).

Flow measurements at PA-8.9 were made at a waterfall located approximately 350 ft east of the confluence of Pajarito Canyon and Starmer Gulch. Flow at PA-8.9 was observed on 27 separate occasions (days) from July 22, 1994, through February 7, 1997. A total of 11 measurements were made during the period February 10, 1995, through February 7, 1997 (data are shown in Figure 5). Figure 5 also illustrates average daily discharge measurements at gage E240 and monthly precipitation for the period of investigation. Flow varied from 0.049 cfs on May 15, 1996, to 0.395 cfs on June 20, 1995. The May 15, 1996 measurement was obtained during the end of an extremely dry period; therefore, for the interval measured, we estimate that baseflow at PA-8.9 was about 0.049 cfs during the investigation. If our baseflow estimate is correct, the total volume of baseflow passing through this reach at PA-8.9 for 1 yr would be approximately 35.5 acre-ft.

Surface-water discharge in middle Pajarito Canyon is recorded at LANL's gaging station E245, which is located approximately 3.5 mi east and downstream of PA-8.9 (Figure 2). During the 1995 Water Year, there were 252 days of recorded flow at E245 with a total of 293 acre-ft of discharge (Shaull et al., 1996a). During the 1996 Water Year, there were only 13 days of recorded flow, yielding a total of 7.7 acre-ft (Figure 4; Shaull et al., 1996b). Hence, streamflow observed during the 1996 Water Year at PA-8.9 rarely reached E245. These data show that perennial conditions exist in Pajarito Canyon at varying distances east of the investigation area. In addition, these data suggest that streamflow and total discharge in Pajarito Canyon from source springs appear to be dependent on precipitation.

As mentioned above, Arroyo De Ladelfe, a small southern tributary of Pajarito Canyon located east of PA-8.9 (Figure 2), contributes some surface-water flow to Pajarito Canyon. On November 9, 1995, flow from this tributary into Pajarito Canyon was measured at 0.034 cfs. The surface-water contributions of this tributary to Pajarito Canyon could not be recorded at PA-8.9 as its confluence is located east and downstream from this gage. Flow is supplied by one major perennial spring (Bulldog Spring), whose discharge was estimated at approximately 15 gpm. This reach supports a diverse, well-balanced, moderately-intolerant macroinvertebrate community (Ford-Schmid, 1996). Continuous flow from this Pajarito Canyon tributary was observed throughout the investigation.

CAÑON DE VALLE (VA-2.7)

The majority of surface-water flow in Cañon de Valle at VA-2.7 is apparently supplied by Burning Ground and SWSC (named for Sanitary Waste System Consolidation plant) Springs, which are located west (upstream) of VA-2.7 (Figure 2). On October 18, 1996, flows from Burning Ground and SWSC Springs were measured at 12.4 gpm (0.028 cfs) and 1.3 gpm (0.003 cfs) respectively. Streamflow at VA-2.7 was measured at 0.036 cfs approximately 20 min after flow from the springs was measured; the measurement data show that the stream gained about 0.005 cfs between the springs and VA-2.7. Observations during the past 4 yrs show that flow from VA-2.7 normally extends east (downstream) about 1.5 to 2.0 mi.

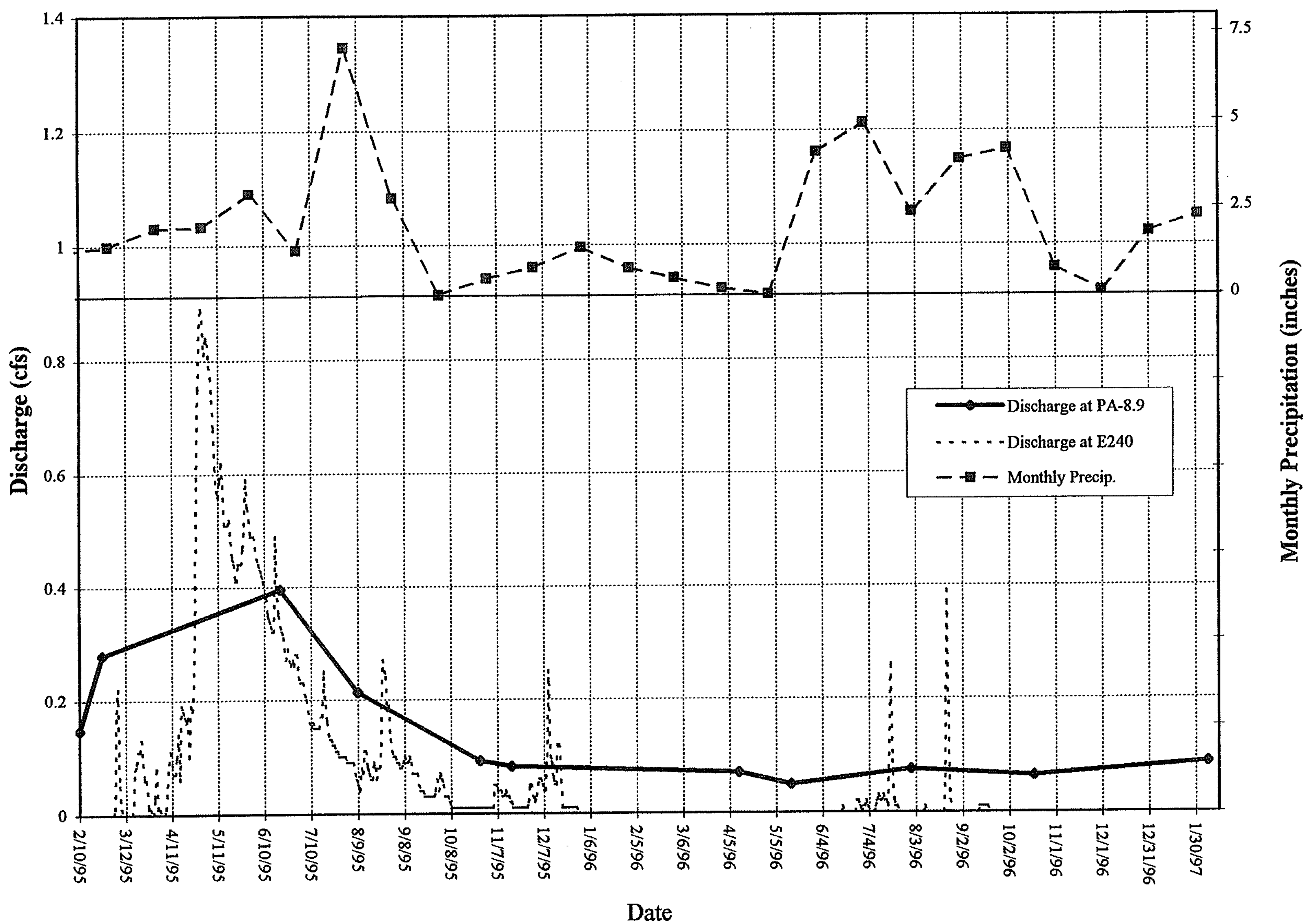

Figure 5. Relationship between periodic NMED discharge measurements for upper Pajarito Canyon at PA-8.9,discharge at LANL's gaging station E240, and monthly precipitation at LANL's Technical Area 16 Meteorological Station.

Flow-measurement data were collected at VA-2.7, utilizing a 24" diameter culvert, located beneath a road-crossing and adjacent to Material Disposal Area P (MDA P; Figure 2). Flow at VA-2.7 was observed on 31 separate occasions (days) from August 12, 1994, through February 7, 1997. A total of 15 measurements were made during the period March 17, 1995, through February 7, 1997 (data are shown in Figure 6). Flow varied from 0.023 cfs on May 24, 1996, to 0.179 cfs on May 5, 1995. Using a rate suggested by our data of 0.023 cfs, the total volume of baseflow passing VA-2.7 for 1 yr would be approximately 16.7 acre-ft.

WATER-QUALITY RESULTS

METHODS

Samples were collected in February so as to avoid major contributions by regional snowmelt and/or localized storm-water runoff.

Filtered and unfiltered water samples were collected for the following laboratory analyses: dissolved metals, total recoverable metals, total metals, gross alpha/beta (filtered), anions, non-metal inorganics (e.g., nitrate plus nitrite as nitrogen), volatile organic compounds (VOCs) and high-explosive compounds (HECs). Samples for inorganic analyses were collected in open-mouth, plastic, 1-liter bottles, and were field rinsed three times with stream water prior to sampling. VOC samples were collected in pre-acidified (HCl) 40-ml glass vials with septum (zero headspace). HECs were collected in 1-liter, amber, glass bottles. Samples for analysis of total metals and non-metal inorganics were acidified in the field with nitric acid and sulfuric acid respectively. Those for analysis of dissolved metals and gross alpha/beta were filtered through a 0.45 μm filter and acidified with nitric acid in the field. Samples for anion and HEC analysis were unpreserved and unfiltered.

All samples were shipped via overnight carrier to a contract laboratory at an approximate temperature of 4° C. Samples were analyzed in accordance with the latest edition of U.S. Environmental Protection Agency (EPA) SW-846 methods and within EPA's method-detection limits. Analytical methods and detection limits are listed on Tables 2 through 4.

All field pH and temperature data were obtained using an Orion Model 290A ion-specific meter with an automatic-temperature-compensated electrode. Specific conductance and dissolved oxygen were measured using an Orion Model 124 meter and a YSI 51B respectively. Field equipment was calibrated according to manufacturer's specifications prior to use.

PAJARITO CANYON (PA-8.9)

Pajarito Canyon surface-water samples were collected at PA-8.9 on February 7, 1997, a time at which total stream flow (0.088 cfs) was almost twice that of the assumed baseflow (0.049 cfs). The excess flow was probably the result of ground-water return flow through the alluvium,

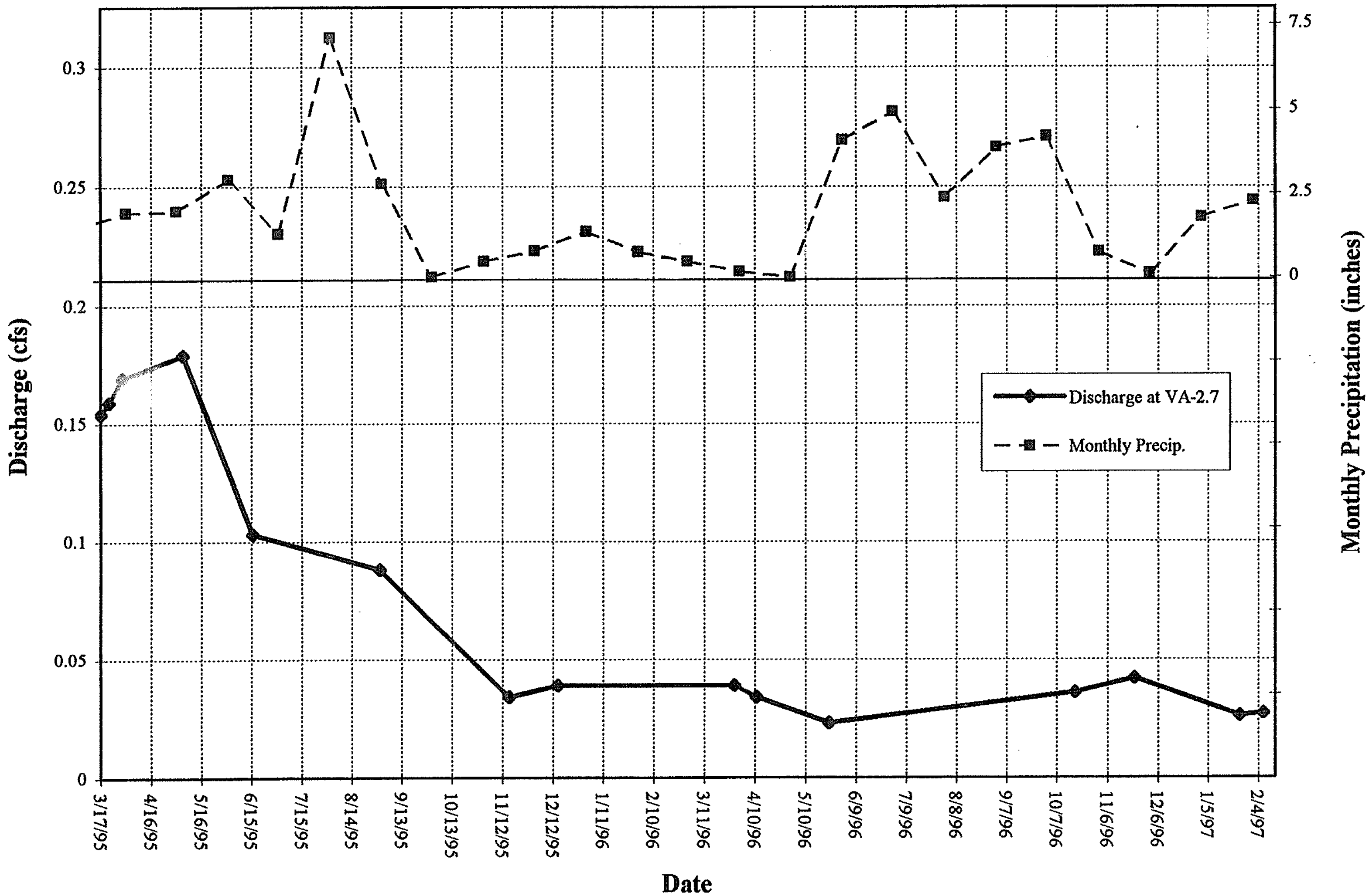

Figure 6. Relationship between periodic NMED discharge measurements for upper Cañon de Valle at VA-2.7 and monthly precipitation at LANL's Technical Area 16 Meteorological Station.

Table 2. Summary of NMED analytical results and field data for inorganic constituents in surface-water samples collected at PA-8.9 and VA-2.7 on February 7, 1997, upper Pajarito Canyon and Cañon de Valle, Los Alamos National Laboratory, New Mexico.

Analyte[1]	Method[2]	Type	PA-8.9	VA-2.7
Ca	6010A	D	16	19
Mg	6010A	D	5	6
K	6010A	D	4	4
Na	6010A	D	25	22
Ag	6010A	D	<0.01	<0.01
Al	6010A	D	0.6	<0.2
As	6010A	D	<0.01	<0.01
B	6010A	D	<0.1	<0.1
Ba	6010A	D	<0.1	2.2
Be	6010A	D	<0.005	<0.005
Cd	6010A	D	<0.005	<0.005
Cr	6010A	D	<0.01	<0.01
Co	6010A	D	<0.01	<0.01
Cu	6010A	D	<0.01	<0.01
Fe	6010A	D	0.3	<0.1
Total Hg	7470	T	<0.0002	<0.0002
Li	6010A	D	<0.01	<0.01
Mn	6010A	D	<0.01	0.09
Mo	6010A	D	<0.01	<0.01
Ni	6010A	D	<0.02	<0.02
Pb	6010A	D	<0.003	<0.003
Sb	6010A	D	<0.02	<0.02
Total Recoverable Se	6010A	T	<0.005	<0.005
Si	6010A	D	19	21
Sn	6010A	D	<0.02	<0.02
Sr	6010A	D	0.12	0.13
Tl	6010A	D	<0.01	<0.01
V	6010A	D	<0.01	<0.01
Zn	6010A	D	<0.02	<0.02
Cl	300.0	NA	48	21
F	300.0	NA	<0.1	0.2
CO3	310.0	NA	<5	<5
HCO3	310.0	NA	39	77
TOTAL PHOSPHORUS AS P	365.2	NA	<0.05	0.08
SO4	300.0	NA	7	10
NITRATE + NITRITE as N	353.3	NA	0.55	1.0
TOTAL KJELDAHL NITROGEN AS N	351.2	NA	<2.5	<2.5
AMMONIA AS N	350.3	NA	<0.5	<0.5
GROSS ALPHA (pCi/L)	900.0/9310 Modified	D	<1.7	<1.8
GROSS BETA (pCi/L)	900.0/9310 Modified	D	4.0+/-2.2[3]	3.4+/-2.0[3]
TOTAL DISSOLVED SOLIDS (TDS)	160.1	NA	180	160
TOTAL SUSPENDED SOLIDS	160.2	NA	<10	<10
FIELD pH (Standard Unit)	NA	NA	7.09	7.21
FIELD SPECIFIC CONDUCTANCE (uS/cm)	NA	NA	230	215
FIELD TDS (ppm)	NA	NA	176	164
TEMPERATURE (degrees Celsius)	NA	NA	2.2	0.5
DISSOLVED OXYGEN	NA	NA	11.0	11.2

1 - All results are in mg/L, except where noted.
2 - EPA Method Number.
3 - Reported uncertainties are the Estimated Total Propagated Uncertainties (2 sigma).
NA - Not analyzed or not applicable.
T - Total fraction (non-filtered).
D - Dissolved fraction passed through a < 0.45 micron filter.

Table 3. NMED analytical results for Volatile Organic Compounds in surface-water samples collected at PA-8.9 and VA-2.7 on February 7, 1997, upper Pajarito Canyon and Cañon de Valle, Los Alamos National Laboratory, New Mexico.

	PA-8.9		VA-2.7	
ANALYTE[1]	Conc. (ug/L)	DL	Conc. (ug/L)	DL
ACETONE	ND	10	3 JB	10
ACETONITRILE (1)	ND	N/A	ND	N/A
ACROLEIN (1)	ND	N/A	ND	N/A
ACRYLONITRILE (1)	ND	N/A	ND	N/A
ALLYL CHLORIDE (1)	ND	N/A	ND	N/A
BENZENE	ND	5	ND	5
BROMODICHLOROMETHANE	ND	5	ND	5
BROMOFORM	ND	5	ND	5
BROMOMETHANE	ND	10	ND	10
2-BUTANONE (MEK)	ND	10	ND	10
CARBON DISULFIDE	ND	5	ND	5
CARBON TETRACHLORIDE	ND	5	ND	5
CHLOROBENZENE	ND	5	ND	5
CHLORODIBROMOMETHANE	ND	5	ND	5
CHLOROETHANE	ND	10	ND	10
CHLOROFORM	ND	5	ND	5
CHLOROMETHANE	ND	10	ND	10
CHLOROPRENE (1)	ND	N/A	ND	N/A
1,2-DIBROMOETHANE (EDB)	ND	5	ND	5
1,2-DIBROMO-3-CHLOROPROPANE	ND	5	ND	5
DIBROMOMETHANE	ND	5	ND	5
DICHLORODIFLUOROMETHANE	ND	5	ND	5
1,1-DICHLOROETHANE	ND	5	ND	5
1,2-DICHLOROETHANE (EDC)	ND	5	ND	5
1,1-DICHLOROETHENE	ND	5	ND	5
IODOMETHANE	ND	5	ND	5
ISOBUTYL ALCOHOL (1)	ND	N/A	ND	N/A
METHACRYLONITRILE (1)	ND	N/A	ND	N/A
METHYL METHACRYLATE (1)	ND	N/A	ND	N/A
4-METHYL-2-BUTANONE	ND	10	ND	10
PENTACHLOROETHANE (1)	ND	N/A	ND	N/A
PROPIONITRILE (1)	ND	N/A	ND	N/A
STYRENE	ND	5	ND	5
TRANS--1,2-DICHLOROETHENE	ND	5	ND	5
TRANS-1,4-DICHLORO-2-BUTENE (1)	ND	N/A	ND	N/A
1,2-DICHLOROPROPANE	ND	5	ND	5
CIS--1,3-DICHLOROPROPENE	ND	5	ND	5
TRANS--1,3-DICHLOROPROPENE	ND	5	ND	5
ETHYLBENZENE	ND	5	ND	5
ETHYL METHACRYLATE (1)	ND	N/A	ND	N/A
2-HEXANONE	ND	10	ND	10
METHYLENE CHLORIDE	ND	5	ND	5
1,1,1,2-TETRACHLOROETHANE	ND	5	ND	5
1,1,2,2-TETRACHLOROETHANE	ND	5	ND	5
TETRACHLOROETHENE	ND	5	ND	5
TOLUENE	ND	5	ND	5
1,1,1-TRICHLOROETHANE	ND	5	ND	5
1,1,2-TRICHLOROETHANE	ND	5	ND	5
1,2,3-TRICHLOROPROPANE	ND	5	ND	5
TRICHLOROETHENE	ND	5	ND	5
TRICHLOROFLUOROMETHANE	ND	5	ND	5
VINYL ACETATE	ND	5	ND	5
VINYL CHLORIDE	ND	10	ND	10
o-XYLENE	ND	5	ND	5
p- & m-XYLENE	ND	5	ND	5
TOTAL XYLENES	ND	5	ND	5

1 - Method Used: 8260
ND - Not detected
DL - Method detection limit
B - Analyte found in Blank
J - Estimated value, analyte found below detection limit
(1) - Analyte searched for by ion and not quantitated
N/A - Not applicable

Table 4. NMED analytical results for High-Explosive Compounds in surface-water samples collected at PA-8.9 and VA-2.7 on February 7, 1997, upper Pajarito Canyon and Cañon de Valle, Los Alamos National Laboratory, New Mexico.

	PA-8.9		VA-2.7	
ANALYTE[1]	Conc. (ug/L)	DL	Conc. (ug/L)	DL
2-AMINO-4,6-DNT	ND	0.25	2.0	0.25
4-AMINO-2,6-DNT	ND	0.25	2.1	0.25
OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZOCINE (HMX)	ND	1.0	8.2	1.0
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE (RDX)	ND	0.84	30	0.84
1,3,5-TRINITROBENZENE (1,3,5-TNB)	ND	0.26	ND	0.26
1,3-DINITROBENZENE (1,3-DNB)	ND	0.25	ND	0.25
TETRYL (METHYL-2,4,6-TRINITROPHENYLNITRAMINE)	ND	1.0	ND	1.0
NITROBENZENE (NB)	ND	1.0	ND	1.0
2,4,6-TRINITROTOLUENE (2,4,6-TNT)	ND	0.25	ND	0.25
2,4-DINITROTOLUENE(2,4-DNT) & 2,6-DINITROTOLUENE(2,6-DNT)	ND	0.25	ND	0.25
o-NITROTOLUENE (2-NT)	ND	1.0	ND	1.0
p-NITROTOLUENE (4-NT)	ND	1.0	ND	1.0
m-NITROTOLUENE (3-NT)	ND	1.0	ND	1.0

[1] - Method Used: Modified 8330
ND - Not detected
DL - Method detection limit

localized snowmelt runoff within the canyon bottom and/or along the canyon hillsides. At the time of sampling, the flowing reach only extended from the source springs to PA-8.9 and beyond. Field measurements include: pH at 7.09 S.U.; temperature at 2.2°C; specific conductance at 230 μS/cm; and dissolved oxygen at 11.0 mg/L. Turbidity was not measured in the field; however, laboratory analysis of total suspended solids yielded concentrations less than 10 mg/L. All analytical results are presented in Tables 2 through 4.

Surface water at PA-8.9 is predominantly a calcium/sodium-bicarbonate type with 180 mg/L total dissolved solids. Major cation concentrations include 16 mg/L calcium, 5 mg/L magnesium, 4 mg/L potassium and 25 mg/L sodium; major anion concentrations include 39 mg/L bicarbonate, 48 mg/L chloride and 7 mg/L sulfate. Data for dissolved trace-metal concentrations were limited because the majority of the results were below the method detection limits used by the laboratory. However, three dissolved trace metals were detected: 0.6 mg/L aluminum, 0.3 mg/L iron and 0.12 mg/L strontium. Total mercury and total recoverable selenium were not detected above the laboratory reporting limits of 0.0002 mg/L and 0.005 mg/L respectively.

Of the various nitrogen constituents, only nitrate plus nitrite as nitrogen was detectable (0.55 mg/L). VOCs and HECs were not measured at levels above analytical detection limits. Gross alpha/beta activities were detected at <1.7 pCi/L and 4.0 pCi/L respectively.

CAÑON DE VALLE (VA-2.7)

Cañon de Valle water samples were collected at VA-2.7 on February 7, 1997. During sample collection, flow was measured at 0.027 cfs, which was slightly greater than our initial assumption of 0.023 cfs for baseflow. Field-parameter results, such as pH and specific conductance, as well as laboratory results for major ion chemistry at VA-2.7 generally parallel those for PA-8.9 (see Tables 2-4). The dissolved-trace metals aluminum and iron were absent at VA-2.7; however, barium and manganese were detected as dissolved species at 2.2 mg/L and 0.09 mg/L respectively. Concentrations of bicarbonate and nitrate plus nitrite as nitrogen were about twice those observed in Pajarito Canyon at PA-8.9. Several HECs were also detected above the laboratory reporting limit: Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) at 8.2 μg/L, Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) at 30 μg/L, 4-Amino-2,6-DNT at 2.1 μg/L and 2-Amino-4,6-DNT at 2.0 μg/L. All analytical results are presented in Tables 2 through 4.

CONCLUSIONS

Flow and water-quality data obtained in this investigation support four main conclusions:

1) perennial surface-water conditions exist in upper reaches of Pajarito Canyon and Cañon de Valle, both of which are located in the western portion of LANL,

2) volume and extent of streamflow appears to vary seasonally in response to precipitation, as demonstrated by lower discharge rates measured during the drought of 1995-96,

3) water-quality data collected during the study period suggest that Laboratory-derived contaminants exist in the Cañon de Valle study reach, but appear to be absent in Pajarito Canyon, and

4) contaminants of major concern identified in Cañon de Valle surface water are dissolved barium and RDX; both are present at levels exceeding EPA's (Region IX) screening action levels (1 mg/L and 0.61 μg/L respectively).

The increased understanding of perennial surface-water conditions has implications for the conceptual hydrogeologic model of the Pajarito Plateau as well as ecological evaluations and clean-ups conducted by LANL's Environmental Restoration Project at the adjacent TAs. An improved conceptual model is a first step toward protection of the regional drinking-water supply. Perennial reaches enhance wildlife habitat by supporting riparian vegetation and provide a water supply (hard to come by in the high desert of northern New Mexico). Because of their ecological importance, wetlands and riparian corridors are afforded a greater level of protection under federal statutes, such as the Clean Water Act. The hydrochemical information presented can be compared to New Mexico Water Quality Control Commission standards in order to protect surface-water quality. The presence of contaminants indicates the need for continued monitoring of these perennial reaches.

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