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Precipitation Events and Storm Water Runoff Events at Los Alamos National Laboratory after the Cerro Grande Fire

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Precipitation Events and Storm Water Runoff Events at Los Alamos National Laboratory after the Cerro Grande Fire

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CONTENTS

ABSTRACT 1

1.0 Introduction 1

2.0 Brief Climatology of the Pajarito Plateau 3

2.1 Precipitation Pattern in the Winter of 1999-2000 5
2.2 Precipitation in the Summer of 2000 after the Cerro Grande Fire 6
2.3 Summary of Storm Water Runoff Characteristics in 2000 9

3.0 Description of Runoff Sampling Events after the Cerro Grande Fire 14

3.1 June 2, 2000 14
3.2 June 28, 2000 15
3.3 July 9, 2000 18
3.4 July 16 to 19, 2000 19
3.5 July 21, 2000 20
3.6 July 25, 2000 22
3.7 July 29, 2000 23
3.8 August 9, 2000 25
3.9 August 13, 2000 26
3.10 August 18, 2000 27
3.11 August 24, 2000 29
3.12 August 31, 2000 30
3.13 September 8, 2000 30
3.14 September 12, 2000 31
3.15 October 7, 2000 32
3.16 October 11-12, 2000 32
3.17 October 23, 2000 34
3.18 October 27-28, 2000 42

Acknowledgments 47

References 47

Appendix A. Figures showing the pattern of precipitation in 2000 on days runoff samples were collected. 49

Appendix B. Water Quality Database Location Names 68

Figures

Figure 1-1. Regional location of Los Alamos National Laboratory. 2
Figure 2-1. Total monthly precipitation and snowfall recorded at TA-6 November 1999 through April 2000. 6
Figure 2-2. Total monthly precipitation recorded at TA-6 May through October 2000. 7
Figure 2-3. Precipitation recorded at individual LANL meteorological stations, June 1 to October 31, 2000 8
Figure 2-4. Storm water sampling stations on the Pajarito Plateau. 10
Figure 2-5. Peak runoff recorded in 2000 compared with historical peak flows. 13
Figure 3-1. Precipitation at TA-53 and Pajarito Mountain and average hourly streamflow at gages in Los Alamos Canyon on June 2 and 3, 2000. 14
Figure 3-2. Precipitation at TA-6 and the Water Canyon RAWS and average hourly streamflow in Pajarito and Water Canyons on June 28, 2000. 16
Figure 3-3. Precipitation at TA-6 and average hourly flow at gage E042 on July 9, 2000. 18

Figure 3-4. Precipitation at the Quemazon Canyon RAWS and flow at gage E025 on July 18, 2000. 21
Figure 3-5. Precipitation at upper Los Alamos Canyon RAWS and streamflow at gage E042 in Los Alamos Canyon above SR 4 from July 18 to 22, 2000 22
Figure 3-6. Precipitation at TA-53 and flow at gage E039 in DP Canyon on July 25 and 26, 2000. 23
Figure 3-7. Precipitation at TA-16 and TA-49 and hydrograph of streamflow at gage E265 in Water Canyon below SR 4 on July 29 and 30, 2000 24
Figure 3-8. Precipitation at TA-54 and hydrograph of streamflow at gage E230 in Cañada del Buey on July 29, 2000 24
Figure 3-9. Precipitation at TA-49 and TA-54 and flow at gages E230 and E267 on August 9, 2000 25
Figure 3-10. Precipitation at the Water Canyon RAWS and flow at stream gage E265 in Water Canyon on August 13 and 14, 2000 26
Figure 3-11. Precipitation at TA-54 and flow at gage E230 in Cañada del Buey on August 18, 2000 27
Figure 3-12. Precipitation at TA-49 and flow at gage E265 in Water Canyon on August 18, 2000. 28
Figure 3-13. Precipitation at TA-49 and TA-54 and flow at gage E275 on August 18, 2000. 29
Figure 3-14. Flow at gage E025 in Los Alamos Canyon on September 11 and 12, 2000. 31
Figure 3-15. Precipitation at TA-6 and TA-53 and flow at gage E042 in Los Alamos Canyon on October 11 and 12, 2000. 33
Figure 3-16. Precipitation at TA-6 and TA-54 and flow at Gage E230 on October 11 and 12, 2000. 34
Figure 3-17. Precipitation at TA-6 and TA-53 and flow at gages E060, E030, and E042 on October 23 and 24, 2000. 36
Figure 3-18. Precipitation recorded at TA-6 and Pajarito Mountain on October 23, 2000 38
Figure 3-19. Precipitation at TA-6 and TA-54 and flow in Pajarito Canyon at gage E250 on October 23 and 24, 2000. 39
Figure 3-20. Precipitation at TA-6 and TA-54 and flow at gages E218 and E230 in Cañada del Buey on October 23 and 24, 2000. 40
Figure 3-21. Precipitation at Water Canyon and Pajarito Canyon RAWS and TA-49 and flow at gages E265, E267, and E275 on October 23 and 24, 2000. 41
Figure 3-22. Precipitation at TA-6 and TA-53 and flow at gages E060, E040 and E042 on October 27-30. 44
Figure 3-23. Precipitation at TA-6 and TA-54 and runoff at E230 and E250 on October 27 and 28, 2000. 45
Figure 3-24. Precipitation at TA-49 and TA-54 and flow at gage E275 in Ancho Canyon on October 27 and 28, 2000. 46
Figure A-1. Pattern of precipitation recorded on the Pajarito Plateau on June 2, 2000. 50
Figure A-2. Pattern of precipitation recorded on the Pajarito Plateau on June 28, 2000. 51
Figure A-3. Pattern of precipitation recorded on the Pajarito Plateau on July 9, 2000. 52
Figure A-4. Pattern of precipitation recorded on the Pajarito Plateau on July 17, 2000. 53
Figure A-5. Pattern of Precipitation recorded on the Pajarito Plateau on July 18, 2000 54
Figure A-6. Pattern of precipitation recorded on the Pajarito Plateau on July 25, 2000. 55
Figure A-7. Pattern of precipitation recorded on the Pajarito Plateau on July 29, 2000 56
Figure A-8. Pattern of precipitation recorded on the Pajarito Plateau on August 9, 2000. 57
Figure A-9. Pattern of Precipitation recorded on the Pajarito Plateau on August 13, 2000 58
Figure A-10a. Pattern of precipitation recorded on the Pajarito Plateau on the morning of August 18, 2000 59
Figure A-10b. Pattern of precipitation recorded on the Pajarito Plateau on the afternoon of August 18, 2000. 60
Figure A-11. Pattern of precipitation recorded on the Pajarito Plateau on September 8, 2000. 61
Figure A-12. Pattern of precipitation recorded on the Pajarito Plateau on October 7, 2000. 62
Figure A-13. Pattern of precipitation recorded on the Pajarito Plateau on October 11, 2000. 63
Figure A-14. Pattern of precipitation recorded on the Pajarito Plateau on October 12, 2000. 64
Figure A-15. Pattern of precipitation recorded on the Pajarito Plateau on October 23, 2000. 65
Figure A-16. Pattern of precipitation recorded on the Pajarito Plateau on October 27, 2000. 66
Figure A-17. Pattern of precipitation recorded on the Pajarito Plateau on October 28, 2000. 67

Tables

Table 2-1. Meteorological Observation Stations at Los Alamos National Laboratory. 4
Table 2-2. Average Daily Climate Variables at LANL Meteorological Stations. 4
Table 2-3. Storm Water Runoff Collection Sites at LANL. 11
Table 2-4. Storm Water Runoff Samples Collected in 2000. 12
Table 2-5. Analytical Suite Numbers and Codes 12
Table 3-1. Storm Water Runoff Samples Collected on June 2 and 3, 2000 15
Table 3-2. Record Peak Flows Observed on June 28, 2000. 16
Table 3-3. Storm Water Runoff Samples Collected on June 28, 2000. 17
Table 3-4. Summary of Runoff Samples Collected July 9, 2000. 19
Table 3-5. Storm Water Runoff Samples Collected July 16 through July 19, 2000 20
Table 3-6. Samples Collected in Lower Los Alamos Canyon near SR 4 on July 21, 2000. 22
Table 3-7. Samples Collected in Middle DP Canyon on July 25, 2000. 23
Table 3-8. Storm Water Runoff Samples Collected on July 29, 2000. 25
Table 3-9. Storm Water Runoff Samples Collected on August 9, 2000. 26
Table 3-10. Storm Water Runoff Samples Collected on August 13, 2000. 27
Table 3-11. Storm Water Runoff Samples Collected on August 18, 2000. 28
Table 3-12. Surface Water Samples Collected from the Pajarito Canyon Retention Structure on August 24, 2000. 30
Table 3-13. Surface Water Samples Collected in Upper Los Alamos Canyon on August 31, 2000. 30
Table 3-14. Storm Water Runoff Samples Collected on September 8, 2000. 31
Table 3-15. Surface Water Samples Collected at Gage E025 on September 12, 2000 32
Table 3-16. Storm Water Runoff Samples Collected on October 7, 2000. 32
Table 3-17. Storm Water Runoff Samples Collected on October 11 and 12, 2000 33
Table 3-18. Storm Water Runoff Samples Collected on October 23, 2000 35
Table 3-19. Storm Water Runoff Samples Collected October 27, 28, and 30, 2000 43

Precipitation Events and Storm Water Runoff Events at Los Alamos National Laboratory after the Cerro Grande Fire

by

Richard J. Koch, David A. Shaull, Bruce M. Gallaher, and Michael R. Alexander

ABSTRACT

This report describes fire-related precipitation and storm water runoff events that occurred during 2000 at the Los Alamos National Laboratory (LANL) after the Cerro Grande Fire. Storm water runoff events are described from stream gaging stations where storm water runoff samples were collected between June 2 and October 29, 2000. The report incorporates available information pertaining to the location of significant precipitation events, precipitation amounts, and resulting storm water flow rates and flow volumes and lists the storm water runoff samples that were collected at LANL in 2000. The report is intended to provide the background information necessary to assist in the understanding of the chemical water quality data obtained from the storm water runoff samples.

1.0 Introduction

Los Alamos National Laboratory (LANL) is located on 43 mi^2 of the Pajarito Plateau on the east flank of the Jemez Mountains (the Sierra de los Valles) of north-central New Mexico (Figure 1-1). Bandelier National Monument is located south of LANL, and the Santa Fe National Forest is located on the slopes of the Sierra de los Valles west and north of LANL.

The Pajarito Plateau slopes to the east-southeast and changes in elevation from west to east from about 7600 ft to about 6300 ft, for a total change in elevation of about 1300 ft; canyons and mesas extend along the entire slope of the plateau. Significant larger-scale topographic features exist in the vicinity of the plateau, such as the broad north-south trending Rio Grande Valley to the east and the Sierra de los Valles to the west, which extend to over 10,000 ft, up to 3000 ft above the plateau. The local and regional topographical features contribute to the meteorological complexity of the site and significantly influence the local meteorology of the Laboratory (Baars et al. 1998).

This report describes fire-related precipitation and storm water runoff events that occurred during 2000 at LANL after the Cerro Grande Fire. Storm water runoff events are described from stream gaging stations where storm water runoff samples were collected between June 2 and October 29, 2000. The report incorporates available information pertaining to the location of significant precipitation events, precipitation amounts, and storm water flow rates and flow volumes and the storm water runoff samples that were collected at LANL in 2000. Descriptions of storm water runoff samples that were not influenced by the Cerro Grande Fire, such as storm water samples routinely collected at Technical Area (TA) 54, Material Disposal Area (MDA) G, are not included in this report. The report is intended to provide the background information necessary to assist in the understanding of the chemical water quality data obtained from the storm water runoff samples.

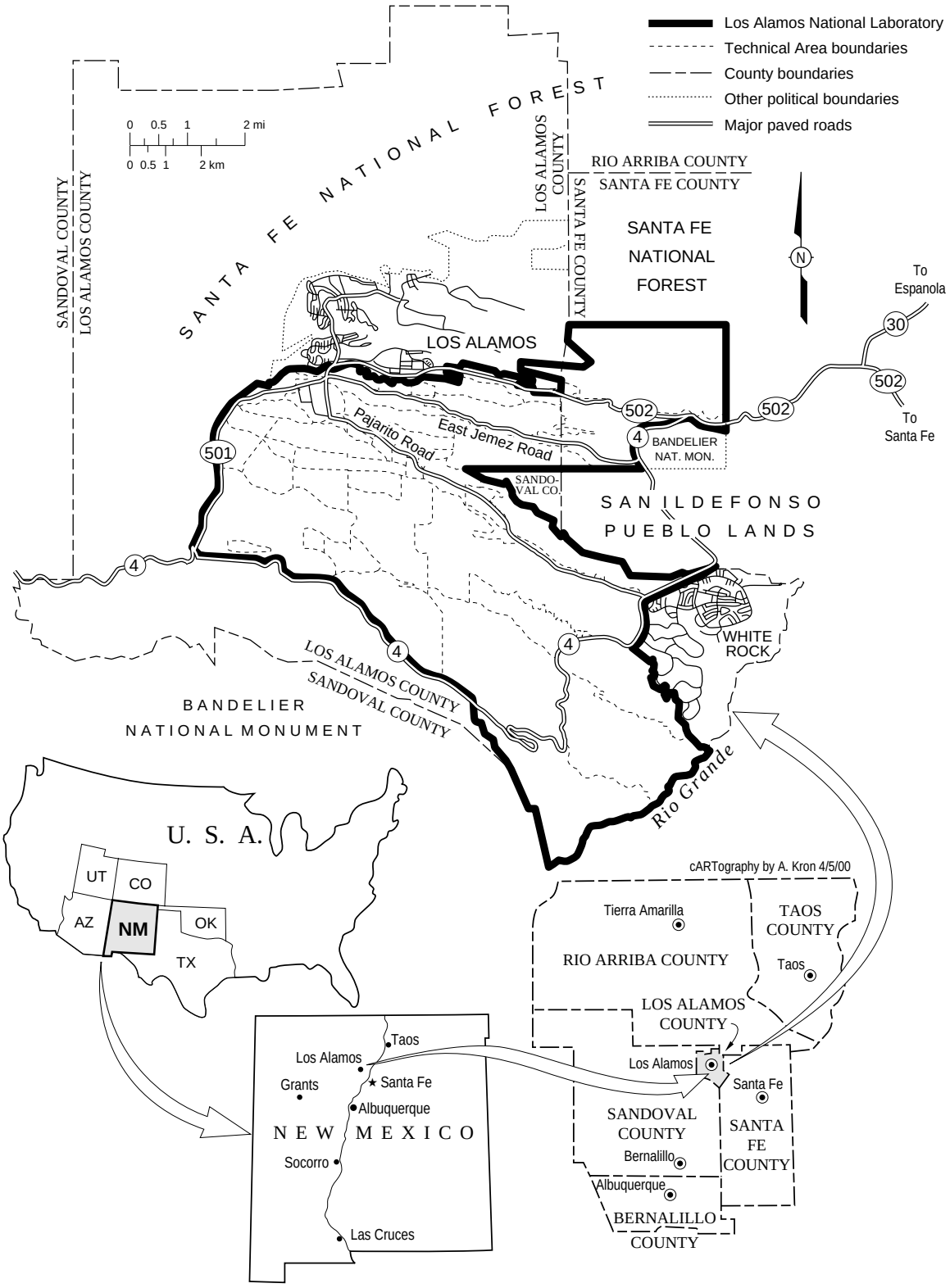


Figure 1-1. Regional location of Los Alamos National Laboratory.

2.0 Brief Climatology of the Pajarito Plateau

The Pajarito Plateau has a temperate, semiarid mountain climate that is largely influenced by elevation. Large temperature and precipitation differences are observed across the Laboratory because of the 1000-ft elevation change across the Pajarito Plateau. General information about the climate of the Laboratory area is provided in the annual environmental surveillance reports (e.g., Environmental Surveillance Program [2000]). Bowen (1990) provides detailed data compilations and extensive statistical summaries, including projected probabilities for climate. Much of the following summary of climate is from the LANL Weather Machine on the following Laboratory web site: http://weather.lanl.gov/. General weather conditions for Los Alamos and the Laboratory are reported from data collected at the meteorological tower located at TA-6.

Four distinct seasons occur on the Pajarito Plateau. Spring is usually windy and dry. Summer begins with warm, usually dry conditions in June, followed by a two-month rainy season in July and August when afternoon convection thunderstorms containing hail and lightning are common. Autumn is the end of the rainy season when the climate returns to drier, cooler, and calmer weather. Winters are generally mild with occasional winter storms that contain large snows and cause frigid temperatures. Mid-latitude winter storms drop far enough to the south to keep the ground covered with snow for about two months each winter.

Meteorological variables at LANL are measured at five towers located on the Pajarito Plateau. Four of the towers are located on mesas and one tower is located in Los Alamos Canyon, which is one of the larger canyons on the plateau. The meteorological observation stations and information about the stations are listed in Table 2-1. A sixth tower was recently installed on Pajarito Mountain to help predict wind shifts across the plateau below.

A wide variety of meteorological variables are measured across the network of observation stations to provide adequate information for the various demands for weather data at the Laboratory. Data collected at the observation stations include wind, temperature, pressure, relative humidity and dew point, and solar and terrestrial radiation. Wind variables are measured at different heights above ground levels on the meteorological towers, including 37.5 ft, 75 ft, and 150 ft, and at the TA-6 tower at 300 ft. The atmospheric state variables, precipitation, and radiative energy fluxes are measured at 5 ft above the ground surface. The data are obtained through direct measurement or calculation from most sites every 15 minutes, and some variables such as precipitation are totaled for each 24-hr period (Baars et al. 1998).

In addition to the period of record available for the active stations listed in Table 2-1, precipitation data are available from several meteorological stations located at Bandelier National Monument. Data from two sites in particular—Cerro Grande, located in the Sierra de los Valles in the western part of the monument, and Frijolito, located near the park headquarters in the eastern part of the monument—were used in the construction of precipitation pattern figures in Appendix A. After the Cerro Grande Fire in May 2000, several remote automated weather stations (RAWS) were installed in the Sierra de los Valles north and west of Los Alamos. Data from these weather stations were also used in construction of figures in this document.

Table 2-2 lists the average daily climate variables for each of the active meteorological stations at the Laboratory. The highest average daily wind speed is recorded at TA-49, and the lowest average wind speed is at TA-41 in Los Alamos Canyon. The highest average daily maximum temperature is recorded at TA-54, and the lowest minimum temperature is recorded at TA-41. The highest average annual precipitation is at TA-6, and the lowest average annual precipitation is at TA-54. The average surface soil moisture (0- to 3-in. depth) is highest at TA-6 (25.65%), but the highest average soil moisture to a depth of 6 in. is at TA-54.

Table 2-1. Meteorological Observation Stations at Los Alamos National Laboratory.

Station Name	Location	Elevation (ft)	Period of Record	Comment
Meteorological Towers				
TA-6	South of TA-3, Upper Pajarito Plateau	7424	2/90 to present	Official meteorological station for LANL and Los Alamos
TA-41	Los Alamos Canyon south of town site	6914	11/93 to present	Provides information about meteorology in the canyons
TA-49	Frijoles Mesa	7045	6/87 to present	Provides information for Bandelier National Monument
TA-53	Los Alamos Neutron Science Center	6990	2/92 to present	
TA-54	MDA-G, White Rock	6548	1/92 to present	MDA-G observation station, previous station record at MDA-G from 1979 to 1992
Pajarito Mt.	Pajarito Mountain	10360	8/97 to present	Installed in 1994, reconfigured in 1997
SODAR	TA-6	7414	2/90 to present	Sound detection and ranging
Precipitation-Only Stations				
TA-16	S-Site	7635	1/77 to present	Precipitation measurement
TA-74	State Road (SR) 4 / SR 501 Intersection	6370	7/81 to present	Test Well 1, Pueblo Canyon
North Community	Los Alamos	7420	1/86 to present	Northwest side of Los Alamos

Information adapted from Baars et al. (1998) p. 7-8.

Table 2-2. Average Daily Climate Variables at LANL Meteorological Stations.

	Units	TA-6	TA-41	TA-49	TA-53	TA-54
Atmospheric Variables						
Average Wind Speed	m/s	2.49	1.66	3.16	2.90	2.74
Maximum Temperature	Degree-C	15.03	15.61	16.18	16.58	17.58
Minimum Temperature	Degree-C	1.77	0.66	3.44	4.36	0.99
Average Relative Humidity	%	50.83		47.30	49.02	52.01
Average Dew Point	Degree-C	-2.80			-2.05	-2.15
Average Precipitation	In./yr	19.69		18.68	15.97	14.57
Radiative Energy Variables						
Short Wave Irradiance (incoming)	mJ/m^2	18.87	14.49	19.14	18.94	19.23
Net Radiation	mJ/m^2	7.04				5.72
Sensible Heat Energy	mJ/m^2	3.23				5.45
Latent Heat Energy	mJ/m^2	2.32				0.99
Subsurface/Ground Variables						
Average Soil Moisture – 3 in.	%	25.65				12.32
Average Soil Moisture – 6 in.	%	29.84				31.02
Ground Heat Flux	mJ/m^2	0.85				0.15

Source: LANL Weather Machine

Several factors influence the temperature of the Pajarito Plateau, however, elevation is the primary influence; and at elevations of the mesas that are generally over 7000 ft, the plateau is cooler in the summer than nearby locations that are at lower elevation. The changes in elevation of the plateau are reflected in the sloping nature of the plateau and the configuration of the mesas and canyons, which combine to cause daily temperature changes. In the evening and at night, cooled air drains off the plateau

and flows down the canyons; thus, nighttime temperatures on the mesas are often warmer than those in the canyons and at lower elevations.

Another factor affecting the temperature is the lack of moisture in the atmosphere. With less moisture, there is less cloud cover, which allows a significant amount of solar heating during the daytime and radiative cooling during the nighttime. This heating and cooling often cause a wide range of daily temperatures, which averages 56°F. July is the warmest month of the year with an average daily high of 81°F. January is the coldest month when the temperatures range from an average daily high of 40°F to a low of 17°F.

Relative humidity varies considerably over daily periods, but monthly average values vary little during the year. Relative humidity ranges from a low of 39% in June to a high of 56% in December and averages 51% over the entire year. Absolute humidity ranges from a low of 2.4 g of water/m^3 of air in January to a high of 8.7 g/m^3 in July and August, when moist subtropical air invades the region during the rainy season. Fog in the Pajarito Plateau area is very rare, occurring less than five times a year on average.

The average annual precipitation from rainfall and the water-equivalent from frozen precipitation is 18.7 in. However, the annual total fluctuates considerably from year to year, with the standard deviation of the fluctuation being 4.8 in. The lowest recorded annual precipitation is 6.8 in., and the highest is 30.3 in. The maximum precipitation recorded for a 24-h period is 3.5 in., and the maximum 15-minute precipitation in the period of record is 0.9 in.

Because of the eastward slope of the Pajarito Plateau terrain, there is a large east-to-west gradient in precipitation across the plateau. White Rock often receives 5.1 in. less annual precipitation than does the official observing station at TA-6, and the eastern flanks of the Sierra de los Valles often receive an equivalent amount of additional precipitation. About 36% of the annual precipitation is received during the July and August rainy season.

The Pajarito Plateau experiences an average 61 thunderstorm days each year, about twice the national average. Lightning and hail frequently accompany the thunderstorms. Hailstones 0.25 in. in diameter are common, and stones as large as 1 in. have been reported. Hail has caused significant damage to property and vegetation and localized accumulations of 3 in. have been observed.

Winter precipitation occurs mostly as snow. The snow is generally dry with, on average, 20 units of snow equivalent to one unit of water. The annual snowfall averages 59 in., but, from year to year, the amount of snow is quite variable. The standard deviation of annual snowfall is 28 in. The highest recorded snowfall for one season is 153 in., and the highest recorded snowfall for a 24-h period is 22 in. In a typical winter season there are 14 days containing snowfall exceeding 1 in. and 4 days of snowfall exceeding 4 in. The extreme single-storm snowfall on record is 48 in.

Wind conditions on the Pajarito Plateau are generally light, having an average annual wind speed of 5.5 mph. However, the windy period from mid-March to early June sustains wind speeds exceeding 8.8 mph 20% of the time during the daytime, and the daily maximum wind gust exceeds 31 mph about 20% of the time. The highest wind gust on record is 77 mph. High winds are associated with the passage of weather fronts, thunderstorms, and mid-latitude storm systems. Tornadoes have not touched the ground in the Pajarito Plateau area, however, funnel clouds have been observed in Los Alamos and Santa Fe Counties.

2.1 Precipitation Pattern in the Winter of 1999-2000

Northern New Mexico, as well as much of the Southwestern US, had been in a drought during 1999 and the early months of 2000. The total annual rainfall for 1999 recorded at the TA-6 meteorological station was 16.31 in., 87% of the normal annual precipitation of 18.73 in. Snowfall in 1999 was only 28.8 in.,

49% of the annual normal snowfall of 59.1 in. The winter months from November 1999 through April 2000 were even drier in the Los Alamos area. The snowfall for the season totaled 15.7 in., 26% of the normal seasonal snowfall of 59.9 in. Figure 2-1 shows the pattern of total monthly precipitation and snowfall recorded at the TA-6 meteorological station during the winter of 1999 and 2000. Normal monthly snowfall and precipitation are also shown for comparison.

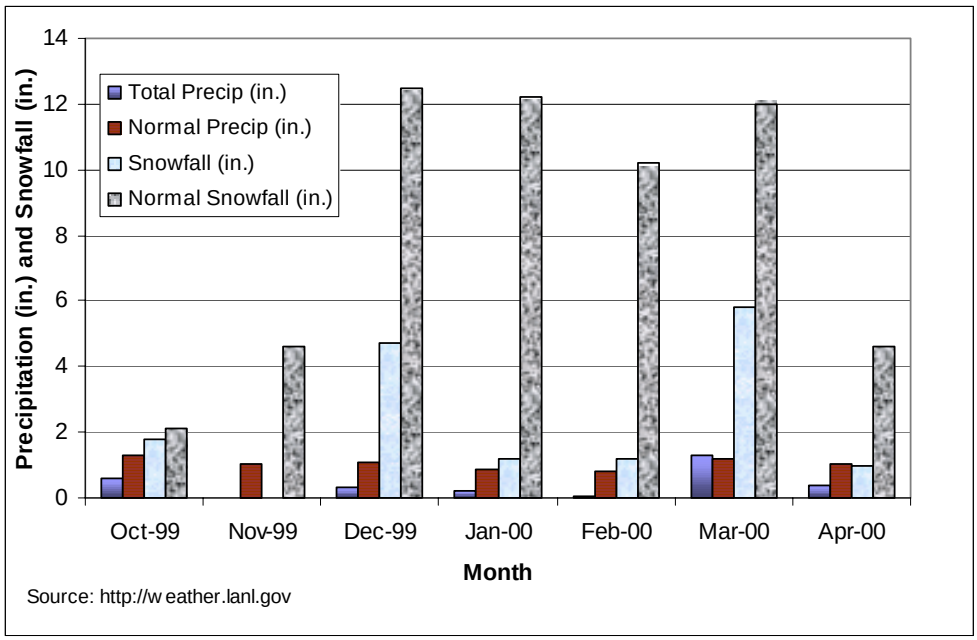


Figure 2-1. Total monthly precipitation and snowfall recorded at TA-6 November 1999 through April 2000.

Meteorological stations at LANL received below normal precipitation for every month from October 1999 through April 2000, except for a short period in late March that provided normal precipitation for that month. Winter snow pack for the 1999-2000 season was well below normal; the local Pajarito Ski Area did not open during the entire 1999-2000 winter season. The Palmer Drought Index for early May indicated that northern New Mexico was in a moderate drought (Palmer Index between -2.0 and -2.9) (USDOI 2000).

On May 4, 2000, the Bandelier National Monument conducted a prescribed fire near the top of Cerro Grande. On May 5, at approximately 1300 hours, the prescribed burn was declared a wildfire under the management of a locally staffed Type 3 Interagency Management Team. On May 7 at approximately 1230 hours, a Type 1 Interagency Management Team was ordered when the fire burned off of National Monument land. The fire was transitioned to the team at 0600 hours on May 8. The Laboratory declared emergency measures and did not open on Monday, May 8, and, as a result of the Cerro Grande Fire, was under the control of the Emergency Management Office for about two weeks during which time normal Laboratory operations were suspended.

2.2 Precipitation in the Summer of 2000 after the Cerro Grande Fire

Figure 2-2 shows the pattern of total monthly precipitation and snowfall recorded at the official LANL TA-6 meteorological station after the Cerro Grande Fire from May through October 2000. Normal monthly precipitation and snowfall amounts are also shown for comparison.

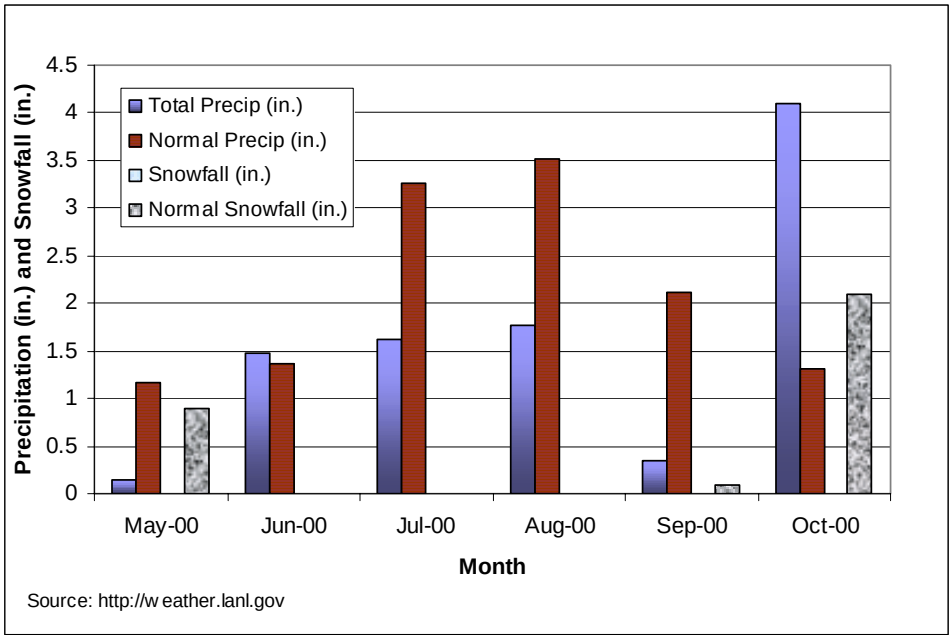


Figure 2-2. Total monthly precipitation recorded at TA-6 May through October 2000.

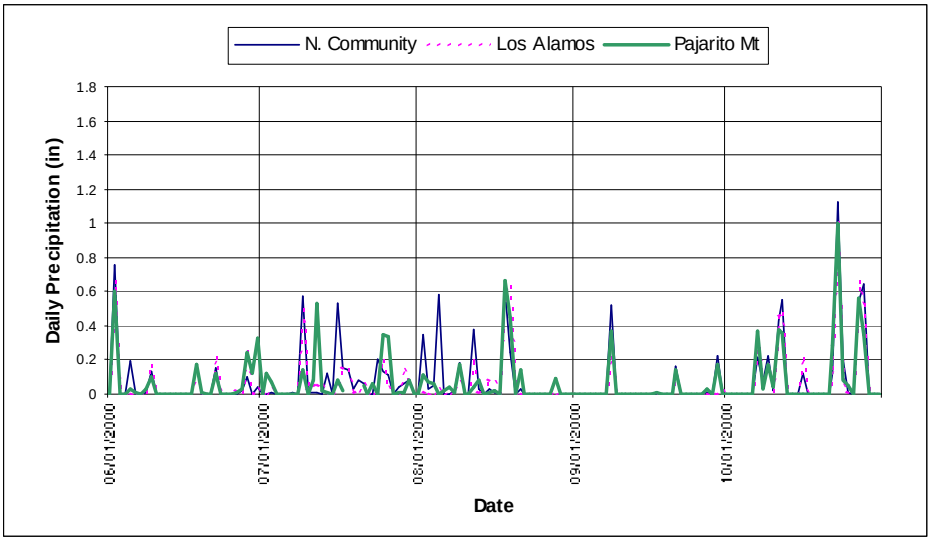
Precipitation received in May was 0.15 in., about 13% of the average May precipitation of 1.17 in. Precipitation in June totaled 1.47 in., slightly higher than the normal of 1.36 in. Precipitation in the months of July, August, and September was significantly below normal, with 50% of normal precipitation received in July and August and only 16% of normal precipitation received in September. October was a relatively wet month with a total precipitation of 4.1 in., 310% of normal.

Precipitation recorded at individual LANL meteorological stations from June 1 through October 31 are shown in Figures 2-3a, -3b, and -3c. These figures show the total daily precipitation recorded at stations north and west of LANL (Figure 2-3a: North Community, Los Alamos, and Pajarito Mountain stations), stations in the western and southern portions of LANL (Figure 2-3b: TA-6, TA-16, and TA-49), and stations in the eastern part of LANL (Figure 2-3c: TA-53, TA-54, and TA-74). Precipitation isopleth maps in Appendix A show the pattern of precipitation received on the Pajarito Plateau on specific days when runoff samples were collected. Further descriptions of individual precipitation events are in Section 3.

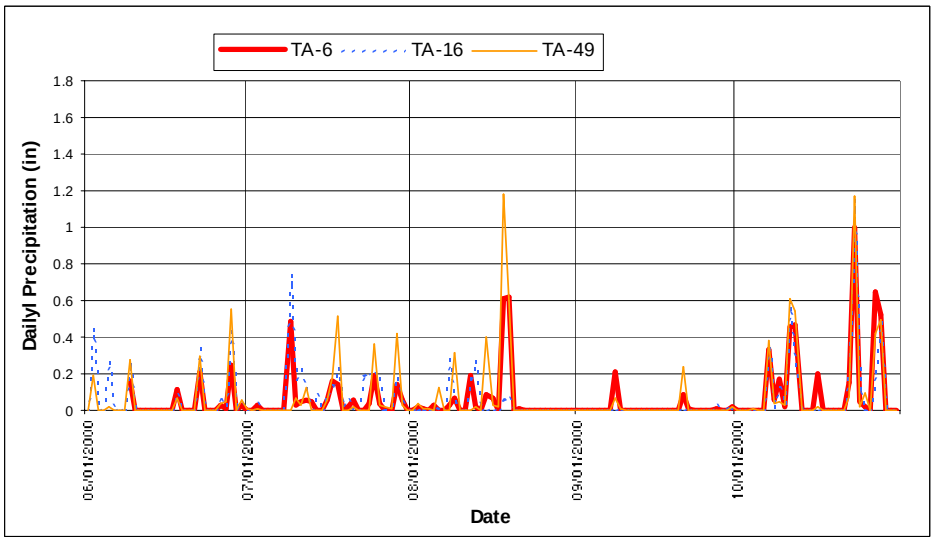
The pattern of precipitation received on the Pajarito Plateau during the summer of 2000 changed each month as different types of precipitation events occurred. Precipitation events in June appear to have been thunderstorms that were more localized and brief in nature. During June, thunderstorms likely occurred in response to diurnal heating of the ground causing localized thunderstorms to form over higher terrain. In June, two significant thunderstorm events occurred, one on June 2, and another on June 28. On June 2, the highest precipitation recorded was north and west of the Laboratory at Pajarito Mountain and the North Community meteorological stations, where a relatively localized high-intensity storm of short duration (0.76 in. in 2 hr) occurred.

The most destructive runoff event of the summer occurred on June 28 when a short-duration (30-minute) relatively high-intensity thunderstorm occurred over the flanks of the Sierra de los Valles just west of the Laboratory (see Appendix A Figure A-2). Rainfall recorded at TA-16 was 0.43 in., and the Water Canyon and Pajarito Canyon RAWS received 0.79 and 0.69 in., respectively. Although not historically significant rainfall amounts, the resulting runoff from the areas burned by the Cerro Grande Fire was significant.

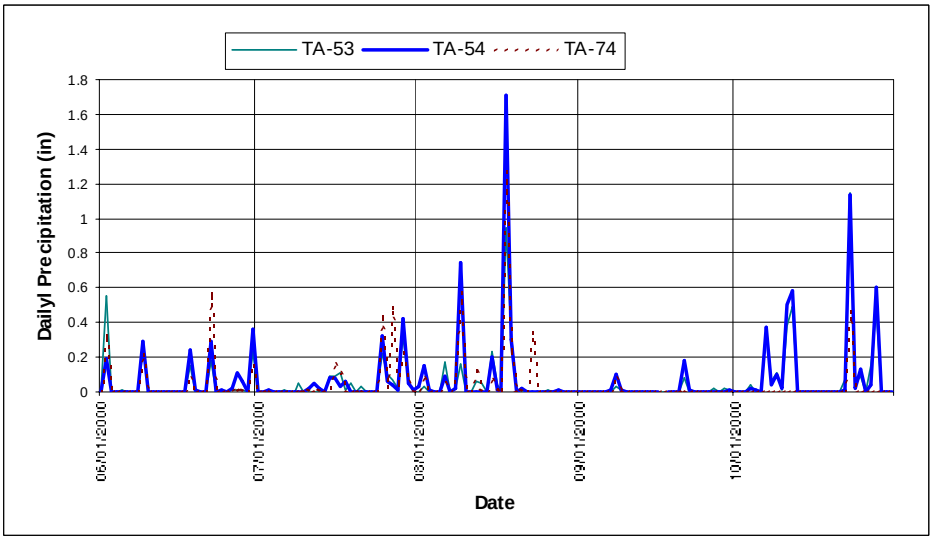
In July, the summer monsoon rains begin as tropical moisture moves northward into New Mexico from Mexico. In July, the highest precipitation recorded was at the stations located along the western side of



2-3a



2-3b



2-3c

Figure 2-3. Precipitation recorded at individual LANL meteorological stations, June 1 to October 31, 2000.

the Laboratory, where precipitation seemed to be highest along the steep elevation change of the mountain-front Pajarito Fault line. The highest amount of precipitation (0.73 in.) occurred at TA-16 on July 9. Monsoon rains continued into August, when the greatest amount of precipitation recorded was at the eastern, lower-elevation meteorological stations during two separate events on August 9 (0.74 in. at TA-54) and August 18 (1.71 in. at TA-54). Precipitation events in July and August appear to be of longer duration in July and August compared with those recorded in June.

September was a relatively dry month with only two significant precipitation events of relatively small amounts. The highest precipitation recorded was on September 9 at the North Community station where 0.52 in. was received. Most other meteorological stations received less than half this amount.

October was a relatively wet month with several multiple-day precipitation events. Precipitation recorded throughout the plateau during each precipitation event was quite similar, suggesting that the storms must have blanketed the entire area. During the first half of the month, precipitation was received at all stations over a 6-day period. Near the end of the month, two significant multiple-event precipitation events occurred on October 24-25 and on October 27-28.

Precipitation pattern maps for each sampled storm event provide further evidence of the different precipitation patterns that occurred over the Pajarito Plateau in the summer of 2000 (see Appendix A).

2.3 Summary of Storm Water Runoff Characteristics in 2000

In 1991, the Laboratory began regularly monitoring runoff from storm events on Laboratory property in Pueblo and Los Alamos Canyons. The number of monitoring locations (stream gages) was augmented from 1995 to 1999 and the stream gages were equipped with automated runoff samplers. By the year 2000, the sampling network comprised 60 sampling stations. Figure 2-4 shows the locations of the storm water sampling stations on the Pajarito Plateau.

In 2000, LANL conducted an extensive environmental monitoring and sampling program to evaluate the effects of the Cerro Grande Fire at the Laboratory and especially to evaluate if the Laboratory may have impacted public and worker health and the environment as a result of the fire. Storm water sampling activities were conducted according to the *Institutional Monitoring and Sampling Plan for Evaluating Impacts of the Cerro Grande Fire* (LANL 2000).

Using the automated flow monitoring stations and visual inspections of runoff conditions, Laboratory personnel collect samples at the following sites:

1) upstream of Laboratory property as storm water moves onto Laboratory property from the west,
2) on Laboratory property as storm water originates at and moves through the Laboratory, and
3) at sites at the downstream side of the Laboratory near the eastern boundary.

At times, runoff samples are also collected manually at specific locations where stream gages and automatic samplers are not located. These samples are designated as manual, or grab, runoff samples.

A list of the stream gage sampling stations and manual collection sites that were sampled during the 2000 season is in Table 2-3. This table shows the canyon where the sample collection sites are located, the common name of the collection site, and whether automated or manual runoff samples were collected at each site.

Runoff samples were collected on 27 days during the summer 2000 runoff season. A list of the dates when runoff samples were collected and the locations that were sampled is in Table 2-4. Some runoff

samples were collected on days following precipitation events, so the sample dates do not necessarily reflect the dates of precipitation. Some sample collection sites were sampled on consecutive days when runoff continued after a storm event, or after another storm event.

Table 2-5 lists the analytical suites and the code letters that are used in following sections to describe the analyses that were performed on the storm water runoff samples that were collected in 2000. The analytical suite letter codes are used in sample collection tables in Section 3. Refer to Table 2-5 for the meaning of the analytical suite codes.

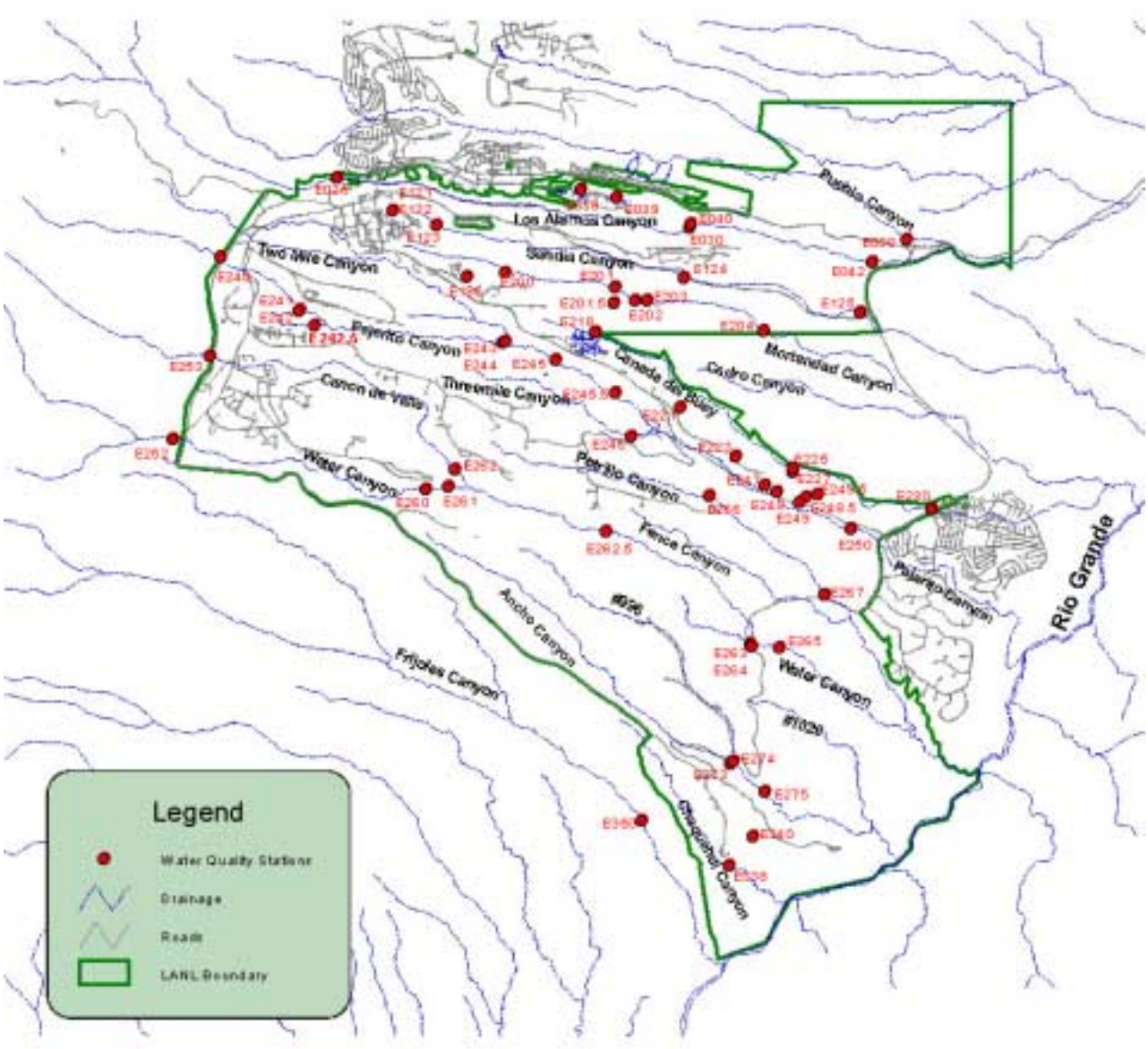


Figure 2-4. Storm water sampling stations on the Pajarito Plateau.

Table 2-3. Storm Water Runoff Collection Sites at LANL.*

Gage	Canyon	Location	Collection Method
E025	Los Alamos	Los Alamos Canyon at Omega Bridge	Automated and Manual
E030	Los Alamos	Los Alamos Canyon above DP Canyon	Automated
E038	DP	DP Canyon at Head	Manual
E039	DP	DP Canyon below Meadow at TA-21	Automated
E040	DP	DP Canyon at Los Alamos Canyon	Automated
E042	Los Alamos	Los Alamos Canyon above SR 4	Automated
E060	Pueblo	Pueblo Canyon above Los Alamos Canyon	Automated
E122	Sandia	Sandia Canyon at TA-3	Automated
E196	Mortandad	Effluent Canyon at TA-55	Automated
E218	Cañada del Buey	Cañada del Buey at TA-46	Automated
E221	Cañada del Buey	TA-54 MDA-J	Automated
E223	Cañada del Buey	TA-54 MDA-L	Automated
E230	Cañada del Buey	Cañada del Buey above SR 4 at White Rock	Automated
E240	Pajarito	Pajarito Canyon above SR 501	Automated and Manual
E241	Pajarito	Pajarito Canyon at TA-22	Automated
M2417	Pajarito	Starmers Gulch above SR 501	Manual
E242	Pajarito	Starmers Gulch at TA-22	Automated
E250	Pajarito	Pajarito Canyon above SR 4	Automated
E252	Water	Water Canyon above SR 501	Manual
E253	Cañon de Valle	Cañon de Valle above SR 501	Manual
E263	Water	Water Canyon above SR 4	Automated and Manual
E265	Water	Water Canyon below SR 4	Automated and Manual
E267	Potrillo	Potrillo Canyon above SR 4	Automated
E273	Ancho	Ancho Canyon above SR 4	Automated and Manual
E275	Ancho	Ancho Canyon below SR 4	Automated and Manual
E247	Pajarito	TA-54 MDA-G (Formerly G-1)	Automated
E248	Pajarito	TA-54 MDA-G (Formerly G-2)	Automated
E248.5	Pajarito	TA-54 MDA-G (Formerly G-3)	Automated
E249.5	Pajarito	TA-54 MDA-G (Formerly G-4)	Automated
E227	Pajarito	TA-54 MDA-G (Formerly G-6)	Automated
EULR	Los Alamos	Los Alamos Canyon above reservoir	Manual
ELAR	Los Alamos	Los Alamos Reservoir Discharge	Manual
ELAW	Los Alamos	Los Alamos Canyon at Retention Pond above SR 4	Manual
EGS4	Guaje	Guaje Canyon at SR 502	Manual
EPRP	Pajarito	Pajarito Canyon at Retention Pond	Manual
M2436	Pajarito	Twomile Canyon above SR 501	Manual
E18C	Pajarito	Pajarito Canyon at TA-18 Culvert	Manual
EPG1	Pajarito	Pajarito Canyon at G-1 Pump Station	Manual
ER3X	Rendija	Rendija Canyon at 3rd Crossing	Manual
ES4C	Pajarito	Pajarito Canyon at SR 4 Culvert	Manual

* See Appendix B, Table B-1 for Water Quality Database location names.

Table 2-4. Storm Water Runoff Samples Collected in 2000.

Collection Date	Locations Sampled [a]
02-Jun	E030, E040, E042
03-Jun	E025, E042
28-Jun	E240, E241, E242, E250, E252, E253, E263, E265, E18C, EPG1, ES4C
09-Jul	E042, EGS4
15-Jul	E223
17-Jul	E122, E196, E223, ER3X
18-Jul	E025
21-Jul	ELAW
25-Jul	E039
29-Jul	E227, E230, E265, E248, E248.5, E265
09-Aug	E221, E227, E230, E247, E248, E248.5, E267
14-Aug	E265
15-Aug	E249.5
18-Aug	E227, E230, E248.5, E265, E273, E275
24-Aug	EPRP
31-Aug	EULR, ELAR
08-Sep	E240, EGS4
12-Sep	E025
07-Oct	E196, E223
11-Oct	E122, E227, E247, E248, E248.5
12-Oct	E040, E042, E230, E249.5
23-Oct	E030, E038, E039, E040, E042, E060, E218, E230, E240, M2417, E252, E253, E265, E267, E275, E249.5, M2417, M2436
24-Oct	E250
25-Oct	E248.5
27-Oct	E039, E040, E042, E060, E250, E263, E265
28-Oct	E230, E248.5, E250, E273, E275
30-Oct	E042

a. See Table 2-3 for location names of sampling stations

Table 2-5. Analytical Suite Numbers and Codes.

Analytical Suite Number Code	Analytical Suite	Analytical Suite Code Name	Analytes
G	General Inorganic	Gen Inorg	ALK-CO3, ALK-CaCO3, cyanide (CN) (amenable), CN(Total), COD, Ca, Cl(-1), K, NH3, NO3-NO2, Na, P, Specific Conductance (SP), SO4(-2), Specific Gravity (SPGR), Si, TDS, TKN, TSS, VOLSOL
G1	General Inorganic	Gen Inorg	TSS, SPGR, and/or VOLSOL, CN
R	Radionuclides	RAD	Am-241, Pb-210, Po-210, Pu-238 Pu-239,240; Ra-226, Ra-228, SR 90 Th-228, Th-230, Th-232, U-234, U-235,236, U-238, Plus gamma spectroscopy
M	Metals	Metals	Ag, Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, Ti, Tl, U, V, Zn
P	Pesticide/PCB	Pest/PCB	See ESP 2000, Table A12 for list of PCB analytes and Table A-9 for analytical methods.
HE	High Explosive Compounds	HEXP	See ESP 2000, Table A-13 for list of analytes and Table A-9 for analytical methods.
VOC	Volatile Organic Compounds	VOA or VOC	See ESP 2000, Table A-10 for list of analytes and Table A-9 for analytical methods.
S	Semivolatile Organic Compounds	SVOA or SVOC	See ESP 2000, Table A-11 for list of analytes and Table A-9 for analytical methods.
D/F	Dioxins/Furans	Diox/Fur	

One of the notable effects of the Cerro Grande Fire was increased runoff from precipitation events during the summer of 2000. When localized thunderstorms occurred over the higher elevations of the Sierra de los Valles, such as those that generally occurred in June, runoff from burned slopes was significantly higher in canyons downstream of the precipitation than previously recorded. Record high runoff resulting from the 30-minute June 28 event was experienced at stream gages located along the western boundary of the Laboratory. Gages in upper Pajarito Canyon, Cañon de Valle, and Water Canyon experienced flood conditions and were destroyed by record high runoff events.

The peak flow observed at stream gages in 2000 compared with previously observed maximum runoff rates are shown in Figure 2-5. Runoff data are available for 19 stream gages, of which 12 gages experienced record high runoff rates in 2000. The highest runoff observed was at gage E240 in Pajarito Canyon at the western Laboratory boundary on June 28 where over 1000 cubic feet per second (cfs) was estimated to have resulted from the 0.69 in. recorded at the nearby Pajarito Canyon RAWS. Gage E240 was destroyed by the floodwaters. Stream gage E241, located in Pajarito Canyon downstream from E240, also experience record high runoff and was also destroyed during the June 28 flood event. Other stream gages that received record runoff rates on June 28 were E242 in middle Pajarito Canyon, E253 in Cañon de Valle, and Water Canyon gages E252, E261, E263, and E265.

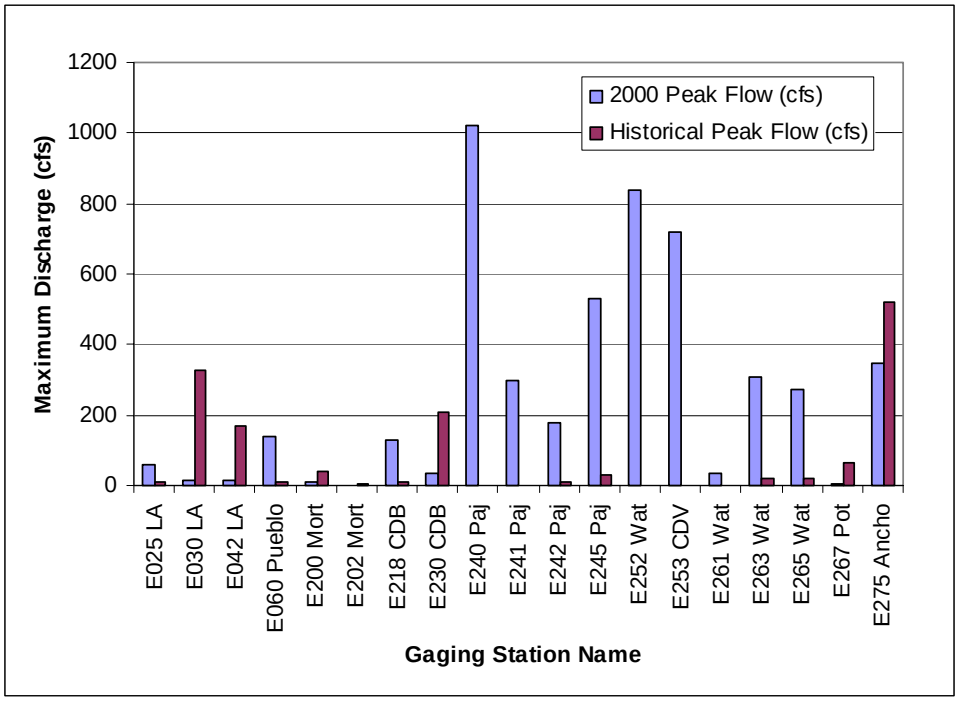


Figure 2-5. Peak runoff recorded in 2000 compared with historical peak flows.

Monsoonal thunderstorms in July and August created higher precipitation at lower elevations on the plateau where higher runoff rates were observed at stream gages located on the eastern, downstream side of the Laboratory. The highest runoff rates observed at gage E230 in Cañada del Buey in 2000 were recorded on August 9; however, the runoff was only about 16% of the historical high observed for this station, probably because the fire affected a relatively small portion of the upper reaches of Cañada del Buey. The highest runoff recorded at gage E025 in Los Alamos Canyon near Omega Bridge occurred on July 18, which resulted from a precipitation event in the upper part of the watershed, where 0.64 in. was received at the upper Los Alamos Canyon RAWS, 1.09 in. at the Quemazon Canyon RAWS, and 0.14 in. was received at the TA-6 station.

Additional information about precipitation and runoff in specific canyons for each runoff event for which samples were collected is presented in following sections.

3.0 Description of Runoff Sampling Events after the Cerro Grande Fire

3.1 June 2, 2000

The first significant precipitation event after the Cerro Grande Fire occurred on June 2. The pattern of precipitation that was recorded on the Pajarito Plateau on June 2 is shown in Appendix A Figure A-1. The official LANL meteorological station was damaged by the Cerro Grande Fire and did not record the precipitation event. Other meteorological stations around the Pajarito Plateau recorded rainfall ranging from 0.19 in. at TA-49 to 0.76 in. at the North Community station in Los Alamos, with an average rainfall across the Pajarito Plateau of about 0.5 in. Rainfall recorded on Pajarito Mountain was 0.6 in., and 0.55 in. were recorded at TA-53. Three of the eight RAWS operated by the US Forest Service recorded rainfall in the storm and indicated that most of the precipitation was received in a one- to two-hour period. The precipitation was from a thunderstorm that passed through the area during the afternoon hours from 1600 to 1800 hours. The higher volumes of precipitation (>0.7 in.) were received west of the Los Alamos town site, and lower volumes (<0.2 in.) were recorded at lower elevations of the Pajarito Plateau at the southeastern part of the Laboratory. The hourly precipitation received at Pajarito Mountain and TA-53 on June 2 is shown in Figure 3-1.

Figure 3-1 shows the hydrograph of stream flow at stream gages E025, E030, and E042 in Los Alamos Canyon during the runoff event. Stream flow in the upper and middle part of the canyon was maintained by discharges from Los Alamos Reservoir, which was being drained at the time. Base flow at gage E025 on June 2 was about 5 cfs and at gage E030 was about 2 cfs. Base flow did not extend to gage E042.

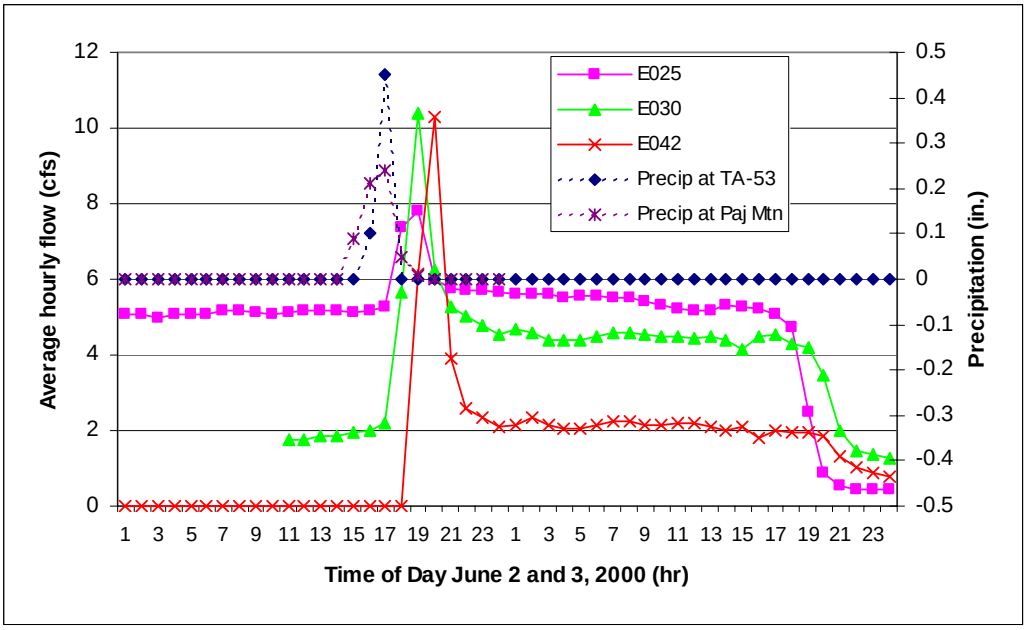


Figure 3-1. Precipitation at TA-53 and Pajarito Mountain and average hourly streamflow at gages in Los Alamos Canyon on June 2 and 3, 2000.

As a result of the precipitation event, increased flow at gage E025 began at 1640 hours, and the peak flow was 11.4 cfs at 1755 hours. Increased flow began at gage E030 at 1655 hours, and the peak flow was 12.8 cfs at 1805 hours. Flow at gage E042 began at 1840 hours, and the peak flow in Los Alamos Canyon was 17.3 cfs at gage E042 at 1910 hours. Flow at gage E040 in lower DP Canyon was estimated to be 20 cfs.

The runoff data indicate that flow increased downstream as runoff entered Los Alamos Canyon from tributaries and as a result of precipitation within the middle part of the watershed. As a result of draining Los Alamos Reservoir, flow in Los Alamos Canyon continued at about 5 cfs at E025, 4 cfs at E030, and 2 cfs at E042 throughout most of June 3 (see Figure 3-1). The total volume of runoff that passed through gage E042 on June 2 and 3 was approximately 263,000 cubic ft.

As a result of the June 2 storm, storm water flowed in Los Alamos Canyon throughout the length of the canyon on Laboratory property and continued to flow off Laboratory property to the Rio Grande. Personnel of the Water Quality and Hydrology Group (ESH-18) collected samples manually and from three automated sampling stations in Los Alamos Canyon on June 2 and 3. Storm water runoff samples were collected at two sites in Los Alamos Canyon and one site in DP Canyon on June 2 and two sites in Los Alamos Canyon on June 3. The sites sampled on June 2 and 3, the sample identification numbers, field preparation information (filtered or unfiltered samples), and analytical suites are listed in Table 3-1.

On June 2, automated storm water runoff samples were collected for analyses. On June 3, runoff samples were collected manually and portions of the samples were filtered for laboratory analyses. The filtered samples are used to determine the dissolved concentrations of constituents and the unfiltered samples are used to determine concentrations of metals and radionuclides. The suspended sediment fraction of the samples was also analyzed for radionuclides.

Table 3-1. Storm Water Runoff Samples Collected on June 2 and 3, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
02-Jun	E030	PS00061E030		Automated	UF	G, M, R, P, S
02-Jun	E030	PS00062E030		Automated	UF	G1
02-Jun	E040	PS00061E040		Automated	UF	G, M, R, P, S
02-Jun	E040	PS00062E040		Automated	UF	G1
02-Jun	E042	PS00061E042		Automated	UF	G, M, R
02-Jun	E042	PS00062E042		Automated	UF	G1
03-Jun	E025	PS00061E025		Manual	UF	G, M, R, P, S
03-Jun	E025	PF00061E025		Manual	F	G1, M, R
03-Jun	E025	PS00062E025		Manual	UF	G1
03-Jun	E042	PS00063E042		Manual	UF	G, M, R, P, S
03-Jun	E042	PF00063E042		Manual	F	G1, M, R
03-Jun	E042	PS00064E042		Manual	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.2 June 28, 2000

The second significant precipitation event after the Cerro Grande Fire occurred on June 28. The pattern of precipitation that was recorded on the Pajarito Plateau on June 28 is shown in Figure A-2. The official LANL meteorological station at TA-6 recorded 0.25 in. but the heaviest rainfall was received west of the Laboratory on the flanks of the Sierra de los Valles in the vicinity of Pajarito Canyon and Water Canyon. The Water Canyon RAWS received the largest amount of precipitation, 0.79 in. in about 1 hour from 1200 to 1300 hours, and the Pajarito Canyon RAWS received 0.69 in. Other meteorological stations around the Pajarito Plateau recorded rainfall ranging from 0.01 in. at TA-53 to 0.25 in. at Pajarito Mountain, with an average rainfall across the western plateau area of about 0.25 in. Nine RAWS recorded rainfall in the storm. The precipitation was from a thunderstorm that climaxed over the area midday from 1200 to 1300 hours. The higher volumes of precipitation (>0.5 in.) were received west of TA-16, and lower volumes (<0.1 in.) were recorded at Los Alamos town site, TA-53, and TA-54.

The precipitation caused flooding conditions in canyons west of LANL. Stream gages in Pajarito Canyon (E240, E241, and E242), Cañon de Valle (E253), and Water Canyon (E252) were destroyed by the ensuing floodwaters. Record high runoff volumes were observed in Pajarito Canyon at gages E240, E241, E242, and E245, Cañon de Valle at gage E253, and in Water Canyon at gages E252, E261, E263, and E265 on June 28 as a result of the storm event. Table 3-2 lists the record flows that were observed on this date and Figure 3-2 shows the available hydrographs of stream gages E242 and E250 in middle and lower Pajarito Canyon, respectively, and gages E263 and E265 in lower Water Canyon that were not destroyed in the runoff event. The peak flow in Pajarito Canyon at the former location of gage E240 upstream of SR 501 was 1020 cfs, a record for observed flows on Laboratory property (previous peak flow was 520 cfs in Ancho Canyon in 1993).

Table 3-2. Record Peak Flows Observed on June 28, 2000.

Station	Canyon	Date of Peak Flow	2000 Peak Flow (cfs)	Historical Peak Flow (cfs)	Start of Period of Record
E240	Pajarito	6/28/00	1020	2.4	Oct-93
E241	Pajarito	6/28/00	300	0.21	Mar-99
E242	Pajarito	6/28/00	180	10	Oct-99
E245	Pajarito	6/28/00	532	30	Nov-93
E250	Pajarito	6/17/99	14.4	20	Nov-93
E252	Water	6/28/00	840	0.29	Oct-94
E253	Cañon de Valle	6/28/00	720	0	Oct-94
E261	Water	6/28/00	37	0	Oct-98
E263	Water	6/28/00	306	20	Oct-98
E265	Water	6/28/00	274	21	Oct-93

Data from Water Quality and Hydrology Group (ESH-18); data are provisional

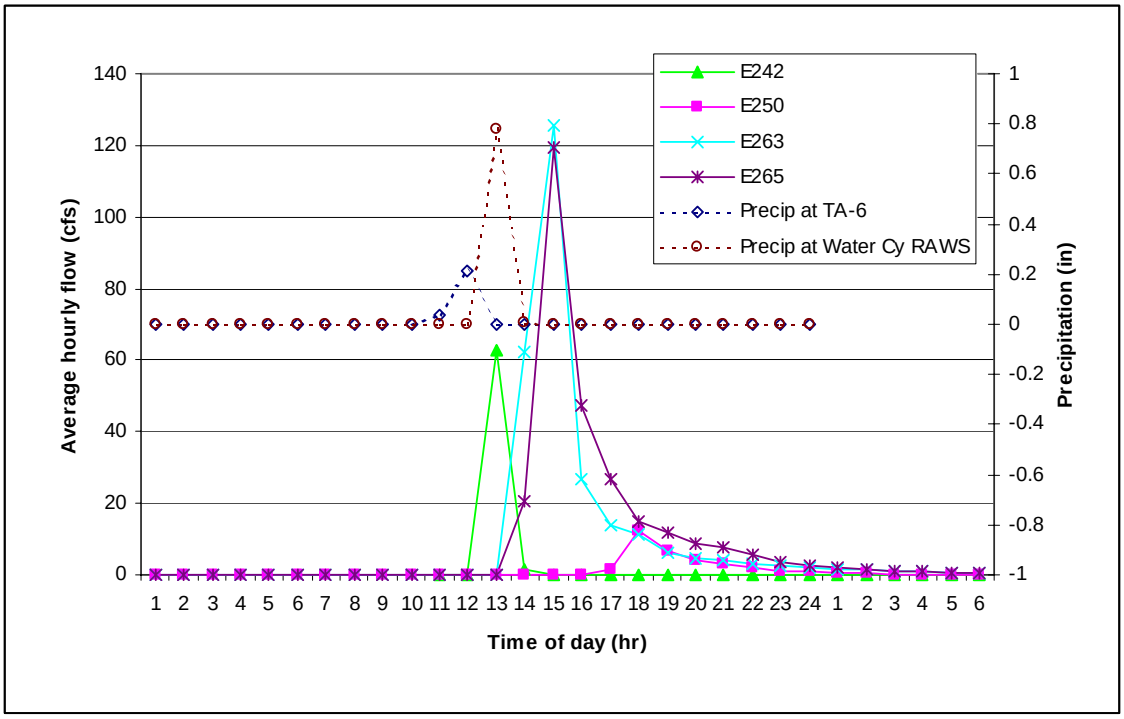


Figure 3-2. Precipitation at TA-6 and the Water Canyon RAWS and average hourly streamflow in Pajarito and Water Canyons on June 28, 2000.

As a result of the June 28 storm, storm water runoff flowed in Pajarito Canyon and Water Canyon throughout the length of the canyons on Laboratory property and continued to flow off Laboratory property to the Rio Grande. ESH-18 personnel collected samples from 11 sites, including seven sites in Pajarito Canyon, one site in Cañon de Valle, and three sites in Water Canyon. The storm water runoff samples collected on June 28 are listed in Table 3-3.

Table 3-3. Storm Water Runoff Samples Collected on June 28, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
28-Jun	E240	PF00063E240		Automated	F	G, M, R
28-Jun	E240	PS00063E240		Automated	UF	G, M, R, HE, P, S
28-Jun	E240	PS00064E240		Automated	UF	G1
28-Jun	E241	PF00061E241		Automated	F	G, M, R
28-Jun	E241	PS00061E241		Automated	UF	G, M, R, P
28-Jun	E241	PS00062E241		Automated	UF	G1
28-Jun	E242	PF00065E242		Automated	F	G, M, R
28-Jun	E242	PS00065E242		Automated	UF	G, M, R, P, S
28-Jun	E242	PS00066E242		Automated	UF	G1
28-Jun	E250	PF00061E250		Automated	F	G. M, R
28-Jun	E250	PS00061E250		Automated	UF	G, M, R, HE, P, S
28-Jun	E250	PS00062E250		Automated	UF	G1
28-Jun	E252	PS00061E252		Manual	UF	G, M, R, S
28-Jun	E252	PS00062E252		Manual	UF	G1
28-Jun	E253	PS00061E253		Manual	UF	G, M, R, HE, P, S
28-Jun	E253	PS00062E253		Manual	UF	G1
28-Jun	E263	PF00061E263		Manual	F	R
28-Jun	E263	PS00061E263		Manual	UF	G, M, R, HE, P, S
28-Jun	E263	PS00062E263		Manual	UF	G1
28-Jun	E265	PF00061E265		Manual	F	G, M, R
28-Jun	E265	PS00061E265		Manual	UF	G, M, R, HE, P, S
28-Jun	E265	PS00062E265		Manual	UF	G1
28-Jun	E18C	PF00061E18C		Manual	F	G, M, R
28-Jun	E18C	PS00061E18C		Manual	UF	G, M, R, P, S
28-Jun	E18C	PS00062E18C		Manual	UF	G1
28-Jun	EPG1	PF00061EPG1		Manual	F	R
28-Jun	EPG1	PS00061EPG1		Manual	UF	G, R
28-Jun	EPG1	PS00062EPG1		Manual	UF	G1
28-Jun	ES4C	PF00065ES4C		Manual	F	G1, M, R
28-Jun	ES4C	PS00065ES4C		Manual	UF	G, M, R, HE, P, S
28-Jun	ES4C	PS00066ES4C		Manual	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

Flow at gage E242 in Starmer's Gulch, a tributary to Pajarito Canyon near the western Laboratory boundary, began at 1210 hours, and the peak flow was 180 cfs at 1240 hours. The flow at this site was relatively brief (about one hour) because of the small drainage area above this gage; the total volume of runoff in Starmer's Gulch resulting from the runoff event was approximately 250,000 cubic ft.

Flow at gage E250 in lower Pajarito Canyon began at 1655 hours and continued at low flow rates for about eight hours. The peak flow at gage E250 was 14.4 cfs at 1710 hours, which was less than the historical maximum that was observed on June 17, 1999, when 20 cfs were recorded (Shaull et al. 2000).

Flow continued at gage E250 in declining amounts until about midday on June 29. The total volume of runoff that passed through gage E250 on June 28 and 29 was approximately 120,000 cubic ft.

Flow at gage E265 in lower Water Canyon began at 1400 hours and continued at low flow rates about one day. The peak flow was 270 cfs at 1400 hours, and the total volume of water that passed through the gage was about 950,000 cubic ft.

3.3 July 9, 2000

The third significant precipitation event after the Cerro Grande Fire occurred on July 9. The pattern of precipitation that was recorded on the Pajarito Plateau on July 9 is shown in Figure A-3. The pattern is similar to that recorded on June 28 where the highest precipitation was recorded along the western margin of the Laboratory. The official LANL meteorological station at TA-6 recorded 0.49 in. but the heaviest rainfall was received west of Los Alamos on the flanks of the Sierra de los Valles at the Pueblo Canyon RAWS, which recorded 0.81 in. The TA-16 station received 0.73 in., and the Pajarito Canyon and Water Canyon RAWS received 0.66 and 0.6 in., respectively. The hourly precipitation received at TA-6 on July 9 is shown in Figure 3-3.

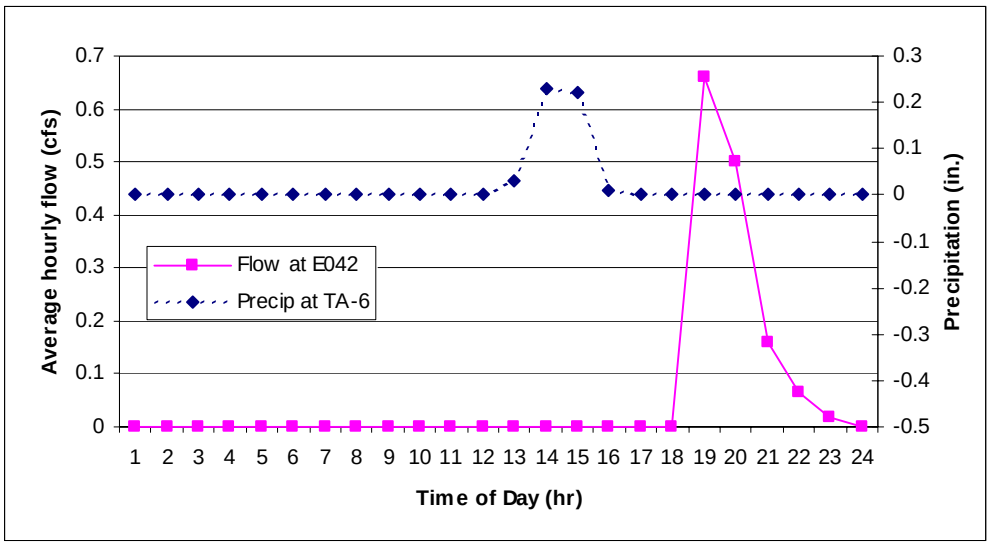


Figure 3-3. Precipitation at TA-6 and average hourly flow at gage E042 on July 9, 2000.

Meteorological stations located in the central and eastern part of the Laboratory at TA-49, TA-54, and TA-74 did not record precipitation and only 0.05 in. were received at TA-53. Pajarito Mountain received 0.14 in. and the upper Los Alamos RAWS received 0.21 in. The precipitation was apparently from a localized thunderstorm that climaxed over the western Pajarito Plateau between 1300 and 1500 hours. The higher volumes of precipitation (>0.5 in.) were received along the western boundary of the Laboratory, and lower volumes (<0.1 in.) were observed in the eastern part of the Pajarito Plateau. Precipitation north of Los Alamos town site on July 9 was variable. The Guaje Canyon RAWS received 0.22 in., the Garcia Canyon RAWS received 0.12 in., and the Santa Clara Canyon RAWS received 0.65 in.

The average hourly flow at gage E042 on July 9 is shown in Figure 3-3. Flow at gage E042 began at 1825 hours when the peak flow of 1.28 cfs was recorded. The flow continued for about six hours and the total volume of runoff at gage E042 was approximately 5000 cubic ft. The flow in Guaje Canyon at SR 502 above the confluence with Los Alamos Canyon was estimated to be 40 cfs at the time the sample was collected. As a result of the July 9 precipitation, storm water flowed in Los Alamos Canyon throughout

the length of the canyon on Laboratory property and continued to flow off Laboratory property. The total extent of flow in the canyon is not known and it is not known if runoff reached the Rio Grande. Storm water runoff also flowed in Guaje Canyon at the confluence with Los Alamos Canyon. On July 9 personnel from ESH-18 collected runoff samples from two sites, one sample was manually collected in Guaje Canyon at SR 502, and automated samples were collected in lower Los Alamos Canyon at gage E042. The samples that were collected July 9 are listed in Table 3-4.

Table 3-4. Summary of Runoff Samples Collected July 9, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
07/09	E042	PF00071E042	1939	Automated	F	G1, M, R
07/09	E042	PS00071E042	1939	Automated	UF	G, M, R, HE, P, S
07/09	E042	PS00072E042		Automated	UF	G1
07/09	M090	PF00071EGS4	1850	Manual	F	G1, M, R
07/09	M090	PS00071EGS4	1850	Manual	UF	G, M, R, HE, P, S
07/09	M090	PS00072EGS4				G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.4 July 16 to 19, 2000

During the middle of July, several localized thunderstorms occurred over the Pajarito Plateau and Sierra de los Valles. Because of the localized nature of the precipitation events, runoff samples were collected at gaging stations and in canyons where runoff occurred on July 16 to 19.

On July 16, thunderstorms occurred primarily north and west of Los Alamos where the Garcia Canyon, Guaje Canyon, and Quemazon Canyon RAWS each received over 1.4 in. of rainfall. Meteorological stations around Los Alamos received light rainfall, generally less than 0.1 in. The small amount of precipitation on July 16, however, caused flow at one sampler in upper Sandia Canyon at gage E122 where one runoff sample was collected on July 16. The flow at this station was primarily runoff from parking lots and streets at TA-3 and was not related to runoff from areas significantly impacted by fire. Runoff samples were collected at gage E122 at 2312 hours, after 0.05 in. of rainfall was received at TA-6 between 2200 to 2230 hours on the evening of July 16. Storm water runoff samples collected on July 16 are listed in Table 3-5.

On July 17, local midday thunderstorms produced precipitation at the Laboratory that ranged from 0.02 in. at Pajarito Mountain to 0.18 in. at TA-49; the TA-6 meteorological station received 0.16 in. The highest rainfall amounts were recorded west of Los Alamos in upper Los Alamos Canyon, upper Pueblo Canyon, and upper Rendija Canyon. The upper Los Alamos Canyon RAWS received 0.27 in. and the Pueblo Canyon RAWS received 0.21 in. Figure A-4 shows the pattern of precipitation that was recorded on the Pajarito Plateau on July 17.

As a result of the precipitation received on July 17, runoff samples were collected in Rendija Canyon (site ER3X) and again in upper Sandia Canyon at gage E122. Manual runoff samples were collected in middle Rendija Canyon at the third road crossing of the stream near the boundary between Government Services Agency land and US Forest Service land. Table 3-5 lists the runoff samples that were collected July 16 through 19.

On July 18, a thunderstorm occurred in the Sierra de los Valles west of Los Alamos. The heaviest precipitation was recorded at the Quemazon Canyon RAWS, which recorded a total of 1.09 in., most of which was received between 1400 and 1600 hours. Precipitation received at the Laboratory ranged from 0.01 in. at TA-53 to 0.51 in. at TA-49. The TA-6 meteorological station received 0.14 in. Figure A-5 shows the pattern of precipitation recorded on the Pajarito Plateau on July 18.

Table 3-5. Storm Water Runoff Samples Collected July 16 through July 19, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
16-Jul	E122	PS00071E122	2312	Automated	UF	G, P
17-Jul	E122	GS00073E122	1322	Automated	UF	G1, M
17-Jul	E122	PS00073E122	1507	Automated	UF	G, M, R
17-Jul	E122	PS00074E122	1507	Automated	UF	G1
17-Jul	E196	GS00071E196	1316	Automated	UF	M
17-Jul	E196	PS00071E196	1316	Automated	UF	G, M, R
17-Jul	E196	PS00072E196	1316	Automated	UF	G1
17-Jul	E223	GF00073E223	1507	Automated	F	M
17-Jul	E223	GS00073E223	1507	Automated	UF	G, M, S
17-Jul	E223	PS00073E223	1507	Automated	UF	G, R, P, S
17-Jul	E223	PS00074E223	1507	Automated	UF	G1
17-Jul	ER3X	GF00071ER3X	1400	Manual	F	M
17-Jul	ER3X	PF00071ER3X	1400	Manual	F	G1, M, R
17-Jul	ER3X	PS00071ER3X	1400	Manual	UF	G, M, R
17-Jul	ER3X	PS00072ER3X	1400	Manual	UF	G1
18-Jul	E025	GF00071E025	1841	Automated	F	M
18-Jul	E025	GS00071E025	1841	Automated	UF	G1, M
18-Jul	E025	PF00071E025	1841	Automated	F	G1, M, R
18-Jul	E025	PS00071E025	1841	Automated	UF	G, M, R, P, S
18-Jul	E025	PS00073E025	1854	Automated	UF	G1
19-Jul	E025	PS00072E025	1200	Manual	UF	G1
19-Jul	E025	PS00074E025	1330	Manual	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

Automated runoff samples were collected in middle Los Alamos Canyon at gage E025 on July 18, and samples were collected manually on July 19. Figure 3-4 shows the hourly precipitation recorded at the Quemazon Canyon RAWS and the average hourly flow at gage E025. The precipitation occurred in the middle afternoon at Quemazon Canyon and a small amount of flow, resulting from local precipitation, began at E025 at 1520 hours, which lasted for about two hours. The main flow event, resulting from precipitation in the upper part of the watershed, began at gage E025 at 1840 hours. Automated runoff samples were collected at 1841 and 1854 hours (see Table 3-5). The peak flow was 23.8 cfs at 1900 hours, and a small amount of flow continued into July 19. The total volume of water that passed through gage E025 as a result of the precipitation was approximately 200,000 cubic ft. On July 19, water stored in the Los Alamos Canyon Reservoir was drained to permit maintenance and repair on the dam structure and to prevent breach of the dam. When the release of water from the dam reached gage E025, two samples were manually collected on July 19 for the analyses of total suspended solids.

3.5 July 21, 2000

The precipitation event that occurred over the eastern flank of the Sierra de los Valles on the afternoon of July 18 created storm water runoff and runoff debris that collected in the Los Alamos Reservoir in upper Los Alamos Canyon. The increased runoff from the fire-affected areas caused the outflow culverts in the dam to plug, which did not allow water to flow from the reservoir downstream. The debris was removed from the outflow culverts the next day, July 19, and water was allowed to drain from the reservoir into Los Alamos Canyon. The water released from the reservoir passed through stream gage E042 (Los Alamos Canyon at Los Alamos), located upstream of SR 4 near the eastern Laboratory boundary. The pattern of precipitation recorded on the Pajarito Plateau on July 18 is shown in Figure A-5, and the hourly precipitation received at the Quemazon Canyon RAWS is shown in Figure 3-4.

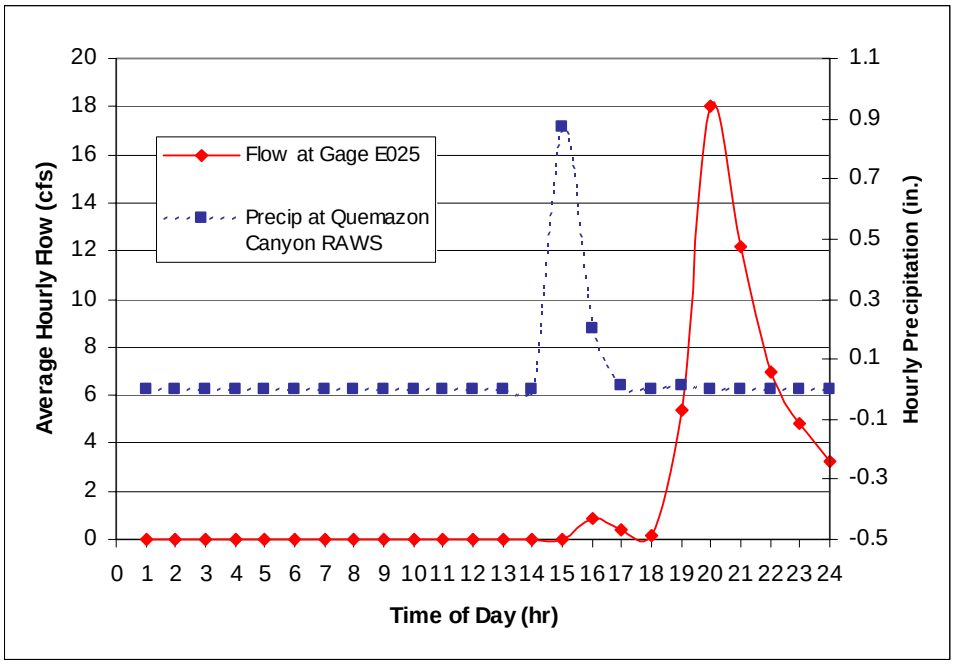


Figure 3-4. Precipitation at the Quemazon Canyon RAWS and flow at gage E025 on July 18, 2000.

Figure 3-5 shows the hydrograph of the stream flow measured at gage E042 on July 18 through 22 and the hourly precipitation received at the upper Los Alamos Canyon RAWS on July 18. The peak flow at gage E042 that resulted from the precipitation event on July 18 was 5.6 cfs at 2255 hours. The flow associated with the precipitation event decreased to about 0.05 cfs by midday on July 19. The total volume of runoff at gage E042 on July 18 and 19 as a result of the precipitation event was approximately 95,000 cubic ft.

Discharge from the reservoir arrived at gage E042 at 1945 hours on the evening of July 19 at a maximum flow of 8.7 cfs. The discharge from the reservoir passed through the gage for about three days. The total volume of water that passed through gage E042 during this time was approximately 680,000 cubic ft. The discharge from the stream gage entered the site of the low-head weir retention pond, which at the time was undergoing construction in lower Los Alamos Canyon just upstream of SR 4. The water hindered construction activities and was pumped from the retention pond structure around the low-head weir into lower Los Alamos Canyon downstream of the structure.

In compliance with Laboratory discharge requirements, a grab sample of the water pumped from the low-head weir was collected from Los Alamos Canyon downstream of the retention pond and near SR 4 at 1119 hours on July 21. At the time of collection of the samples, flow at gage E042 was 1.1 cfs. The water samples are similar to storm water runoff, however, the runoff was temporarily retained in Los Alamos Reservoir in upper Los Alamos Canyon on July 18-19 and again in the retention pond near SR 4 on July 20-21 before being pumped into lower Los Alamos Canyon and discharged off site.

The runoff samples collected in Los Alamos Canyon on July 21 are listed in Table 3-6. Both filtered and unfiltered samples of the runoff were obtained for analysis. The samples were sent to General Engineering Laboratories, Inc. in Charleston, South Carolina, for analysis for radionuclides, metals, general inorganic constituents, SVOCs, and PCBs.

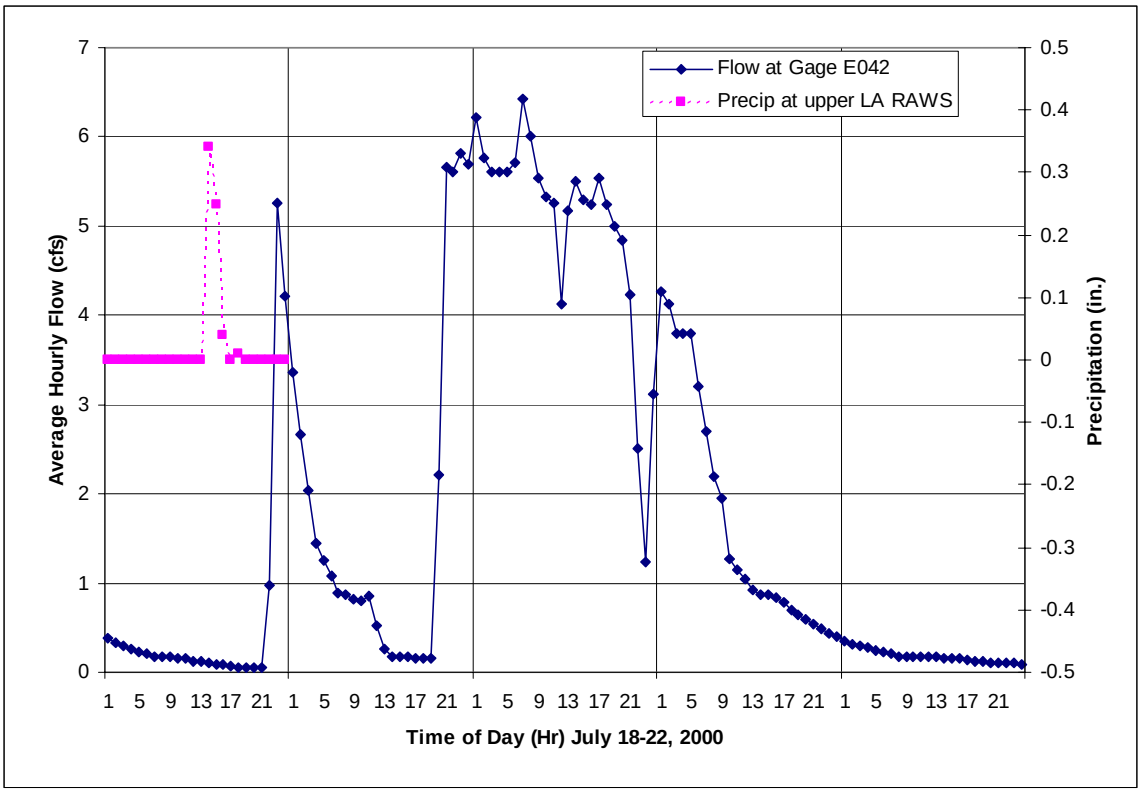


Figure 3-5. Precipitation at upper Los Alamos Canyon RAWS and streamflow at gage E042 in Los Alamos Canyon above SR 4 from July 18 to 22, 2000.

Table 3-6. Samples Collected in Lower Los Alamos Canyon near SR 4 on July 21, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
21-Jul	ELAW	GF00071ELAW	1119	Manual	F	G1, M, R
21-Jul	ELAW	GS00071ELAW	1119	Manual	UF	G, M, R, P, S
21-Jul	ELAW	GS00072ELAW	1122	Manual	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.6 July 25, 2000

A precipitation event occurred over the Pajarito Plateau on July 25. Figure A-6 shows the pattern of precipitation recorded at area meteorological stations. Most stations in the western part of the Laboratory, in Los Alamos, and along the flanks of the mountains received about 0.1 in. of precipitation, however, heavier amounts of precipitation were received in the Sierra de los Valles and along the south and east sides of the Laboratory. The heaviest precipitation, 0.43 in., was received at TA-74; TA-54 received 0.32 in. and TA-53 received 0.22 in. The hourly precipitation received at TA-53 is shown in Figure 3-6. The majority of the precipitation was received at TA-53 between 2000 and 2100 hours during the evening on July 25.

As a result of the precipitation event, storm water runoff in middle DP Canyon passed through stream gage E039. The average hourly flow at gage E039 on July 25 is shown in Figure 3-6. The flow began at 2220 hours and continued until about 0400 hours on the morning of July 26. The peak flow was 1.45 cfs at 2220 hours, and the total volume of runoff was approximately 5800 cubic ft.

Automated storm water runoff samples were collected at gage E039 at 2124 and 2151 hours on July 25. Table 3-7 lists the samples that were collected. Filtered and unfiltered samples were collected for the analyses of metals, and unfiltered samples were collected for the analyses of general inorganic constituents and SVOCs.

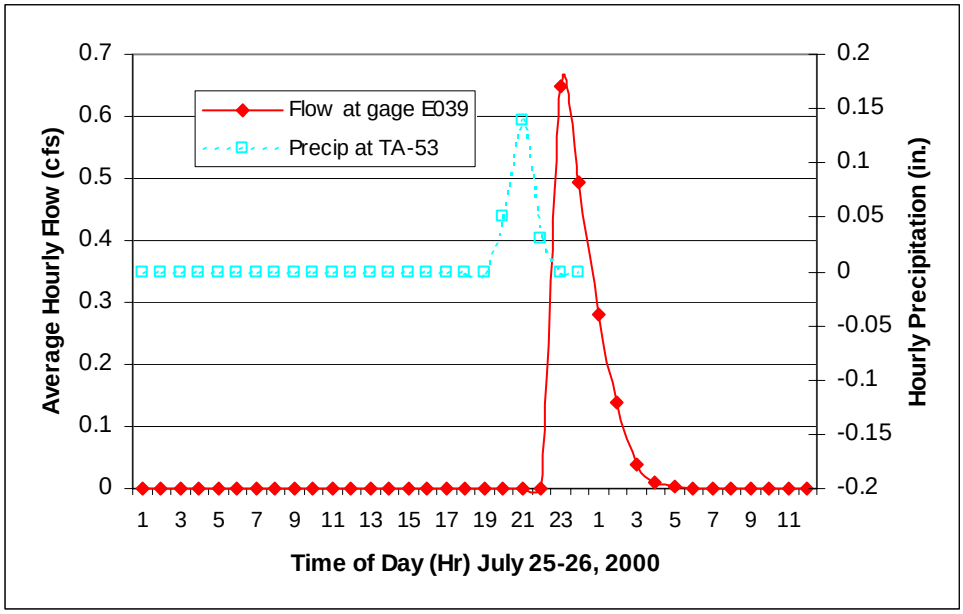


Figure 3-6. Precipitation at TA-53 and flow at gage E039 in DP Canyon on July 25 and 26, 2000.

Table 3-7. Samples Collected in Middle DP Canyon on July 25, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
25-Jul	E039	GF00071E039	2124	Automated	F	M
25-Jul	E039	GS00071E039	2124	Automated	UF	G1, M, S
25-Jul	E039	GS00072E039	2151	Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.7 July 29, 2000

A precipitation event occurred over the southeastern part of the Pajarito Plateau on the evening of July 29. A total of 0.37 in. of rain was recorded at the TA-49 meteorological station between 1800 and 1830 hours; 0.1 inch of rain was recorded at the TA-6 meteorological station, 0.4 in. was recorded at the TA-54 meteorological station, and 0.17 in. were recorded at the TA-16 station. Figure A-7 shows the pattern of precipitation that was recorded across the Pajarito Plateau on July 29.

On July 29, storm water runoff samples were collected near the eastern boundary of the Laboratory at gage E230 in lower Cañada del Buey and at gage E265 in lower Water Canyon below SR 4. Figure 3-7 shows the hourly precipitation recorded at TA-16 and TA-49 and the hydrograph of streamflow measured at gage E265 in Water Canyon at SR 4. The precipitation was received between 1800 and 1900 hours, and flow at gage E265 began at 2055 hours. The peak flow was 14 cfs at 2230 hours, and the gage flowed at over 1 cfs for about five hours and continued to flow at small rates throughout July 30. The total volume of runoff that passed through gage E265 was approximately 91,000 cubic ft.

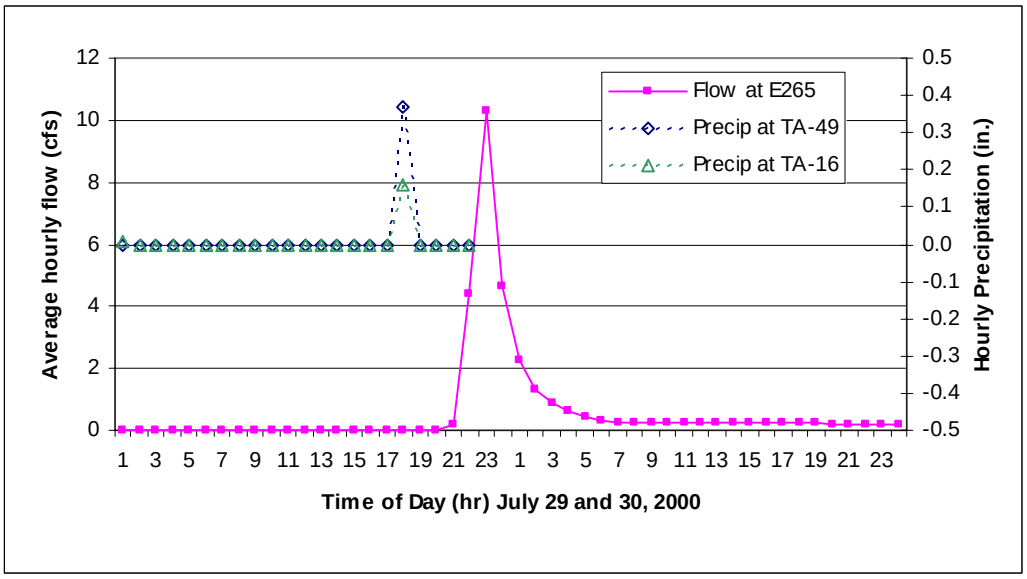


Figure 3-7. Precipitation at TA-16 and TA-49 and hydrograph of streamflow at gage E265 in Water Canyon below SR 4 on July 29 and 30, 2000.

Figure 3-8 shows the precipitation received at TA-54 and the hydrograph of streamflow at gage E230 in Cañada del Buey on July 29. Precipitation was received at TA-54 from 1800 to 1830 hours, and flow commenced at gage E230 at 1910 hours; the peak flow was 4.9 cfs at 1925 hours. Flow occurred at gage E230 for one hour and 50 minutes and the total volume of runoff that passed through the gage was approximately 6500 cubic ft.

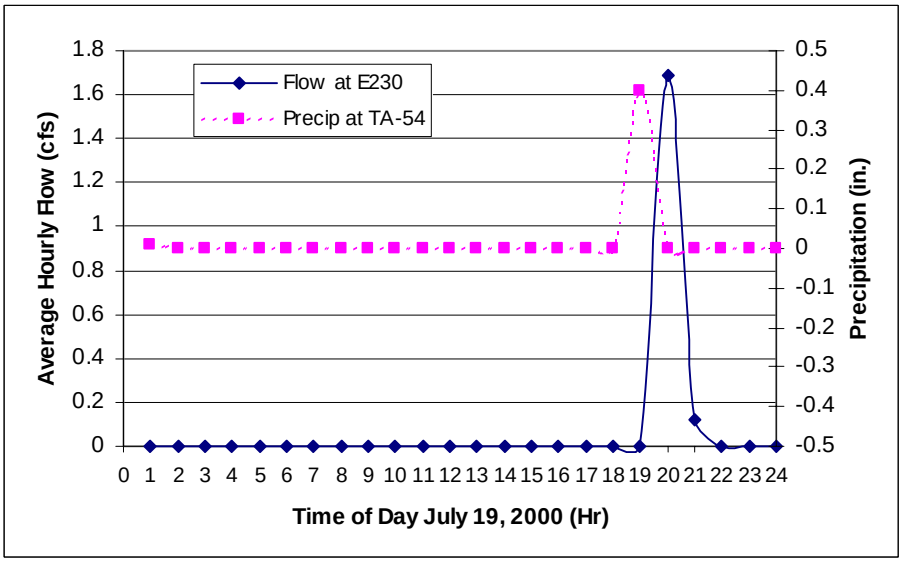


Figure 3-8. Precipitation at TA-54 and hydrograph of streamflow at gage E230 in Cañada del Buey on July 29, 2000.

Automated storm water runoff samples were collected at stream gages E230 and E265 during the runoff event. Table 3-8 lists the storm water runoff samples that were collected on July 29 in Water Canyon and Cañada del Buey.

Table 3-8. Storm Water Runoff Samples Collected on July 29, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
29-Jul	E230	GS00081E230		Automated	UF	G, M, H-3, P, S
29-Jul	E230	GF00081E230		Automated	F	M
29-Jul	E230	GS00082E230	1912	Automated	UF	G1
29-Jul	E265	GF00081E265		Automated	F	R
29-Jul	E265	GS00081E265		Automated	UF	G, M, R, HE, P
29-Jul	E265	GS00082E265		Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.8 August 9, 2000

A precipitation event occurred over the eastern Pajarito Plateau on August 9. The TA-54 meteorological station recorded a total of 0.74 in., the TA-6 station recorded 0.07 in., the TA-53 station recorded 0.16 in., and 0.31 in. were recorded at the TA-49 meteorological station. Figure A-8 shows the pattern of precipitation that occurred over the Pajarito Plateau on August 9. The precipitation was associated with a thunderstorm that occurred between 1900 and 2000 hours on the evening of August 9.

The flow event resulting from the precipitation was recorded at stream gage E230 in Cañada del Buey located upstream of SR 4 and White Rock and at stream gage E267 in Potrillo Canyon at SR 4. The average hourly flow at gage E230 for August 9 is shown in Figure 3-9. Flow began at gage E230 at 2000 hours and continued for about two hours. The peak flow was 32 cfs at 2035 hours on the evening of August 9, and the total volume of flow was approximately 62,000 cubic ft.

The average hourly flow at stream gage E267 in Potrillo Canyon for August 9 is shown in Figure 3-9. Flow at this gage began at 2010 hours and continued for about one hour and 45 minutes. The peak flow was 6.7 cfs at 2030 hours on the evening of August 9, and the total volume of runoff that passed through the gage was approximately 20,000 cubic ft.

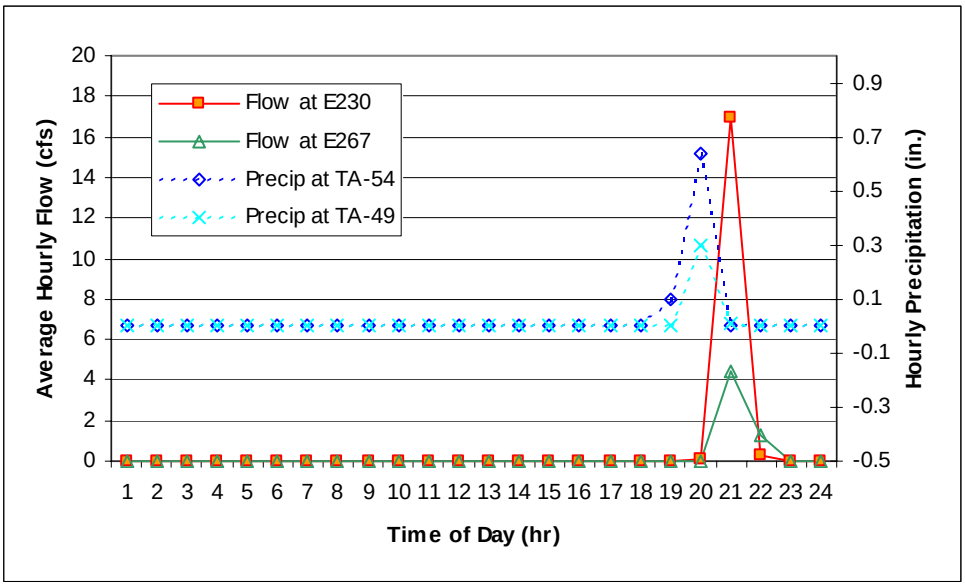


Figure 3-9. Precipitation at TA-49 and TA-54 and flow at gages E230 and E267 on August 9, 2000.

Storm water runoff samples collected on August 9 are listed in Table 3-9. Unfiltered samples were collected at all sites. Samples from E230 were analyzed for total suspended solids and radionuclides, and samples from E267 were analyzed for radionuclides, general inorganics, metals, and PCBs.

Table 3-9. Storm Water Runoff Samples Collected on August 9, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
09-Aug	E230	GS00083E230	1953	Automated	UF	G1, R
09-Aug	E230	GS00084E230	2003	Automated	UF	G1
09-Aug	E221	GS00081E221	2010	Automated	UF	G, M, P
09-Aug	E221	GS00082E221	2022	Automated	UF	G1
09-Aug	E267	GS00081E267	2010	Automated	UF	G, M, R, P
09-Aug	E267	GS00082E267	2025	Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.9 August 13, 2000

A localized precipitation event occurred over the southern part of the Pajarito Plateau on the afternoon of August 13. The thunderstorm was apparently very localized over the southern part of the plateau; the Water Canyon RAWS recorded 0.66 in., and the TA-49 meteorological station only recorded 0.02 in. The TA-54 station did not record precipitation, and the TA-6 station recorded 0.02 in. Figure A-9 shows the pattern of precipitation recorded on the Pajarito Plateau on August 13. The precipitation occurred in the mid-afternoon between 1400 and 1600 hours. Figure 3-10 shows the hourly rainfall recorded at the Water Canyon RAWS on August 13.

The flow event associated with the thunderstorm was recorded at stream gage E265 in Water Canyon below SR 4. Base flow at the gaging station was about 2 cfs throughout the day on August 13. The runoff from the precipitation began at the gage at 1725 hours on the evening of August 13. The average hourly flow at this stream gage for August 13 and 14 is shown on Figure 3-10. The peak flow was 23 cfs at 1815 hours on the evening of August 13. The total volume of flow through the gage resulting from the precipitation event was approximately 340,000 cubic ft.

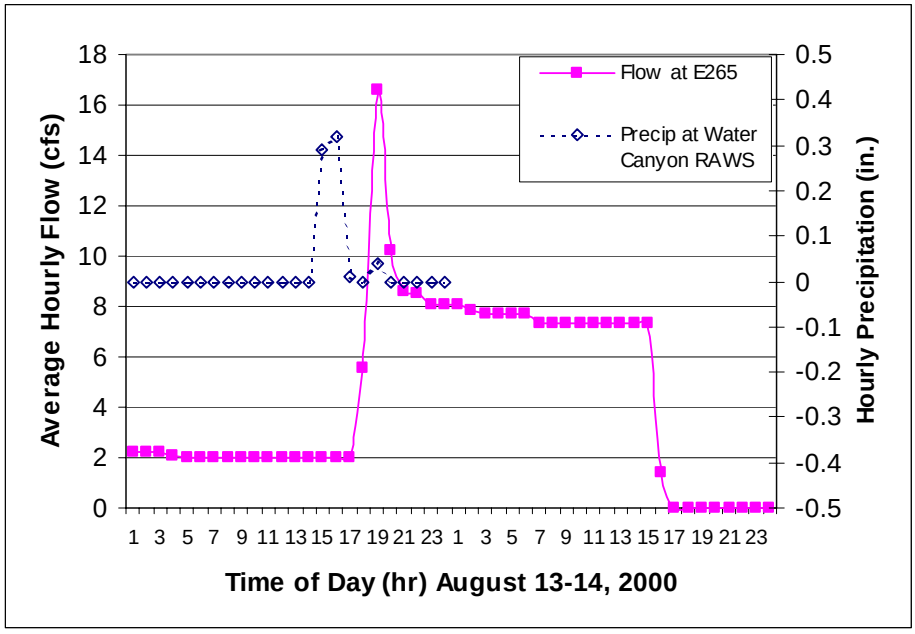


Figure 3-10. Precipitation at the Water Canyon RAWS and flow at stream gage E265 in Water Canyon on August 13 and 14, 2000.

Automated storm water runoff samples were collected at stream gage E265 in lower Water Canyon on the evening of August 13. Table 3-10 lists the samples that were collected. The first sample was collected at 1907 hours, and the second sample was collected at 1913 hours.

Table 3-10. Storm water runoff samples collected on August 13, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
13-Aug	E265	GS00083E265	1907	Automated	UF	G, M, R, HE
13-Aug	E265	GS00084E265	1913	Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.10 August 18, 2000

Several precipitation events occurred over the eastern Pajarito Plateau on August 18, one in the early morning hours, another in the afternoon, and one during the evening hours. The TA-54 meteorological station recorded 0.26 in. by 0215 hours and 0.36 in. between 1530 and 1630 hours, and daily total of 1.72 in. The TA-6 meteorological station recorded 0.61 in., and the TA-53 station recorded 0.95 in. for the day. The hourly precipitation recorded at TA-54 near stream gage E230 on August 18 is shown on Figure 3-11.

The pattern of precipitation on the Pajarito Plateau that was received before 0300 hours on August 18 is shown in Figure A-10a. Higher precipitation received during the early morning hours was along the eastern part of the Laboratory at TA-54 and TA-74. The pattern of precipitation received during the afternoon and evening on August 18 is shown in Figure A-10b. Like the early morning precipitation event, more precipitation was received along the eastern part of the Laboratory during the afternoon and evening. For the period from 1200 to 2000 hours in the evening, TA-54 received 0.42 in. and TA-74 received 0.34 in. Very light precipitation was received along the western part of the Laboratory in the afternoon, generally less than 0.05 in.

Gage E230

Two flow events associated with the larger precipitation events on August 18 were recorded at stream gage E230 in Cañada del Buey. The average hourly flow at this stream gage for August 18 is shown in Figure 3-11. Resulting from the early morning precipitation event, the peak flow was 1.5 cfs at 0215 hours, and a total flow volume of about 2300 cubic ft passed through the gage during 75 minutes of flow.

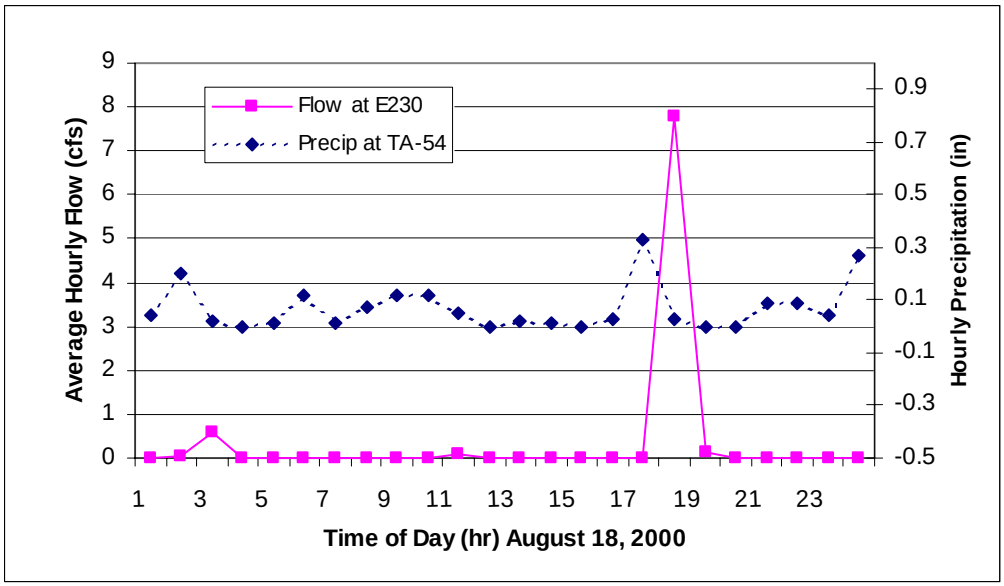


Figure 3-11. Precipitation at TA-54 and flow at gage E230 in Cañada del Buey on August 18, 2000.

Resulting from the afternoon precipitation event, flow began at 1700 hours, and the peak flow was 31 cfs at 1715 hours on August 18. Flow continued for about two hours, and a total of about 28,000 cubic ft of water passed through gage E230.

Automated storm water runoff samples were collected at stream gage E230 during both the morning and afternoon runoff events. Table 3-11 lists the storm water runoff samples that were collected on August 18. Unfiltered samples were collected at 0201 hours (GS00083E230), filtered and unfiltered samples were collected at 1658 hours (samples GS00085E230 and GF00085E230), and an unfiltered sample was collected at 1714 hours (sample GS00086E230) on August 18.

Table 3-11. Storm Water Runoff Samples Collected on August 18, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
18-Aug	E230	GS00083E230	0201	Automated	UF	G
18-Aug	E230	GS00085E230	1658	Automated	UF	G, M, R
18-Aug	E230	GF00085E230	1658	Automated	F	M, R
18-Aug	E230	GS00086E230	1714	Automated	UF	G1
18-Aug	E265	GF00085E265	0905	Manual	F	M, R
18-Aug	E265	GS00085E265	0905	Manual	UF	G, M, R, HE, P, S, V
18-Aug	E265	GS00086E265	0906	Manual	UF	G1
18-Aug	E273	GS00081E273	2315	Automated	UF	G, M
18-Aug	E273	GS00082E273	2315	Automated	UF	G1
18-Aug	E275	GS00081E275	1712	Automated	UF	G, M
18-Aug	E275	GS00082E275	1712	Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

Gage E265

Between 0600 and 1200 hours on the morning of August 18, TA-49 received 0.45 in. of rain. The heaviest precipitation was recorded between 0900 and 1000 hours. The hourly precipitation recorded at TA-49 on August 18 is shown in Figure 3-12. The precipitation caused flow in Water Canyon and manual runoff samples were collected at gage E265 on the morning of August 18 just after 0900 hours (see Table 3-11). The peak flow in the morning as a result of the morning precipitation was 0.19 cfs at 1025 hours in the morning of August 18.

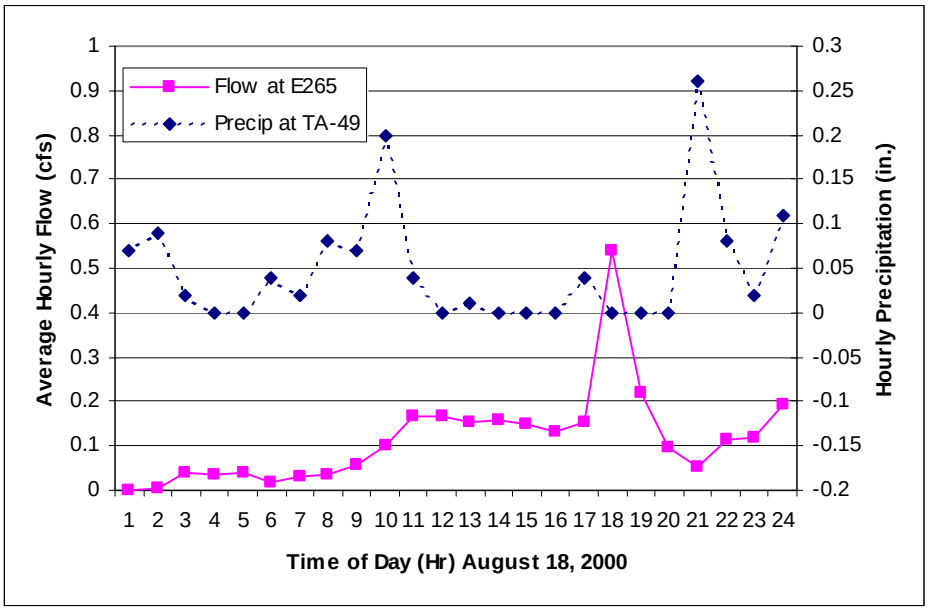


Figure 3-12. Precipitation at TA-49 and flow at gage E265 in Water Canyon on August 18, 2000.

A relatively small precipitation event occurred at TA-49 between 1600 and 1615 hours on the afternoon of August 28, when 0.04 in. of rain was recorded. This relatively small precipitation event created flow at gage E265 beginning at 1700 hours (see Figure 3-12). The peak flow was 1.09 cfs at 1705 hours.

Gages E273 and E275

A late-afternoon thunderstorm event occurred over the eastern Pajarito Plateau between 1530 and 1630 hours when 0.36 in. of rain was received at TA-54 and a smaller amount of rainfall was received at TA-49. A late-evening thunderstorm occurred at TA-49 between 2000 and 2200 hours, during which time 0.34 in. was recorded and a lesser amount was recorded during this period at TA-54. Figure 3-13 shows the hourly precipitation recorded at TA-49 and TA-54 on August 18.

Storm water runoff samples were collected at gage E275 in Ancho Canyon below SR 4 on the afternoon of August 18. Figure 3-13 shows the average hourly flow at gage E275. Flow began at the gage at 1712 hours, and the peak flow rate was 21 cfs at 1720 hours; flow continued for approximately 55 minutes in Ancho Canyon at gage E275 due to the precipitation event and the total volume of runoff was approximately 17,000 cubic ft.

Storm water runoff samples were also collected at gage E273 in Ancho Canyon above SR 4 on the evening of August 18 at 2315 hours. The flow resulted from the late-evening precipitation event between 2000 and 2200 hours that was received at TA-49. The stage-discharge relationship for gage E273 has not yet been established, thus a hydrograph for this gage is not available.

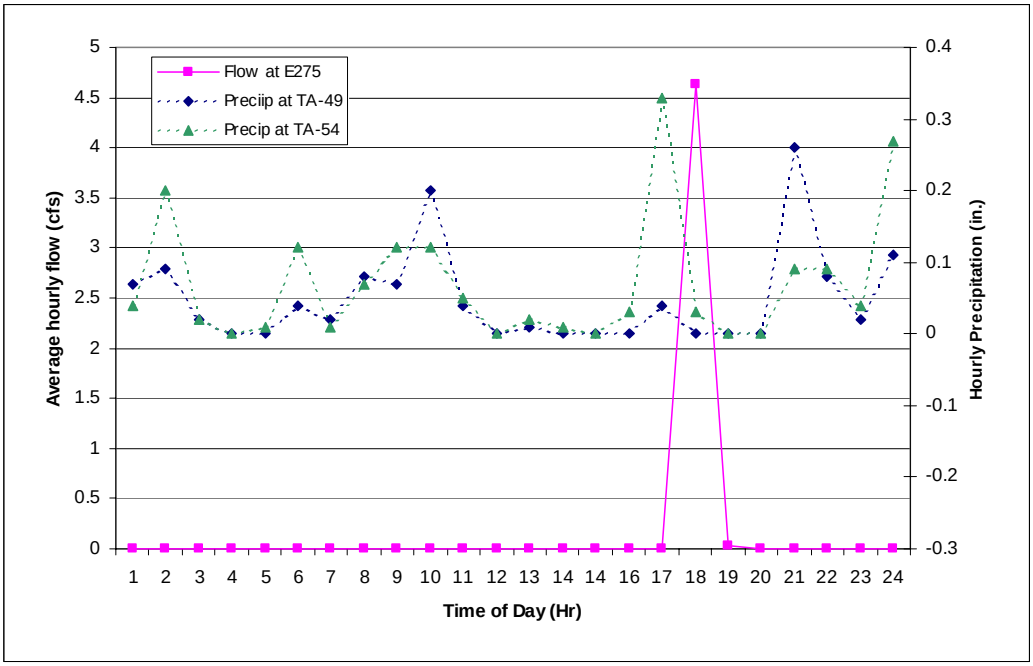


Figure 3-13. Precipitation at TA-49 and TA-54 and flow at gage E275 on August 18, 2000.

3.11 August 24, 2000

The Pajarito Canyon retention structure was being constructed in August 2000 to prevent flood damage in lower Pajarito Canyon. As a result of precipitation received on August 18 and 19, runoff in Pajarito Canyon was impounded upstream of the construction site in middle Pajarito Canyon. On August 24, samples of the standing water in the retention structure were collected and are listed in Table 3-12.

Table 3-12. Surface Water Samples Collected from the Pajarito Canyon Retention Structure on August 24, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
24-Aug	EPRP	GF00081EPRP	1134	Manual	F	G, M, R
24-Aug	EPRP	GS00081EPRP	1134	Manual	UF	G, M, R

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.12 August 31, 2000

Surface water samples were collected from two sites in upper Los Alamos Canyon on August 31. The previous significant precipitation recorded at the upper Los Alamos Canyon RAWS occurred on August 21, 2000, when 0.21 in. of rain was received; a small amount of precipitation (0.02 in.) was recorded on August 28. No precipitation was recorded at this station on August 29, 30, and 31. The Quemazon Canyon RAWS recorded a total of 0.28 in. on August 28 but precipitation was not recorded on August 29, 30, or 31 in the upper Los Alamos Canyon watershed.

The surface water samples collected on August 31 are listed in Table 3-13. The samples were collected from two sites, one upstream of the Los Alamos Canyon Reservoir (Location EULR) and another from the water discharging from the reservoir. Both filtered and unfiltered samples were collected for analyses.

Table 3-13. Surface Water Samples Collected in Upper Los Alamos Canyon on August 31, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
31-Aug	EULR	GF00081EULR		Manual	F	G, M, R
31-Aug	EULR	GS00081EULR		Manual	UF	G, M, R, HE, P, S
31-Aug	ELAR	GF00081ELAR	0942	Manual	F	G, M, R
31-Aug	ELAR	GS00081ELAR	1000	Manual	UF	G, M, R, HE, P, S

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.13 September 8, 2000

A precipitation event occurred over the Sierra de los Valles and the Pajarito Plateau on the afternoon of September 8. The heaviest precipitation was received in the mountains west of Los Alamos and along the flanks of the Sierra de los Valles north of Los Alamos. Figure A-11 shows the pattern of precipitation that was received on September 8. The meteorological station on Pajarito Mountain recorded a total of 0.37 in., the upper Los Alamos Canyon RAWS recorded 0.58 in., and the Pajarito Canyon RAWS recorded 0.58 in. The TA-6 station recorded 0.21 in., and the North Community station in northern Los Alamos recorded 0.52 in. Most areas at the Laboratory received 0.1 in. or less. RAWS north of Los Alamos received 0.98 in. at Garcia Canyon and 1.1 in. at Santa Clara Canyon. The precipitation event near Los Alamos occurred from about 1400 to 1530 hours on the afternoon of September 9.

Storm water runoff samples were collected from two sites on September 9. Table 3-14 lists the runoff samples that were collected on September 9. Runoff samples were collected from upper Pajarito Canyon at SR 501 and from lower Guaje Canyon at SR 502. The stream gage in upper Pajarito Canyon at SR 501 (E240) was destroyed by the June 28 flood event and was not operational at the time of sample collection. Personnel collecting the runoff sample noted that flow in upper Pajarito Canyon at the former site of gage E240 was approximately 1 cfs at the time of sample collection.

Manual (grab) storm water runoff samples were also collected in Guaje Canyon at SR 502 near the confluence with Los Alamos Canyon during the runoff event. The samples were collected at 1828 and 1835 hours in the evening of September 8. Guaje Canyon at SR 502 is an ungaged site, therefore a hydrograph of flow is not available. Personnel estimated that flow in lower Guaje Canyon was 30 cfs at the time of sample collection.

Table 3-14. Storm Water Runoff Samples Collected on September 8, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
08-Sep	E240	GF00091E240	1648	Manual	F	G, M, R
08-Sep	E240	GS00091E240	1648	Manual	UF	G, M, R, HE, P, V, S
08-Sep	E240	GS00092E240	1656	Manual	UF	G1
08-Sep	M090	GF00091EGS4	1828	Manual	F	G, M, R
08-Sep	M090	GS00091EGS4	1828	Manual	UF	G, M, R, HE, P, V, S
08-Sep	M090	GS00092EGS4	1835	Manual	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.14 September 12, 2000

Runoff from the precipitation event that occurred over the Sierra de los Valles on the afternoon of September 8 was partially retained in the Los Alamos Canyon Reservoir and, together with perennial flow from springs, was allowed to discharge to Los Alamos Canyon. The precipitation event on September 8 is described in Section 3.12.

The precipitation event was recorded at stream gage E025 in Los Alamos Canyon. Throughout the day on September 8 a small amount of flow from the release of water from Los Alamos Canyon Reservoir passed though gage E025 until runoff from the precipitation event was recorded from 1500 to 1700 hours. The peak flow rate was 9.8 cfs at 1625 hours on the afternoon of September 8.

Several days after the precipitation event, on September 11 and 12, water was released from the Los Alamos Canyon Reservoir at a rate sufficient to be recorded at gage E025. The hydrograph of flow at gage E025 in Los Alamos Canyon for September 11 and 12 is shown in Figure 3-14. Flow greater than 0.5 cfs associated with the release from the reservoir passed through the gage for about 25 hours. The total volume of water that passed through gage E025 was about 330,000 cubic ft.

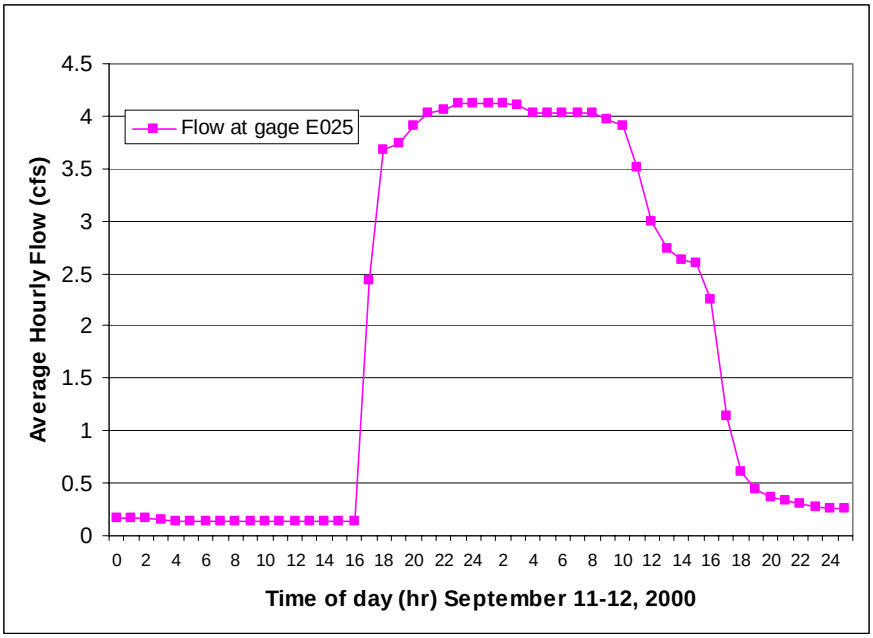


Figure 3-14. Flow at gage E025 in Los Alamos Canyon on September 11 and 12, 2000.

Manual (grab) surface water samples were collected at the site of gage E025 during the release event at 1007 and 1010 hours on the morning of September 12. Table 3-15 lists the surface water samples that were collected on September 12. Unfiltered and filtered samples were collected for analysis.

Table 3-15. Surface Water Samples Collected at Gage E025 on September 12, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
12-Sep	E025	GF00091E025	1007	Manual	F	G, M, R
12-Sep	E025	GS00091E025	1007	Manual	UF	G, M, R, HE, P, V, S
12-Sep	E025	GS00092E025	1010	Manual	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.15 October 7, 2000

A precipitation event occurred over the Sierra de los Valles and the Pajarito Plateau on the evening of October 7. The meteorological stations across the plateau recorded at total of 0.33 to 0.37 in. for the day. Pajarito Mountain recorded a total of 0.37 in., the TA-6 station recorded 0.33 in., and the TA-53 station recorded 0.37 in. RAWS located on US Forest Service land in the Sierra de los Valles recorded 0.26 in. near Garcia Canyon, 0.27 in. in Pueblo Canyon, 0.43 in. in upper Los Alamos Canyon and 0.34 in. in Pajarito Canyon. The pattern of precipitation that was recorded on the Pajarito Plateau on October 7 is shown in Figure A-12. The average precipitation received at the Laboratory on October 7 was about 0.35 in.

During the precipitation event, storm water runoff samples were collected at two sites at the Laboratory, at TA-55 and at TA-54 MDA-L. Table 3-16 lists the storm water runoff samples that were collected on October 7. During the precipitation event, storm water runoff samples were collected in Cañada del Buey at the TA-54 MDA-L gaging station E226. Automated samples were collected at 1750 and 1753 hours during the evening of October 7. Unfiltered samples were collected for analysis. Runoff samples were also collected in the Mortandad Canyon tributary known as Effluent Canyon at gaging station E196 at 2023 and 2025 hours during the evening of October 7.

Table 3-16. Storm Water Runoff Samples Collected on October 7, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
07-Oct	E223	GS00101E223	1750	Automated	UF	G, M, R, P
07-Oct	E223	GS00102E223	1753	Automated	UF	G1
07-Oct	E196	GF00101E196	2023	Automated	F	R
07-Oct	E196	GS00101E196	2023	Automated	UF	G, M, R
07-Oct	E196	GS00102E196	2025	Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

3.16 October 11-12, 2000

Several precipitation events occurred over the Pajarito Plateau on the afternoon and evening of October 11 and throughout the day on October 12. On October 11, meteorological stations across the plateau recorded a range of precipitation from 0.38 to 0.61 in. for the day. The station at TA-6 recorded a total of 0.46 in., and the station at TA-54 recorded a total of 0.50 in. RAWS recorded 0.43 in. in Pueblo Canyon, 0.51 in. in upper Los Alamos Canyon, and 0.36 in. in Pajarito Canyon. Figure A-13 shows the pattern of precipitation that was recorded in the Sierra de los Valles and on the Pajarito Plateau on October 11. In general, more precipitation was recorded in the southern part of the plateau on October 11.

On October 12, TA-6 received a total of 0.47 in. and TA-54 received a total of 0.58 in. Figure A-14 shows the pattern of precipitation recorded on the Pajarito Plateau on October 12. In general, more

precipitation was recorded in the eastern part of the Laboratory and lesser amounts were received along the western border areas of the Laboratory.

Los Alamos Canyon

Flow in Los Alamos Canyon at gage E042 began at 0700 hours the morning of October 12. The peak flow rate was 3.8 cfs at 0705 hours. Automated storm water runoff samples were collected at 0705 and 0725 hours at gage E042. Table 3-17 lists the samples that were collected. The flow decreased at gage E042 on October 12 until, in response to a late-afternoon precipitation event, another runoff event occurred at 2040 hours. The peak flow during the second runoff event was 1.65 cfs at 2205 hours. Flow associated with the second runoff event continued until 1410 hours on the afternoon of October 13. Figure 3-15 shows the precipitation at TA-6 and TA-53 on October 11 and 12 and flow at gage E042 on October 12 and 13. The total volume of runoff associated with the October 12 morning runoff event was approximately 22,000 cubic ft, and the total volume of runoff associated with the October 12 afternoon runoff event was approximately 15,600 cubic ft.

Table 3-17. Storm Water Runoff Samples Collected on October 11 and 12, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
11-Oct	E122	GS00101E122	1721	Automated	UF	G, M
11-Oct	E122	GS00102E122	1733	Automated	UF	G1
12-Oct	E040	GS00101E040	0548	Automated	UF	G1, R
12-Oct	E040	GS00102E040	0548	Automated	UF	G1
12-Oct	E042	GS00101E042	0705	Automated	UF	G1, R
12-Oct	E042	GS00102E042	0725	Automated	UF	G1
12-Oct	E230	GS00101E230	0500	Automated	UF	G, M
12-Oct	E230	GS00102E230	0505	Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

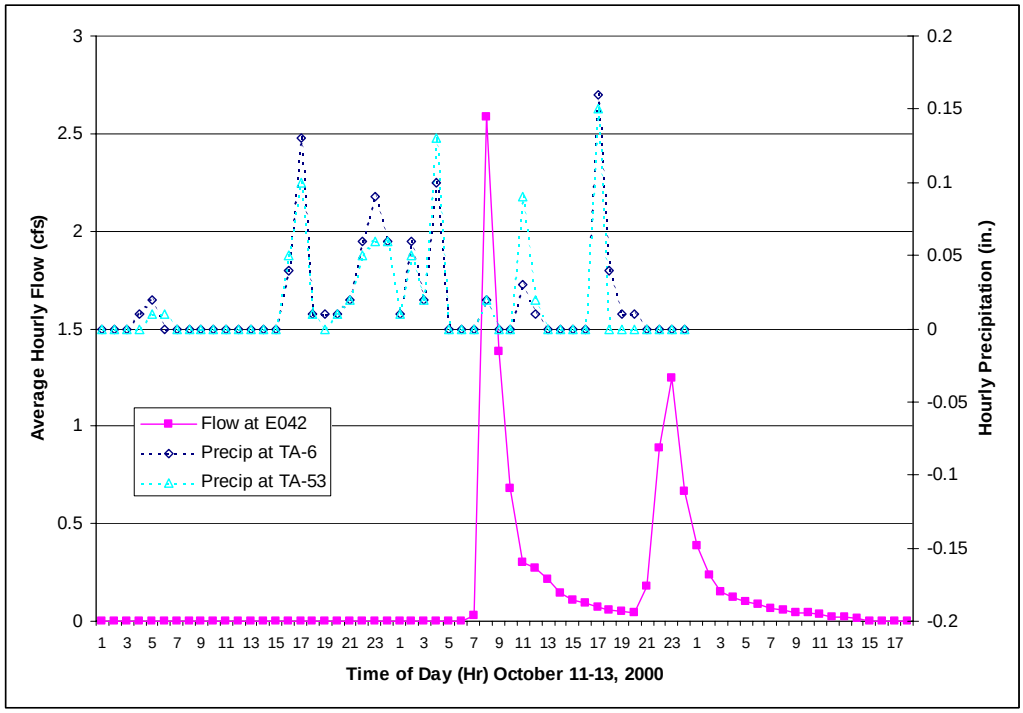


Figure 3-15. Precipitation at TA-6 and TA-53 and flow at gage E042 in Los Alamos Canyon on October 11 and 12, 2000.

DP Canyon

Storm water runoff samples were collected in lower DP Canyon above the confluence with Los Alamos Canyon at gage E040 on the morning of October 12. The samples were collected at 0548 hours. Flow data from stream gage E040 are not available.

Sandia Canyon

Storm water runoff samples were collected in upper Sandia Canyon at gage E122 on the afternoon of October 11. Figure 3-15 shows the hourly precipitation at TA-6 on October 11. Runoff flow rates are not available for gage E122. Samples collected on October 11 are listed in Table 3-17.

Cañada del Buey Gage E230

The precipitation events on October 11 did not create flow at gage E230 in Cañada del Buey. However, an early-morning precipitation event on October 12 produced 0.25 in. of rain at TA-54 between 0100 and 0500 hours. Figure 3-16 shows the hourly precipitation recorded on October 11 and 12 at TA-6 and TA-54 and the flow at gage E230 in Cañada del Buey on October 11 and 12. Runoff began at 0505 hours and continued for about one hour. The peak flow was 2.9 cfs at 0515 hours, and the runoff volume during the early-morning runoff event was approximately 3700 cubic ft.

Automated storm water runoff samples were collected at 0500 and 0505 hours on the morning of October 12. Table 3-17 lists the samples that were collected on October 12.

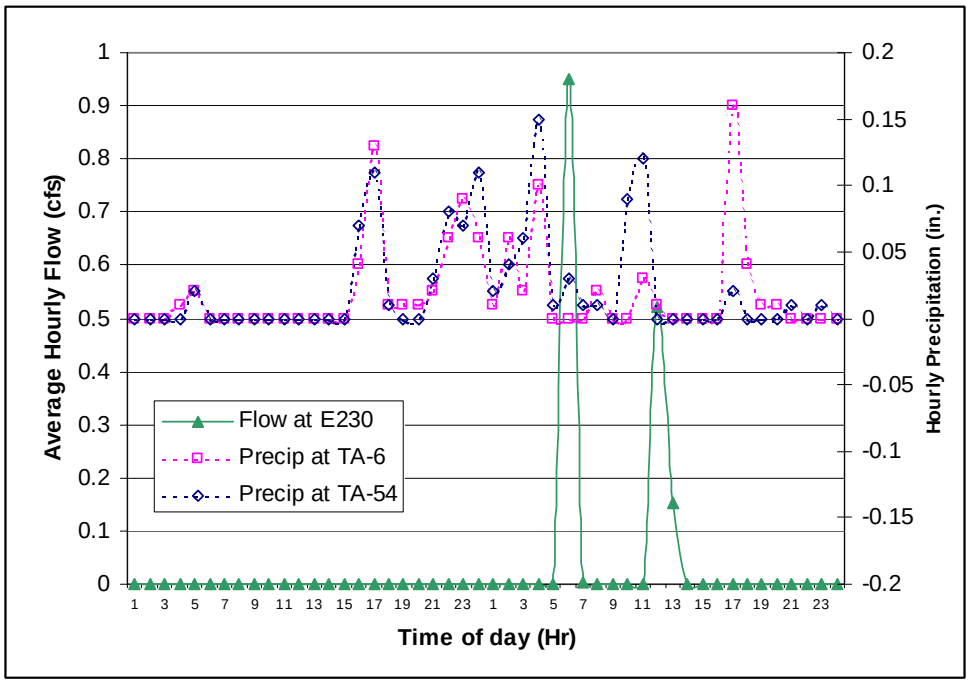


Figure 3-16. Precipitation at TA-6 and TA-54 and flow at Gage E230 on October 11 and 12, 2000.

3.17 October 23, 2000

Precipitation was received over the Sierra de los Valles and the Pajarito Plateau throughout the day on October 23. Precipitation was received during three main periods of the day, at about 0700 to 0800 hours in the morning, in the afternoon from about 1300 to 1400 hours, and in the evening from 2200 to 2300 hours. Meteorological stations across the plateau recorded a range of precipitation from 0.46 to 1.84 in. for the day with an average precipitation of 1.17 in. The station at TA-6 recorded a total of 1.0 in., and the station at TA-54 recorded a total of 1.14 in. RAWS located on US Forest Service land recorded 1.15 in. in

Pueblo Canyon, 1.84 in. in upper Los Alamos Canyon, and 1.49 in. in Pajarito Canyon. Figure A-15 shows the pattern of total precipitation that was recorded in the Sierra de los Valles and on the Pajarito Plateau on October 23. In general, higher amounts of precipitation were received in the Sierra de los Valles west of the Laboratory and in the southeastern part of the Laboratory.

During the precipitation events on October 23 and on the following day on October 24, a total of 41 storm water runoff samples were collected from 16 sites across the Laboratory. Table 3-18 lists the samples that were collected on October 23 and 24. The following sections describe the runoff event at each collection site.

Table 3-18. Storm Water Runoff Samples Collected on October 23, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
Pueblo Canyon						
23-Oct	E060	GF00101E060	1739	Automated	F	M
23-Oct	E060	GS00101E060	1739	Automated	UF	G, M
23-Oct	E060	GS00102E060	1806	Automated	UF	G1
Los Alamos-DP Canyon						
24-Oct	E030	GS00101E030	1120	Manual	UF	G, M
23-Oct	E038	GS00101E038	1045	Manual	UF	CN, VOLSOL
23-Oct	E039	GS00101E039	1411	Automated	UF	G, M
23-Oct	E039	GS00102E039	1426	Automated	UF	G1
23-Oct	E040	GS00101E040	1450	Automated	UF	G, M
23-Oct	E040	GS00102E040	1450	Automated	UF	G1
23-Oct	E042	GF00103E042	1536	Automated	F	G, M, R
23-Oct	E042	GS00103E042	1536	Automated	UF	G, M, R, S
23-Oct	E042	GS00104E042	1536	Automated	UF	G1
Pajarito Canyon						
23-Oct	E240	GF00101E240	0953	Manual	F	G, M, R
23-Oct	E240	GS00101E240	0953	Manual	UF	G, M, R
23-Oct	E240	GS00102E240	0959	Manual	UF	G1
23-Oct	E240	GS00103E240	1452	Manual	UF	G1, CN, HE, P, S, V
23-Oct	M2417	GF001012417	1427	Manual	F	G, M, R
23-Oct	M2417	GS001012417	1427	Manual	UF	G, M, R, HE, S, V
23-Oct	M2417	GS001022417	1429	Manual	UF	G1
23-Oct	M2436	GF001012436	1506	Manual	F	G, M, R
23-Oct	M2436	GS001012436	1506	Manual	UF	G, M, R, HE, P, S, V
23-Oct	M2436	GS001022436	1511	Manual	UF	G1
24-Oct	E250	GF00101E250	0555	Automated	F	G, M, R
24-Oct	E250	GS00101E250	0555	Automated	UF	G, M, R, HE, P, S, V
24-Oct	E250	GS00102E250	0810	Automated	UF	G1
Cañada del Buey						
23-Oct	E218	GS00101E218	1422	Automated	UF	G1, CN
23-Oct	E218	GS00102E218	1422	Automated	UF	G1
23-Oct	E230	GS00103E230	1425	Automated	UF	G, M, R, HE, S
23-Oct	E230	GS00104E230	2056	Automated	UF	G1
Water Canyon						
23-Oct	E252	GF00101E252	1443	Manual		G, M, R
23-Oct	E252	GS00101E252	1443	Manual		G, M, R, HE, P, S, V
23-Oct	E252	GS00102E252	1444	Manual		G1
23-Oct	E265	GF00101E265	1715	Automated	F	G, M
23-Oct	E265	GS00101E265	1715	Automated	UF	G, M, R, HE, P, S, V
23-Oct	E265	GS00102E265	1715	Automated	UF	G1
Cañon de Valle						
23-Oct	E253	GF00101E253	1519	Manual	F	G, M, R
23-Oct	E253	GS00101E253	1519	Manual	UF	G, M, R, HE, P, S, V
23-Oct	E253	GS00102E253	1519	Manual	UF	G1

Table 3-18 cont.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
Potrillo Canyon						
23-Oct	E267	GF00101E267	2036	Automated	F	G, M, R
23-Oct	E267	GS00101E267	2036	Automated	UF	G, M, R
23-Oct	E267	GS00102E267	2106	Automated	UF	G1
Ancho Canyon						
23-Oct	E275	GS00101E275	2050	Automated	UF	G, M
23-Oct	E275	GS00102E275	2105	Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

Pueblo Canyon

Gage E060

Automated storm water runoff samples were collected in lower Pueblo Canyon upstream of Los Alamos Canyon at gage E060 on the evening of October 23. Figure 3-17 shows the precipitation recorded at TA-53 and TA-6 on October 23 and flow at gage E060 on October 23 and 24. Flow began at gage E060 at 1735 hours, and the peak flow was 8.0 cfs at 1740 hours. Storm water runoff samples were collected at gage E060 at 1739 and 1806 hours; the samples collected at gage E060 are listed in Table 3-18. The flow declined at gage E060 until just after midnight, at 0005 hours when another runoff event occurred during the early morning of October 24. Runoff began just after midnight at 0010 hours on October 24, and the peak flow was 25.37 cfs at 0015 hours. This runoff event lasted for about 6.6 hours until 0650 hours on the morning of October 24.

The total volume of runoff that passed through gage E060 during the evening runoff event on October 23 was approximately 32,000 cubic ft. The total volume of runoff that passed through the gage during the morning of October 24 was approximately 70,000 cubic ft.

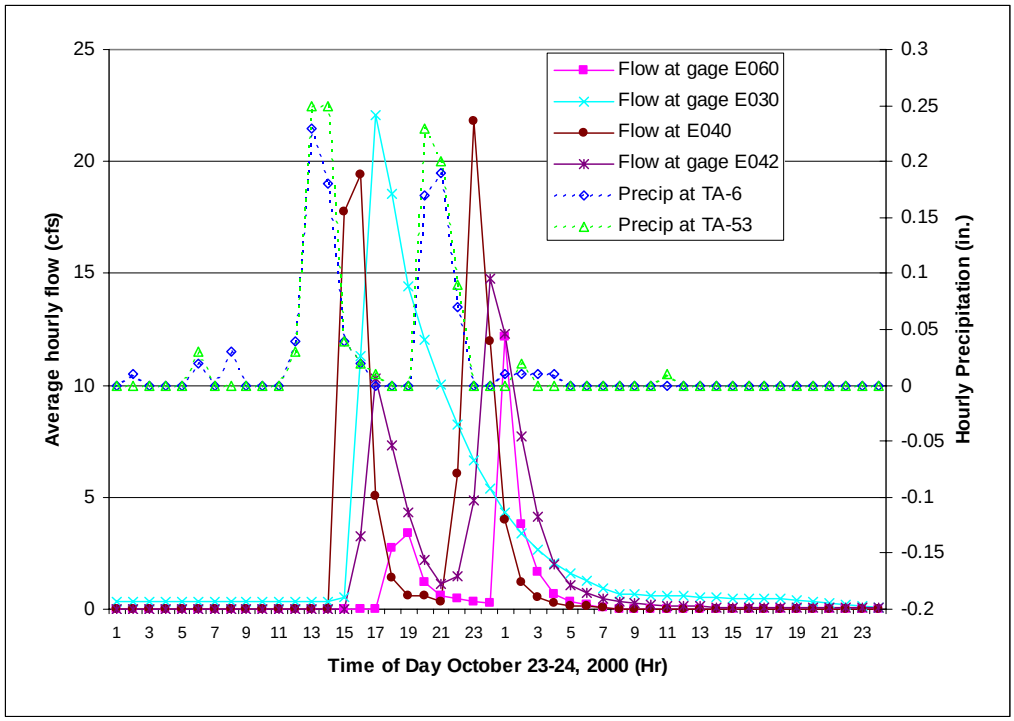


Figure 3-17. Precipitation at TA-6 and TA-53 and flow at gages E060, E030, and E042 on October 23 and 24, 2000.

Los Alamos Canyon and DP Canyon

Gage E030

Storm water runoff at gage E030 in middle Los Alamos Canyon above DP Canyon began at 1345 hours, and the peak flow was 24.5 cfs at 1540 hours. The average hourly flow at gage E030 is shown on Figure 3-17. Flow associated with the runoff event is estimated to have continued until about 2000 hours on the evening of October 24, and a total volume of water that passed through the gage during this time was about 475,000 cubic ft. One surface water sample was collected manually at gage E030 at 1120 hours on the morning of October 24 near the end of the runoff event. At the time the sample was collected flow at gage E030 was estimated to be about 0.5 cfs.

Gage E039

Automated storm water runoff samples were collected in DP Canyon at gage E039 at 1411 and 1436 hours on October 23. Flow rates from the stream gage are not available.

Gage E040

Automated storm water runoff samples were collected in lower DP Canyon at gage E040 at 1450 hours on October 23. Figure 3-17 shows the precipitation recorded at TA-53 and TA-6 on October 23 and the average hourly flow at gage E040 on October 23 and 24. Flow began at 1430 hours, and the peak flow after the initial precipitation event was 34.7 cfs at 1445 hours. The flow declined until 2120 hours when, in response to another precipitation event, flow increased to 28.5 cfs at 2210 hours. Flow continued in declining amounts until 0735 hours on the morning of October 24. The volume of water passing through gage E042 after the initial precipitation event on October 23 was approximately 162,000 cubic ft; the volume of water passing after the second precipitation event was approximately 136,000 cubic ft, and the total volume of water passing gage E040 on October 23 and 24 was approximately 328,000 cubic ft.

Gage E042

Automated storm water runoff samples were collected in lower Los Alamos Canyon at gage E042 on the afternoon of October 23. Figure 3-17 shows the flow at gage E042 on October 23 and 24. Flow began at gage E042 at 1545 hours, and the peak flow was 11.7 cfs at 1555 hours. Storm water runoff samples were collected at gage E042 at 1536 hours. Flow declined at the gage until 2240 hours when flow increased in response to another runoff event. The total volume of runoff that passed through the gage during the afternoon and evening of October 23 was approximately 112,000 cubic ft.

A second runoff event began at gage E042 at 2245 hours on the evening of October 23. The peak flow during the second runoff event was 17.2 cfs at 2310 hours, and a small amount of runoff continued throughout October 24. The total volume of runoff that passed through gage E042 during the second runoff event was approximately 174,000 cubic ft.

Pajarito Canyon

Gage E240

Storm water runoff samples were collected manually in Pajarito Canyon above SR 501 on October 23. Figure 3-18 shows the hourly precipitation recorded at TA-6 and on Pajarito Mountain on October 23. Runoff resulting from the early-morning precipitation event was sampled at 0953 and 0959 hours. The flood event on June 28 destroyed the stream gage at this location, thus flow records are not available. Sampling personnel estimated the flow in Pajarito Canyon at this location was approximately 4 cfs at the time of sampling.

The early-afternoon precipitation event caused additional flow in Pajarito Canyon above SR 501. Another runoff sample was collected at the site of gage E240 at 1452 hours. Sampling personnel estimated that flow in the canyon was approximately 4 cfs at the time of sampling.

M2417: South Fork of Pajarito Canyon (Starmer's Gulch) above SR 501

Storm water runoff samples were collected manually in the south fork of Pajarito Canyon (also called Starmer's Gulch) on the afternoon of October 23. The samples were collected from the stream channel upstream of SR 501 at 1427 and 1429 hours after about 0.5 in. of rain was received in the area during the previous two hours (see Figure 3-18). This sample location is an ungaged site. Sampling personnel estimated flow in the south fork of Pajarito Canyon was about 3 cfs at the time the sample was collected. The samples collected are listed in Table 3-18.

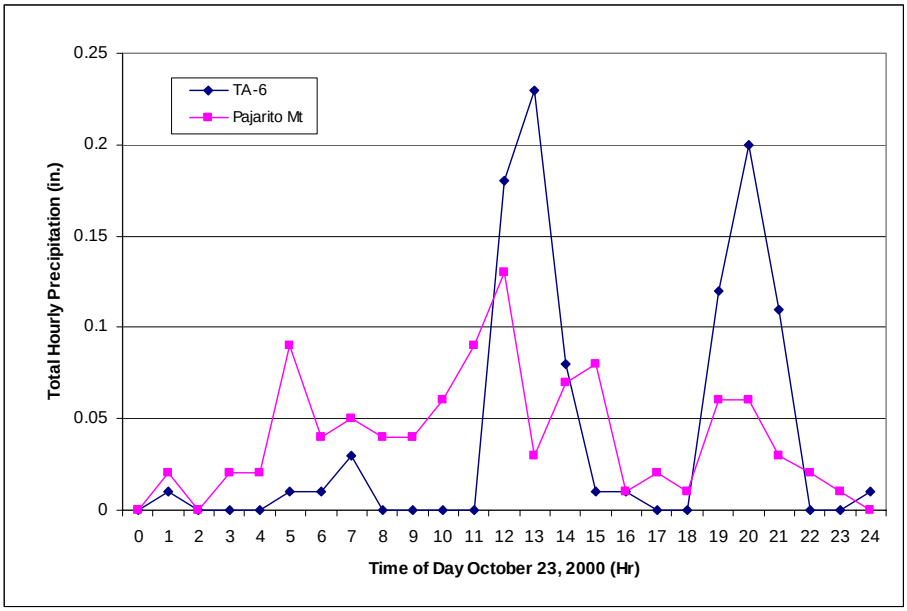


Figure 3-18. Precipitation recorded at TA-6 and Pajarito Mountain on October 23, 2000.

M2436: Twomile Canyon above SR 501

Storm water runoff samples were collected manually in Twomile Canyon, a tributary to Pajarito Canyon, on the afternoon of October 23. The samples were collected from the stream channel upstream from SR 501 at 1506 and 1511 hours after about 0.5 in. of rain was received in the area during the previous two hours (see Figure 3-18). No stream gage is present at this location. Sampling personnel estimated flow in the south fork of Pajarito Canyon was about 5 cfs at the time the sample was collected. The samples collected are listed in Table 3-18.

Gage E250

Automated storm water runoff samples were collected in lower Pajarito Canyon at gage E250 on the morning of October 24. Figure 3-19 shows the precipitation recorded at TA-54 and TA-6 on October 23 and flow at gage E250 on October 23 and 24. Flow began at gage E250 at 0535 hours on the morning of October 24, and the peak flow was 1.6 cfs at 0640 hours. Flow continued at the gage for 15 hours until 2035 hours on October 24. The total volume of runoff that passed through gage E250 during this period was approximately 19,500 cubic ft.

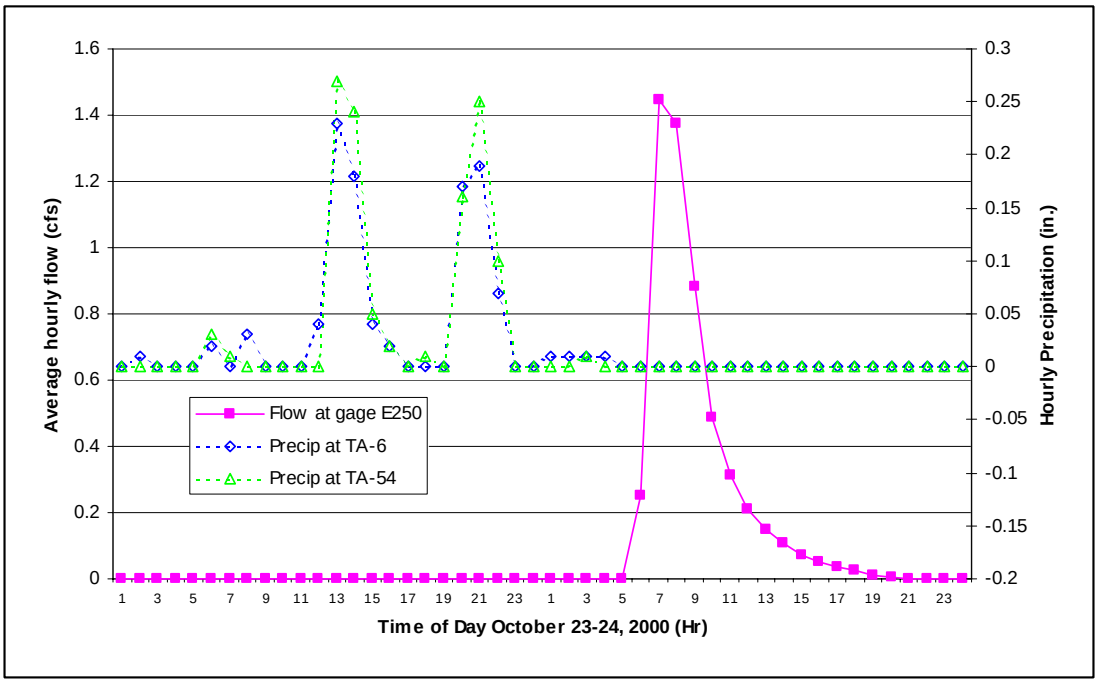


Figure 3-19. Precipitation at TA-6 and TA-54 and flow in Pajarito Canyon at gage E250 on October 23 and 24, 2000.

Cañada del Buey

Gage E218

Automated storm water runoff samples were collected in upper Cañada del Buey near TA-46 at gage E218 on the afternoon of October 23. Figure 3-20 shows the precipitation recorded at TA-6 and TA-54 on October 23 and flow at gage E218 on October 23 and 24. Flow began at gage E218 at 1340 hours, and the peak flow was 8.12 cfs at 1425 hours. Storm water runoff samples were collected at 1422 hours; the samples collected at gage E218 are listed in Table 3-18. Flow continued at the gage for three hours and 45 minutes until 1725 hours; the total volume of runoff that passed through the gage during this time was approximately

20,000 cubic ft. Another flow event occurred during the evening of October 23 in response to another precipitation event. Flow began at gage E218 at 2040 hours and continued until 0130 hours on the morning of October 24. During this second runoff event approximately 23,700 cubic ft of water passed through the gage.

Gage E230

Automated storm water runoff samples were collected in lower Cañada del Buey at gage E230 on the afternoon of October 23. Figure 3-20 shows the precipitation recorded at TA-6 and TA-54 on October 23 and flow at gage E230 on October 23 and 24. Flow began at gage E230 at 1400 hours, and the peak flow was 2.2 cfs at 1445 hours. Flow continued at the gage for about 2.1 hours until 1605 hours; the total volume of runoff that passed through the gage during this period was approximately 4,950 cubic ft.

The evening precipitation event on October 23 created additional flow at gage E230. Flow began at 2050 hours, and the peak flow during this event was 4.9 cfs at 2140 hours. This flow event lasted for about 5.25 hours until 0205 hours on the morning of October 24. The total volume of runoff that passed through the gage during this period was approximately 41,000 cubic ft.

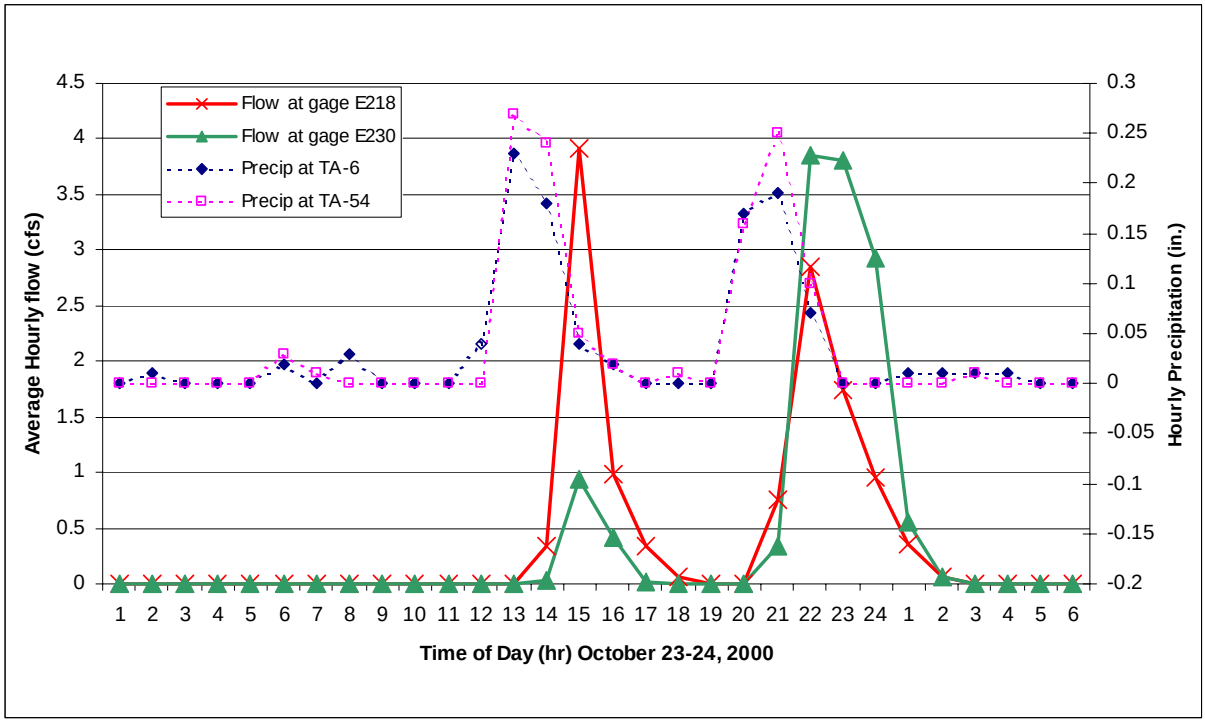


Figure 3-20. Precipitation at TA-6 and TA-54 and flow at gages E218 and E230 in Cañada del Buey on October 23 and 24, 2000.

Storm water runoff samples were collected at 1425 and 2056 hours on the afternoon and evening of October 23. The samples that were collected at gage E230 are listed in Table 3-18.

Cañon de Valle, Gage E253

Storm water runoff samples were collected manually in upper Cañon de Valle above SR 501 at the site of gage E253 on October 23. Figure 3-18 shows the hourly precipitation recorded at the Pajarito Canyon and Water Canyon RAWS on October 23. Runoff resulting from the afternoon precipitation event was sampled at 1519 hours, after the afternoon precipitation event. The flood on June 28 destroyed the stream gage at this location; thus flow records are not available. Sampling personnel estimated the flow in Cañon de Valle at this location was approximately 2 cfs at the time of sampling.

Water Canyon

Gage E252

Storm water runoff samples were collected manually in upper Water Canyon above SR 501 at the site of gage E252 on October 23. Figure 3-18 shows the hourly precipitation recorded at the Pajarito Canyon and Water Canyon RAWS on October 23. Runoff resulting from the afternoon precipitation event was sampled at 1443 and 1444 hours, after the afternoon precipitation event. The flood on June 28 destroyed the stream gage at this location; thus flow records are not available. Sampling personnel estimated the flow in Water Canyon at this location was approximately 5 cfs at the time of sampling. The samples collected are listed in Table 3-18.

Gage E265

Automated storm water runoff samples were collected in lower Water Canyon at gage E265 on the afternoon of October 23. Figure 3-21 shows the precipitation recorded at TA-49 and the Water Canyon and Pajarito Canyon RAWS on October 23 and flow at gage E265 on October 23 and 24. Flow began at

gage E265 at 1345 hours as the result of local precipitation, but the peak flow was 37.6 cfs at 1720 hours, resulting from runoff from up-canyon. Storm water runoff samples were collected at 1715 hours during the runoff event (Table 3-18).

Flow decreased at gage E265 for about three hours until 2035 hours when a slight increase in flow was recorded in response to another local precipitation event that occurred the evening of October 23. Storm water runoff from up-canyon resulting from the evening precipitation event arrived at gage E265 shortly after midnight at 0020 hours on October 24. The peak flow from this precipitation event was 39.6 cfs at 0030 hours, and flow continued at the gage in decreasing amounts throughout October 24. The total volume of runoff that passed through the gage during the first precipitation and runoff event was approximately 200,000 cubic ft. The total volume of runoff resulting from the evening precipitation and runoff event was approximately 400,000 cubic ft, of which some runoff was likely from the earlier precipitation event (see Figure 3-21).

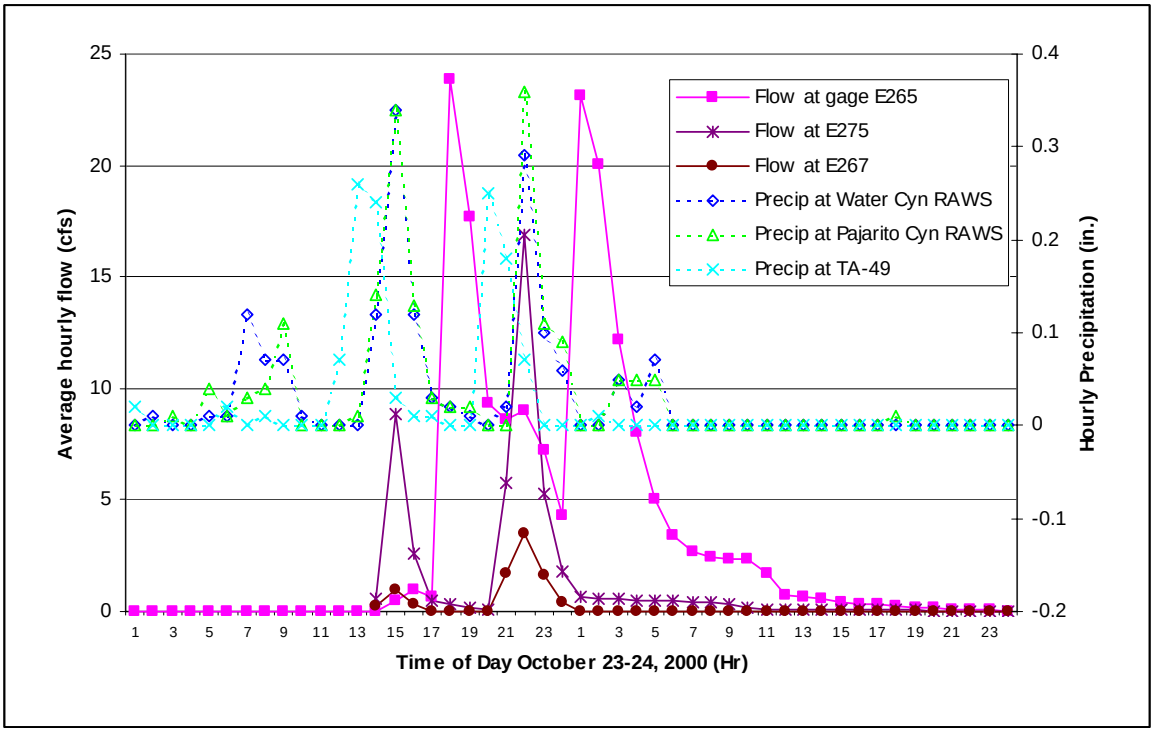


Figure 3-21. Precipitation at Water Canyon and Pajarito Canyon RAWS and TA-49 and flow at gages E265, E267, and E275 on October 23 and 24, 2000.

Ancho Canyon, Gage E275

Automated storm water runoff samples were collected in lower Ancho Canyon at gage E275 on the evening of October 23. Figure 3-21 shows the precipitation recorded at TA-49 and the Water Canyon and Pajarito Canyon RAWS on October 23 and flow at gage E275 on October 23 and 24. Flow began at gage E275 at 1400 hours as the result of local afternoon precipitation; the peak flow in the afternoon was 22.9 cfs at 1430 hours. Flow decreased at the gage for about three hours until 2030 hours when an increase in flow was recorded in response to another precipitation event that occurred the evening of October 23. Storm water runoff samples were collected at 2050 and 2105 hours during the evening runoff event. The peak flow resulting from the second precipitation and runoff event was 34 cfs at 2120 hours; flow continued at the gage in decreasing amounts until 2030 hours on October 24. The total volume of runoff that passed through the gage during the first runoff event was approximately 47,000 cubic ft, and the total volume of runoff resulting from the evening runoff event was approximately 125,000 cubic ft.

Potrillo Canyon, Gage E267

Automated storm water runoff samples were collected in lower Potrillo Canyon at gage E267 on the evening of October 23. Figure 3-21 shows the precipitation recorded at TA-49 and the Water Canyon and Pajarito Canyon RAWS on October 23 and flow at gage E275 on October 23 and 24. Flow began at gage E275 at 1345 hours as the result of local afternoon precipitation; the peak flow in the afternoon was 1.7 cfs at 1440 hours. Flow decreased at the gage until 1610 hours when flow ceased. The total volume of runoff during this flow event was approximately 5,200 cubic ft.

A second runoff event was recorded in response to another precipitation event that occurred the evening of October 23. Runoff began again at gage E267 at 2035 hours, and the peak flow was 5.6 cfs at 2055 hours. Storm water runoff samples were collected at 2050 and 2105 hours during the evening runoff event. Flow continued at the gage in decreasing amounts until 2355 hours on October 23. The total volume of runoff that passed through the gage during the second runoff event was approximately 25,600 cubic ft.

3.18 October 27-28, 2000

Intermittent precipitation was received over the Sierra de los Valles and the Pajarito Plateau on the afternoon and evening of October 27 and in the early morning hours on October 28. A significant precipitation event occurred over the western part of the Laboratory between 1600 to 1800 hours on the afternoon of October 27, when 0.59 in. was received at TA-6; very little precipitation was received over the eastern part of the Laboratory on this date. Figure A-16 shows the pattern of precipitation that was received over the Pajarito Plateau on October 27. The heaviest precipitation was received at TA-6 and the upper Los Alamos Canyon RAWS, which received a daily total of 0.65 in. and 0.67 in., respectively.

Additional precipitation was received on the morning of October 28 from about midnight to 0900 hours. Figure A-17 shows the pattern of precipitation that was received on the Pajarito Plateau on October 28. The Laboratory received about 0.5 to 0.6 in. on October 28. TA-54 received 0.6 in. and TA-6 received 0.52 in. on the morning of October 28. The heaviest precipitation amounts were received in the upper Los Alamos Canyon watershed where 0.78 in. was recorded at the upper Los Alamos Canyon RAWS and 0.9 in. was recorded at the Quemazon RAWS.

During the precipitation event on October 27 and on the following days on October 28 and October 30, a total of 24 storm water runoff samples were collected at 11 sites across the Laboratory. Table 3-19 lists the runoff samples that were collected on October 27, 28, and 30. The following sections describe the runoff event at collection sites where stream gage data are available.

Pueblo Canyon, Gage E060

Storm water runoff began to flow at gage E060 in lower Pueblo Canyon at 2050 hours on the evening of October 27. The peak flow was 38.2 cfs at 2115 hours, and the flow decreased at the gage until 0505 hours on the morning of October 28, when, as a result of additional precipitation during the early morning hours, another flow event occurred. The peak flow during the runoff event on October 28 was 15.8 cfs at 0820 hours. Flow at gage E060 continued throughout October 28. Figure 3-22 shows the hourly precipitation at TA-6 and TA-53 and the flow at gage E060 on October 27 and 28. Flow at gage E060 is sometimes supported by effluent discharge from the Los Alamos County Bayo wastewater treatment plant in lower Pueblo Canyon.

Automated storm water runoff samples were collected at 2114 and 2304 hours on the evening of October 27 during the initial runoff event. The samples that were collected are listed in Table 3-19. The volume of runoff that passed through gage E060 during the first runoff event was approximately 240,000 cubic ft. The volume of water that passed through the gage on October 28 during the second runoff event was

approximately 390,000 cubic ft. The total volume of water that passed through the gage as a result of storm water runoff on October 27 and 28 was approximately 630,000 cubic ft.

Los Alamos Canyon and DP Canyon, Gage E042

Automated storm water runoff samples were collected in middle DP Canyon at gage E039 and in lower DP Canyon at gage E040. The samples were collected at 1751 and 1810 hours on the afternoon of October 27. The samples are listed in Table 3-19. The stage-discharge relationship for gage E039 has not been established. The flow at gage E040 in lower DP Canyon is shown on Figure 3-22. Flow began at 1805 hours on the evening of October 27, and the peak flow was 63.8 cfs at 1810 hours. Flow at gage E040 declined overnight until, in response to additional precipitation on the morning of October 28, flow increased slightly for a short time from 0100 to 0115 hours and significantly increased at 0420 hours. The peak flow associated with the precipitation received during the early morning on October 28 was 17.38 cfs at 0600 hours. Flow continued at gage E040 until 0200 hours on the morning of October 29. The volume of runoff that passed through gage E040 as a result of the precipitation on October 27 was approximately 145,000 cubic ft, and the volume of water passing through the gage as a result of the precipitation on the morning of October 28 was approximately 122,000 cubic ft. The total volume of water that discharged from DP Canyon to Los Alamos Canyon on October 27 and 28 was about 267,000 cubic ft.

Table 3-19. Storm Water Runoff Samples Collected October 27, 28, and 30, 2000.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
Pueblo Canyon						
27-Oct	E060	GF00103E060	2114	Automated	F	R
27-Oct	E060	GS00103E060	2114	Automated	UF	G1, R
27-Oct	E060	GS00104E060	2304	Automated	UF	G1
Los Alamos-DP Canyon						
27-Oct	E039	GS00103E039	1751	Automated	UF	G, M
27-Oct	E039	GF00103E039	1751	Automated	F	G, M
27-Oct	E039	GS00104E039	1751	Automated	UF	G1
27-Oct	E040	GF00105E040	1810	Automated	F	G, M, R
27-Oct	E040	GS00105E040	1810	Automated	UF	G, M, H-3
27-Oct	E040	GS00106E040	1810	Automated	UF	G1
27-Oct	E042	GS00105E042	1905	Automated	UF	G1, R
27-Oct	E042	GF00105E042	1905	Automated	F	G, M
30-Oct	E042	GS00107E042	1050	Automated	UF	G1
Cañada del Buey						
28-Oct	E230	GS00105E230	0442	Automated	UF	G, M, HE
28-Oct	E230	GF00105E230	0442	Automated	F	G, M
28-Oct	E230	GS00106E230	0442	Automated	UF	G1
Pajarito Canyon						
27-Oct	E250	GF00103E250	2352	Automated	F	G1, M, R
27-Oct	E250	GS00103E250	2352	Automated	UF	G, M, R, HE
28-Oct	E250	GS00104E250	0023	Automated	UF	G1
Water Canyon						
27-Oct	E263	GF00101E263	1911	Automated	F	G, M
27-Oct	E263	GS00101E263	1911	Automated	UF	G, M, H-3, HE, SV
28-Oct	E263	GS00102E263	0254	Automated	UF	G1
27-Oct	E265	GF00103E265	1715	Automated	F	G1, M, R

Table 3-19 cont.

Date	Gage	Sample ID	Time (hr)	Sample Type	F/UF	Suite
27-Oct	E265	GS00103E265	1715	Automated	UF	G1, M, R
27-Oct	E265	GS00104E265	2026	Automated	UF	G1
Ancho Canyon						
28-Oct	E273	GS00101E273	0422	Automated	UF	G, M
28-Oct	E273	GF00101E273	0422	Automated	F	G1
28-Oct	E273	GS00102E273	0440	Automated	UF	G1
28-Oct	E275	GS00103E275	0508	Automated	UF	G, M
28-Oct	E275	GS00104E275	0508	Automated	UF	G1

UF = Unfiltered, F = Filtered; See Table 2-3 for location names and Table 2-5 for explanation of Analytical Suite Codes

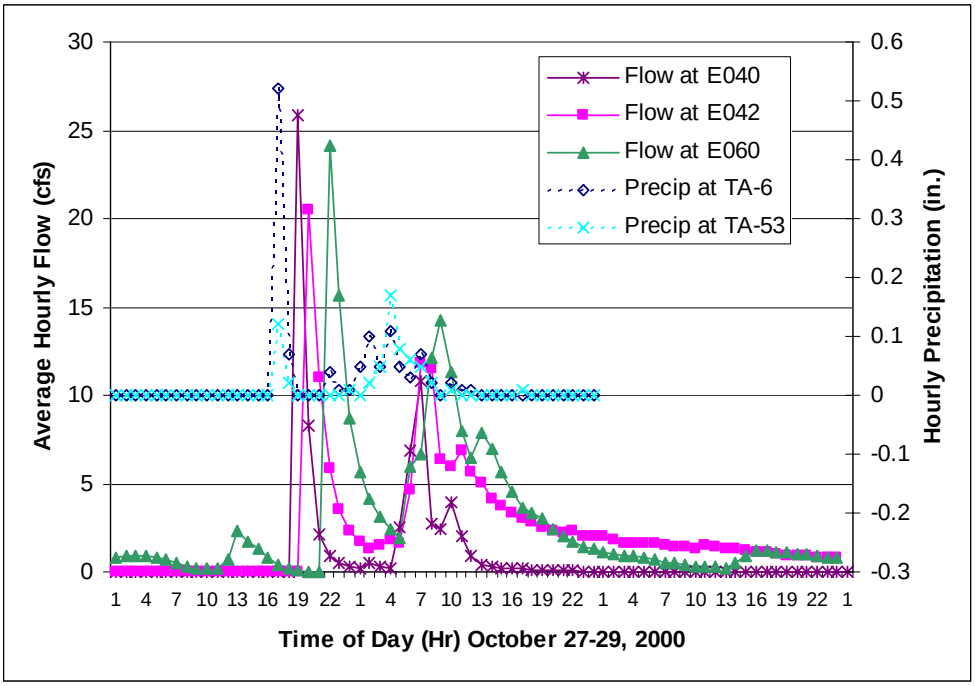


Figure 3-22. Precipitation at TA-6 and TA-53 and flow at gages E060, E040 and E042 on October 27–30.

Storm water runoff began to flow in lower Los Alamos Canyon at gage E042 at 1905 hours on the evening of October 27. The peak flow resulting from precipitation on October 27 was 32.2 cfs at 1935 hours, and the flow decreased at the gage until 0220 hours on the morning of October 28, when, due to additional precipitation, another runoff event occurred. The peak flow during the runoff event on October 28 was 17.2 cfs at 0640 hours, and runoff continued throughout October 28 and 29. Figure 3-22 shows the hourly precipitation at TA-6 and TA-53 and the average hourly flow at gage E042 on October 27, 28, and 29. The volume of runoff that passed through gage E042 after the precipitation on October 27 was approximately 170,000 cubic ft, and the volume of runoff passing through the gage on October 28 and 29 as a result of the precipitation on the morning of October 28 was approximately 448,000 cubic ft. The flow during the afternoon and evening of October 28 and on October 29, about 2 cfs, is probably residual discharge from the Los Alamos Canyon Reservoir.

Automated storm water runoff samples were collected at gage E042 on the evening of October 27 at 1905 hours during the initial runoff event and again on the morning of October 30 at 1050 hours after the second runoff event. The samples collected are listed in Table 3-19.

Cañada del Buey

As a result of precipitation received on October 27 and during the early morning hours on October 28, storm water runoff began to flow at gage E230 in lower Cañada del Buey at 0440 hours on the morning of October 28. The peak flow was 8.1 cfs at 0530 hours, and flow continued at the gage until 0915 hours. Figure 3-23 shows the hourly precipitation at TA-6 and TA-54 and the average hourly flow at gage E230 on October 27 and 28. The total volume of water that passed through the gage was approximately 38,000 cubic ft. Storm water runoff samples were collected at 0442 hours during the runoff event. The runoff samples are listed in Table 3-19.

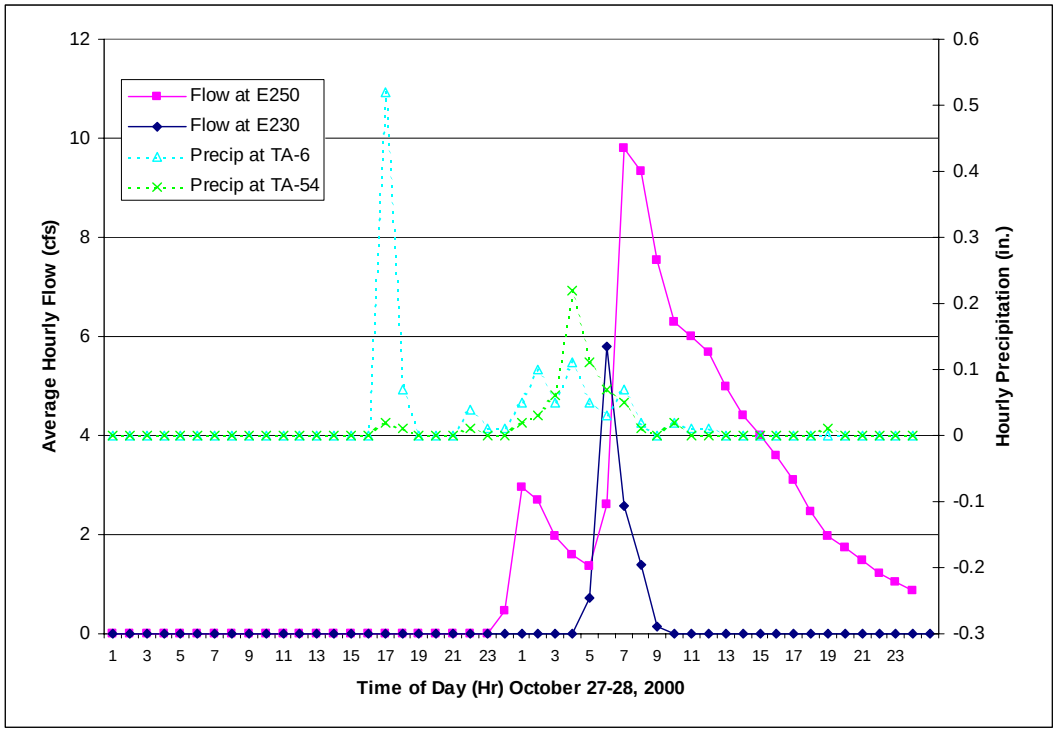


Figure 3-23. Precipitation at TA-6 and TA-54 and runoff at E230 and E250 on October 27 and 28, 2000.

Pajarito Canyon

As a result of precipitation received on October 27, storm water runoff began to flow at gage E250 in lower Pajarito Canyon at 2345 hours on the evening of October 27. The peak flow was 3.1 cfs at 0010 hours on October 28, and flow declined at the gage until 0445 hours when, as a result of additional precipitation on the morning of October 28, another runoff event occurred. The peak flow during the second runoff event was 10.9 cfs at 1030 hours, and flow continued at the gage throughout the day on October 28 and into October 29. Figure 3-23 shows the hourly precipitation at TA-6 and TA-54 and the average hourly flow at gage E250 on October 27 and 28. The volume of water that passed through the gage during the first runoff event was approximately 37,000 cubic ft. The volume of water that passed through gage E250 during the second runoff event on October 28 was approximately 280,000 cubic ft. Storm water runoff samples were collected at 2352 hours and 0023 hours during the initial runoff event (see Table 3-19).

Ancho Canyon

Automated storm water runoff samples were collected in Ancho Canyon above SR 4 at gage E273 on the morning of October 8. Flow rates at this gage are not available. The samples were collected at 0422 and 0440 hours. The samples that were collected are listed in Table 3-19.

Storm water runoff began at gage E275 in lower Ancho Canyon below SR 4 at 0510 hours on the morning of October 28. The peak flow was 6.9 cfs at 0525 hours, and a small amount of flow continued at the gage throughout the day on October 28. Figure 3-24 shows the hourly precipitation at TA-49 and TA-54 and the average hourly flow at gage E275 on October 27 and 28. The total volume of water that passed through the gage on October 28 was approximately 28,000 cubic ft. Storm water runoff samples were collected at 0508 hours during the runoff event (see Table 3-19).

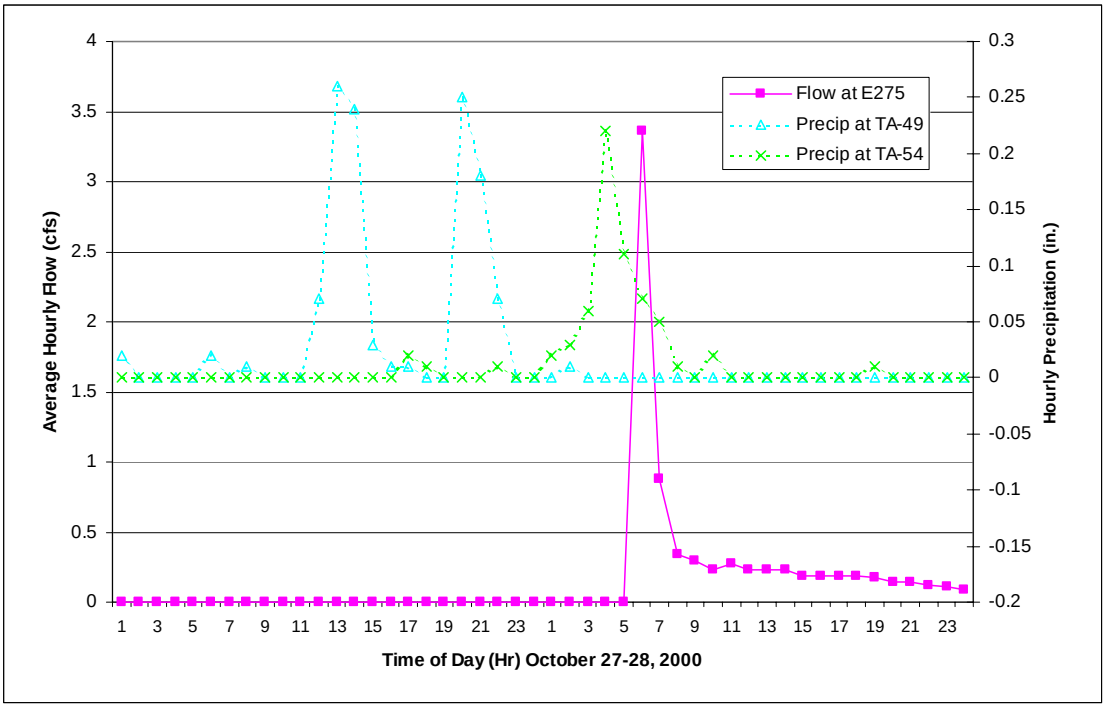


Figure 3-24. Precipitation at TA-49 and TA-54 and flow at gage E275 in Ancho Canyon on October 27 and 28, 2000.

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The authors would like to thank all those who helped contribute data and/or time to the compilation of this report. Mr. Steve Rae of the Water Quality and Hydrology Group (ESH-18) provided funding and support for the project. Mr. David Shaull (co-author) and Chris MacLean of the Water Quality and Hydrology Group (ESH-18) provided stream gage data that were used to construct the flow diagrams.

Ms. Kay Beeley of the National Park Service at Bandelier National Monument provided precipitation data for two locations within the National Monument. Mr. Keith Jacobsen and others of the Air Quality Group (ESH-17) assisted in obtaining access to precipitation records.

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Appendix A. Figures showing the pattern of precipitation in 2000 on days runoff samples were collected.

Daily precipitation data used to create the following precipitation isopleth maps were obtained from the following sources.

- The Laboratory Air Quality Group (ESH-17) maintains precipitation data for several Los Alamos National Laboratory area meteorological stations at their web page at www.weather.lanl.gov

- The Desert Research Institutes (DRI) Remote Area Weather Stations (RAWS) that are provided though interagency cooperation of the Bureau of Land Management, National Interagency Fire Center, and the Western Region Climate Center. The data are available at the DRI web site at http://www.wrcc.dri.edu/losalamos/

- The Bandelier National Monument provided precipitation data for two stations, one at Cerro Grande, and another at the main monument headquarters, called Frijolito. Thanks to Kay Beeley of the National Park Service for providing these data.

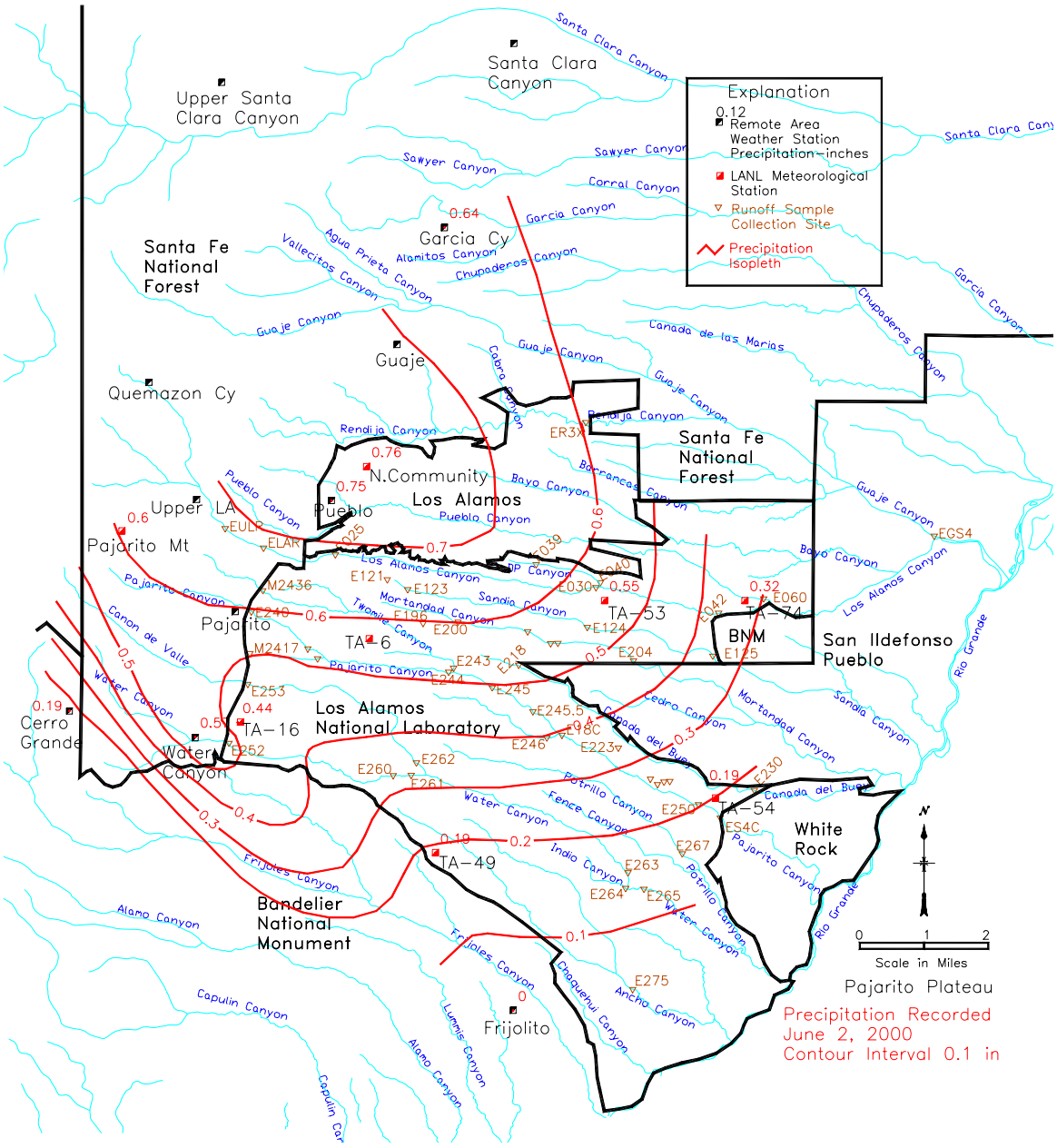


Figure A-1. Pattern of precipitation recorded on the Pajarito Plateau on June 2, 2000.

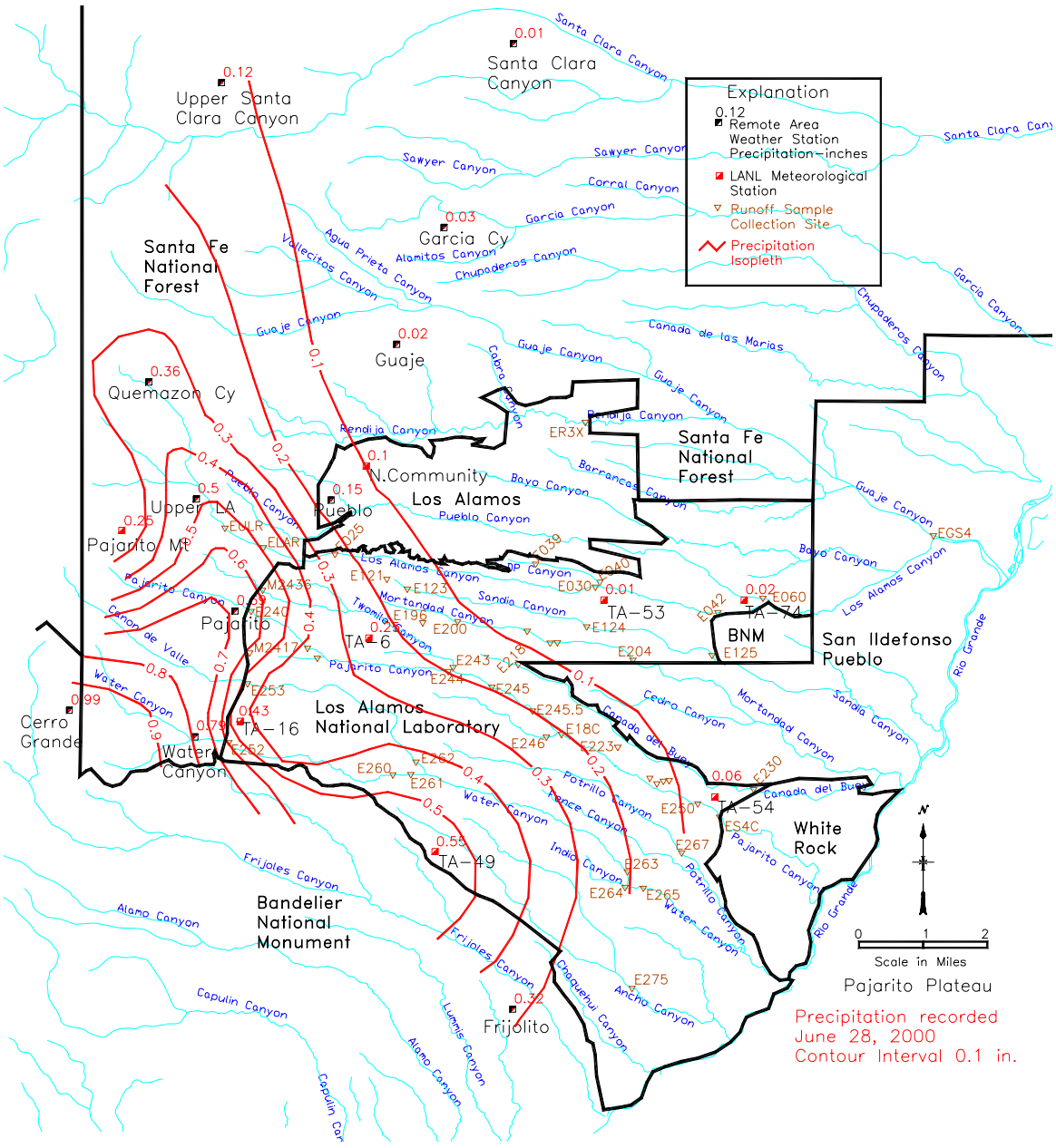


Figure A-2. Pattern of precipitation recorded on the Pajarito Plateau on June 28, 2000.

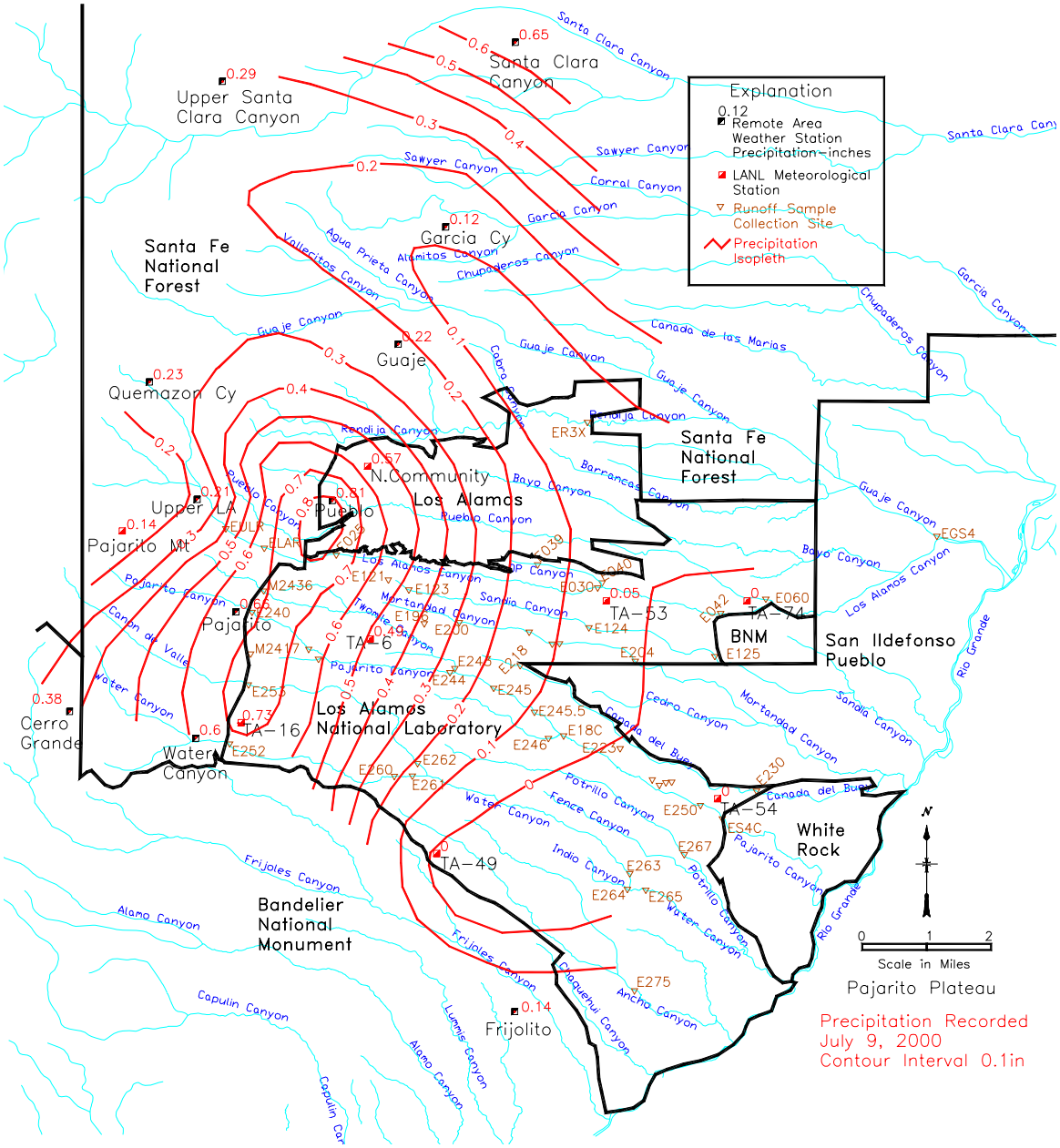


Figure A-3. Pattern of precipitation recorded on the Pajarito Plateau on July 9, 2000.

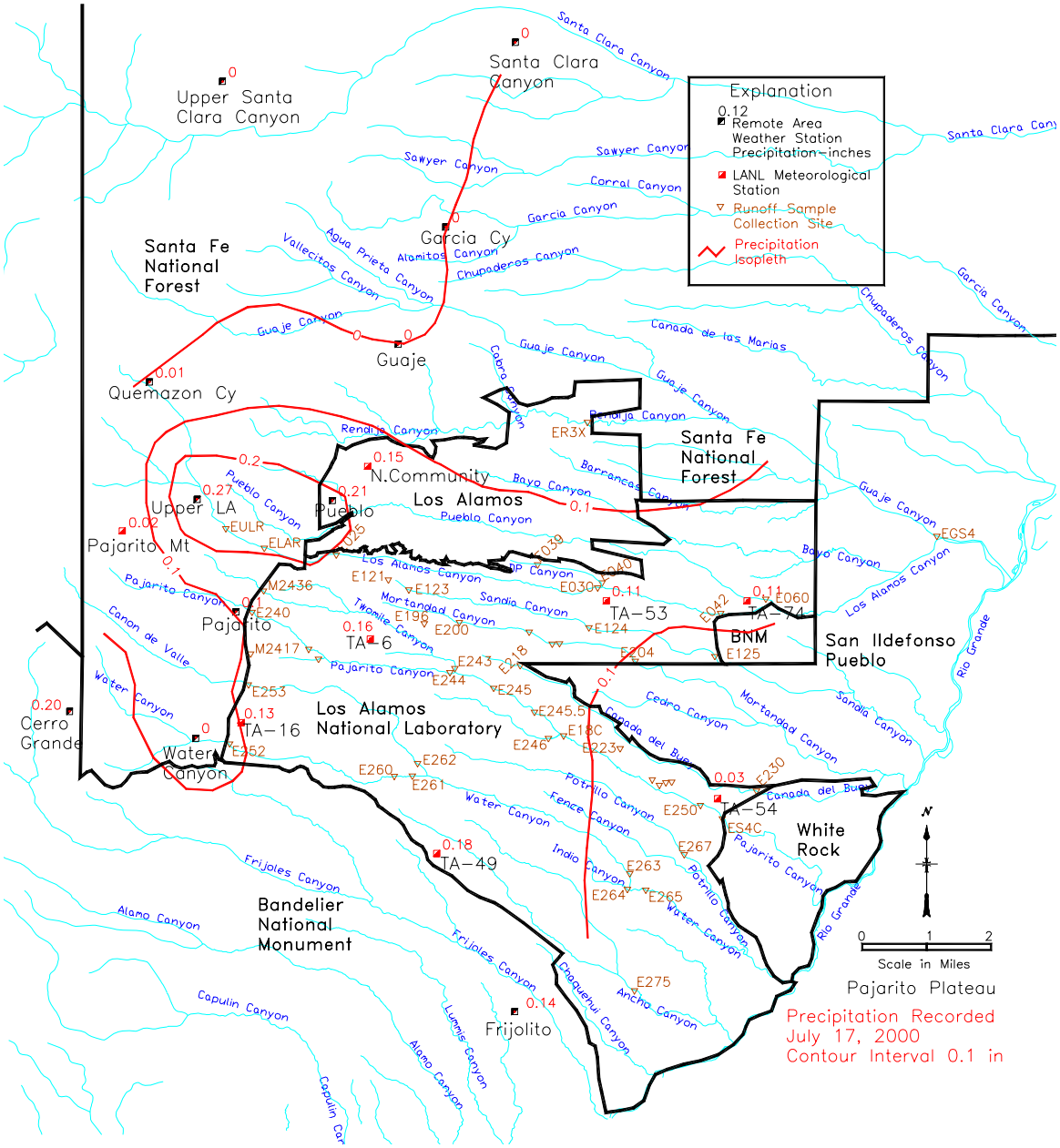


Figure A-4. Pattern of precipitation recorded on the Pajarito Plateau on July 17, 2000.

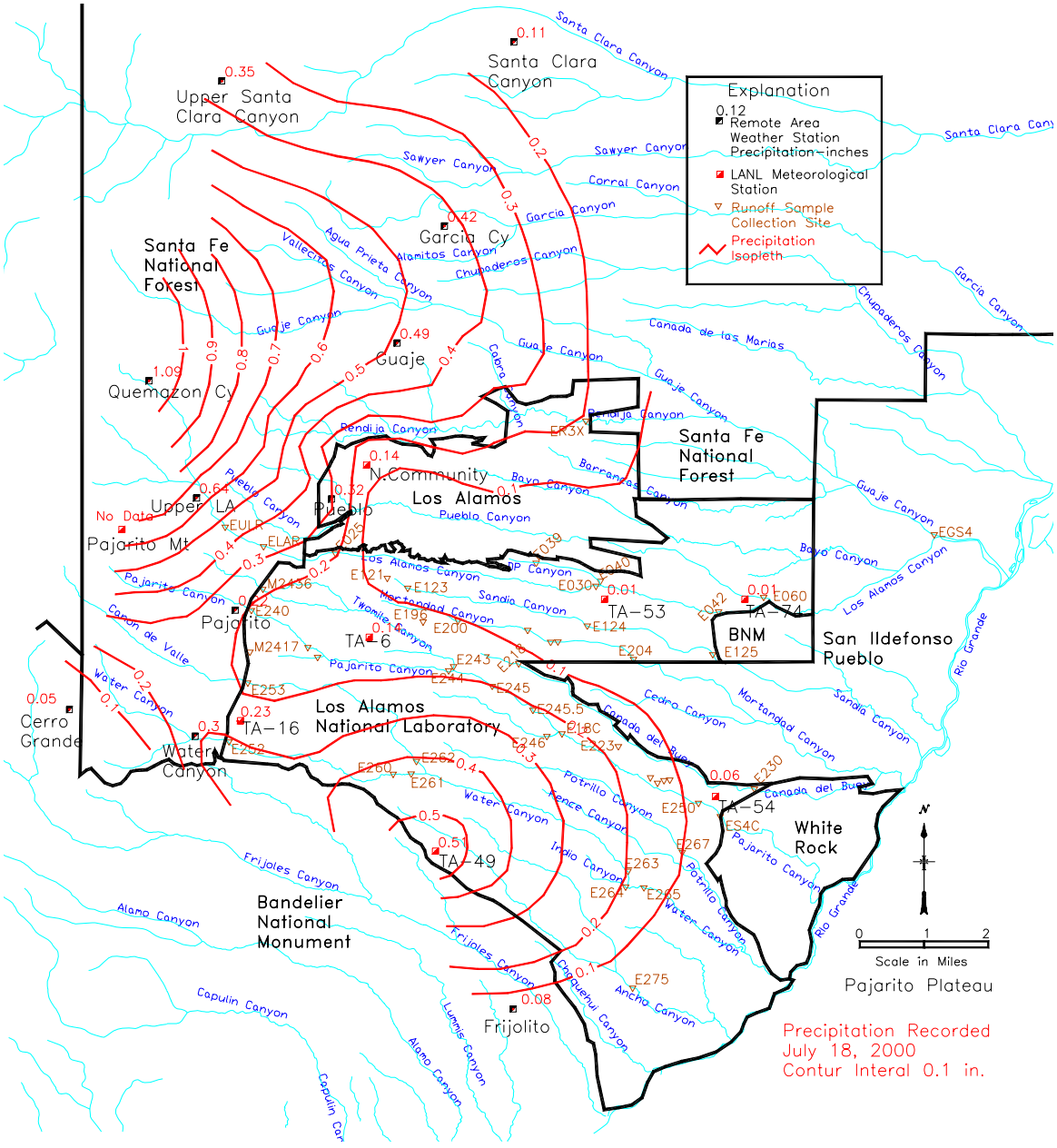


Figure A-5. Pattern of Precipitation recorded on the Pajarito Plateau on July 18, 2000.

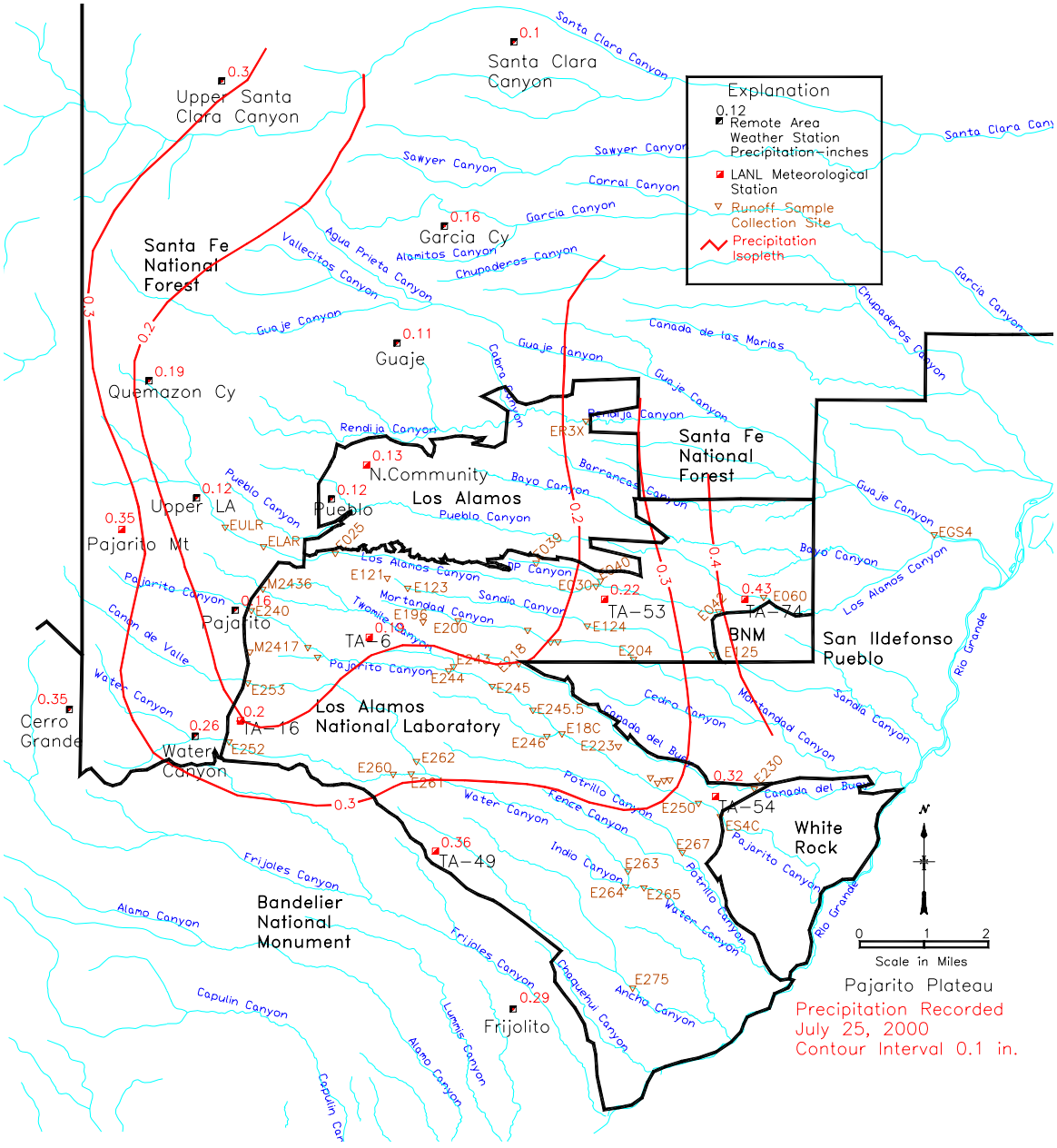


Figure A-6. Pattern of precipitation recorded on the Pajarito Plateau on July 25, 2000.

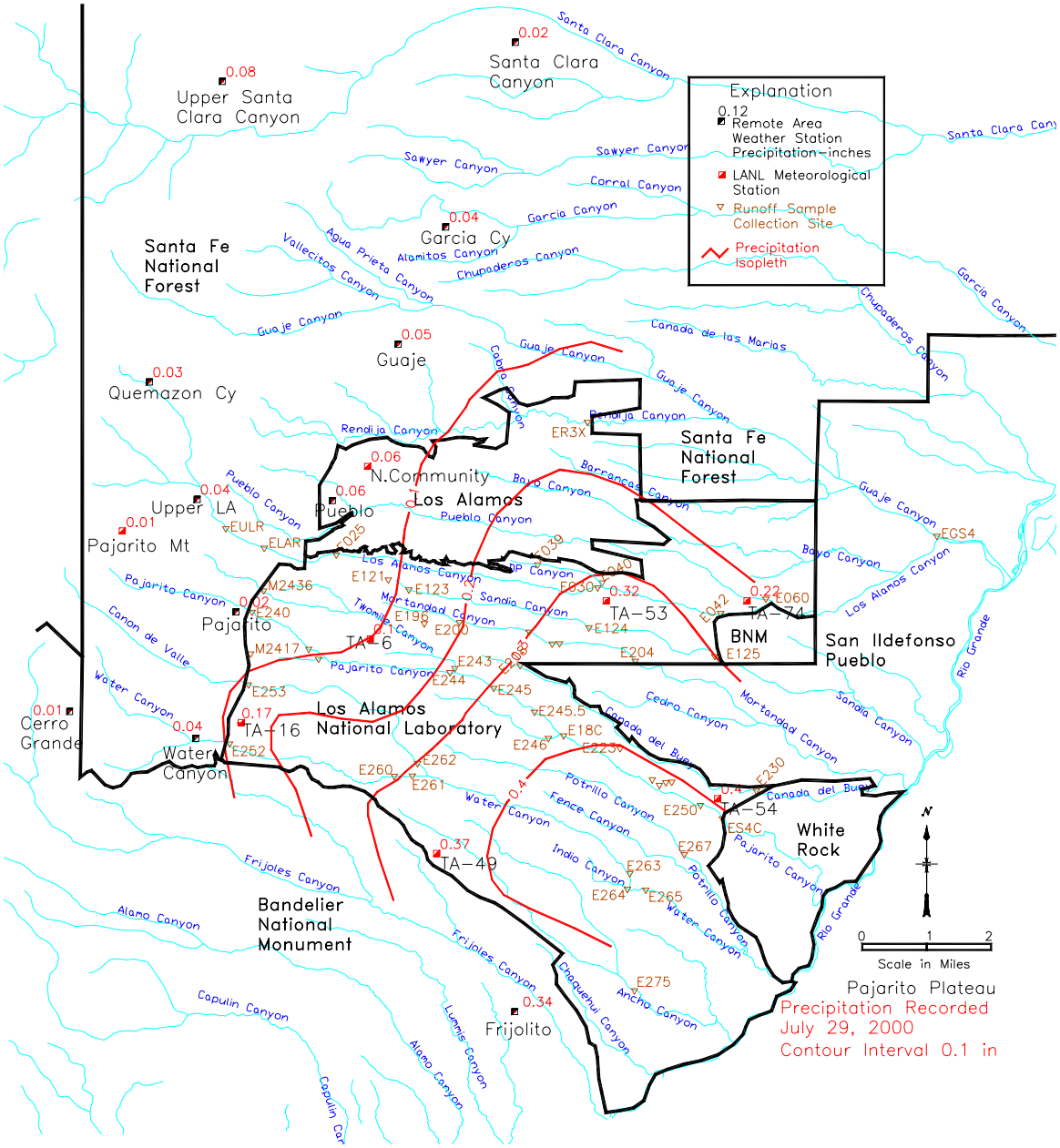


Figure A-7. Pattern of precipitation recorded on the Pajarito Plateau on July 29, 2000.

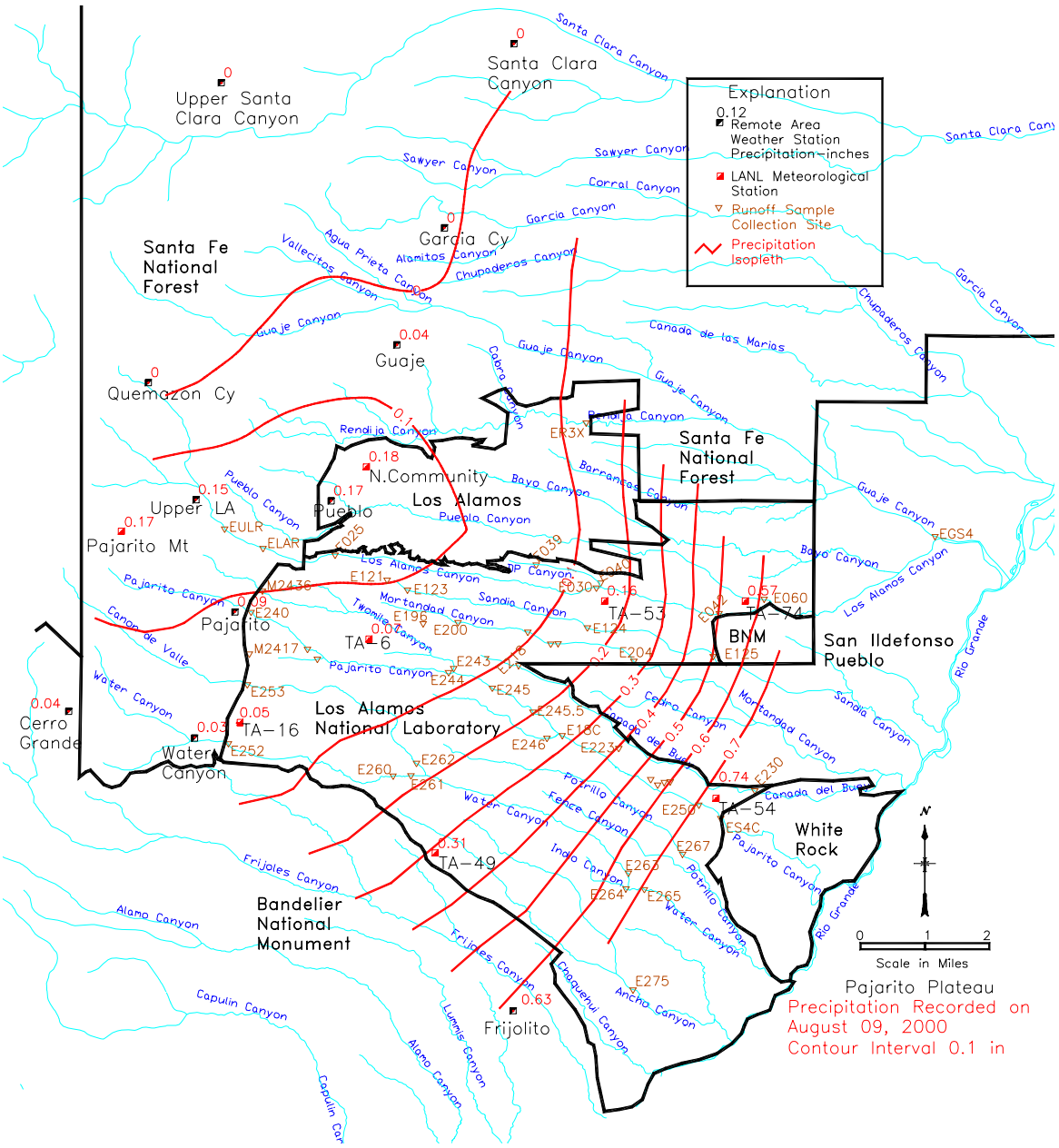


Figure A-8. Pattern of precipitation recorded on the Pajarito Plateau on August 9, 2000.

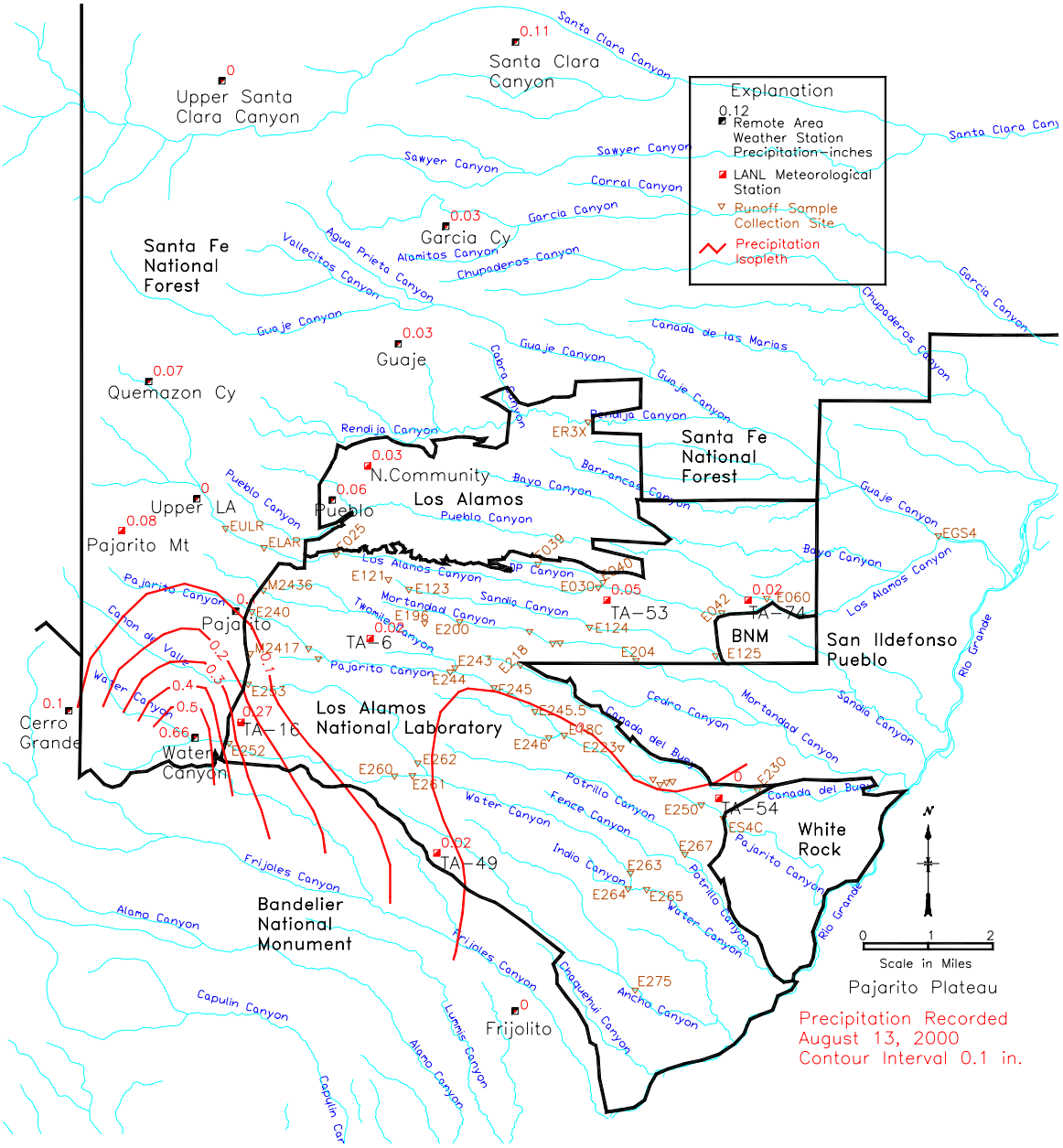


Figure A-9. Pattern of precipitation recorded on the Pajarito Plateau on August 13, 2000.

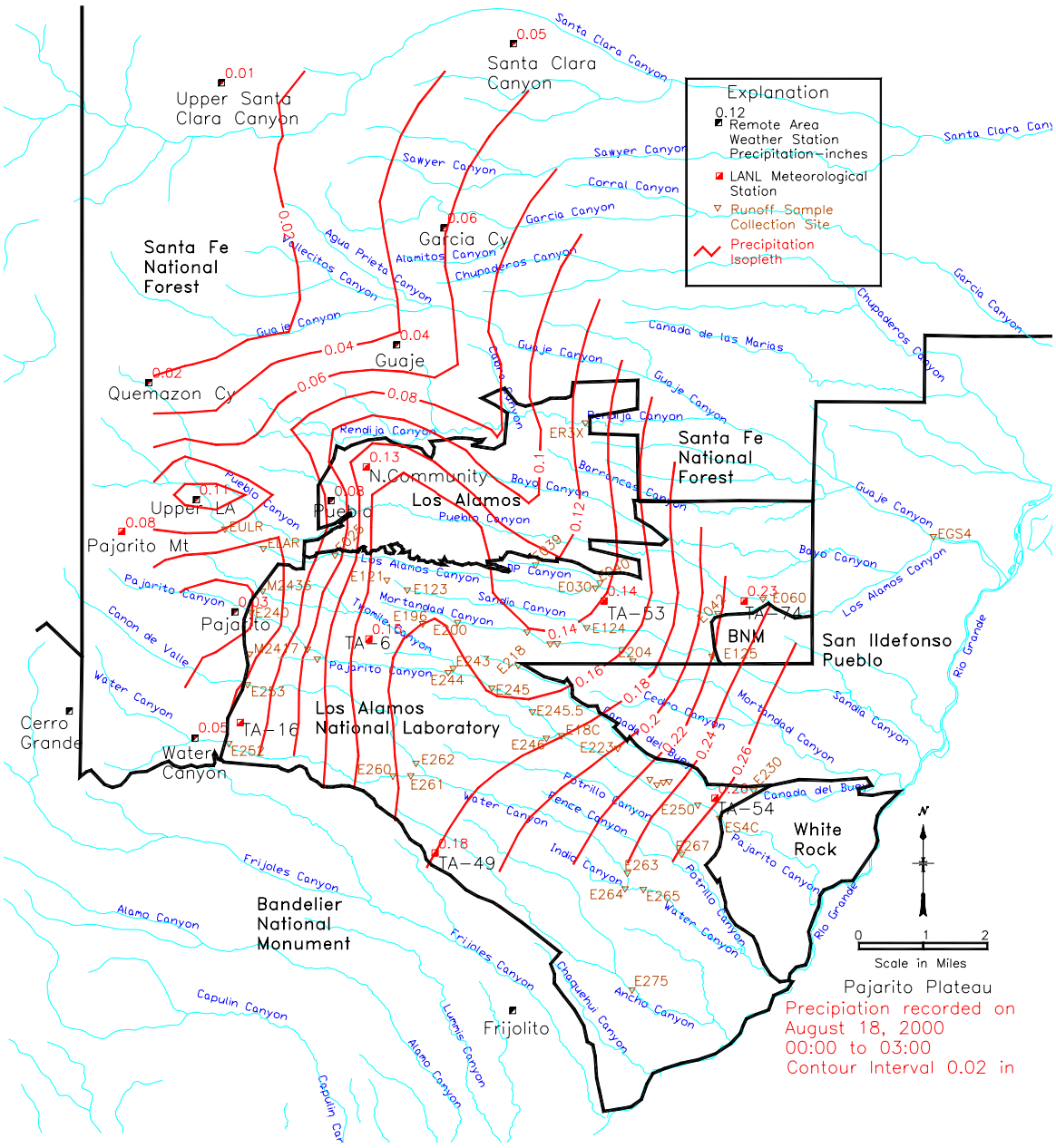


Figure A-10a. Pattern of precipitation recorded on the Pajarito Plateau on the morning of August 18, 2000.

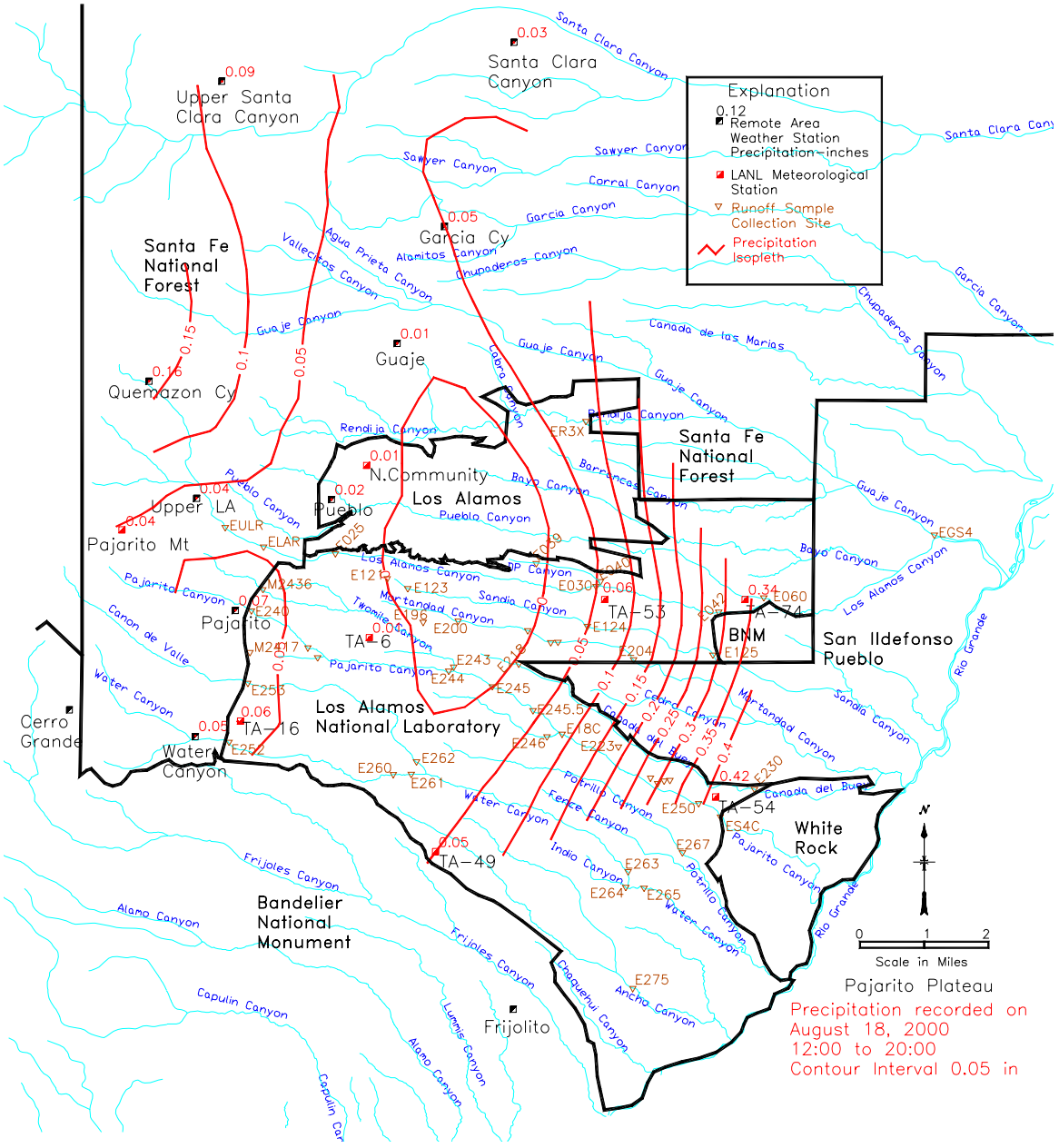


Figure A-10b. Pattern of precipitation recorded on the Pajarito Plateau on the afternoon of August 18, 2000.

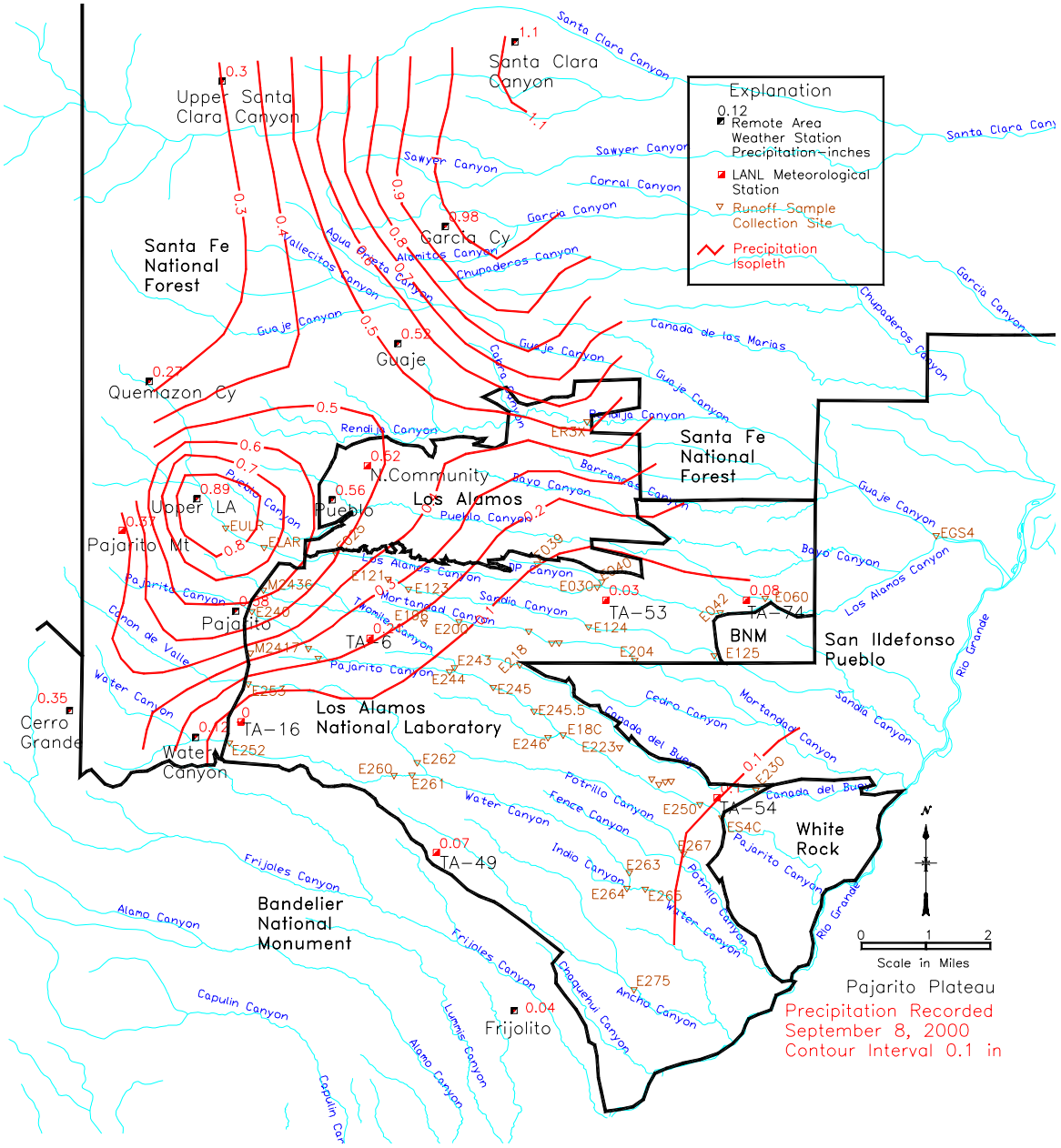


Figure A-11. Pattern of precipitation recorded on the Pajarito Plateau on September 8, 2000.

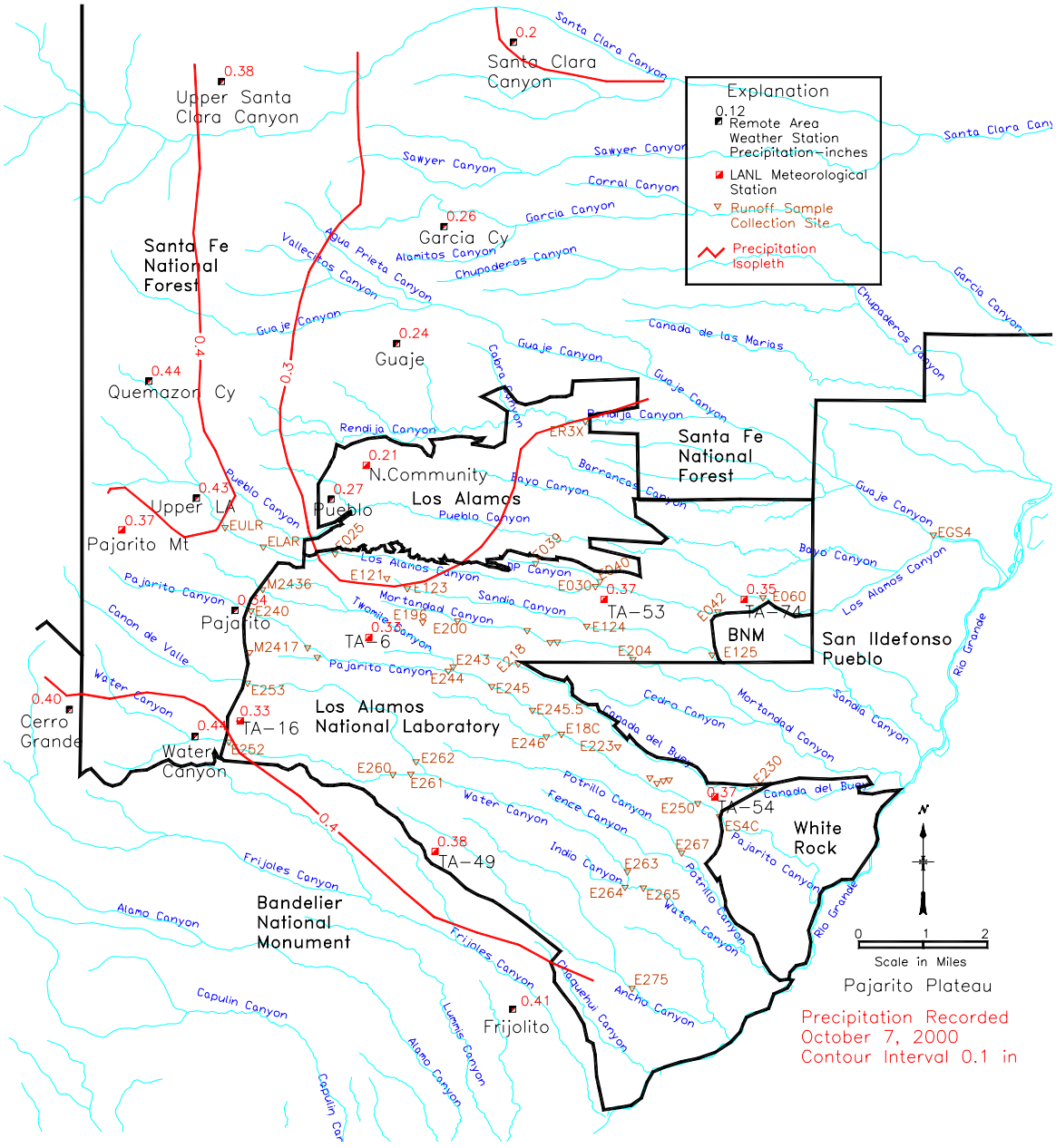


Figure A-12. Pattern of precipitation recorded on the Pajarito Plateau on October 7, 2000.

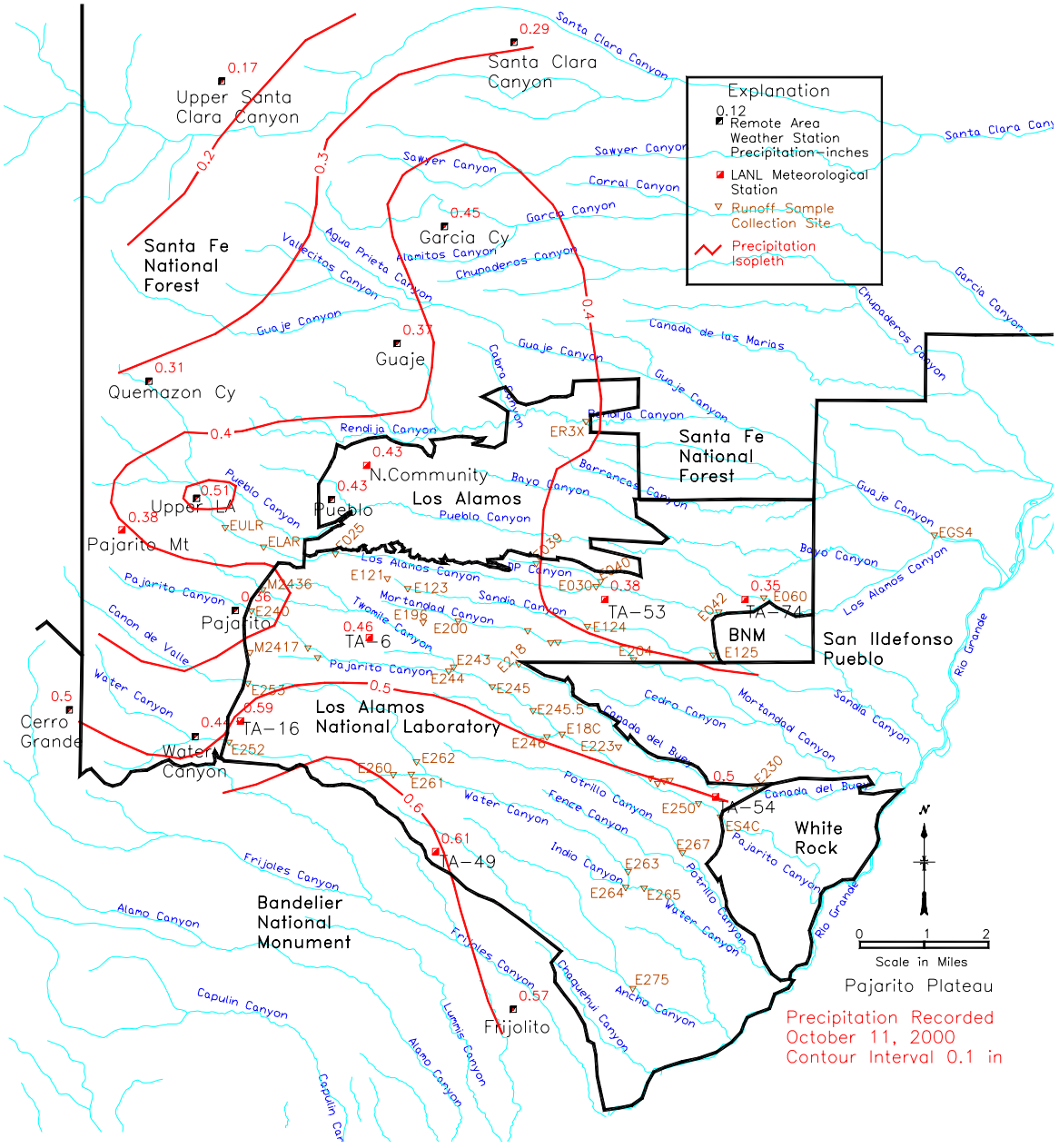


Figure A-13. Pattern of precipitation recorded on the Pajarito Plateau on October 11, 2000.

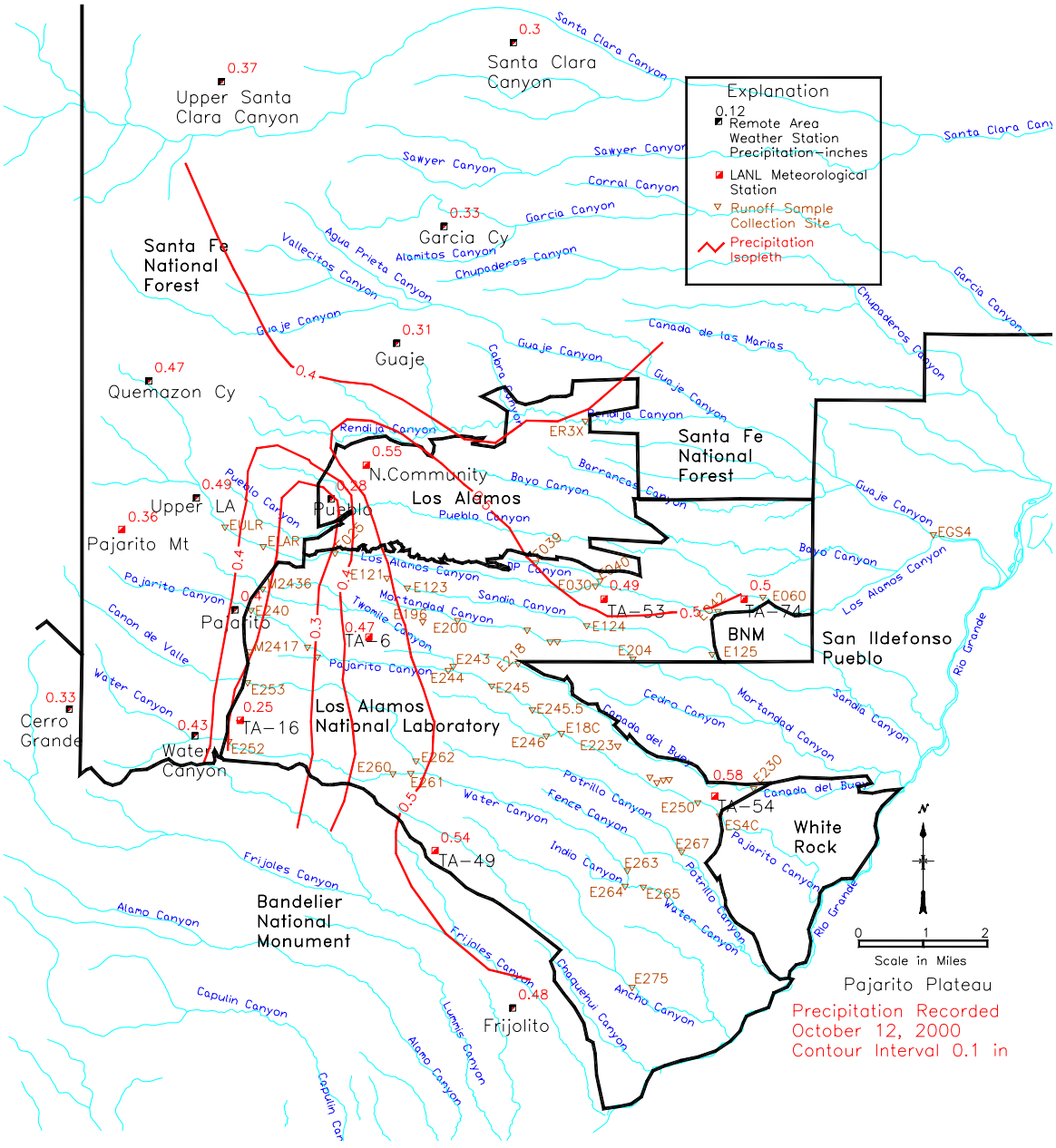


Figure A-14. Pattern of precipitation recorded on the Pajarito Plateau on October 12, 2000.

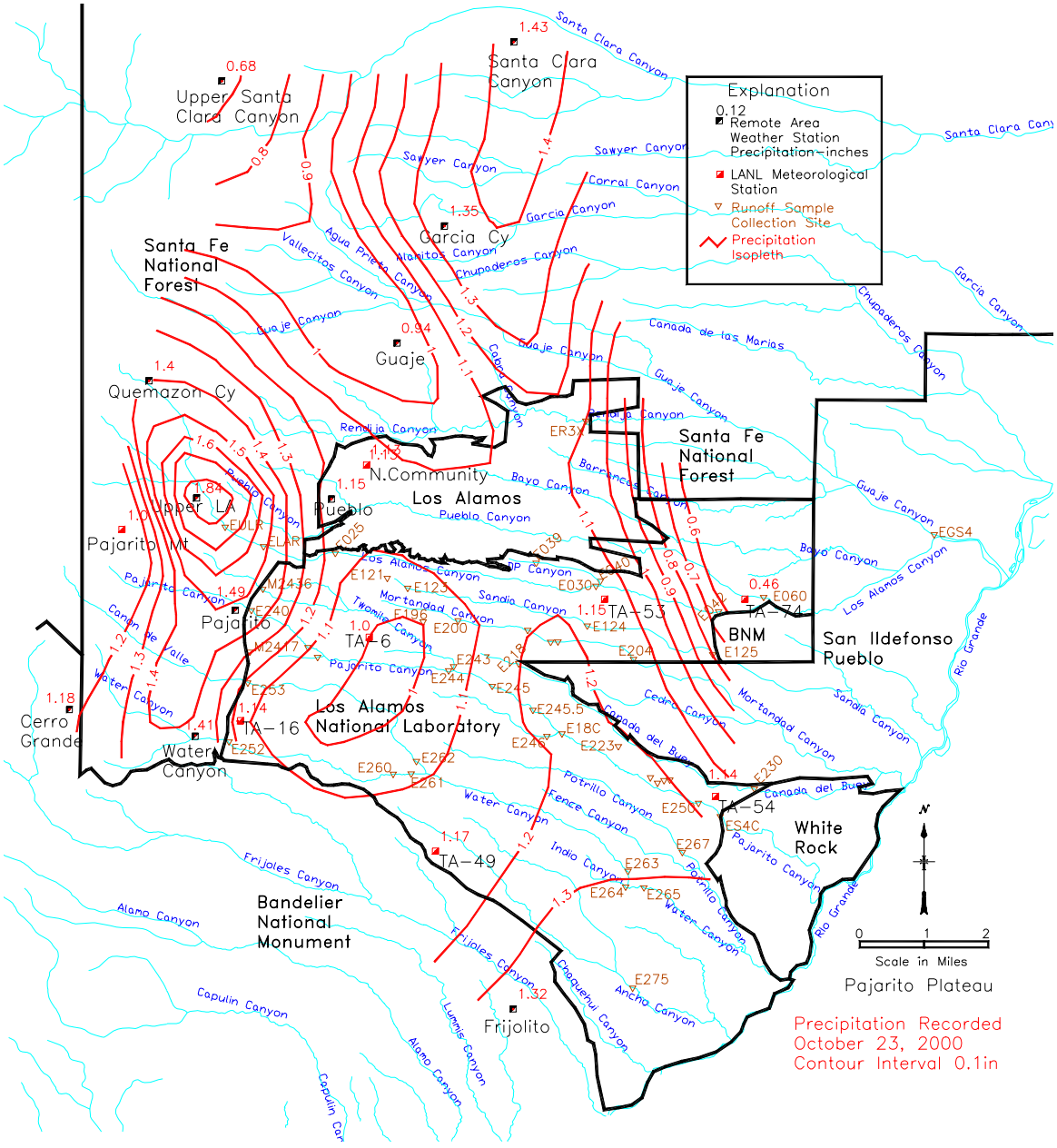


Figure A-15. Pattern of precipitation recorded on the Pajarito Plateau on October 23, 2000.

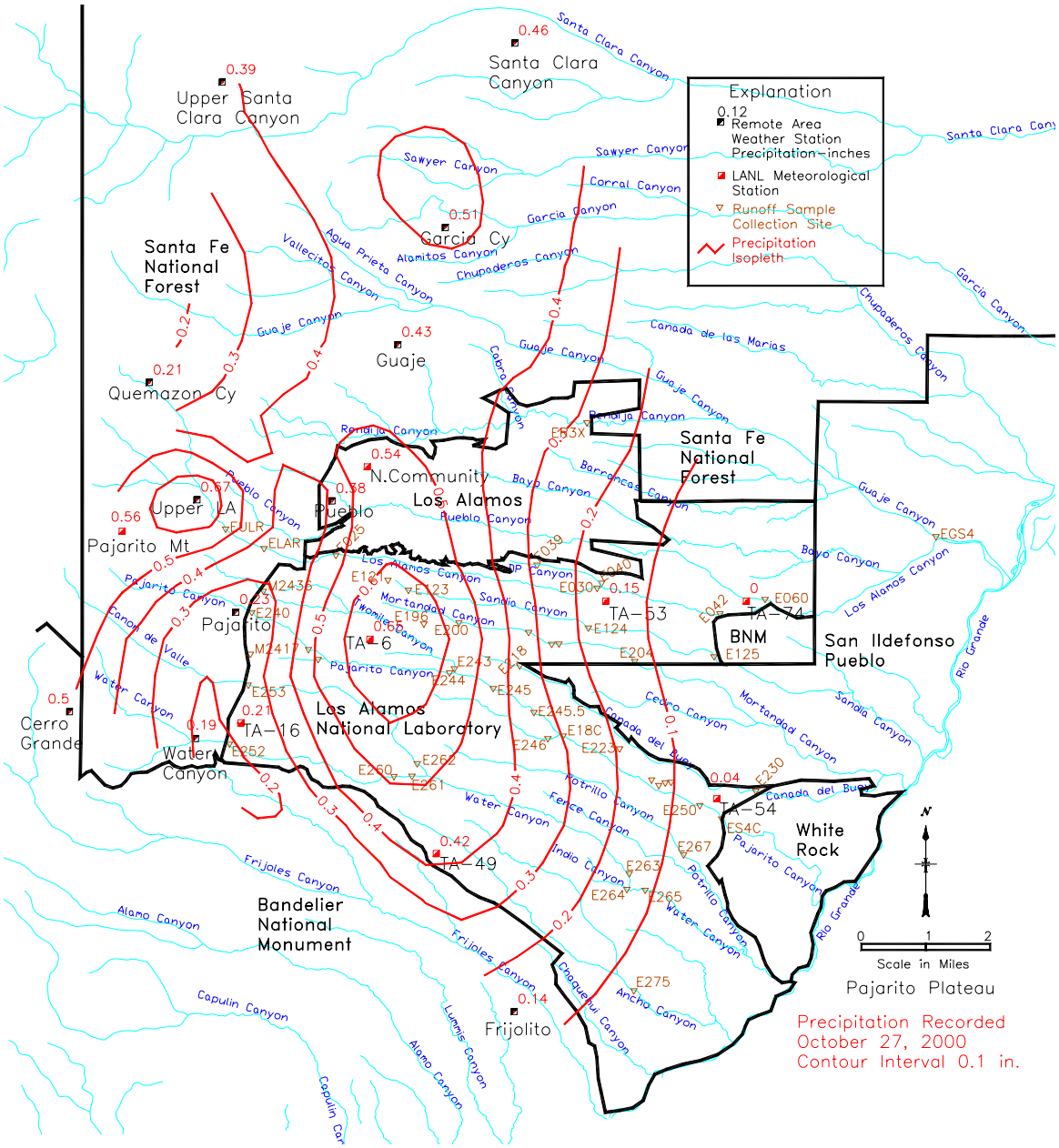


Figure A-16. Pattern of precipitation recorded on the Pajarito Plateau on October 27, 2000.

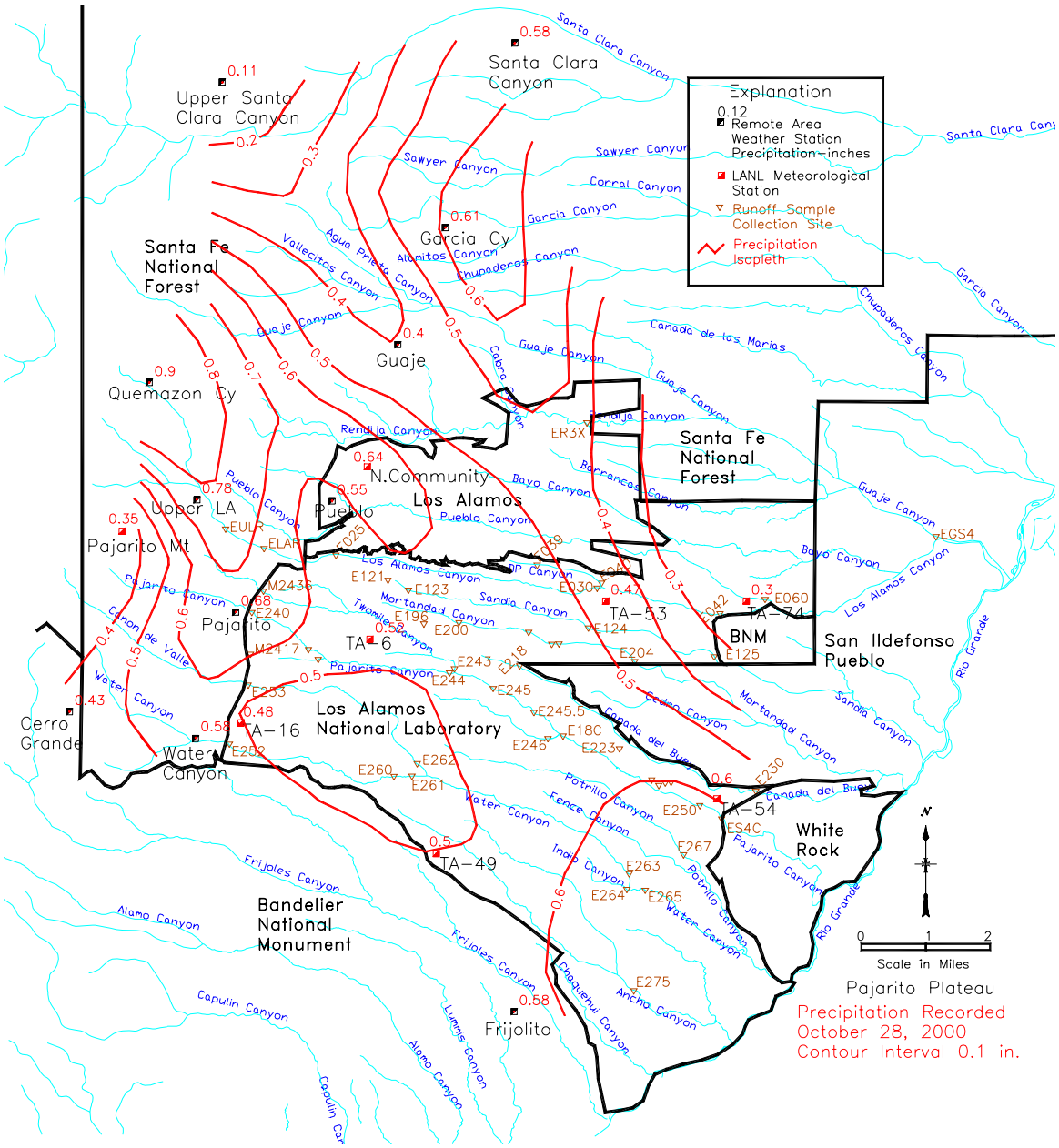


Figure A-17. Pattern of precipitation recorded on the Pajarito Plateau on October 28, 2000.

Appendix B. Water Quality Database Location Names

Table B-1. Water Quality Database Locations Names

Gage	Canyon	Location Name Table 2-3	WQDB Database Location
E025	Los Alamos	Los Alamos Canyon at Omega Bridge	Los Alamos Canyon at Los Alamos, NM
E030	Los Alamos	Los Alamos Canyon above DP Canyon	Los Alamos Canyon below TA-2 near Los Alamos, NM
E038	DP	DP Canyon at Head	Head of DP Canyon
E039	DP	DP Canyon below Meadow at TA-21	DP Canyon below Meadow at TA-21
E040	DP	DP Canyon at Los Alamos Canyon	DP Canyon at Mouth
E042	Los Alamos	Los Alamos Canyon above SR 4	Los Alamos Canyon near Los Alamos, NM
E060	Pueblo	Pueblo Canyon above Los Alamos Canyon	Pueblo Canyon near Los Alamos, NM
E122	Sandia	Sandia Canyon at TA-3	Sandia Canyon near Roads & Grounds at TA-3
E196	Mortandad	Effluent Canyon at TA-55	TA-55
E218	Cañada del Buey	Cañada del Buey at TA-46	Cañada del Buey at TA-46
E221	Cañada del Buey	TA-54 MDA-J	Area J
E223	Cañada del Buey	TA-54 MDA-L	Area L
E230	Cañada del Buey	Cañada del Buey above SR 4 at White Rock	Cañada del Buey at White Rock, NM
E240	Pajarito	Pajarito Canyon above SR 501	Pajarito Canyon above SR 501 near Los Alamos, NM
E241	Pajarito	Pajarito Canyon at TA-22	Pajarito Canyon at TA-22
E2417	Pajarito	Starmer's Gulch above SR 501	Starmer's Gulch above SR 501
E242	Pajarito	Starmer's Gulch at TA-22	Starmer's Gulch at TA-22
E250	Pajarito	Pajarito Canyon above SR 4	Pajarito Canyon above SR 4 near White Rock, NM
E252	Water	Water Canyon above SR 501	Water Canyon above SR 501 near Los Alamos, NM
E253	Cañon de Valle	Cañon de Valle above SR 501	Cañon de Valle above SR 501 near Los Alamos, NM
E263	Water	Water Canyon above SR 4	Water Canyon at SR 4
E265	Water	Water Canyon below SR 4	Water Canyon below SR 4 near White Rock, NM
E267	Potrillo	Potrillo Canyon above SR 4	Potrillo Canyon near White Rock, NM
E273	Ancho	Ancho Canyon above SR 4	Ancho Canyon at TA-39
E275	Ancho	Ancho Canyon below SR 4	Ancho Canyon near Bandelier National Park, NM
E247	Pajarito	TA-54 MDA-G (Formerly G-1)	G-1
E248	Pajarito	TA-54 MDA-G (Formerly G-2)	G-2
E248.5	Pajarito	TA-54 MDA-G (Formerly G-3)	G-3
E249.5	Pajarito	TA-54 MDA-G (Formerly G-4)	G-4
E227	Pajarito	TA-54 MDA-G (Formerly G-6)	G-6
EULR	Los Alamos	Los Alamos Canyon above reservoir	Upper Los Alamos Reservoir
ELAR	Los Alamos	Los Alamos Reservoir Discharge	Los Alamos Reservoir
ELAW	Los Alamos	Los Alamos Canyon at Retention Pond above SR 4	Los Alamos Weir
EGS4	Guaje	Guaje Canyon at SR 502	Guaje at SR 502
EPRP	Pajarito	Pajarito Canyon at Retention Pond	Pajarito Retention Pond
E2436	Pajarito	Twomile Canyon above SR 501	Twomile at SR 501
E18C	Pajarito	Pajarito Canyon at TA-18 Culvert	TA-18 Culvert
EPG1	Pajarito	Pajarito Canyon at G-1 Pump Station	Flood Water Over Bank Pajarito at G-1
ER3X	Rendija	Rendija Canyon at 3rd Crossing	Rendija 3rd Crossing
ES4C	Pajarito	Pajarito Canyon at SR 4 Culvert	Pajarito SR 4 Culvert

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