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Quality of Storm Water Runoff at Los Alamos National Laboratory in 2000 with Emphasis on the Impacts of the Cerro Grande Fire

Los Alamos NATIONAL LABORATORY

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ABSTRACT

In May 2000, the Cerro Grande Fire burned about 7400 acres of mixed conifer forest on the Los Alamos National Laboratory (LANL), and much of the 10,000 acres of hillslopes draining onto LANL was severely burned. The resulting burned landscapes raised concerns of increased storm water runoff and transport of contaminants by runoff in the canyons traversing LANL. The first storms after the fire produced runoff peaks that were up to 200 times greater than prefire levels. Total runoff volume for the year 2000 increased 50%, despite a decline in total precipitation of 13% below normal and a general decrease in the number of monsoonal thunderstorms.

To evaluate the possible water quality impact to water bodies downstream of LANL, runoff events were monitored and sampled throughout the summer runoff season at over 40 sites on and around LANL. Samples collected from the runoff were analyzed for radionuclide, metal, inorganic, and organic constituents. The runoff water quality data are evaluated by comparing with historical levels and relevant standards and, where possible, by examination of spatial and temporal trends. These comparisons indicate whether the results in 2000 after the Cerro Grande Fire vary significantly from previous years and provide some environmental health context to the individual results. Two companion studies use these runoff results to quantify potential health risks associated with the storm water (IFRAT 2001; Kraig et al. in preparation).

Runoff quality was highly variable, a function of streamflow and proximity to the burned areas and LANL legacy sources. Consistent with runoff associated with other forest fires around the world, the first pulses of runoff after the fire contained ash and newly eroded soil that were enriched in radionuclides from past atmospheric fallout, metals, minerals, and nutrients. These fire-related constituents were carried downstream in runoff and were mostly deposited on LANL lands. LANL-derived constituents are evident in runoff collected near major sources. The LANL impacts to runoff, however, were often masked after mixing in stream channels with the fire-related constituents.

Concentrations of most fire-related constituents declined through the runoff season partly due to flushing of the ash from the upstream hillslopes and stream channels. Sample results indicate that most (commonly 95% or more) of the radionuclides and metals were bound to suspended sediments in the runoff and were not dissolved in the water. Median concentrations of radionuclides in runoff collected at LANL's upstream boundary increased by 10 to 50 times from prefire levels, showing an accelerated movement of fallout radionuclides and metals that had accumulated in vegetation and soil and was present in the ash from the burned hillslopes. In contrast, median concentrations of radionuclides in runoff collected from the downstream LANL boundary were approximately the same as previous years. Larger magnitude stream flows resulted in an increase in the total quantity of radionuclides and metals that were carried downstream from LANL. The total activity of cesium-137, strontium-90, and uranium transported across the downstream boundary increased by about 10 times, primarily the result of increased runoff from burned areas.

1.0 Summary of Findings

In May 2000 the Cerro Grande Fire burned about 43,000 acres of mixed conifer forest near Los Alamos, NM. The fire burned about 7400 acres on the Los Alamos National Laboratory (LANL). In addition to the burning that occurred on LANL, about 10,000 acres of watersheds draining onto LANL from adjacent United States Forest Service (Santa Fe National Forest) lands burned. In these Forest Service watersheds above the Laboratory, from 20% to 80% of the acreage was considered “high-severity burn.” After the Cerro Grande Fire, a large amount of residual ash was left in burned areas. The source of much of the material carried in storm water runoff during the 2000 runoff season was from ash and debris left by the Cerro Grande Fire. Radionuclide and metals concentrations in ash increased by up to an order of magnitude relative to prefire sediment and soil concentrations. The ash is composed of the concentration remains of burned vegetation and forest litter, and non-flammable constituents like minerals, metals, and radioactive elements accumulated in the forest through decades of fallout. Within a few miles of LANL, the forest also may have contained some plutonium-239,240 accumulated from past Laboratory air emissions.

Because of its short-lived nature, storm water runoff is not a source of municipal, industrial, or irrigation water, though wildlife and livestock may use the runoff. Storm water runoff is important to monitor, however, because it is one of the principal agents for moving fire- and Laboratory-derived constituents offsite and possibly into the Rio Grande.

This report describes the water quality of storm water runoff samples collected through the summer runoff season of June through October 2000, illustrates the results of the analyses of the storm water runoff sampling, and provides an evaluation of the effect of the fire on storm water runoff in 2000. For important water quality constituents, the results of the storm water runoff sampling in 2000 are evaluated spatially and temporally and are compared with historical results and appropriate water quality standards. We considered standards developed for protection of livestock watering, wildlife habitat, public exposure, and groundwater—because the runoff may affect underlying shallow groundwater. Dissolved constituents of health concern, but not included in the above list of standards, were compared to the Environmental Protection Agency (EPA) and the Department of Energy (DOE) primary drinking water standards. The drinking water standards are included only for added perspective, as the standards are applicable only to community drinking water systems and not to runoff.

Interpreting storm water quality data from semi-arid environments presents inherent problems. The possible permutations of flow and water quality often require large data sets to be collected before rigorous statistical analyses may be performed. Thus, some of our findings in this report are broad and preliminary.

1.1 Runoff

One of the most pronounced environmental effects resulting from forest fires is increased runoff from precipitation events. The maximum runoff yield before the fire from Cañon de Valle and Pajarito and Water Canyons west of the Laboratory (along State Road [SR] 501) was 1.26 cfs/mi^2. The discharge yield on June 28 for these same locations ranged from 250 to 540 cfs/mi^2, increasing more than 200 times from prefire peaks. Before the fire, the upstream average flow was about 220 ac-ft per year, and the prefire downstream average flow was about 120 ac-ft per year. In year 2000 after the fire, the total flow upstream of the Laboratory was 325 ac-ft, about 1.5 times higher than the prefire average, and the total downstream flow was 176 ac-ft, also about 1.5 times the prefire average. The increased volume of flow (50% increase) in 2000 is attributed to increased runoff after the Cerro Grande Fire, as total precipitation for the year was 13% below normal.

In 2000, storm water runoff samples were collected at 40 stream sites at LANL and at two locations near LANL, including Rendija Canyon and Guaje Canyon. Including both unfiltered samples and filtered samples, a total of 299 storm water runoff samples were collected in 2000, of which 122 samples were analyzed for radionuclides, 289 samples were analyzed for general inorganic constituents, and 143 samples were analyzed for trace metals. Additionally, some samples were analyzed for high explosives (HE) compounds, pesticides and polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). A total of 18,800 data results were obtained from the analyses of the samples.

1.2 General Water Quality (Common Minerals, Nutrients, and Cyanide)

Consistent with most other forest fires around the world, the first pulses of runoff after the fire were enriched in minerals and nutrients concentrated in the ash and eroded from the newly-exposed and hydrophobic surface soils. Of particular concern was the detection of significant levels of fire-associated cyanide in the early runoff events. Cyanide, if present in certain chemical forms (free or amenable cyanide) can be toxic to aquatic biota and wildlife. Detailed testing of the cyanide, however, indicated the vast preponderance of the cyanide was of less toxic forms. No fish kills in the Los Alamos area or in the Rio Grande have been reported. Elevated levels of these constituents were found in runoff several months after the fire.

The general water quality constituents that were measured in concentrations substantially higher in 2000 than historical maximum concentrations include calcium, cyanide, potassium, and phosphate. Amenable cyanide was found in concentrations greater than the New Mexico wildlife habitat standard in three samples from Water Canyon.

The large runoff events often drained the heavily burned areas and carried large quantities of sediment and black ash. In a filled storm water sample container, for example, 25% or more of the volume can be sediment. The maximum total suspended solids (TSS) concentration in 2000 runoff (76,000 mg/L) was 77% larger than the prefire maximum. The total mass of suspended solids measured at all upstream stations was about 2700 metric tons (MT), and the total mass of suspended sediment measured at all downstream stations was about 1200 MT. The TSS data indicate that about 1500 MT of suspended sediment, which included ash and muck and fine sediment material, were deposited in channels and floodplains at LANL during the 2000 runoff season.

1.3 Radionuclides

This report focuses on the long-lived radionuclides most commonly associated with Laboratory operations: americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, uranium, and tritium.

The initial runoff events that drained the Jemez Mountains carried radionuclides derived from worldwide fallout and perhaps from past Laboratory air emissions. They were attached to suspended sediment and ash. As the flows traversed LANL, some of the material settled out in depositional areas and some was transported beyond the Laboratory's eastern boundary. The net effect was to slightly increase the overall inventory of radionuclides in some of the LANL canyons and in Rio Grande sediments. In drainages with a significant legacy of LANL-derived radionuclides, particularly Pueblo and Los Alamos Canyons, it is difficult to separately distinguish Cerro Grande Fire-derived radionuclides from LANL-derived. Regardless, all but one of the measurements for specific radionuclides were below comparison standards.

- Concentrations of most of the target radionuclides in storm water runoff in 2000 after the Cerro Grande Fire were greater than Laboratory-wide prefire levels. The most pronounced differences were seen in samples collected immediately upstream of the Laboratory and reflect fire effects. Median concentrations of plutonium-239,240 at the upstream stations increased by 50 times over prefire levels, while the other fallout radionuclides increased 5 to 15 times. These runoff data support the possibility that a significant fraction (about two-thirds) of the plutonium-239,240 in Cerro Grande Fire ash is from past Laboratory air emissions.

- The increases in most of the radionuclide concentrations are attributable to two main factors: increased ash and sediment load in runoff and the enhanced constituent concentrations in the ash. The peak concentrations of americium-241, plutonium-238, and tritium were from locations impacted by LANL operations (DP Canyon and Material Disposal Area [MDA] G). Radionuclide concentrations were significantly lower in filtered samples than in unfiltered samples. About 75% to 95% of the radioactivity in a runoff sample was typically associated with particles (ash, silt, clay, etc.) carried by the runoff rather than dissolved in the water.

- Despite the increases from prefire levels, none of the target radionuclides in unfiltered runoff exceeded DOE Derived Concentration Guidelines (DCGs) for public exposure. Gross alpha concentrations exceeded the State of New Mexico Livestock Watering Standard (15 pCi/L) in about one-half of the runoff samples—the significance is not clear, however, because many of these exceedances were from samples collected upstream of the Laboratory, indicating natural sources.

- All filtered storm water runoff samples met EPA and DOE drinking water standards for specific radionuclides and gross alpha, except for one sample. The EPA standard for strontium-90 (8 pCi/L) was exceeded in one sample collected on July 21 from the Los Alamos Canyon weir construction site, where the concentration of strontium-90 was 26.6 pCi/L. The source of the dissolved strontium; 90 in this sample could be fire-related or from historical Laboratory releases.

- Along the Laboratory's downstream boundary, monthly flow-weighted average radionuclide concentrations in unfiltered runoff show that peak concentrations occurred in June and July, with 5- to 20-fold increases above prefire averages during these months for cesium-137, strontium-90, and uranium. Concentrations of these same constituents dropped considerably during August, September, and October. The decline in runoff concentrations is partly due to flushing of ash from the LANL drainages during July and August and the occurrence of less intense, late season rainfall events in August, September, and early October that largely missed the mountains west of the Laboratory.

- The radionuclides that show increased total activity passing downstream locations in 2000 are cesium-137, plutonium-239,240, strontium-90, and uranium. The activity in runoff that passed downstream stations at LANL in 2000 was 2.3 mCi of cesium-137, 0.6 mCi of plutonium-239,240, and 2.3 mCi of strontium-90. The mass of uranium that passed downstream was approximately 3 kg. Most of the uranium (89%) and strontium-90 (68%), about half of the cesium-137 (47%), and a portion of plutonium-239,240 (13%) is attributable to natural background concentrations in canyon sediments. The portion of the activity of radionuclides not attributable to background concentrations in suspended sediment is largely attributable to the effects of the Cerro Grande Fire for cesium-137, plutonium; 239,240, and strontium-90. This is due to the increased flows after the fire and radioactivity in the ash and sediment.

- During relatively low magnitude runoff events, we see clear LANL impacts near historical release areas (DP Canyon, Los Alamos Canyon) and active operating sites (MDA-G). However, those sources are masked or substantially diluted during the large flow events that are dominated by Cerro Grande Fire sources.

1.4 Metals

Of 23 metals, 19 had higher flow-weighted average unfiltered concentrations in 2000 than previous years along the Laboratory's downstream boundary. Silver appears to be the only metal that is predominantly LANL-derived. It is most often detected in the southern canyons of the Laboratory, particularly Water Canyon.

Metals in unfiltered runoff that were greater than minimum standards include mercury (4% of samples) and selenium (27%). Natural sources of these metals are evident, but it is unclear if LANL sources also are present. Dissolved metals concentrations above minimum standard values were aluminum, iron, manganese, and antimony. All of these dissolved metals are attributable to natural sources.

Metals with concentrations in the suspended sediment fraction of the runoff that were greater than screening levels include iron, manganese, and thallium. Of these, manganese and iron were most often encountered in concentrations above the screening levels. The majority of the runoff samples, however, contain metals concentrations that meet the screening levels.

1.5 Organics

The bio-accumulator compounds, PCBs and dioxins/furans, were not found in runoff above analytical detection limits. HE compounds detected include HMX, RDX, Tetryl, and several isomers of nitrobenzene and nitrotoluene. Except for HMX and RDX, these compounds were detected only in the large runoff event of June 28. When performing the analyses on the samples collected on June 28, however, the commercial analytical laboratory noted substantial matrix interferences because of the high ash content in these samples, and these values are suspect. Most of these HE compounds were detected in samples collected upstream or in canyons north of the Laboratory. Trace (sub-part per billion) levels of HMX and RDX also were detected in a runoff sample collected in lower Water Canyon at SR 4 (gage E265) in late October.

Detections of SVOCs included five organic compounds, including benzoic acid, benzyl alcohol, and pyridine, which are thought to be products of combustion of forest fuels. Benzoic acid was detected throughout the runoff season in many fire-impacted drainages, and pyridine was detected in Guaje Canyon, north of the Laboratory. The one VOC detected in runoff in 2000 was 1,4-Dichlorobenzene. The three detections of this compound were at levels very near the analytical detection limit, and samples were collected from locations upstream of the Laboratory. Detections of all of organic chemicals except one were at concentrations below the EPA Region 6 screening values for tap water (EPA 2001). One runoff sample from Technical Area (TA) 54 MDA-G station G-4 contained bis(2-ethylhexyl)phthalate at a concentration approximately three times larger than the EPA screening level.

1.6 Summary of Fire and LANL Impacts

In summary, the primary effects of the Cerro Grande Fire with respect to storm water runoff are observed as higher runoff yields and higher runoff rates and volumes for what otherwise would have been relatively insignificant precipitation and runoff events. A consequence of higher runoff rates and volumes was the transport of higher suspended sediment loads. These sediment loads from the fire-impacted areas (mainly ash) carried higher concentrations of calcium, cyanide (total and amenable), potassium, ammonia, phosphate, barium, iron, manganese, cesium-137, plutonium-239,240, and strontium-90. The concentrations of calcium, barium, iron, ammonia, and strontium-90 in runoff declined through the runoff season.

Laboratory impacts to runoff observed at onsite and downstream locations in specific canyons include increased concentrations in silver, tritium, americium-241, plutonium-238, plutonium-239,240, strontium; 90, and HE compounds. Additionally, there is evidence that a substantial portion of the plutonium-239,240 in the Cerro Grande Fire ash may be from historic air stack emissions at the Laboratory.

Regardless of source(s), the vast majority of the results were below health-based standards or guidelines.

1.7 Background Information

In May 2000 the Cerro Grande Fire burned about 43,000 acres of mixed conifer forest near Los Alamos, NM. The fire burned about 7400 acres on LANL, about 6% of which was considered high-severity burn (BAER 2000). In addition to the burning that occurred on LANL, about 10,000 acres of watersheds draining onto LANL from adjacent United States Forest Service (Santa Fe National Forest) lands burned. In these Forest Service watersheds above the Laboratory, from 20% to 80% of the acreage was considered high-severity burn. Table 1-1 lists the percentages of the upper watershed areas that were affected by the fire, and Figure 1-1 shows the areas of burn severity of the Cerro Grande Fire. On LANL, most of the area burned was considered low-severity burn, but numerous small structures burned and some inactive waste sites had cover vegetation that was at least partially burned.

Table 1-1. Impact of Cerro Grande Fire to the Upper Watershed Areas.

Canyon	Percentage of Watershed Affected by Fire		Burn Severity (%)		
	Burned	Unburned	Low	Medium	High
Guaje	71	29	22	26	22
Rendija	100	0	2	10	88
Pueblo	100	0	2	1	96
Los Alamos	75	25	43	0.5	32
Pajarito	100	0	44	3	53
Water	94	6	49	5	40

Source: BAER 2000, p. 280

The increases in runoff and sediment yields after the fire were anticipated to be severe due to the steepness of the burned terrain and high severity of the burn, creating water-shedding hydrophobic soils. Peak flows from the upper watersheds after the fire were predicted by the Burned Area Emergency Rehabilitation Team (BAER 2000) to be hundreds of times greater than prefire conditions, even with aggressive postfire rehabilitation treatments. Table 1-2 shows the predicted peak flows in the upper watersheds of each canyon after a 25-yr, 1-hr storm event before the fire and after the fire.

Table 1-2. Predicted Peak Flow (cfs) from Upper Watersheds.

	Prefire	Postfire	Postfire Treated
Guaje	7	437	NA
Rendija	1	2398	1740
Pueblo	9	1278	983
Los Alamos	24	281	238
Pajarito	1	460	NA
Water	4	504	NA

Source: BAER 2000; data shown for 25-yr, 1-hr storm event of 1.9-in. precipitation

This report describes the water quality of storm water runoff samples collected through the summer runoff season of June through October 2000, illustrates the results of the analyses of the storm water runoff sampling, and provides an evaluation of the effect of the fire on storm water runoff in 2000. For important water quality constituents, the results of the storm water runoff sampling in 2000 are evaluated spatially and temporally and are compared with historical results and appropriate water quality standards for storm water runoff. Significant precipitation events and storm water runoff events that occurred at LANL in 2000 after the Cerro Grande Fire are described in a separate report by Koch et al. (2001) and are summarized in this report. When compared to prefire conditions, significant changes were observed in the magnitude of runoff, sediment yield, and water quality.

1.8 General Impacts of Fire on Watersheds

Many of the fire impacts observed to date also have been recorded in studies of fires elsewhere, as well as locally with earlier crown fires in the Los Alamos area. Watersheds undergo significant responses to wildfire in southwest ecosystems. The responses include changes in the runoff characteristics, sediment yield, and water chemistry. The burning of the understory and forest litter triggers many of these changes. Under prefire conditions, the grasses and brush within a forest canopy serve to slow and capture precipitation, nutrients, and sediments. In the absence of the vegetative cover, the runoff becomes flashier, with sharper, higher magnitude flood peaks. For example, after the 1977 La Mesa Fire and the 1996 Dome Fire in the Jemez Mountains, peak flows in Frijoles and Capulin Canyons were estimated

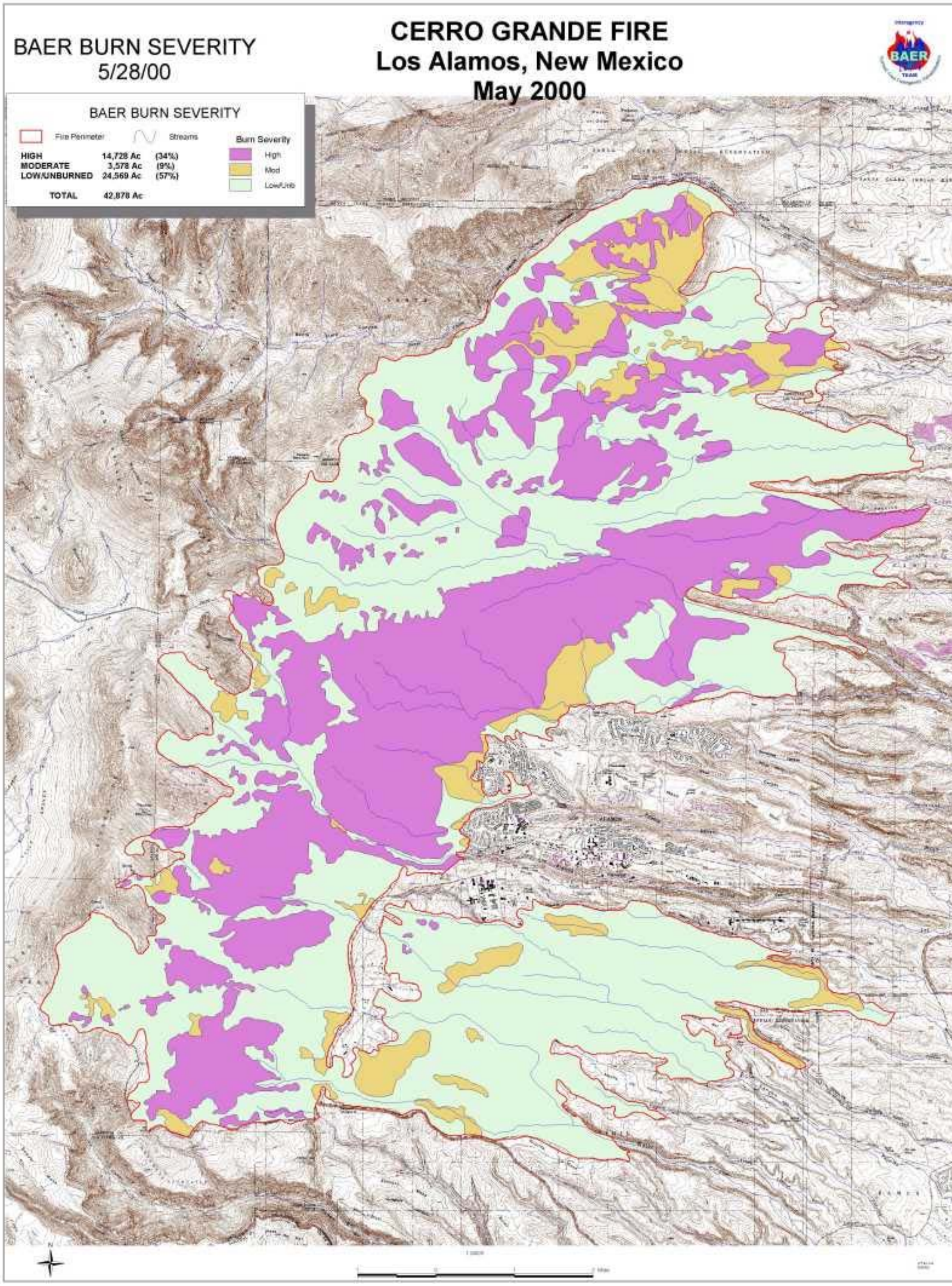


Figure 1-1. Cerro Grande Fire burned area.

to be 164 and 123 times greater than the pre-burn peaks, respectively (Veenhuis 2001). With less vegetative uptake and retention, the total water yields from burned watersheds are higher. Once the runoff begins, loose soils and ash are quickly removed from the steeper hill slopes. Fire-associated debris can suddenly be delivered directly to streams in large quantities.

Wildfires can also interrupt uptake of anions and cations by vegetation and speed mineral weathering. The concentrations of inorganic ions increase in streams after a fire (DeBano et al. 1979). The sudden addition of substantial quantities of carbon and minerals (like calcite) to the watershed initiates geochemical and pH changes.

After the La Mesa Fire in 1977, an investigation of water quality perturbations in the base flow of Rito de los Frijoles showed a slight increase in calcium, bicarbonate, chloride, fluoride, and total dissolved solids (TDS). Runoff samples showed elevated suspended sediment, barium, calcium, iron, bicarbonate, manganese, lead, phenol, and zinc concentrations (Purtymun and Adams 1980). Base-flow water quality returned to normal three to five years after the fire. To understand the chemical water quality changes noted in runoff water after the Cerro Grande Fire, a summary of the reported effects of fire on runoff water chemistry and soils was compiled by Bitner et al. (2001). For general inorganic parameters, increases in dissolved calcium, magnesium, nitrogen, phosphorous, and potassium and pH has been observed in runoff after forest fires. Metals and radionuclides have been much less studied, but manganese, copper, zinc, and cesium-137 have been observed to increase in runoff after a forest fire.

Of note are studies that describe the concentration of fallout-associated radionuclides in ash, and subsequently, in runoff at other locations where forest fires have occurred (Amiro et al. 1996, Paliouris et al. 1995). The studies conclude that fire caused the mobilization of fallout radionuclides bound to the forest canopy, or in the forest litter, and concentrated them in the ashy layer of the burned surface soil available for erosion.

Except for the destruction of the physical habitat of the streambed and hillsides by floods, the results of previous studies indicate that these changes in chemistry and flow conditions are temporary, usually less than five years. Re-establishment of vegetative ground cover appears to be a critical factor controlling the recovery. Recovery in the hills above Los Alamos may take longer than at other fires, because of the steepness of the slopes and severity of burn.

1.9 Cerro Grande Fire Ash and Muck and Relationship to Sediment and Soil

After the Cerro Grande Fire, a large amount of residual ash was left in burned areas. The source of much of the material carried in storm water runoff during the 2000 runoff season was from ash and debris left by the Cerro Grande Fire. Ash and muck (postfire sediments dominated by reworked ash) were sampled in locations representative of background conditions west (upstream) of the Laboratory (LANL 2000a). Ash samples were also collected in the Viveash Fire area (near Pecos, NM) for comparison with ash samples from the Cerro Grande Fire (Hopkins 2001; Katzman et al. 2001). The results of the sampling document the presence of elevated cesium-137, plutonium-239,240, and strontium-90 concentrations in Cerro Grande Fire ash samples compared to prefire sediment and soils concentrations. An increase in the concentrations of several naturally occurring metals (for example, barium, manganese, and calcium) readily taken up into plant tissue was also observed.

Some radionuclide and metals concentrations in ash increased by up to an order of magnitude relative to prefire sediment and soil. The mean concentration of cesium-137 in seven ash and muck samples collected after the fire in 2000 was 4.4 pCi/g, about five times the upper limit of the prefire background value (BV) for sediments and soils. The mean concentration of strontium-90 in the ash and muck samples was 2.08 pCi/g, about two times the prefire sediment BV; the mean concentration of plutonium-239,240 was 0.37 pCi/g, about five times the sediment BV (LANL 2000b; Katzman et al. 2001). These results are consistent with the scientific literature, which shows forest fires can condense and mobilize natural radionuclides, fallout radionuclides, and metals (Bitner et al. 2001).

Based on a limited data set, ash from the Cerro Grande Fire appears to contain relatively higher plutonium-239,240 concentrations than the ash from the Viveash Fire (Katzman et al. 2001). There is evidence that LANL has contributed somewhat to the existing levels of plutonium-239 and other radionuclides in areas within a few miles of LANL (Fresquez et al. 1998).

2.0 Related Health Assessments

In various sections of this report we compare measured runoff water quality results against a variety of regulatory standards developed to protect human health, wildlife, and livestock for a few generic common water uses. This allows us to quickly test if individual chemicals or radionuclides are present at excessive concentrations. This analysis does not, however, account for the cumulative risk posed by the combination of multiple chemicals or radionuclides, nor does it account for site-specific land uses.

As a complement to this study, several in-depth risk analyses are ongoing to evaluate the cumulative short-term and long-term risks posed by these agents. The most comprehensive risk analysis available to date is from the Interagency Flood Risk Assessment Team (IFRAT) (IFRAT 2001), a consortium of risk scientists from seven state and federal agencies. The IFRAT's study included development of a long-term (30-year) risk assessment that compared ash, ash-containing sediment, and water samples in and around the Pajarito Plateau and LANL before and after the fire. Based on 2000 results, their study shows that common activities, such as swimming or those that result in direct skin contact with ash-containing sediments or water, pose no substantial increased health risk over that posed by the same activities in non-ash containing sediment or water. These findings will be updated after the 2001 runoff season results are available.

A Laboratory risk assessment team is evaluating the short-term (1-year) risks to humans from exposure to post-Cerro Grande Fire runoff and sediments (Kraig et al. 2001).

A separate independent risk assessment is being funded by the New Mexico Environment Department (NMED) and will be available in spring 2002.

3.0 Storm Water Runoff and Sampling Activities in 2000 after the Cerro Grande Fire

The Laboratory monitors runoff (storm water) from Pajarito Plateau stations to evaluate the environmental effects of its operations and to demonstrate compliance with permit requirements. Compliance status is discussed in Chapter 2 of the annual Environmental Surveillance Reports (e.g., LANL 2001). Periodic natural surface runoff occurs in two modes: (1) spring snowmelt runoff that occurs over days to weeks at a low discharge rate and sediment load and (2) summer storm water runoff from thunderstorms that occur over hours at a high discharge rate and sediment load. After drought conditions in early 2000, spring snowmelt runoff was essentially nonexistent, which contributed to the environmental conditions leading up the Cerro Grande Fire. This section discusses the impacts of the summer storm water runoff. Because of the short-lived nature, storm water runoff is not a source of municipal, industrial, or irrigation water, though wildlife and livestock may use the runoff. Storm water runoff is important to monitor, however, because it is one of the principal agents for moving fire- and Laboratory-derived constituents offsite and possibly into the Rio Grande.

3.1 Runoff Monitoring Network

Storm water runoff samples have historically been collected as manual grab samples from usually dry portions of drainages during or shortly after storm water events. Since 1996, storm water runoff samples have been collected using stream-gaging stations, most with automated samplers (e.g., Shaull et al. 2001). Samples are collected when a significant rainfall event causes flow in a monitored portion of a drainage. Many storm water stations are located where drainages cross the Laboratory's boundaries. For the larger drainages, storm water flows are sampled at or near the downstream Laboratory boundary and at locations upstream of the Laboratory. In contrast, storm water runoff from several mesa top sites (for example, MDA-G, MDA-L, TA-55) is sampled at locations that target specific industrial activities, with negligible run-on from other sources. Some runoff events are sampled manually (grab samples) to supplement the automated samplers. Runoff samples from the gaging stations are used to monitor water quality effects of potential contaminants sources such as industrial outfalls or soil contamination sites.

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 many of the stream gages were equipped with automated runoff samplers. By the year 2000, the sampling network comprised 60 sampling stations. Figure 3-1 shows the locations of the storm water sampling stations on the Pajarito Plateau in 2000. Figure 3-2 shows the locations of the manual runoff collection sites.

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 2000b). To document impacts of the Cerro Grande Fire, the Water Quality and Hydrology Group (ESH-18) attempted to sample every runoff event during the runoff season. Unfortunately, most samplers located along the Laboratory's western boundary (background stations) were destroyed by the June 28 runoff event. Based on precipitation records, we estimate that four probable light-to-moderate runoff events along the western boundary were not sampled after the destruction of stations in Cañon de Valle and Pajarito and Water Canyons. We collected over 100 runoff samples from June through October. The majority of these samples were from onsite locations.

The analytical results from storm water runoff samples collected from automated samplers and from manually collected storm water runoff samples provide the data for this report. Procedures used for manually collected samples followed recommended operating procedures outlined by the EPA in the "NPDES Storm Water Sampling Guidance Document, EPA 833-B-92-001" (EPA 1992). Other storm water runoff samples at LANL were collected in 2000 by the NMED DOE Oversight Bureau and by the LANL Environmental Restoration (ER) Project.

Sampling intake tubes are positioned approximately 6 inches above the streambed. The ISCO™ automated samplers (ISCO™ Series #3700 Portable Samplers) are programmed to collect 24 liters of storm water, if adequate volumes are available during the runoff event. The samples are processed by sampling personnel and some samples are filtered to determine dissolved concentrations of analytes and appropriately preserved with acids or bases to stabilize the constituents before analyses. The samples are sent to contract laboratories for the analyses of radionuclides, metals, general water quality parameters, and other constituents.

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

1)< upstream of Laboratory property as storm water moves onto Laboratory property from the Sierra de los Valles to 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.

Additionally, runoff samples are occasionally collected manually at specific locations where stream gages and automatic samplers are not located. These samples are designated as manual, or grab, runoff samples. Manual storm water runoff samples were collected at sites north of the Laboratory in Rendija Canyon and Guaje Canyon, downstream of sites that were formerly used by the Laboratory.

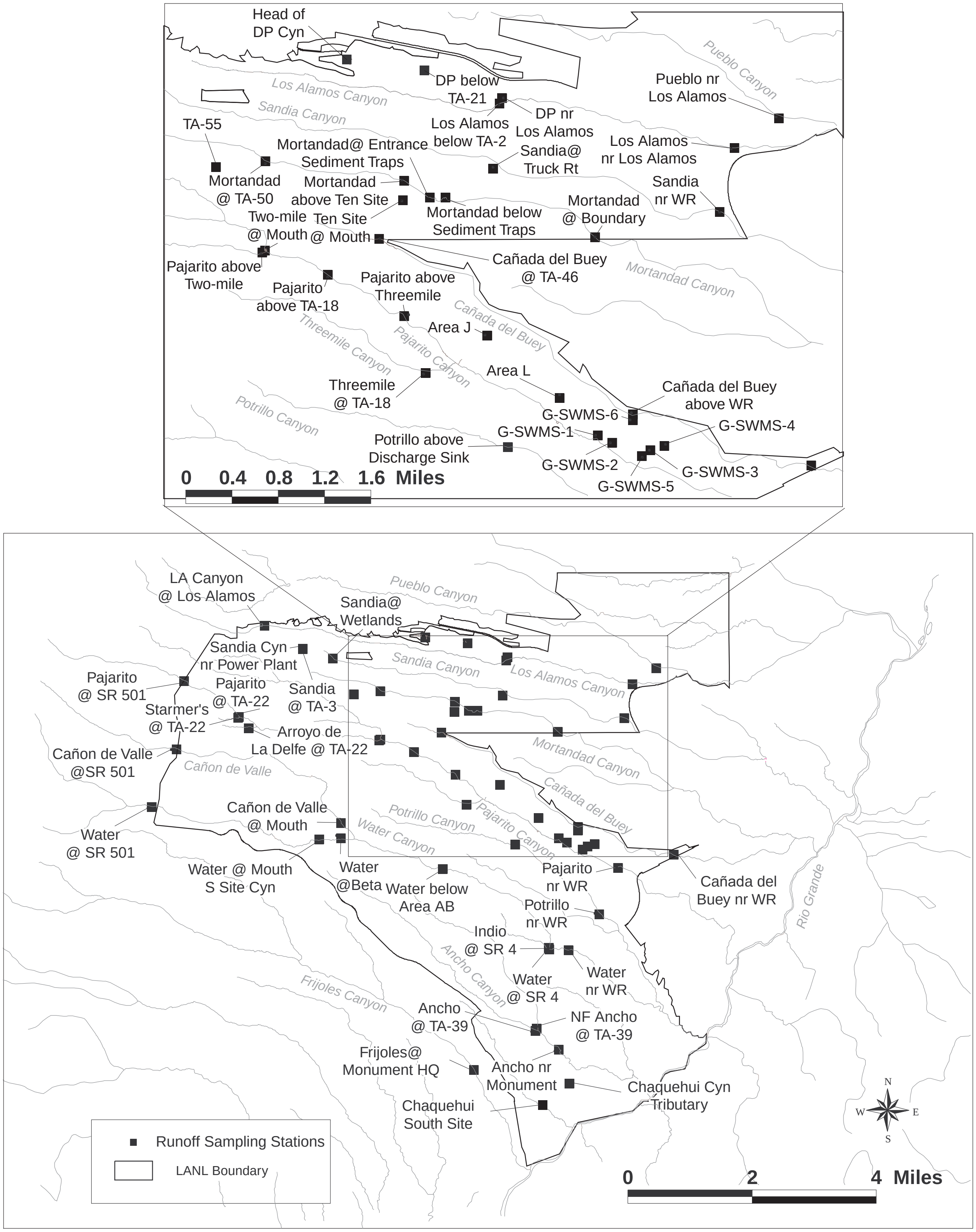


Figure 3-1. Storm water sampling stations on the Pajarito Plateau.

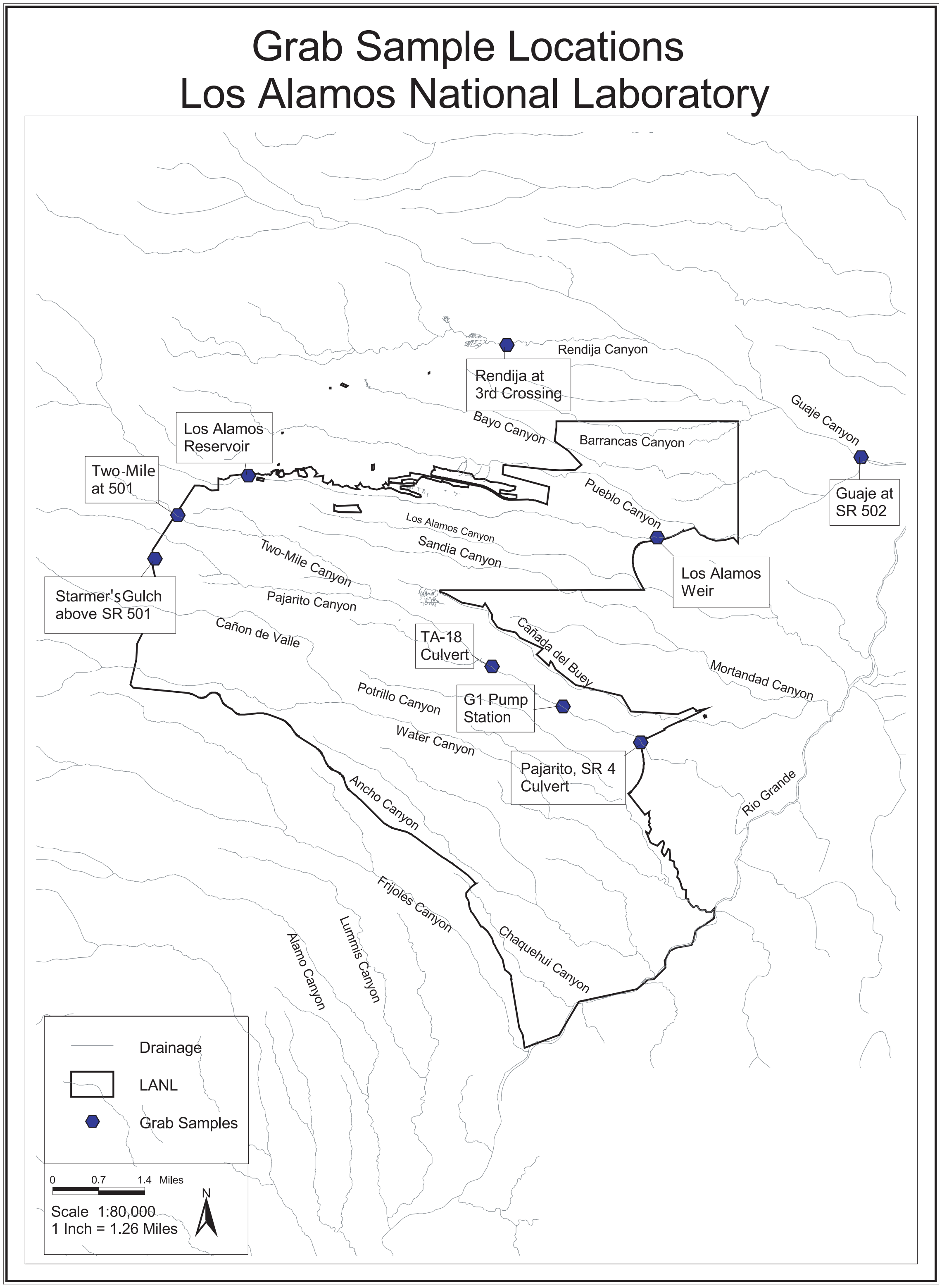


Figure 3-2. Manual runoff collection sites.

3.2 Summary of Runoff in 2000

Runoff flow data at Los Alamos for water year 2000 are reported in the Laboratory's annual surface water report (Shaull et al. 2001) and a description of precipitation and runoff events in 2000 was provided by Koch et al. (2001). Figure 3-3 shows the annual precipitation at TA-6 and the summary of the results of monitoring storm water runoff at upstream and downstream stations for the period from 1994 through 2000. Upstream stations are located in Los Alamos Canyon (gage E025), Pajarito Canyon (E240), Cañon de Valle (E253), and Water Canyon (E252). Downstream stations include Los Alamos Canyon (E042), Sandia Canyon (E125), Cañada del Buey (E230), Pajarito Canyon (E250), Potrillo Canyon (E267), Water Canyon (E265), and Ancho Canyon (E275). Flow data from lower Pueblo Canyon at gage E060 are not shown on Figure 3-3 because no upstream data are available for Pueblo Canyon, and the Los Alamos County sewage treatment plant discharges to lower Pueblo Canyon above gage E060, therefore, most flow at this gage is unrelated to runoff.

Los Alamos Canyon, Pajarito Canyon, and Water Canyon have spring-fed reaches that extend onto the Laboratory where the flow is measured at the upstream gages. Assuming the spring-fed flows are similar from year to year, the annual differences seen in the upstream flows (Figure 3-3) are likely the result of differences in annual runoff volumes. Some years have upstream flows higher than downstream flows, and some years have downstream flows higher, which may be the result of differences in the location of precipitation events from year to year.

The prefire upstream average flow for the period of record is about 220 ac-ft per year, and the prefire downstream average flow is about 120 ac-ft per year. The higher upstream flow reflects the contribution from spring-fed streams that don't extend across the Laboratory to the downstream stations, which primarily record snowmelt and storm water runoff. In year 2000 the total upstream flow at gage E025 in Los Alamos Canyon was 137 ac-ft; estimated flow at other upstream sites when runoff samples were collected was 194 ac-ft, for an estimated total upstream flow of 331 ac-ft, which is about 1.5 times higher than the prefire average. This estimate of flow at upstream sites in 2000 may be low due to the loss of most upstream gages in the June 28 flood event. The total downstream flow in 2000 was 176 ac-ft, also about 1.5 times the prefire average. The increased volume of flow in 2000 is primarily attributed to increased runoff after the Cerro Grande Fire, despite lower precipitation in 2000.

Figure 3-4. shows the hydrographs for each downstream gage at LANL for the 2000 runoff season. Arrows on the figures indicate the flow events that were sampled at each of the gages

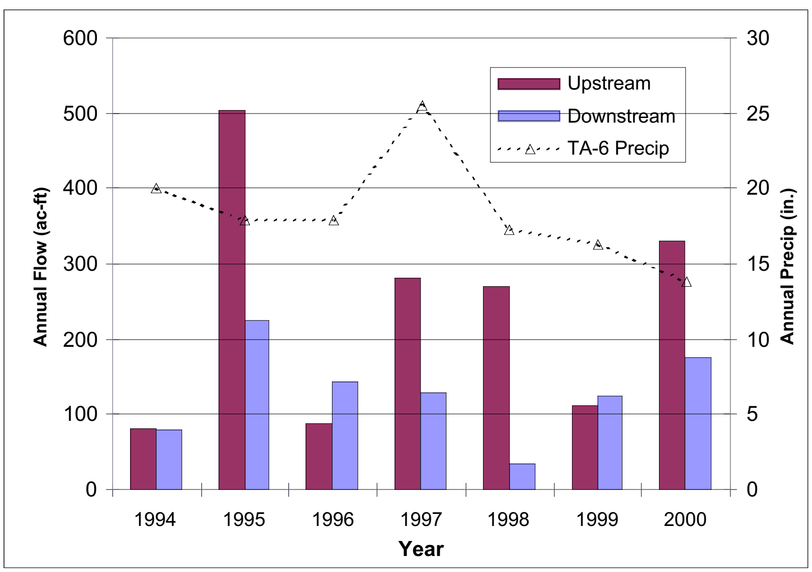
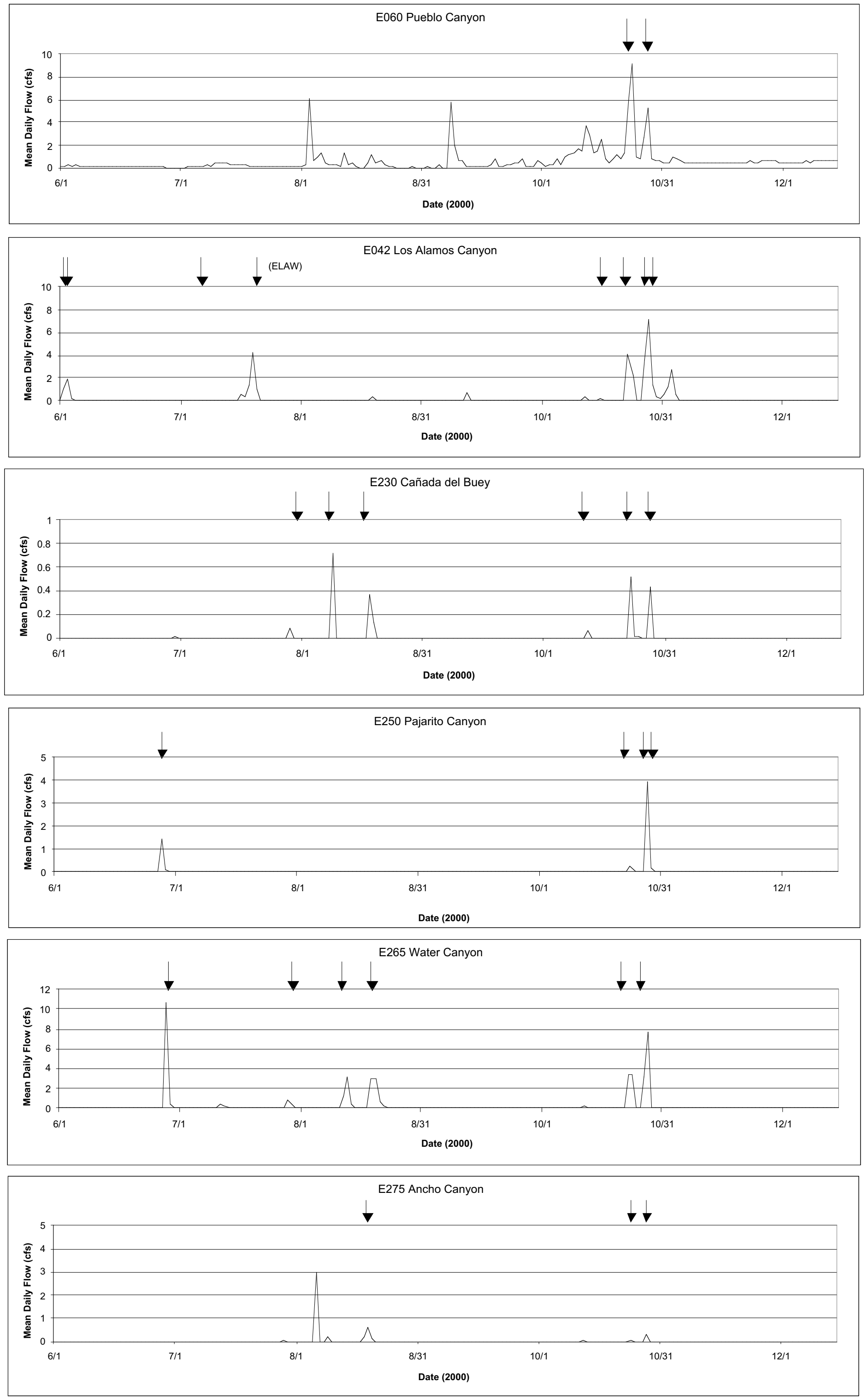


Figure 3-3. Total annual flow at upstream and downstream gaging stations at LANL.



Note scale changes on each chart. Arrows indicate flow events that were sampled at each gaging station.

Figure 3-4. Hydrographs showing mean daily flow (cfs) and samples collected at downstream gages at LANL in 2000.

Gage E060 in Pueblo Canyon was not sampled until near the end of October while gages E042 in Los Alamos Canyon, E230 in Cañada del Buey, E250 in Pajarito Canyon, and E265 in Water Canyon were sampled during each major flow event throughout the runoff season. Several flow events in Ancho Canyon (gage E275) and Potrillo Canyon (gage E267) were not sampled.

Figure 3-5 shows the summary of available data for upstream and downstream runoff in acre-ft for the significant runoff events that were sampled in 2000. The largest runoff event was on June 28, 2000, when the estimated peak event flow in upper Pajarito Canyon at gage E240 was 1020 cfs and the total runoff at E240 was approximately 47.6 ac-ft (Shaull et al. 2001). The combined flow at upstream stations on June 28 was approximately 155 ac-ft, and the combined flow at downstream stations was approximately 25 ac; ft. Runoff at downstream stations on October 23 and October 28 was even higher, about 28 ac-ft and 37 ac-ft, respectively. Most runoff events in 2000, however, were typically less than 5 ac-ft. As a result of the June 28 runoff event, three out of four of the upstream gages were destroyed; at these sites flow was estimated at the time samples were collected during significant runoff events.

In June, higher runoff volumes passed through the upstream gages relative to the downstream gages. Conversely, more runoff appears to have passed through the downstream gages in October. However, because flow was not being gaged at the upstream stations after June 28, and runoff volumes for upstream gages were estimated for significant runoff events, it is likely that not all flow at upstream gages is represented on Figure 3-5.

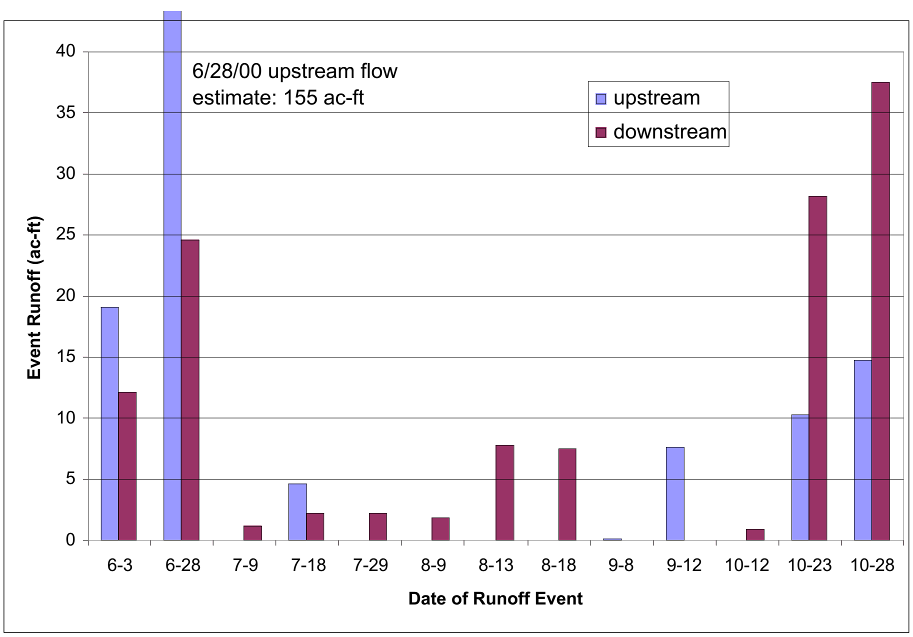


Figure 3-5. Summary of upstream and downstream flow volumes for significant runoff events in 2000.

The maximum runoff yield before the fire from Cañon de Valle and Pajarito and Water Canyons west of SR 501 was 1.26 cfs/mi^2. The discharge yield on June 28 for these same locations ranged from 250 to 540 cfs/mi^2, increasing more than 200 times from prefire peaks. These increases are two to four times greater than those estimated for Frijoles and Capulin Canyons after the 1996 Dome Fire in the Jemez Mountains (Veenhuis 2001).

A comparison of peak discharges before and after the fire is shown in Figure 3-6. Runoff data are available for 19 stream gages, of which 12 gages experienced record high runoff rates in 2000 (Shaull et al. 2001). The highest runoff observed was at gage E240 in Pajarito Canyon at the western Laboratory boundary on June 28 where over 1000 cfs was estimated to have resulted from the 0.69 in. recorded at the nearby Pajarito Canyon Remote Area Weather Station. 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. Additionally, peak discharges of approximately 1000 cfs were calculated for several runoff events for the ungaged Rendija and Guaje Canyons to the north of LANL.

Stream gages that did not have record runoff rates in 2000 after the fire include E030 and E042 in middle and lower Los Alamos Canyon, E200 and E202 in Mortandad Canyon, E250 in lower Pajarito Canyon, E267 in Potrillo Canyon, and E275 in Ancho Canyon. The large runoff experienced in upper Pajarito Canyon on June 28, due to runoff from burned areas in the Sierra de Los Valles, largely dissipated in the lower part of the canyon, and the flow at gage E250 on this date was not a record event (Shaull et al. 2001).

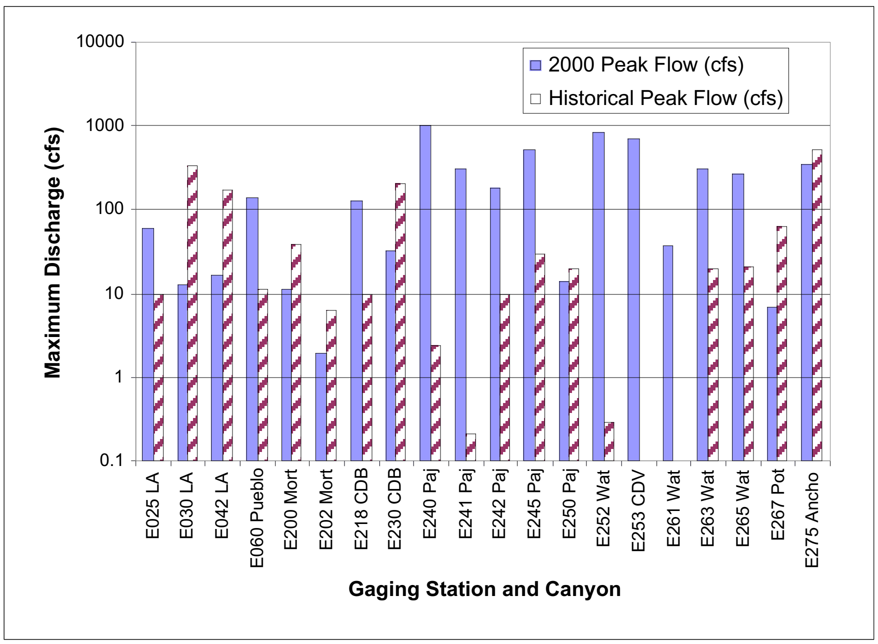


Figure 3-6. Peak flows in 2000 after the Cerro Grande Fire compared with historic flows.

3.3 Potential Impacts to the Rio Grande

This report describes the runoff quality measured on the Pajarito Plateau in 2000. Potential impacts to the Rio Grande will be presented in other companion reports (e.g., IFRAT 2001).

In the Rio Grande exposure scenario, radiological and nonradiological constituents are carried into the river by floods from the Laboratory and the Cerro Grande Fire burn area. Although the pulse of flood waters typically lasts only a few hours, highest concentrations in the Rio Grande will likely occur during the brief several-hour period when the flood waters enter the river.

A major factor controlling impacts to the Rio Grande is dilution. For most of the summer months, average daily flows in the Rio Grande were more than a thousand times greater than the combined flows in LANL canyons along the Laboratory's downstream boundary. Under extreme conditions, during the brief period when flood waters are entering the Rio Grande, we calculated that Pajarito Plateau concentrations will be diluted by at least four times (Kraig et al. in preparation).

3.4 Storm Water Sampling in 2000

A list of the stream gage sampling stations and manual collection sites that were sampled during the 2000 season is in Table 3-1. Storm water runoff samples were collected at 40 stream sites at LANL in 2000. This table shows the canyon where the sample collection sites are located, the common name of the collection site, whether automated or manual runoff samples were collected at each site, and the relative location (upstream, onsite, downstream, or near-site) for each collection site. In 2000 runoff samples were collected at two locations near LANL, including in Rendija Canyon at the third road crossing (ER3X - near the eastern property boundary between LANL and United States Forest Service land, and in lower Guaje Canyon at SR 502 [EGS4]). All other storm water collection sites are located on LANL property.

Table 3-1. Storm Water Runoff Collection Sites at LANL.

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

[a]Up = upstream, On = onsite, Down = downstream, Offsite = Off LANL site

Storm water 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 3-2. 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.

Table 3-2. Dates and Locations of Storm Water Runoff Collection 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, 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 3-1 for location names of sampling stations

The complete list of all storm water runoff samples that were collected in 2000 is in Appendix A. This table also shows the analytical suite(s) that were performed for each sample. The number and types of analyses that were performed on the storm water runoff samples are summarized in Table 3-3. Including both unfiltered samples and filtered samples, a total of 299 storm water runoff samples were collected in 2000, of which 122 samples were analyzed for radionuclides, 289 samples were analyzed for general inorganic constituents, and 143 samples were analyzed for trace metals. Additionally, some samples were analyzed for HE compounds, pesticides and PCBs, VOCs, and SVOCs. A total of 18,800 data results were obtained from the analyses of the samples.

Table 3-3. Summary of Analyses Performed on Runoff Samples in 2000.

Sample Type	General Water Chemistry	Radionuclides	Metals	Pesticides - PCBs	SVOCs	HE	VOCs
Unfiltered Samples	190	75	86	45	41	31	12
Filtered Samples	99	47	57	0	0	0	0
Total Samples Analyzed	289	122	143	45	41	31	12

If an adequate volume of water was available at an automated sampling device, three samples were usually collected for analyses at each collection site: (1) an unfiltered sample for various analyses, (2) a filtered sample for various analyses, and (3) an unfiltered sample specifically for TSS analysis. Appendix A lists the sample ID numbers and indicates whether the sample was filtered (F) or unfiltered (UF) and the analytical suites and number of analyses that were obtained for each sample. Depending on the volume of sample that was available from the automated sampling device and/or the specific runoff event, all three sample types could not always be collected for all analyses. If the volume of water for a sample was limited, a priority list of analyses was used to determine the analytical suites, based on parameters such as location of sample site, potential contaminants in watershed area, and regulatory requirements.

The common analytical suites and analytical methods used to obtain general inorganic water quality parameters, important radionuclides, and metals are listed in Table 3-4. Samples analyzed for radionuclides were generally also analyzed using gamma spectroscopy, which provides screening results for about 54 radionuclides. Analyte lists, analytical methods, and quantitation limits for HE compounds, VOCs, SVOCs, and PCBs are provided in Appendix Tables in LANL's annual Environmental Surveillance Reports (e.g., LANL 2000c, Tables A-9, A-10, A-11, A-12, and A-13).

4.0 Storm Water Runoff Quality in 2000

The data presented and discussed in this report were obtained by ESH-18. This group collected most of the storm water runoff samples in 2000 after the Cerro Grande Fire. Other groups that collected limited numbers of storm water runoff samples at or around LANL in 2000 include the US Geological Survey, NMED DOE Oversight Bureau, and the LANL ER Project. The results of the storm water runoff sampling in 2000 for general inorganics are shown in Appendix Table B-1; the results of radionuclide analyses are shown in Appendix Table B-2; and the results of metals analyses are shown in Appendix Table B-3. The data are also available on the internet at the following site:

http://wqdbworld.lanl.gov/ (outside LANL firewall)

A brief description and discussion of the storm water quality in 2000 is provided in the report *Environmental Surveillance at Los Alamos during 2000* (LANL 2001). A detailed analysis of the storm water quality in Los Alamos Canyon during the first significant runoff event after the Cerro Grande Fire has been provided in the report *Storm Water Quality in Los Alamos Canyon following the Cerro Grande Fire* (Johansen et al. 2001).

Interpreting storm water quality data from semi-arid environments presents inherent problems. Runoff is typically short-lived (lasting one or two hours), occurs in localized areas or across broad zones depending on the storm nature (convective vs. frontal), and the water quality varies with streamflow. The possible permutations of flow and water quality often require large data sets to be collected before rigorous statistical analyses may be performed.

Table 3-4. Common Analytes and Analytical Methods for General Water Quality Parameters, Selected Radionuclides, and Metals Analyses.

Water Quality Parameters		Radionuclides		Metals	
Analyte[a]	Method	Analyte	Method	Analyte	Method
ALK-CO^3	SM:A2320B	Am-241	Alpha-Spec	Ag	EPA:200.7
ALK-CO^3+HCO^3	SM:A2320B	GROSSA	EPA:900	Al	EPA:200.7
ALK-HCO^3	SM:A2320B	GROSSB	EPA:900	As	EPA:200.7
Ca	EPA:200.7	Cs-137	Gamma Spec.	B	EPA:200.7
Cl(-1)	EPA:300	H-3	EPA:906.0	Ba	EPA:200.7
CN (amen)	EPA:335.1	Po-210	Alpha-Spec	Be	EPA:200.8
CN (TOTAL)	EPA:335.2	Pu-238	Alpha-Spec	Be	EPA:200.7
COD	EPA:410.4	Pu-239,240	Alpha-Spec	Cd	EPA:200.8
F(-1)	EPA:340.2	Ra-226	EPA:903.1	Co	EPA:200.7
K	EPA:200.7	Ra-228	EPA:904	Cr	EPA:200.7
Mg	EPA:200.7	Sr-90	EPA:905 GFPC[b]	Cu	EPA:200.7
Na	EPA:200.7	Th-228	Alpha-Spec	Fe	EPA:200.7
NH^3	EPA:350.3	Th-230	Alpha-Spec	Hg	EPA:245.1
NH^3-N	EPA:350.1	Th-232	Alpha-Spec	Mn	EPA:200.7
NO^3+NO^2-N	EPA:353.1	U-234	Alpha-Spec	Mo	EPA:200.7
pH	Generic pH	U-235,236	Alpha-Spec	Ni	EPA:200.7
PO^4-P	EPA:365.4	U-238	Alpha-Spec	Pb	EPA:200.8
Si	EPA:200.7			Sb	EPA:200.8
SO^4(-2)	EPA:300			Se	EPA:200.7
Specific Cond	EPA:120.1			Sn	EPA:200.7
Specific Gravity	SM:A2710F			Sr	EPA:200.7
TDS	EPA:160.1			Ti	EPA:200.8
TKN	EPA:351.2			Tl	EPA:200.8
TSS	EPA:160.2			U	EPA:200.8
Oil & Grease	EPA:413.1			V	EPA:200.7
LOI	EPA:160.4			Zn	EPA:200.7

[a]ALK = alkalinity, CN = cyanide, COD = chemical oxygen demand, LOI = loss on ignition, TDS = total dissolved solids, TKN = total kjeldahl nitrogen, TSS = total suspended solids, TSS(m) = maximum TSS concentration.

[b]GFPC = Gas Furnace Proportional Counting

In the Los Alamos area, the Cerro Grande Fire impacts and unusual prefire climatic and hydrologic conditions amplify these problems. Several additional years of observations may be needed to quantify the impacts of the fire. Thus, many of our findings in this report are preliminary.

In the following discussions, the runoff data are evaluated by comparing with historical levels and relevant standards and by examination of spatial and temporal trends, where possible. These comparisons indicate whether the 2000 results vary dramatically from previous years and provide some environmental health context to the individual results. Two companion studies use these runoff results to quantify potential health risks associated with the storm water (IFRAT 2001; Kraig et al. in preparation).

The benchmarks for comparing to historical levels are the prefire, 1995–1999, concentrations from storm water samples collected across the Laboratory. The 1995–1999 data set is used for comparison because, although runoff data were collected before 1995, the post-1995 data have similar sampling methods to the current data. The prefire dataset primarily includes results from Los Alamos Canyon and Cañada del Buey because the availability of prefire runoff data from other drainages is limited. Prefire flow was minimal in many of the drainages because of drought conditions and unusually low runoff yields from the Jemez Mountains. For example, Frijoles Creek’s average annual flow was an order of magnitude less than regional predictions (Leopold 1994); a result attributed to the Plateau’s high permeability and evapotranspiration (Mott 1999).

The general lack of prefire runoff along LANL's western boundary is a major limiting factor to evaluating the year 2000 results. We generally do not have sufficient prefire data to analyze the impacts of the fire and of LANL on a watershed by watershed basis. Runoff in Water Canyon, for example, was largely absent before the fire, yet it contributed much of the offsite flow in 2000. Rather than evaluating the data on a watershed scale, we group the data into three broader geographic categories:

- Upstream (canyon stations along LANL's western boundary and north of LANL--Rendija and Guaje Canyons)
- Onsite (canyon and mesa top stations in central portion of LANL), and
- Downstream (stations near LANL's eastern boundary, along SR 4 and SR 502).

The following discussions of chemical and radiological results include an evaluation with respect to fire; related impacts and LANL-related impacts. Fire-related impacts are generally impacts that are observed primarily at upstream sites, with respect to LANL, and in Guaje and Rendija Canyons north of LANL that can be attributed to runoff from fire-impacted areas. Fire-related impacts are also observed in runoff that originated from upstream fire-impacted areas and extended across LANL in the larger runoff events that flowed through canyons at LANL. LANL-related impacts are interpreted to be those impacts that are not observed at upstream locations and in Guaje or Rendija Canyons, but primarily are observed only at LANL onsite and downstream locations.

4.1 Trend Comparisons Using Flow Adjusted (Weighted) Concentrations

Several chemical time series graphs in this report (see, for example, Appendix C) show how the concentrations of chemicals or radionuclides varied through the 2000 runoff season. The data values represent a wide spectrum of environmental and flow conditions present at the time of sampling. For completeness and to ensure that the data range is represented, all data values are treated alike and displayed similarly in the time series plots. From a chemical transport perspective, however, the larger flow events carry substantially larger quantities of material than the smaller events, and some adjustment is needed to emphasize (weight) the larger events. Thus, for selected analytes, we further evaluate the concentration trends by using an averaging technique to minimize (normalize) the impact of streamflow.

Changes caused by variation of streamflow are particularly troublesome in trend detection efforts (Gilbert 1987). As streamflow increases, many water quality properties and constituents (specific conductance, dissolved solids, major dissolved ions, and dissolved metals) decrease in value or concentration. Other constituent concentrations (suspended sediment and, occasionally, nutrients) increase with increasing streamflow.

Some analytical technique is required to control for, or to remove, the effects of discharge in order to reveal nonclimatological chronological trends (Harned et al. 1981). To estimate changes in TSS concentrations, we used an averaging technique (flow weighting) designed to account for the variation in sediment associated with a changing streamflow regime (Belillas and Roda 1993; Brown and Krygier 1971). We will adjust the measured runoff concentrations by streamflow to preliminarily evaluate trends and changes from prior years.

For this effort, runoff volume and quality data were integrated for the individual drainages. The flow; weighted average concentration of selected analytes in storm water runoff in 2000 and recent years was calculated. First, the concentrations measured at each runoff event were multiplied by the total flow measured or estimated for each event (see Section 3.2), which determines the mass value (in mg, µg, or Ci) of each analyte transported in each flow event. Next, the mass values and total runoff volumes from each individual runoff event were summed for the year, and the total yearly mass value was divided by the total yearly runoff volume to determine the flow-weighted average concentration for each radionuclide for each year:

$$Conc_w = \frac{\sum_{i=1}^{n} C_i \times V_i}{\sum_{i=1}^{n} V_i} = \frac{\text{Total Mass or Activity}}{\text{Total Volume}}$$

where $Conc_w$ = Flow weighted average concentration (mg/L, µg/L, or pCi/L) for period of interest,
C_i = Analyte concentration (mass or activity per L) measured in runoff event i,
V_i = Total volume (L) in runoff event i,
n = Total number of results (samples) in period of interest.

4.2 Box Plots

Many figures in the following discussion show summary "box plots" of the runoff data. Box plots are useful for looking for differences between groups of data. The box plots summarize the distribution of the results of all samples analyzed for each data group, including samples reported as laboratory non-detects. The plots are a convenient way to compare groups of large numbers of data values. Box plots graphically show the minimum, median, and maximum values of the data set and the distribution pattern of the analytical results. Box plots provide a good representation of the variability of the data and the skewness or symmetry of the distribution. Box plots also indicate which data groups may be statistically different—if two boxes do not overlap vertically in the figure, there is a reasonable likelihood that the two groups are significantly different.

The box contains the middle 50% of data values (25th to 75th percentile range, or 1st to 3rd quartiles). The bottom and top of the box is called the inner quartile (IQ) range. The median of the data set is represented by the middle bar in the box. The vertical lines, called whiskers, that extend above and below the box represent high and low data values that are within ±1.5 times the IQ range. Data values beyond the whiskers are shown by solid circles (1.5 to three times the IQ range) and open circles (>3 times IQ) (Tukey 1977). For sample results that are reported below analytical method detection limits by the laboratory, and for results that are reported less than zero, the detection limit values were used to provide a representative distribution pattern for concentration values.

4.3 General Water Quality Parameters in Storm Water Runoff

This section reviews the water quality results for common minerals, nutrients, and cyanide. The results of general water quality parameter analyses of storm water runoff in 2000 are shown in Appendix Table B-1. The number of analyses performed for general inorganic water quality parameters in storm water runoff and the number of detections and non-detections is summarized in Table 4-1. More detailed discussion regarding key fire- and LANL-related chemicals is presented in Appendix C.

The common minerals and nutrients are normally derived from natural soils and plant tissues. Physicochemical changes after the fire enhanced their availability and concentrations increased in water. These responses have been widely studied and reported in the scientific literature. Monitoring results for the Los Alamos area for minerals and nutrients are generally consistent with results from other fires.

The detection of cyanide in the initial runoff events after the fire, however, was less understood and was of considerable concern. In certain chemical forms, cyanide is toxic to aquatic biota and wildlife (Irwin et al. 1997). Fortunately, we have not received any reports of fish kills in the Rio Grande, and it appears as if most of the cyanide was not of a biologically harmful form. Elevated levels of cyanide were present in runoff for several months after the fire. The fire retardant used in the Cerro Grande Fire contains a sodium ferrohexacyanide ($Na_4Fe(CN)_6 \bullet 10H_2O$) compound, which is added as an anti-caking additive and as a corrosion inhibitor to protect the tanks on the slurry bombers. The compound reduces the effects of highly corrosive ammonium and phosphate compounds that are used as the actual fire suppressants (Little and Calfee 2000). Compared to many other cyanide compounds, sodium ferrocyanide is not particularly toxic (MSDS 2001). The CN-anions are complexed with the sodium/iron molecule and are not biologically available. Research has indicated that more biologically harmful cyanide compounds may form upon exposure of the sodium ferrohexacyanide to ultraviolet radiation from sunlight (Little and Calfee 2000). Another possible cyanide source is natural combustion. Smoke from smoldering fires has been shown to contain hydrogen cyanide (HCN) gas (Yolkeson et al. 1997), and it is theoretically possible for some of the gas to be re-deposited on the ground surface. We are not aware of any studies that ascribe cyanide in runoff to this source.

The minimum, maximum, and median concentrations obtained for each general inorganic analyte are shown in Table 4-2. The summary of the results for unfiltered storm water runoff is shown graphically in box-plots in Figure B-1 in Appendix B and the summary for filtered storm water runoff is shown graphically in box-plots in Figure B-2 in Appendix B.

Table 4-1. Summary of Analyses and Laboratory Detections of General Inorganics in Storm Water Runoff Samples in 2000.

Analyte [a]	Unfiltered Samples				Filtered Samples			
	No. Analyses	No. Detects	No. Non-Detects	% Detects	No. Analyses	No. Detects	No. Non-Detects	% Detects
ALK-CO_3	1	0	1	0%	33	1	32	3%
ALK-CO_3+HCO_3	1	1		100%	33	33		100%
ALK-HCO_3	1	1		100%	33	33		100%
Ca	25	25		100%	17	17		100%
Cl^-	2	2		100%	32	32		100%
CN (amen)	93	10	83	11%				
CN (TOTAL)	97	52	45	54%				
COD	79	79		100%				
F^-					4	4		100%
K	25	25		100%	17	17		100%
LOI	59	59		100%	3	3		100%
Mg	94	94		100%	56	56		100%
Na	25	25		100%	17	17		100%
NH_3	22	15	7	68%				
NH_3-N	53	39	14	74%				
NO_3+NO_2-N	71	65	6	92%	3	2	1	67%
Oil & Grease	7	4	3	57%				
PH	3	3		100%				
PO_4-P	76	76		100%	4	4		100%
SO_4	2	2		100%	32	32		100%
Spec. Conductivity	51	51		100%	7	7		100%
TDS					96	95	1	99%
TKN	80	80		100%				
TSS	149	147	2	99%				
TSS(m)	123	123		100%				

[a] ALK = alkalinity, CN = cyanide, COD = chemical oxygen demand, LOI = loss on ignition, TDS = total dissolved solids, TKN = total kjeldahl nitrogen, TSS = total suspended solids, TSS(m) = maximum TSS concentration.

Table 4-2. Summary of General Water Quality Parameters in Storm Water Runoff in 2000 (mg/L)[a].

Analyte	Unfiltered			Filtered			Water Quality Standards[b]	
	Min.	Median	Max.	Min	Median	Max.	Min. Std	Standard Type
Alkalinity-Total				8.2	50.5	230.0		
Ca	8.0	275	1110.0	26.7	58.0	99.0		
Cl				0.25	3.25	53.20	250	NM GW
CN (amen)	0.00304	0.0040	0.06200				0.0052	NM Wildlife
CN (total)	0.00311	0.0116	0.1760				0.20	NM GW
COD	5.44	31.6	851.00					
F				0.10	0.13	0.16	1.6	NM GW
K	1.0	31.6	111.3	5.6	18.9	32.0		
LOI	26.0	203.5	3490.0	1170.0	1200	10500.0		
Mg	0.52	17.9	188.00	0.48	5.25	39.30		
Na	1.00	8.00	14.00	2.00	7.00	12.00		
NH_3-N	0.03	0.73	4.16					
NO_3-N	0.02	0.34	1.27				10	NM GW
pH (SU)	7.15	7.29	7.29				6 - 9	NM GW
PO_4-P	0.08	0.94	14.50	0.16	0.41	0.45		
SO_4				0.41	4.02	16.70	600	NM GW
Spec. Cond. (uS/cm)	22.1	139	573.0	75.7	215.0	365.0		
Specific Gravity	0.00	0.998	1.17	0.98	0.99	1.00		
TDS				17.0	217.0	570.0	1000	NM GW
TKN	0.3	2.64	64.0					
TSS	31.7	4115	76000					

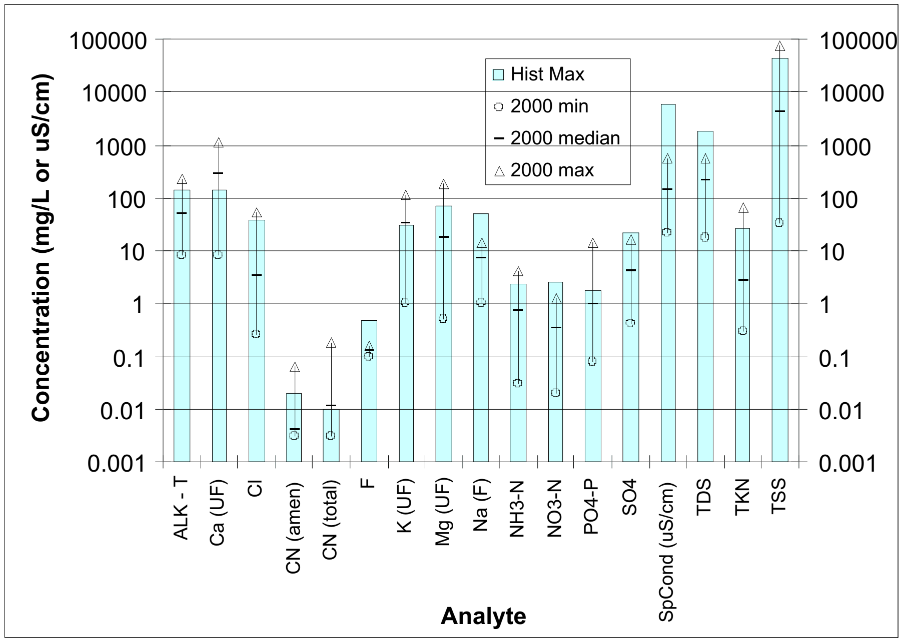
[a]Values in mg/L except where noted; SU = standard units; Spec. Cond. = specific conductance; CN = cyanide; TDS = total dissolved solids; TKN = total kjeldahl nitrogen; TSS = total suspended solids.
[b]Standards presented for comparison purposes. NM GW = New Mexico Water Quality Control Commission (NMWQCC) Groundwater Standards (applicable for these analytes to filtered waters). NM Wildlife = NMWQCC Standards for Interstate and Intratstate Surface Water- Wildlife Habitat Standards (amenable cyanide standard applicable to unfiltered waters).

4.3.1 Comparison with Historical Maximum Concentrations

Figure 4-1 shows the minimum, median, and maximum concentrations of general water quality parameters measured in runoff in 2000 and the historical maximum concentrations measured in runoff from 1995 through 1999. Maximum concentrations of most water quality parameters in 2000 runoff were higher than historical maximums, except for fluoride, sodium, nitrate, and sulfate, which were measured within the range of concentrations historically observed.

The general water quality parameters that were measured in concentrations significantly higher in 2000 than historical maximum concentrations include calcium, total cyanide, potassium, and phosphate.

The maximum calcium concentration in unfiltered runoff in 2000 was 1110 mg/L, significantly higher than the historical maximum of 140 mg/L; 15 of 25 samples (60%) collected in 2000 contained calcium concentrations greater than the historical maximum. Most samples containing calcium concentrations greater than 600 mg/L were collected from high-volume runoff from fire-impacted areas on June 28 in Pajarito Canyon and Water Canyon/Cañon de Valle; the other sample that contained greater than 600 mg/L calcium was collected from high-volume runoff in Guaje Canyon on July 9, which was also from fire; impacted areas.



(UF = Unfiltered Sample; F = Filtered Sample)

Figure 4-1. General water quality parameters in 2000 compared with historical maximum concentrations.

The highest concentration of total cyanide measured before 2000 was 0.01 mg/L, and most historical cyanide analyses were below detection limits. In 2000, however, total cyanide was measured above the detection limit in 52 of 99 samples and the maximum concentration measured was 0.176 mg/L in a sample from Guaje Canyon on July 9. The highest concentration in samples from LANL was 0.176 mg/L in a sample from middle Pajarito Canyon (gage E18C) on June 28. Of six samples with concentrations greater than 0.10 mg/L, four samples were from the June 28 large runoff event, and one was collected from upper Los Alamos Canyon (gage E025) on July 18. The higher cyanide (total) concentrations in 2000 are from runoff from fire-impacted areas.

The maximum concentration of amenable cyanide in 2000 runoff was 0.062 mg/L in a sample collected from upper Water Canyon (gage E252) on June 28. The next highest concentration was 0.0457 mg/L in a sample from lower Water Canyon (gage E265) collected on July 29. In 2000, only 10 of 83 samples (11%) analyzed for amenable cyanide contained detectable concentrations. The prefire highest concentration was 0.02 mg/L, which was approximately the detection limit of historical sample analyses. Amenable cyanide is important because it is a measure of the potentially biologically harmful forms of cyanide. Amenable cyanide is that portion of cyanide that is amenable to chlorination and is comparable to “free acid dissociable” cyanide listed in the New Mexico stream standards.

The highest concentration of potassium in 2000 runoff was 111.3 mg/L in a sample from upper Pajarito Canyon (gage E240) collected on June 28. The previously highest potassium concentration was 30.67 mg/L. In 2000, 13 of 25 samples contained greater than 30 mg/L potassium. The nine highest concentrations of potassium were collected from the high-volume runoff event on June 28. Potassium concentrations correlate with TSS (see following section on TSS).

The highest concentration of phosphate (as phosphorous) in 2000 runoff was 14.5 mg/L in a sample from lower Water Canyon (gage E265) collected on July 29. The highest concentration measured before 2000 was 1.74 mg/L; 27 of 76 samples (35%) in 2000 contained higher concentrations of phosphate and nearly all of these samples were from runoff from fire-impacted areas and all samples containing greater than 2.3 mg/L were from fire-related runoff.

The highest TSS concentration in runoff in 2000 was 76,000 mg/L in a TSS(m) sample collected from Guaje Canyon on September 8. The highest concentration in a sample from LANL runoff was 71,400 mg/L in a sample collected from lower Water Canyon (gage E265) on October 23. The historical maximum concentration of TSS was 43,140 mg/L. In 2000 only 12 of 272 analyses for TSS were above the historical maximum and, except for the sample from Guaje Canyon, all other samples greater than the historical maximum concentration were from lower Water Canyon at gages E263 or E265.

4.3.2 Comparison of General Water Quality Parameters to Standards

The minimum standards that are applicable to storm water runoff are listed in Table 4-2 (also see Appendix Table B-1). The summary of the general water quality parameters for which standards exist is shown in Figure 4-2 with the minimum standard values. The drinking water and groundwater standards are typically compared with results from filtered samples, and wildlife standards are typically compared with unfiltered results.

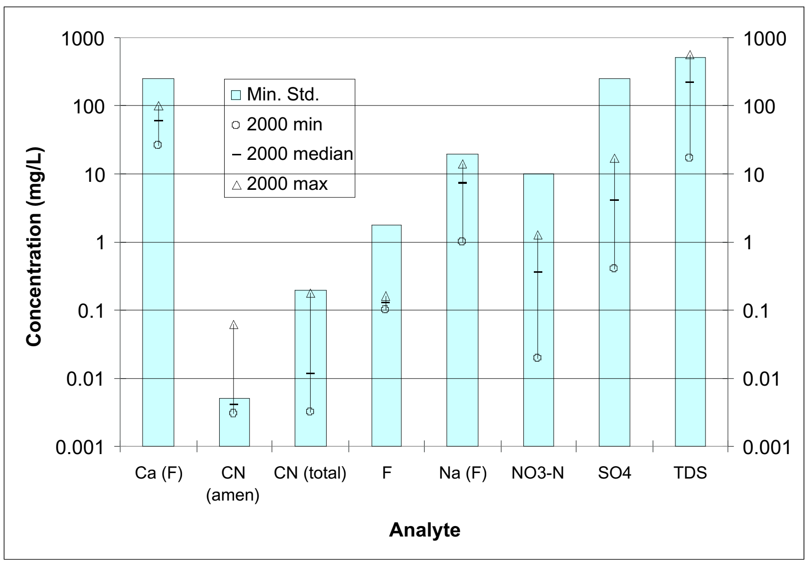


Figure 4-2. Summary of water quality parameters compared with minimum standards.

The water quality parameters that were greater than minimum standards in 2000 runoff include cyanide (amenable) and TDS. Cyanide (amenable) was found in concentrations greater than the NMWQCC wildlife habitat standard in three samples from Water Canyon. The highest concentration of cyanide (amenable) was 0.62 mg/L in a sample from upper Water Canyon (gage E252) collected on June 28. The other samples were from lower Water Canyon (gage E265) collected on July 29 and August 18.

The only runoff sample that contained TDS above the EPA secondary drinking water standard of 500 mg/L was a sample from Guaje Canyon collected on September 8. All runoff samples collected from runoff at LANL were below 500 mg/L TDS.

4.3.3 Total Suspended Sediment

A major impact of the Cerro Grande Fire was substantially increased transport of sediment onto and across the Laboratory. A significant increase in TSS concentrations in storm water runoff from fire; affected areas is caused by a lack of vegetation and higher runoff volumes. The initial runoff events of

June and July carried abundant ash and sediment on a widespread basis, though fire-impacts were seen locally in samples collected in late October. The prefire maximum TSS concentration was 43,140 mg/L, after the fire the maximum TSS concentration in runoff was 76,000 mg/L and 12 samples contained TSS greater than the prefire maximum.

Runoff samples from automated samplers are collected in multiple sample containers that are typically composited before the samples are prepared for laboratory analyses, which routinely include TSS analyses. In 2000, a portion of the sampler container that had the highest apparent turbidity and suspended sediment was packaged separately for a unique TSS analyses that was labeled TSS(m), for maximum TSS. The results of these analyses were reported separately by the laboratory, but are included in the following discussion of TSS results. The routine TSS values are used with other analytical results to calculate mass values of constituents.

Figure 4-3 shows the summary of TSS concentrations of samples from upstream, onsite, and downstream locations and for samples collected in Guaje and Rendija Canyons. The median TSS value at upstream sites in 2000 was 7625 mg/L and at downstream sites was 8610 mg/L. The median TSS value of runoff samples collected on site was 2645 mg/L, significantly lower than upstream and downstream sites and attributed to several onsite samples collected at TA-54 MDA-G that were not fire related and comprised relatively low flow rates and TSS values. The highest concentration of TSS in analytical samples was 59,600 mg/L from Water Canyon below SR 4 on August 12, 2000. The highest TSS(m) concentration in all samples was 76,000 mg/L from Guaje Canyon above SR 4 on September 8.

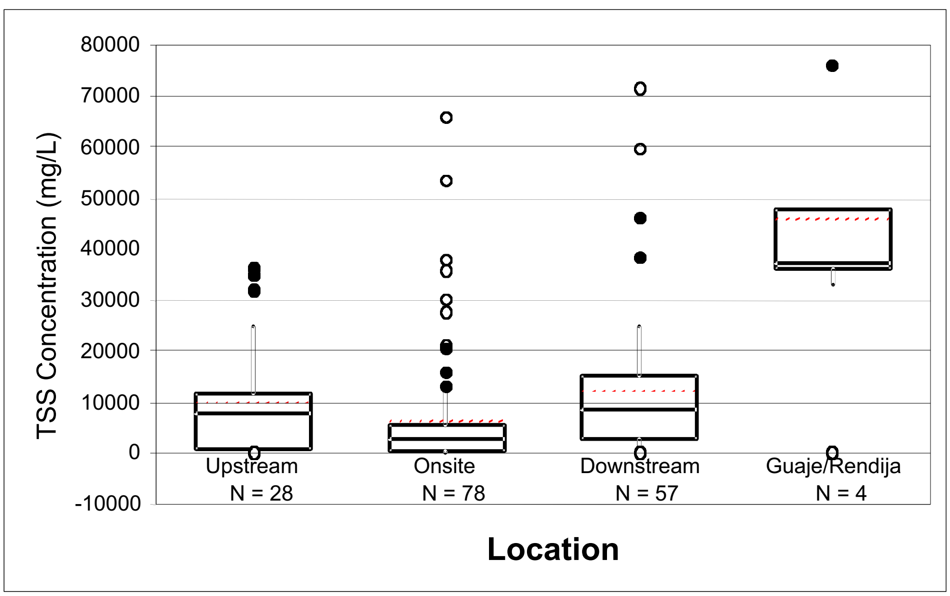


Figure 4-3. Summary of TSS concentrations at upstream, onsite, and downstream locations.

The four runoff samples collected in Guaje and Rendija Canyons have a higher distribution of TSS values than samples collected at LANL, but most values in Guaje and Rendija Canyons are within the range of higher outlier concentrations from onsite and downstream locations. The higher TSS values are associated with high runoff rates from fire-impacted areas of the watersheds.

For most cations and anions, the higher concentrations are associated with higher TSS values that accompany higher runoff rates. Figure 4-4 shows the relationship between calcium, magnesium, potassium, and sodium in unfiltered samples with the TSS concentration. Calcium, magnesium, and potassium generally show a positive correlation with TSS. Sodium and other water quality parameters, such as alkalinity, nitrate, ammonia, and phosphate, are typically dissolved in runoff and do not have a significant correlation to TSS concentration, but tend to correlate more with the TDS concentration.

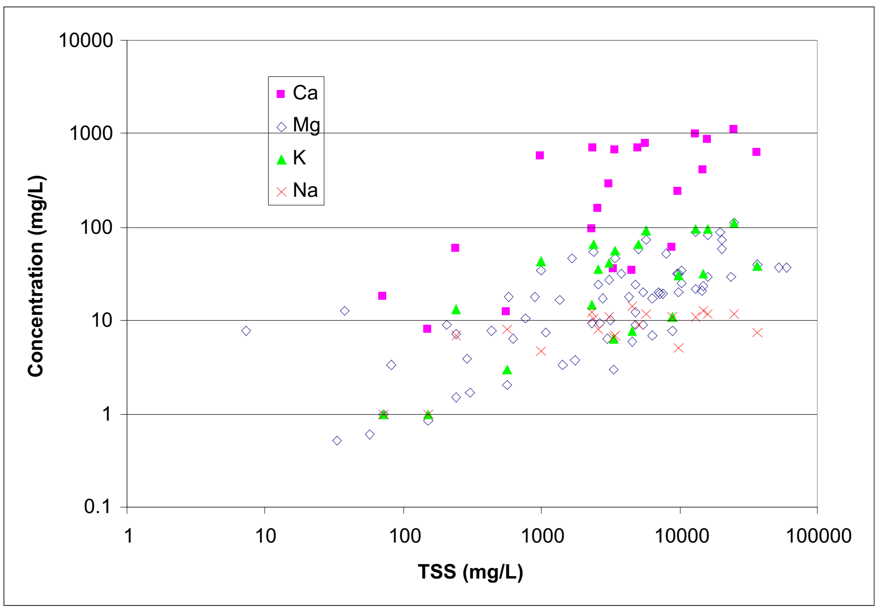
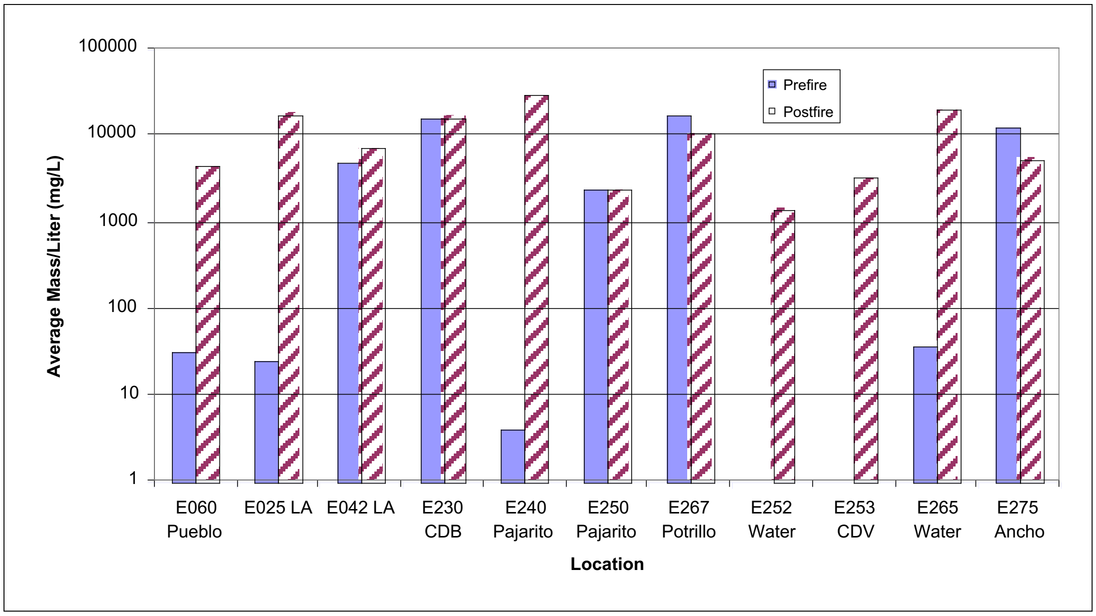


Figure 4-4. Bivariate distribution of selected cations and TSS in unfiltered storm water runoff.

The concentrations of many constituents were elevated above levels observed in previous years. Increases were noted for total alkalinity, calcium, magnesium, potassium, total phosphorous, and cyanide concentrations. These increases were generally due to release of these constituents by fire, changes in chemical states and complexation, and changes in the postfire environment such as increased pH. Previous investigations of storm water runoff characteristics at other locations show increases in many minerals and nutrients after forest fires (e.g., Bitner et al. 2001; DeBano et al. 1979, Helvey et al. 1985, Tiedemann et al. 1978, Belillas and Roda 1993).

Figure 4-5 shows the comparison of available prefire flow-weighted average TSS concentrations with postfire flow-weighted average TSS concentrations at collection sites upstream and downstream of LANL. The flow-weighting technique normalized the effect of abnormal flow events after the fire, allowing for comparison with prefire conditions. Prefire TSS data are available for the years 1996 through 1999 for sites where runoff samples were collected. During this period, storm water runoff samples were collected at only two upstream sites, Pajarito Canyon above SR 501 (gage E240) and Los Alamos Canyon at Los Alamos (gage E025), which were both collected in 1997. The data shown for these collection sites represent single runoff events that are indicative of prefire runoff and suspended sediment conditions. The postfire data often represent multiple runoff events, but because the TSS data are weighted by flow volumes, the comparison with prefire data is possible.



Note: CDB = Cañada del Buey; CDV = Cañon de Valle; LA = Los Alamos.

Figure 4-5. Flow-weighted average TSS concentrations prefire and postfire.

The prefire flow-weighted average TSS concentrations at the downstream sites in Los Alamos Canyon and Pajarito Canyon (E042 and E250, respectively) (Figure 4-5) are about two orders of magnitude higher than the upstream TSS concentrations. The increase in TSS concentrations at the downstream sites in Los Alamos and lower Pajarito Canyons before the fire appears to indicate that more erosion of the stream channels was occurring on the Laboratory relative to the upstream forests before the fire.

The effects of the Cerro Grande Fire on TSS are obvious at the Pueblo Canyon (E060), upper Los Alamos Canyon (E025), upper Pajarito Canyon (E240), Water Canyon (E252 and E265), and Cañon de Valle (E253) collection sites. The postfire average TSS concentrations at these sites are about two to four orders of magnitude higher than observed in prefire samples (see Figure 4-5). The greatest increases in average TSS concentrations after the fire are noted at the two upstream sites in Los Alamos and Pajarito Canyons. Sites where postfire average TSS concentrations are not significantly different from prefire concentrations are Los Alamos Canyon at SR 4 (E042), lower Cañada del Buey at SR 4 (E230), lower Pajarito Canyon above SR 4 (E250), Potrillo Canyon (E267), and Ancho Canyon (E275). Of these sites, Cañada del Buey and Potrillo and Ancho Canyons were not affected by fire over a significant percentage of their watersheds. Upper Los Alamos Canyon and upper Pajarito Canyon were significantly affected by fire, however, as the runoff passed through these canyons, the TSS concentrations dropped significantly from the upstream sites to the downstream sites (see Figure 4-5). Pajarito Canyon has a large runoff retention capacity in the lower part of the canyon and the TSS concentration in the runoff dropped over one order of magnitude between the upstream site (E240) and the downstream site (E250).

Figure 4-6 shows the total mass of suspended sediment that was carried in storm water runoff at all upstream sites and at all downstream sites for each day that runoff samples were collected in 2000. The largest mass of suspended sediment that entered upstream sites at LANL from the Sierra de los Valles was over 2000 MT [2,000,000 kg] as a result of the June 28 storm event. The largest mass of suspended sediment that was carried downstream of LANL occurred on October 23 (430 MT). In August and October, several precipitation events occurred over the Pajarito Plateau that produced runoff and carried suspended sediment downstream of LANL but a significant mass of sediment did not enter LANL from the burned mountain areas (see Figure 4-6).

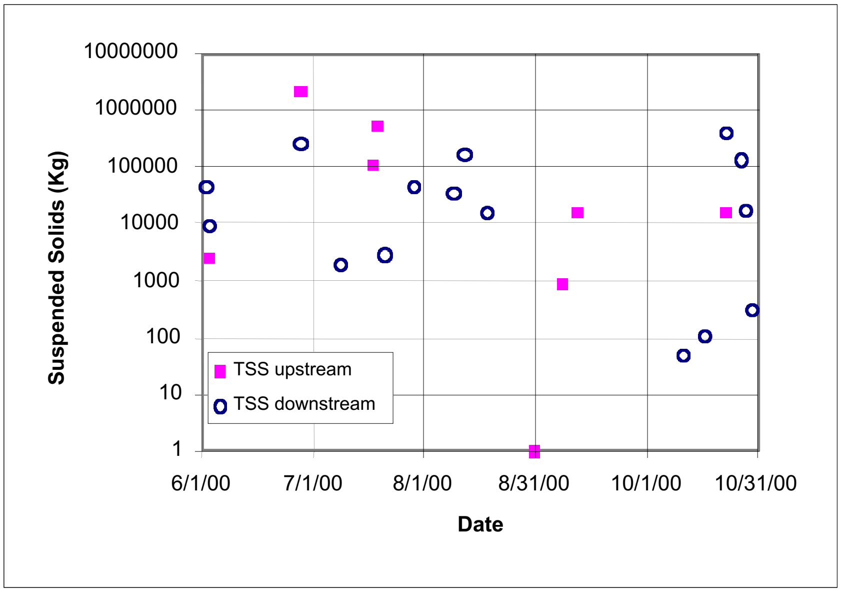


Figure 4-6. Time series of suspended sediment in runoff on specific dates in 2000.

Figure 4-7 shows the monthly total mass of suspended sediment that was transported in runoff at upstream and downstream stations in 2000. In June, July, and September more suspended sediment was carried onto LANL than flowed offsite and downstream of LANL. In August, storm water runoff carried suspended sediment downstream of LANL, but no significant mass of suspended sediment flowed onto LANL. This is the result of the location of precipitation events that occurred more over the central Pajarito Plateau and over LANL in August rather than over the burned areas west and upstream of LANL. In September few precipitation and runoff events were recorded and a small amount of suspended sediment was measured at upstream stations, but no significant runoff or suspended sediment was measured at downstream sites.

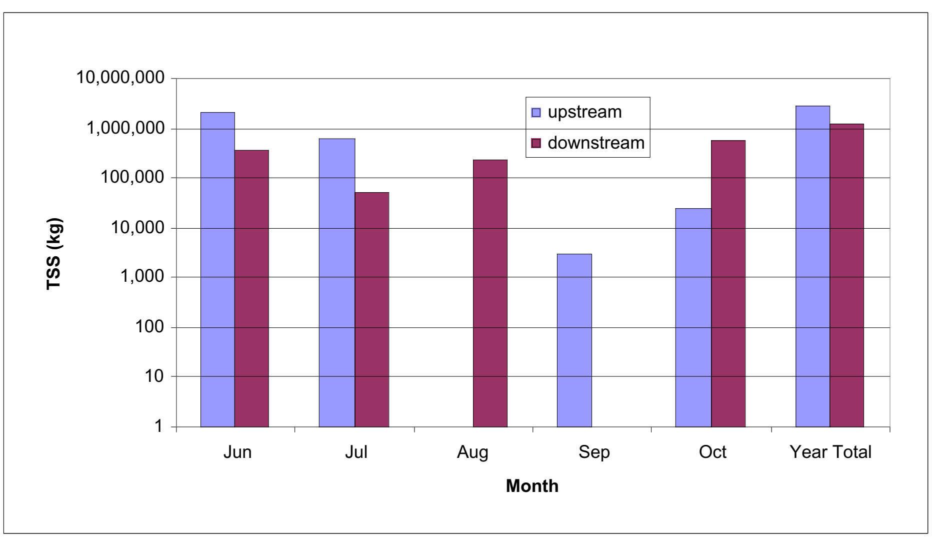
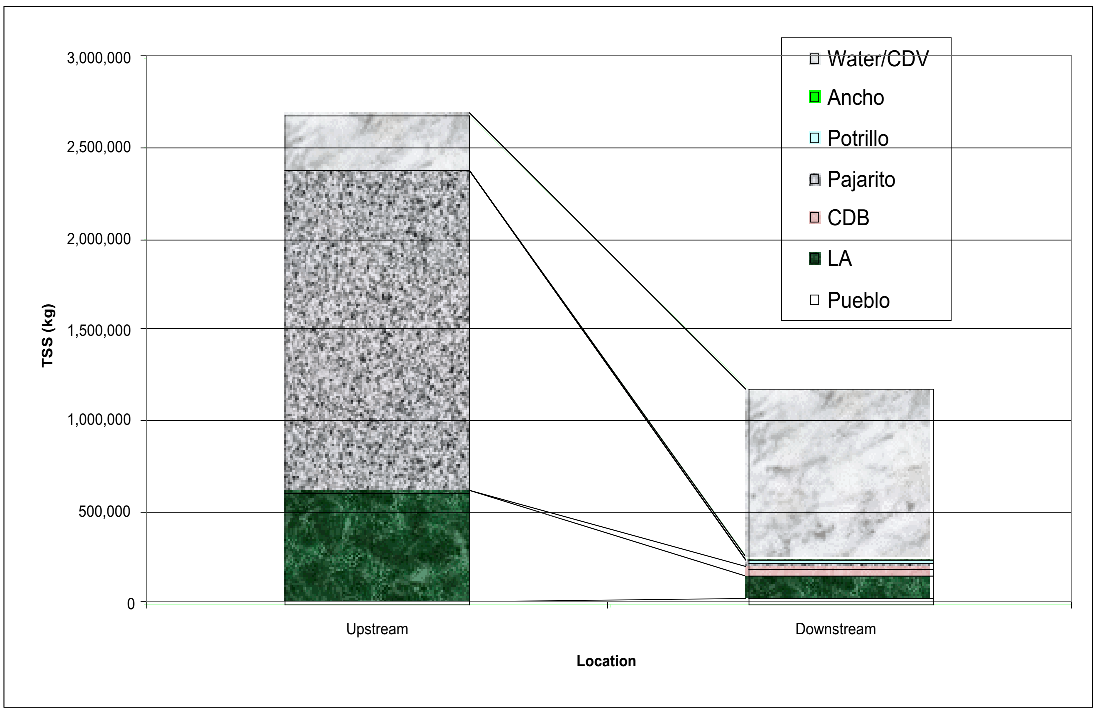


Figure 4-7. Monthly and yearly mass of suspended sediment in runoff in 2000.

The total mass of suspended sediment passing through upstream stations and downstream stations in 2000 is also shown on Figure 4-7 and for each canyon system in Figure 4-8. The total mass of suspended sediment measured at upstream stations was about 2700 MT and the total mass of suspended sediment measured at downstream stations was about 1200 MT. The TSS data indicate that about 1500 MT of suspended sediment, which included ash and muck and fine sediment material, was deposited in floodplains at LANL during the 2000 runoff season. The greatest amount of suspended sediment observed at upstream stations was in Pajarito Canyon (1770 MT), most of which resulted from the June 28, 2000, storm event. However, only a total of about 300 MT of suspended sediment flowed downstream in Pajarito Canyon, which indicates that about 1470 MT of suspended sediment was deposited in the Pajarito Canyon watershed. Suspended sediment in runoff at the upstream Los Alamos Canyon station totaled about 615 MT, and a total of about 120 MT flowed downstream, which indicates that about 495 MT was deposited in the Los Alamos Canyon watershed area.

Suspended sediment that passed through the upstream stations in Water Canyon and Cañon de Valle totaled about 305 MT for the year, and a total of about 940 MT of suspended sediment flowed past the downstream station in Water Canyon. Unlike Pajarito and Los Alamos Canyons, more suspended sediment (about 635 MT) flowed downstream in Water Canyon than entered the watershed at the upstream stations. This may be the result of several precipitation events over the southern and central Pajarito Plateau in August and October that caused significant runoff at downstream stations but little or no runoff at upstream stations.



Note: CDB = Cañada del Buey; CDV = Cañon de Valle; LA = Los Alamos Canyon

Figure 4-8. Total suspended solids passing upstream and downstream stations in 2000.

4.3.4 Summary of General Inorganic Parameters in Runoff

The major impact of the Cerro Grande Fire was substantially increased transport of sediment onto and across the Laboratory. The prefire maximum TSS concentration in runoff was 43,140 mg/L, after the fire, the maximum TSS concentration in runoff was 76,000 mg/L and 12 samples contained TSS greater than the prefire maximum. The total mass of suspended sediment measured at upstream stations was about 2700 MT and the total mass of suspended sediment measured at downstream stations was about 1200 MT. The TSS data indicate that about 1500 MT of suspended sediment, which included ash and muck and fine sediment material, was deposited in floodplains at LANL during the 2000 runoff season.

The general inorganic water quality parameters that were measured in concentrations significantly higher in 2000 than historical maximum concentrations include calcium, cyanide, potassium, and phosphate. The water quality parameters that were greater than minimum standards in storm water runoff in 2000 include cyanide (amenable) and TDS. Cyanide (amenable) was found in concentrations greater than the NMWQCC wildlife habitat standard in three samples from Water Canyon. The highest concentration of cyanide (amenable) was 0.62 mg/L in a sample from upper Water Canyon (gage E252) collected on June 28. The other samples were from lower Water Canyon (gage E265) collected on July 29 and August 18. One sample from Guaje Canyon contained TDS above the EPA secondary drinking water standard of 500 mg/L. All runoff samples collected at LANL contained less than 500 mg/L TDS.

Higher concentrations of calcium in unfiltered runoff from upstream, onsite, and downstream locations are obviously associated with runoff from fire-impacted areas. After the fire, dissolved calcium concentrations were also significantly higher, postfire concentrations were about six to eight times higher than prefire concentrations.

The concentrations of nitrate in runoff do not appear to have been affected by the fire. The median concentrations of ammonia in samples collected in 2000 onsite and downstream were not significantly different compared with samples collected before the fire, however, the maximum concentrations of ammonia observed after the fire were higher than before the fire. The highest ammonia concentrations in runoff were in June and July and lower concentrations were observed later in the runoff season, suggesting that ammonia may have been the result of fire-related impacts.

4.4 Radionuclides in Storm Water Runoff

4.4.1 Summary of Radionuclides in Runoff in 2000

The results of radionuclide analyses of storm water runoff in 2000 are shown in Appendix Table B-2. In 2000 a total of 75 unfiltered storm water runoff samples and 47 filtered samples were analyzed for radionuclides. The summary of the number of analyses performed and the number of detections and non; detections of radionuclides in storm water runoff samples is shown in Table 4-3. Detections are defined as values exceeding both the analytical method detection limit and three times the individual one; standard-deviation measurement uncertainty (LANL 2001, Taylor 1987). On average, radionuclides were detected in 77% of the unfiltered samples and in 50% of the filtered samples in which they were analyzed. Radionuclides that were detected in most of the unfiltered samples (>90%) include lead-210, polonium; 210, thorium-228, thorium-230, thorium-232, uranium (total), uranium-234, and uranium-238. Detections of these radionuclides were less frequent in filtered samples (see Table 4-3).

Table 4-4 shows the minimum, maximum, and median concentration values for the major radionuclides detected in runoff samples in 2000. The summary of the results for radionuclides in unfiltered storm water runoff are shown graphically in Figure B-3 in Appendix B and the summary of radionuclides in filtered storm water runoff is shown graphically in box-plots in Figure B-4 in Appendix B. These figures include all data results including non-detect values, for which MDA concentrations are used to develop the box plots, this lowers the median concentrations shown on the figures. The concentrations of radionuclides measured in storm water runoff samples are quite variable by location and through time, principally depending on whether Cerro Grande Fire ash was present in the drainage at the time of sampling and the suspended sediment concentration of samples.

Table 4-3. Summary of Analyses and Detections of Radionuclides in Storm Water Runoff Samples in 2000.

Analyte	Unfiltered Samples				Filtered Samples			
	No. Analyses	Non Detects	Detects	% Detects	No. Analyses	Non Detects	Detects	% Detects
Am-241	59	10	49	83%	50	36	14	28%
Cs-137	82	50	32	39%	54	53	1	2%
GROSSA	86	29	57	66%	47	25	22	47%
GROSSB	86	15	71	83%	47	0	47	100%
H-3	75	64	11	15%	NA	NA	NA	NA
Pb-210	31	1	30	97%	22	6	16	73%
Po-210	33	2	31	94%	22	7	15	68%
Pu-238	68	35	33	49%	56	50	6	11%
Pu-239,240	69	10	59	86%	56	49	7	13%
Ra-226	35	7	28	80%	20	11	9	45%
Ra-228	33	21	12	36%	23	21	2	9%
Sr-90	69	16	53	77%	46	7	39	85%
Th-228	69	2	67	97%	55	24	31	56%
Th-230	69	1	68	99%	55	14	41	75%
Th-232	69	1	68	99%	55	39	16	29%
U	86	4	82	95%	56	16	40	71%
U-234	69	1	68	99%	57	13	44	77%
U-235,236	69	23	46	67%	57	39	18	32%
U-238	69	3	66	96%	57	15	42	74%
Average %				77%				50%

NA = Not applicable

Table 4-4. Summary of Detections of Selected Radionuclides in Storm Water Runoff in 2000.

Analyte[a]	Unfiltered Samples (pCi/L)					Filtered Samples (pCi/L)				
	Min	Max	Median	Min UF Std.	UF Std. Type [b]	Min	Max	Median	Min. F Std.	F Std. Type
Am-241[c]	0.035	20.7	0.42	30	DOE DCG	0.040	0.863	0.052	15	EPA Prim. DW[d] Std
Cs-137	5.0	511	18	3000	DOE DCG	62.4	62.4	NA[e]	120	DOE DW DCG[f]
Gross Alpha	2.0	570	35.2	15	NM Livestock Watering	1.1	7.0	3.3	15	EPA Prim. DW Std
Gross Beta	4.2	1054	114	1000	DOE DCG	2.6	47.3	14.5	40	DOE DW DCG
H-3	292	1870	500	20,000	NM Livestock Watering	NA	NA	NA		
Pu-238	0.039	7.61	0.227	40	DOE DCG	0.018	0.125	0.078	1.6	DOE DW DCG
Pu-239,240	0.022	24.77	1.05	30	DOE DCG	0.030	0.169	0.055	15	EPA Prim. DW Std
Sr-90	0.78	80.80	10	1000	DOE DCG	0.61	26.60	3.18	8	EPA Primary DW
U (µg/L)	0.11	146	3.39	800	DOE DCG	0.03	8.37	0.56	1.6	DOE DW DCG
U-234	0.055	136	5.59	500	DOE DCG	0.068	3.800	0.696	20	DOE DW DCG
U-235,236	0.064	10	0.589	600	DOE DCG	0.041	0.460	0.163	24	DOE DW DCG
U-238	0.176	134	5.985	600	DOE DCG	0.061	4.970	0.817	24	DOE DW DCG

[a]All data in pCi/L except where noted; [b]Standards for comparison only; [c]Am-241 data shown are by alpha spectrometry method only; [d]DW = drinking water; [e]NA = Not Analyzed; [f]DOE DW DCG = Derived Concentration Guide for drinking water systems. See Appendix B for additional information for water quality standards.

Radionuclide concentrations are significantly lower in filtered samples than in unfiltered samples, usually about an order of magnitude lower. Approximately 75% to 95% of the radioactivity in a runoff sample was typically associated with the suspended sediment (ash, clay, silt, etc.) carried by the runoff and, for the most part, are not dissolved in the runoff.

4.4.2 Comparison with Historical Concentrations

Figure 4-9 shows the minimum, maximum, and median concentrations of radionuclides in unfiltered runoff in 2000 and the maximum historical concentrations of radionuclides in unfiltered runoff. The 1997 through 1999 portion of the historical data set was chosen because it is the period when radionuclide data in storm water runoff were systematically collected at LANL. Maximum concentrations of all the target radionuclides in storm water runoff in 2000 were greater than historical maximums except for uranium. The peak concentrations of cesium-137 and strontium-90 were directly attributable to fire effects, while the peak concentrations of plutonium-238 and tritium were attributable to LANL facilities.

Cesium-137, plutonium-238, and strontium-90 have the largest increases in concentrations in unfiltered runoff in 2000 compared with previous years. The maximum concentration of cesium-137 observed in 2000 was 511 pCi/L compared to an historical maximum of 42.3 pCi/L, about an order of magnitude higher in 2000. This peak cesium-137 value was recorded upstream of the Laboratory and is fire related. The maximum concentration of plutonium-238 in 2000 was 7.61 pCi/L compared with a prefire maximum of 1.53 pCi/L, however the maximum concentration in 2000 was in a sample from TA-54, MDA-G runoff and was not related to the effect of fire. The maximum concentration of strontium-90 in 2000 was 80.8 pCi/L compared with a prefire maximum of 25 pCi/L; this value was seen in Guaje Canyon north of LANL and is attributable to fire impacts.

Figure 4-10 shows the minimum, maximum, and median concentrations of radionuclides in filtered runoff in 2000 and the maximum historical concentrations in filtered runoff. Maximum concentrations measured in 2000 were greater than Laboratory-wide historical maximums for cesium-137, strontium-90, and uranium. The maximum concentrations of other radionuclides were near or below historical maximum concentrations. The higher concentrations of cesium-137 dissolved in runoff in 2000 were in samples from TA-54, MDA-G and MDA-L, which were not related to the effects of fire.

The higher concentrations of dissolved uranium in 2000 were observed in fire-related runoff at onsite and downstream locations where uranium in suspended sediment materials may have had more of an opportunity to dissolve, possibly as the result of chemical changes of the water created by the presence of fire-related compounds.

The most universal increases from prefire levels were seen for both unfiltered and filtered runoff waters at locations upstream of the Laboratory. These increases reflect Cerro Grande Fire impacts. Figures 4-11a and b illustrate the relative increases in upstream, onsite, and downstream changes.

Figure 4-12 shows the median concentrations of radionuclides detected (greater than three times the uncertainty) in unfiltered runoff from downstream locations for the years 1997 through 2000. The median concentrations of most radionuclides in 2000 are lower than previous years, with the exception of strontium-90 and uranium, which were higher in 2000 than previous years. Strontium-90 concentrations were higher in 2000 due to higher concentrations in runoff from fire-impacted areas. The increased concentrations of uranium in runoff may be related to increased uranium concentrations in the ash from fire-impacted areas, geochemical changes in the runoff caused by increased concentrations of metals and inorganics in the ash (e.g., Longmire et al. 2001), and/or to LANL impacts from historical releases at some onsite and downstream locations. Median concentrations of cesium-137 and gross beta activity were higher in previous years while median concentrations of plutonium-238 and plutonium-239 were similar to those observed in previous years.

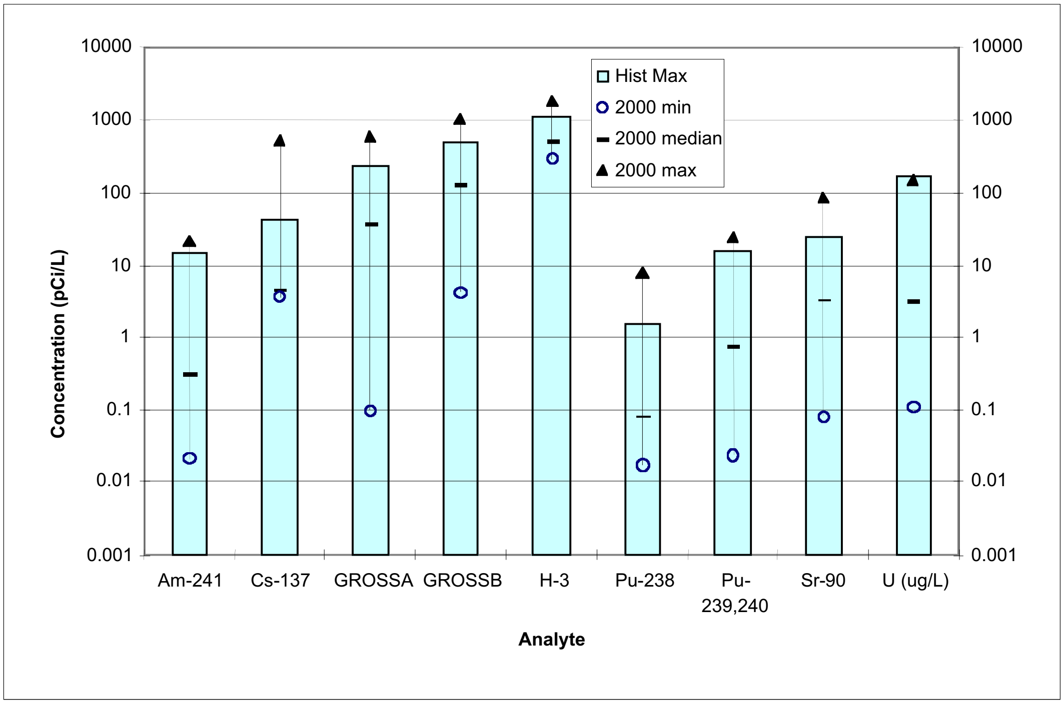


Figure 4-9. Radionuclides in unfiltered runoff in 2000 and historical maximum concentrations.

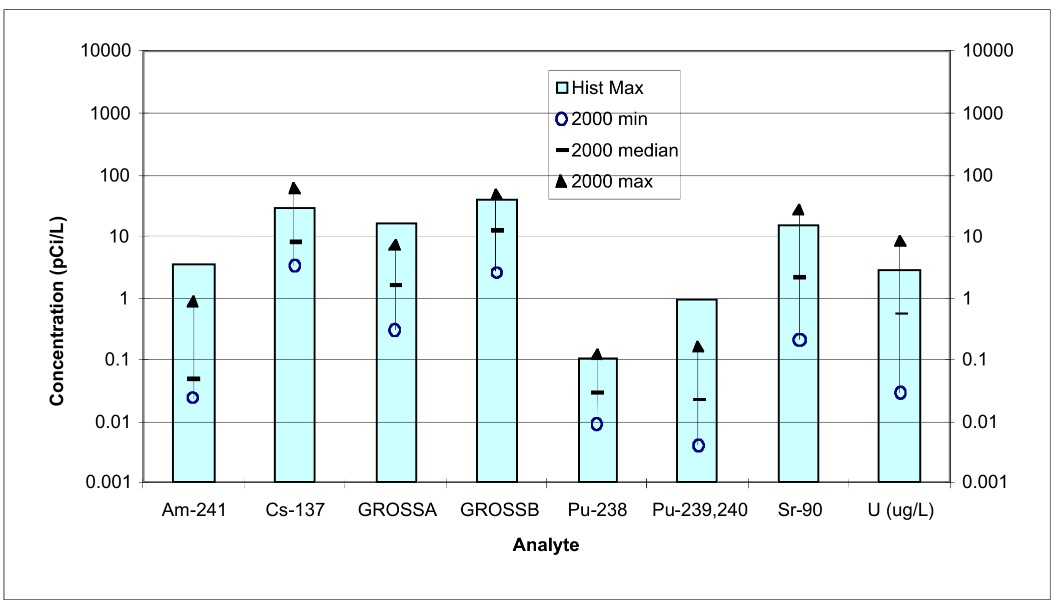


Figure 4-10. Radionuclides in filtered runoff in 2000 and historical maximum concentrations.

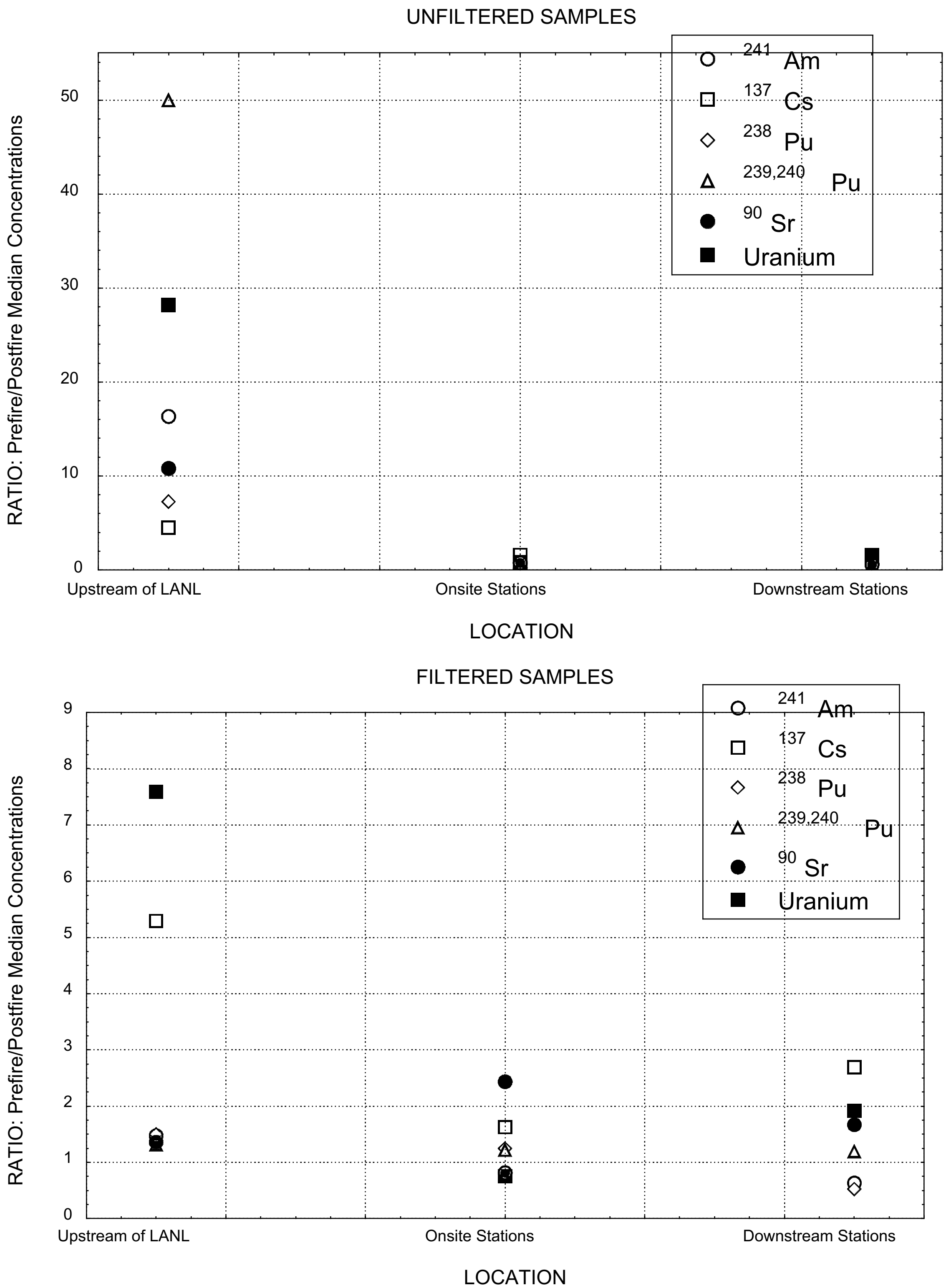


Figure 4-11a and b. Changes in radionuclide concentrations after the fire by proximity to LANL. The figure compares the ratio of median concentrations measured before and after the fire at upstream, onsite, and downstream stations. The largest increases are seen upstream of the Laboratory and are due to the fire.

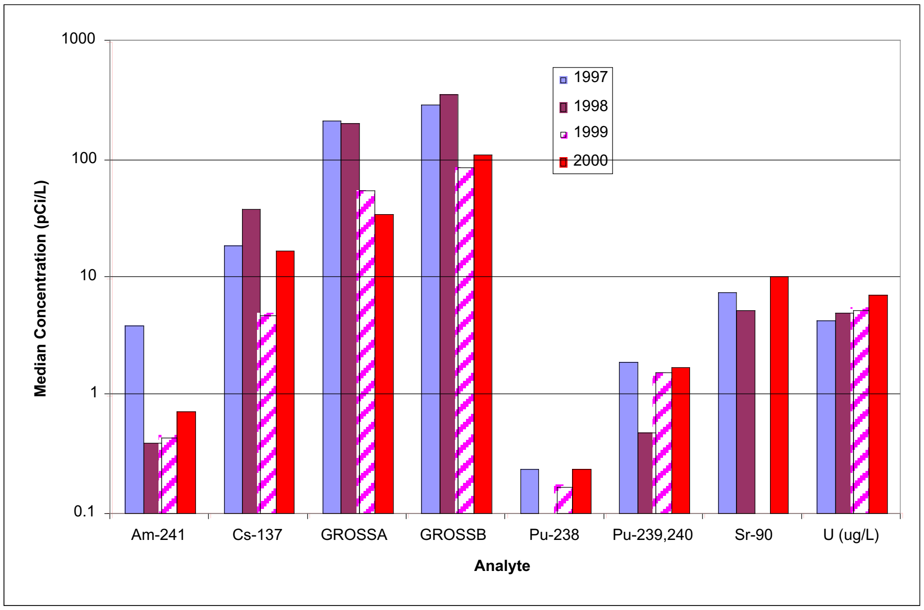


Figure 4-12. Median concentrations of radionuclides detected in unfiltered runoff at downstream locations, 1997–2000.

4.4.3 Comparison of Radionuclides to Standards

Water quality standards have not been established specific to most radionuclides in storm water, however activities of radionuclide concentrations in unfiltered storm water runoff samples can be compared to either the DOE DCGs for public exposure or the NMWQCC stream standards. The NMWQCC stream standards reference the New Mexico Environmental Improvement Board's New Mexico Radiation Protection Regulations (Part 4, Appendix A), however, New Mexico radiation protection activity levels are in general two orders of magnitude greater than the DOE DCGs for public dose, so only the DCGs are usually addressed. In addition, the results for unfiltered runoff samples are compared to NMWQCC standards for livestock watering.

Appendix Table B-3 shows the results of screening the radionuclide concentration in unfiltered runoff to the above noted standards and Figure 4-13 shows the summary of results for unfiltered runoff in 2000 and the minimum standards for unfiltered runoff comparison. In unfiltered samples, gross alpha concentrations were greater than public dose DCG levels (30 pCi/L) and State of New Mexico livestock watering standards (15 pCi/L) at many locations upstream and on the Laboratory. The gross alpha DCG is based on the most restrictive anthropogenic alpha emitters (plutonium-239,-240 and americium-241) and is commonly exceeded by runoff laden with naturally derived alpha emitters (such as the uranium; decay series). The New Mexico livestock standard excludes radon and uranium from the gross alpha limit. The gross beta activity DCG for public dose (1000 pCi/L) was not exceeded in runoff samples from LANL, but was slightly exceeded in one sample collected on July 17, 2000, from Rendija Canyon, which contained 1054 pCi/L with an uncertainty of 64 pCi/L.

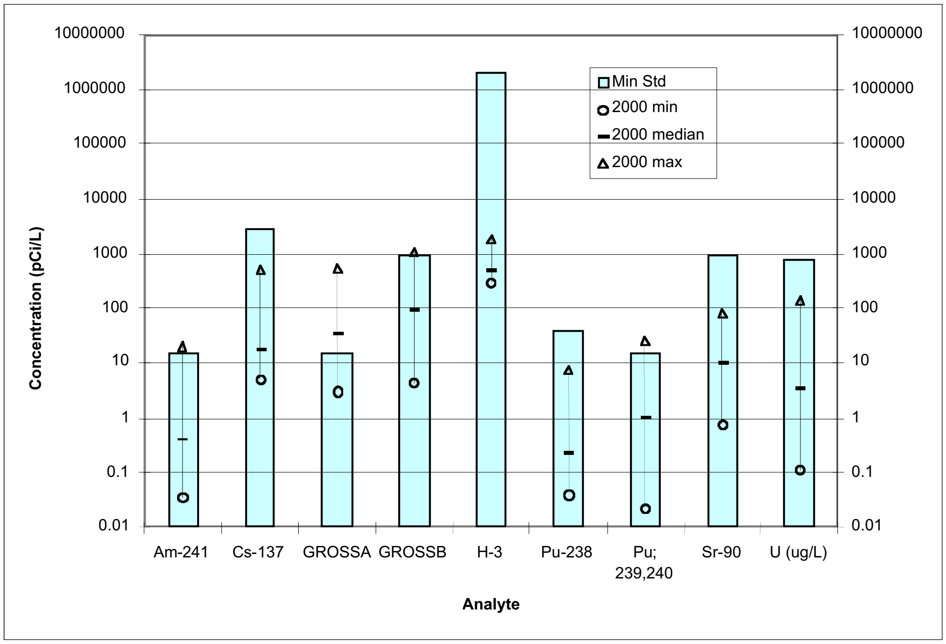


Figure 4-13. Summary of radionuclides in unfiltered runoff compared with minimum standards.

Of the specific alpha and beta emitters measured, none occurred in runoff samples at levels above their respective DCGs for public exposure. The maximum concentration of plutonium-239,240 was 24.77 pCi/L in a sample from lower Los Alamos canyon (gage E042) on July 9 during a low-flow runoff event. Samples collected in Pueblo Canyon on October 23 and 28 contained plutonium-239,240 in concentrations as high as 22.8 pCi/L. One runoff sample collected from lower DP Canyon on October 12 contained americium-241 in a concentration of 20.7 pCi/L.

Appendix Table B-4 shows the results of radionuclides in filtered water samples compared with EPA drinking water standards or DOE DCGs for drinking water systems. The drinking water standards are included only for perspective, as the standards are applicable only to community drinking water systems and not to runoff. Figure 4-14 shows the summary of dissolved radionuclides compared with minimum standards appropriate to filtered runoff. All filtered storm water runoff samples met EPA and DOE drinking water standards for specific radionuclides, except for one sample. The EPA primary drinking water standard for strontium-90 (8 pCi/L) was exceeded in one sample collected on July 21 from the Los Alamos Canyon weir construction site, where the concentration of dissolved strontium-90 was 26.6 pCi/L. The weir was installed in 2000 after the fire in lower Los Alamos Canyon as a sediment catchment structure. The “runoff” sample was collected from water pumped from the weir several days after a runoff event (see Koch et al. 2001). The source of the dissolved strontium-90 in this sample could be fire-related or from historical Laboratory releases. Dissolved strontium-90 concentrations generally were the highest of the individual radionuclides, relative to the standards; more than 10 samples contained dissolved strontium-90 levels that were greater than one-half the EPA drinking water standard (see Appendix Table B-4).

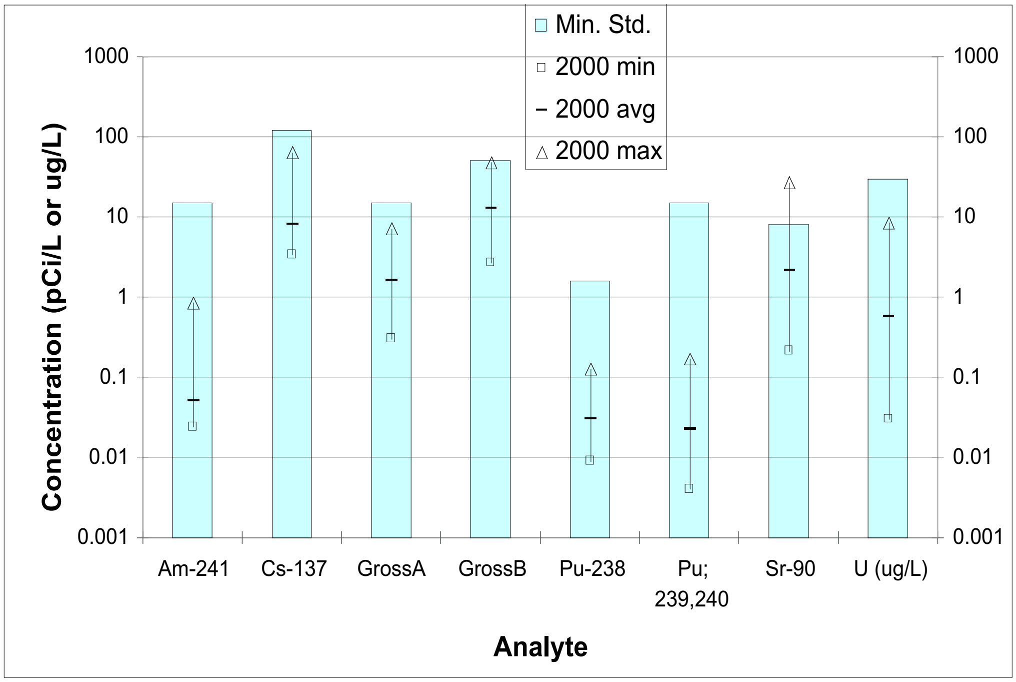


Figure 4-14. Summary of radionuclides in filtered runoff compared with minimum standards.

No samples contained gross alpha or gross beta activities greater than the EPA primary drinking water standards (15 pCi/L and 50 pCi/L, respectively). Dissolved concentrations of americium-241, cesium-137, plutonium-238, and plutonium-239,240 were not detected in concentrations more than the minimum standard values.

4.4.4 Radionuclides in Suspended Sediment

Because the suspended solids comprise such a large portion of the total radionuclide load in the runoff samples, the suspended sediment was investigated for significant levels of the individual radionuclides. The concentrations of radionuclides in the suspended sediment fraction of the runoff samples were calculated using the concentrations of radionuclides in the unfiltered runoff and the TSS concentrations. The calculations were performed for storm water runoff that had TSS concentrations greater than 300 mg/L and did not consider dissolved concentrations in the filtered runoff; therefore, the results are considered maximum concentrations of radionuclides in suspended sediment.

Table 4-5 shows the summary of the results of calculating radionuclide concentrations in suspended sediment at downstream locations and the historic maximum concentrations (1997 through 1999) and the sediment BVs developed for stream sediments at LANL (Ryti et al. 1998; McLin et al. in preparation). The sediment BVs are shown for comparison purposes only because the concentration of radionuclides in deposited stream sediments would be expected to be lower than what is calculated for the suspended sediment, which is selectively comprised of finer grained materials with higher radionuclide concentrations by weight (Johansen et al. 2001). Specific screening levels for radionuclides in suspended sediment in storm water runoff are not available so historical maximum concentrations measured and calculated for radionuclides in suspended sediment in runoff at downstream locations are shown in Figure 4-15 for comparison with the year 2000 downstream runoff.

Table 4-5. Calculated Concentrations of Radionuclides in Suspended Sediment in Downstream Runoff.

Analyte	Number of Calculations	Minimum (pCi/g)	Maximum (pCi/g)	Geometric Mean (pCi/g)	Sediment BV[a] (pCi/g)	Historic Maximum (pCi/g)
Am-241	17	0.006	1.044	0.10	0.04	2.427
Cs-137	19	0.018	9.478	1.15	0.9	6.370
Gross Alpha	20	3.429	64.773	15.0	14.8	96.491
Gross Beta	20	4.308	105.682	25.4	12.0	246.499
Pu-238	19	0.002	0.447	0.030	.006	0.281
Pu-239,240	19	0.015	4.049	0.258	.068	2.398
Sr-90	18	0.028	18.292	1.28	1.3	20.276
U (mg/kg)	22	0.131	14.767	1.15	2.22	6.439

[a]All background values from Ryti et al. (1998) except for gross alpha and gross beta values, which are from McLin et al. in prep.

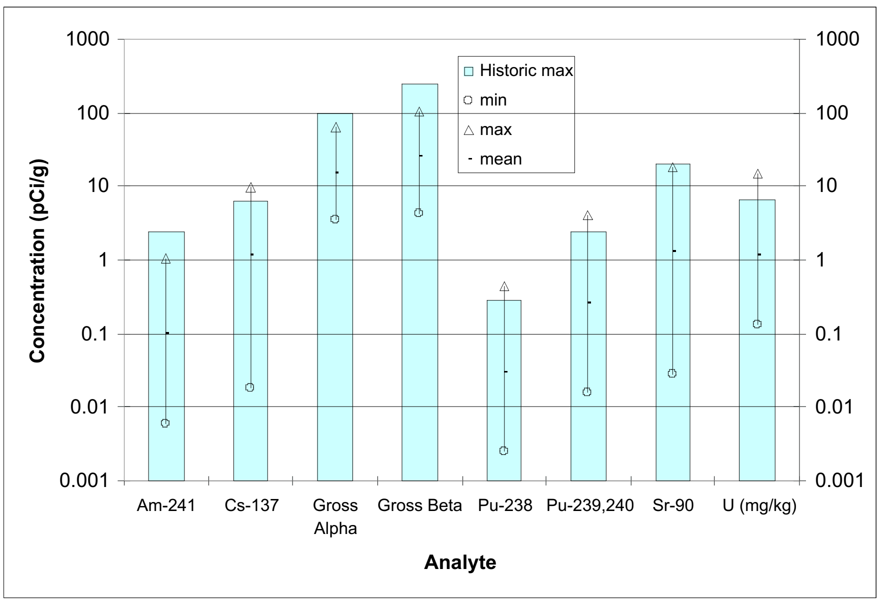


Figure 4-15. Calculated radionuclide concentrations in suspended sediment at downstream locations compared with historic maximum values.

The radionuclides present in higher concentrations in downstream suspended sediments than in previous years include cesium-137, plutonium-238, plutonium-239,240, and uranium. The suspended sediment containing the highest concentrations of cesium-137 was from lower Los Alamos Canyon (gage E042) in a sample collected on June 3. The highest concentrations of plutonium-238 and plutonium-239,240 were from a sample collected from lower Los Alamos Canyon (gage E042) on October 17. The highest concentration of uranium in downstream suspended sediment was from a sample collected in lower Pajarito Canyon (gage E250) on October 27.

Figure 4-16 shows the summary of the calculated radionuclides and uranium concentrations in suspended sediment at downstream locations compared with sediment BVs. Maximum concentrations of all analytes in suspended sediment are greater than the sediment BV, and mean concentrations of all analytes except strontium-90 and uranium are above the sediment BV.

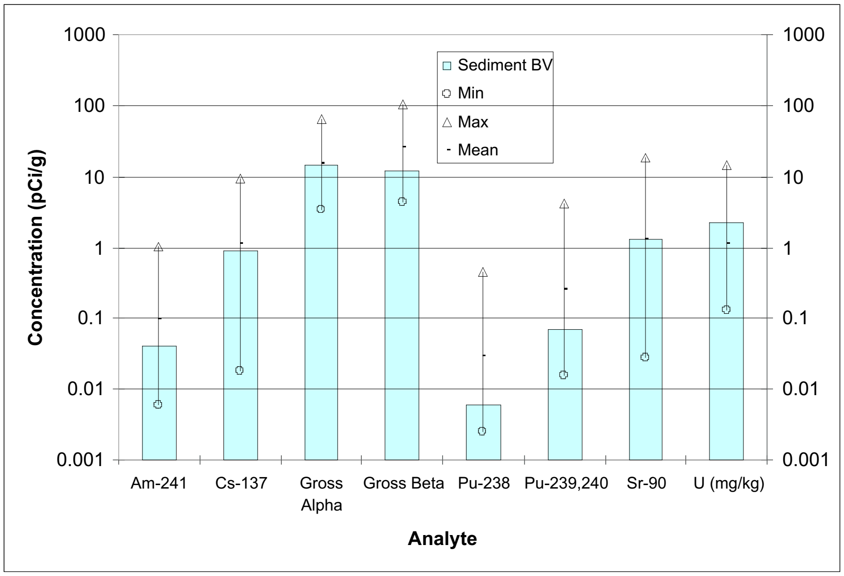


Figure 4-16. Calculated radionuclide concentrations in suspended sediment from downstream locations compared with sediment BVs.

From a public exposure perspective, cesium-137 is the radionuclide likely to be of most concern. Figure 4-17 shows the calculated concentrations of cesium-137 in suspended sediment in samples from upstream, onsite, and downstream locations and for one sample from Guaje Canyon.

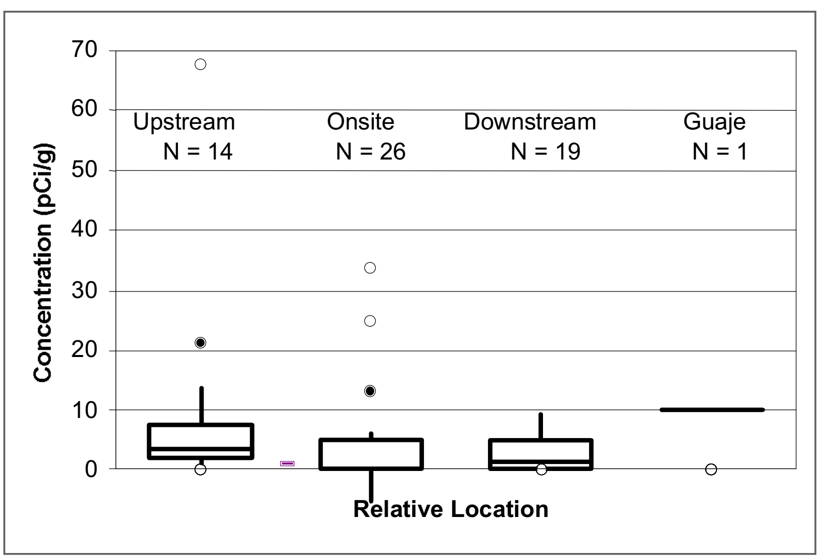


Figure 4-17. Cesium-137 in suspended sediment at upstream, onsite, and downstream locations.

The highest distribution of cesium-137 in suspended sediment was from samples collected at upstream locations, where the highest concentration was 67.5 pCi/g in a sample from Two-mile Canyon above SR 501 collected on October 23. The median concentration from upstream locations was 3.5 pCi/g. The highest concentration from onsite locations was 33.5 pCi/g in a mesa-top runoff sample from TA-54, MDA-L (gage E223) collected on October 7, and the median concentration from onsite locations was 0.4 pCi/g. The highest concentration of cesium-137 in suspended sediment collected from downstream locations was 9.4 pCi/g from lower Los Alamos Canyon (gage E042) on June 3, and the median value from downstream locations was 1.14 pCi/g. The higher suspended sediment concentrations observed at upstream locations in Pajarito Canyon may have at least partially dropped out of suspension in downstream runoff as a result of lowered stream gradients and runoff rates in the middle and lower part of the canyon.

Figure 4-18 shows the time series of calculated concentrations of cesium-137 in suspended sediment for samples from each major canyon system that was associated with flooding after the fire. For Los Alamos Canyon and Water Canyon, the highest concentrations are observed in early runoff events, and later runoff events contained generally lower concentrations of cesium-137 in suspended sediment. In Pajarito Canyon, however, the highest concentration was from Two-mile Canyon, a tributary to Pajarito Canyon on October 23, late in the season. Of the three major flood-related canyons at LANL, the lowest cesium; 137 concentrations in suspended sediment were from the Water Canyon system.

The higher concentrations of cesium-137 in suspended sediment commonly occurred in samples collected at the upstream boundary of LANL, where the radionuclides should be primarily derived from worldwide fallout. Because radionuclides concentrate in finer grained materials that tend to be held in suspension in runoff, the concentrations in stream sediment found in deposits after the runoff events will likely be substantially lower than in suspended sediment in the runoff samples.

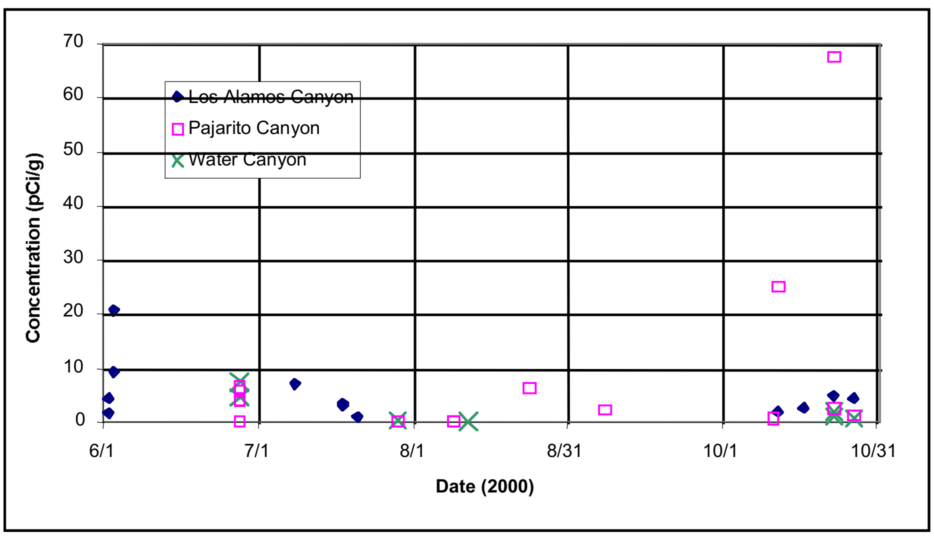
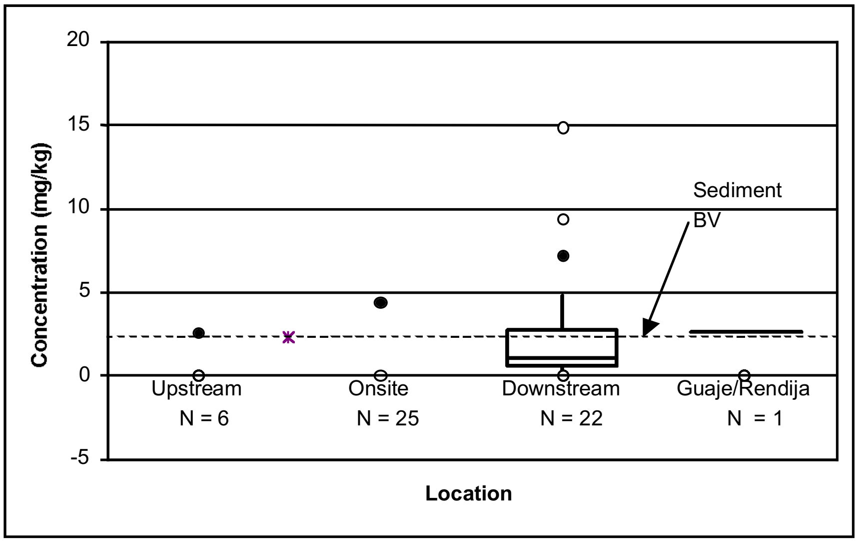


Figure 4-18. Time series of cesium-137 concentrations in suspended sediment.

The calculated uranium concentrations in suspended sediment for upstream, onsite, and downstream LANL locations and for one sample from Guaje Canyon are shown in Figure 4-19. The highest concentration of uranium in suspended sediment in storm water runoff was 14.77 mg/kg in a sample collected from lower Pajarito Canyon (gage E250) on October 27. The highest concentration from upstream locations was 2.57 mg/kg from upper Pajarito Canyon (former gage E240) collected on October 23, and the highest concentration from onsite locations was 4.38 mg/kg in a sample collected from TA-54,



BV = background value

Figure 4-19. Calculated concentrations of uranium in suspended sediment at upstream, onsite, and downstream locations.

MDA-G-4. The median concentrations at upstream, onsite, and downstream locations were 0.46, 1.35, and 1.0 mg/kg, respectively, which are lower than the background value for sediments at LANL (2.2 mg/kg) (Ryti et al. 1998). However, the concentrations of uranium in sediment deposits resulting from the runoff would be expected to be lower than the calculated values for suspended sediment.

The higher concentrations of uranium in suspended sediments from downstream sites likely result from Laboratory impacts, but may partially be due to higher natural background concentrations of uranium in Unit 1v of the Tshirege Member of the Bandelier Tuff, which are about three times higher than other units of the Bandelier Tuff (Ryti et al. 1998). Unit 1v outcrops in the central and eastern portions of the Pajarito Plateau and likely contributes a higher percentage of material to suspended sediment at downstream locations.

4.4.5 Transport of Radionuclides in Storm Water Runoff in 2000

The detection of trends in stream water quality is difficult when concentrations are related to stream flow, the usual situation. This difficulty is amplified after the fire with a more responsive hydrologic environment. To obtain an understanding of how transport of radionuclides along the Laboratory's downstream boundary trended through the runoff season, annual and monthly flow-weighted average concentrations were calculated and trended.

The flow-weighted average concentrations of selected radionuclides for years 1997 through 2000 at downstream stations are shown in Figure 4-20. Sufficient historical data for upstream stations are not available and flow-weighted averages were thus calculated for downstream stations only. These flow; weighted average concentrations for downstream stations may also represent the typical "load" of radionuclides in a unit volume of runoff potentially entering the Rio Grande from storm water runoff at LANL. The flow-weighted average concentrations of selected radionuclides at downstream locations for each month during 2000 after the Cerro Grande Fire are shown in Figure 4-21. The average of the prefire (1997 through 1999) yearly flow-weighted average concentrations (data shown in Figure 4-20) are also shown on Figure 4-21 for comparison purposes. Radionuclides that are observed in higher flow-weighted average concentrations in 2000 after the Cerro Grande Fire include cesium-137, plutonium-239,240, strontium-90, and uranium.

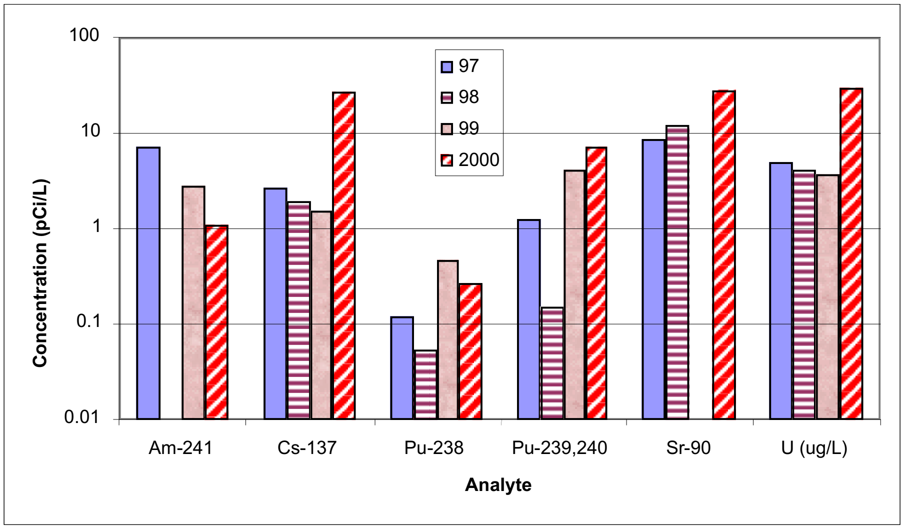


Figure 4-20. Annual flow-weighted average concentrations of radionuclides in downstream runoff, 1997–2000.

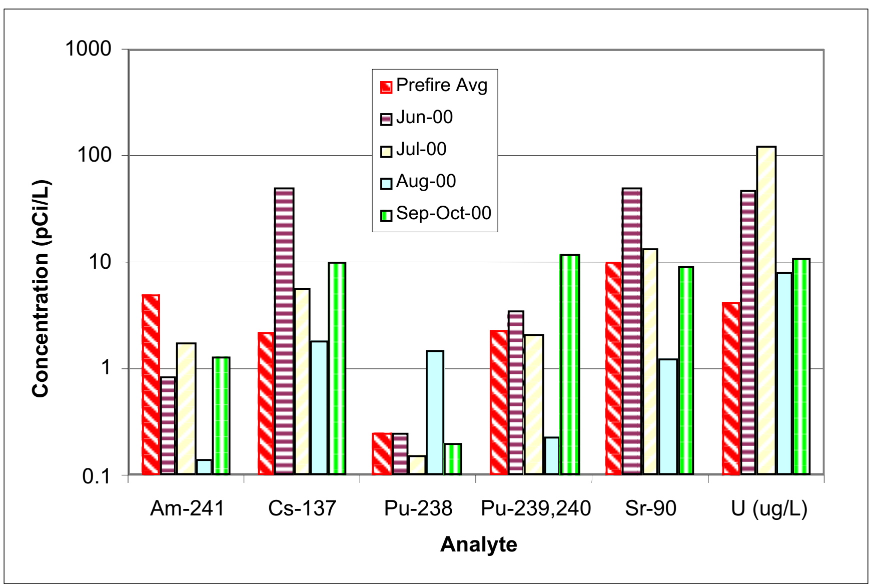


Figure 4-21. Monthly flow-weighted average concentrations of radionuclides in downstream runoff in 2000.

The radionuclide showing the largest increase in 2000 is cesium-137, which has a flow-weighted average concentration after the fire about one order of magnitude higher than before the fire. The measured concentrations of cesium-137 in runoff at downstream stations were not significantly different after the fire compared with prefire concentrations (see Appendix C, Section C.7), but the higher concentrations in the 2000 runoff were associated with large runoff events that raised the flow-weighted average concentrations. The higher flow-weighted average concentrations of cesium-137 were observed in June immediately following the fire (see Figure 4-21) and in October. The highest runoff volumes were observed during these two months (see Figure 3-3), and when the highest fire-related impacts to runoff are observed.

Plutonium-239,240 concentrations measured in downstream runoff in 2000 (see Appendix C, Section C.13) are slightly higher than observed in prefire runoff; the annual flow-weighted average concentration of plutonium-239,240 is also slightly higher in 2000 than for previous years. The observed variation in annual flow-weighted average concentrations before the fire is about one order of magnitude, while the increase in 2000 is slightly higher than the value for 1999; therefore, the significance of the relatively small increase in 2000 over the 1999 value is indeterminable. The highest flow-weighted average concentrations of plutonium-239,240 in 2000 after the fire are in June and October (Figure 4-21), similar to cesium-137 concentrations.

The annual flow-weighted average concentration of strontium-90 appears to be slightly higher in 2000 after the Cerro Grande Fire compared with prefire annual average data (Figure 4-20). In 2000, the highest flow-weighted average concentrations of strontium-90 are in June, directly after the fire, while the concentrations observed in July and October 2000 are similar to the prefire average annual concentration.

The prefire annual average flow-weighted concentration of uranium ranged from 3.8 to 4.8 μg/L (Figure 4; 20). In 2000 after the fire the flow-weighted average uranium concentration was 28.9 μg/L. The measured concentrations of uranium in runoff in 2000 (see Appendix C, Section C.15) do appear to have been significantly affected by the fire. The increase in the flow-weighted average concentration of uranium may be the result of increased runoff after the fire that carried higher masses of suspended sediment material and higher total masses of uranium. The higher monthly average flow-weighted uranium concentrations were in June and July directly after the fire (Figure 4-21), however, all monthly average flow-weighted concentrations of uranium in 2000 were higher than prefire annual averages (Figure 4-21).

The flow-weighted average concentrations of radionuclides are useful to evaluate radionuclide concentrations with respect to total flow volumes; however, it is also useful to examine the total activity of radionuclides that were measured at the downstream LANL stream gages. The total activity is obtained by multiplying the radionuclide concentration measured in each runoff event by the total flow measured for each runoff event and summing the results for each year. Figure 4-22 shows the total activity of radionuclides (in mCi) and uranium (in kg) that was measured at downstream locations in years 1997 through 2000 and that portion of the activity that is related to background concentrations of the radionuclides. The background activities are approximated by multiplying the background values derived for sediments at LANL (Ryti et al. 1998) by the total annual mass of suspended sediment measured at downstream locations. This underestimates the total mass attributable to background sediments because of the finer-grained material transported in storm water.

The radionuclides that show significant increased total activity at downstream locations in 2000 are cesium-137, plutonium-239,240, strontium-90, and uranium. The magnitude of the increase over that shown for flow-weighted averages (Figure 4-20) is due to the higher volumes of runoff experienced in 2000, largely resulting from increased runoff from fire-impacted areas, but also due to natural annual changes in precipitation and runoff (see Figure 3-3). The activity that passed downstream stations at LANL in runoff in 2000 for cesium-137 was 2.3 mCi, for plutonium-239,240 was 0.607 mCi, and for strontium-90 was 2.26 mCi. The mass of uranium that passed downstream was approximately 3 kg.

However, most of the uranium (89%) and strontium-90 (68%), about half of the cesium-137 (47%), and a portion of plutonium-239,240 (13%) is attributable to natural background concentrations in canyon sediments (Figure 4-22). The portion of the activity of radionuclides not attributable to background concentrations in suspended sediment is largely attributable to the effects of the Cerro Grande Fire for cesium-137, plutonium-239,240, and strontium-90. This is mainly due to contribution of the large ash;

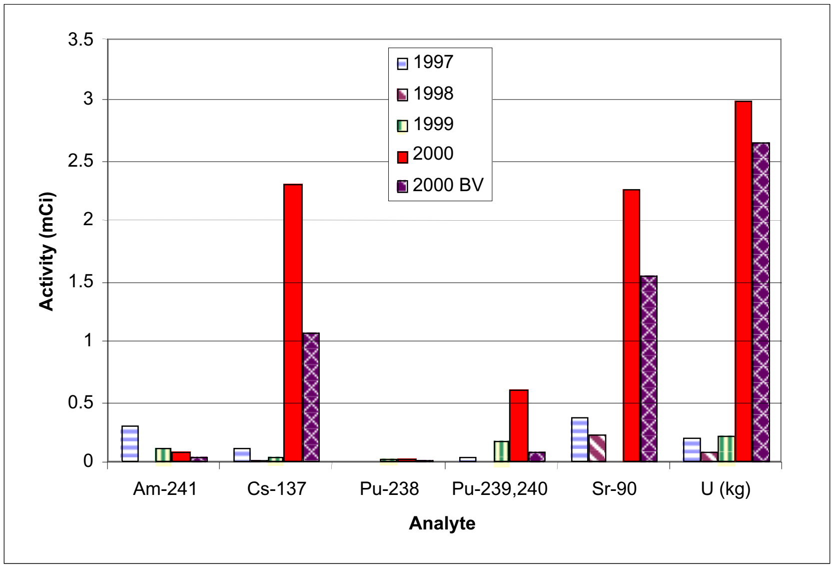


Figure 4-22. Total annual activity of radionuclides at downstream locations. The '2000 BV' bars show the minimum activities that are attributable to background radioactivity in stream sediments.

ladened June 28 runoff event in Water Canyon. However, because such a small portion of plutonium; 239,240 is attributable to fallout—in comparison with the other fallout radionuclides—much of the plutonium-239,240 in the Cerro Grande Fire runoff appears to be LANL-derived, likely from past air emissions (see Section 1.2).

4.4.6 Evidence for LANL-derived Plutonium-239,240 in Cerro Grande Fire Ash

Limited analyses of Cerro Grande Fire ash samples indicate that plutonium-239,240 levels are two to four times greater than in ash samples collected near the Viveash Fire, near Pecos, NM (Katzman et al. 2001). Because environmental conditions at the two fires were roughly comparable, these data suggest an excess of the isotope in the Cerro Grande samples, relative to Viveash. Thus, it is possible that some of the plutonium-239,240 measured in Cerro Grande Fire ash had its source as stack emissions from Laboratory facilities. Prefire soils data reported by the Environmental Surveillance Program support this interpretation by showing that Laboratory perimeter locations have three to four times the regional average for plutonium-239,240 (Fresquez et al. 1998).

The runoff data collected during 2000 appears to be consistent with a LANL contribution in the Cerro Grande ash. Of all the fallout radionuclides measured along the Laboratory's upstream boundary, plutonium-239,240 showed the greatest increase in concentrations (unfiltered waters). The median plutonium-239,240 concentration increased 50 times above prefire levels, while the other fallout radionuclides increased 5 to 15 times (Figure 4-11a and b. Changes in Radionuclide Concentrations After the Fire by Proximity to LANL). Relative to the other fallout radionuclides, the excess of plutonium; 239,240 may reflect LANL sources.

4.4.7 Summary of Radionuclides in Storm Water Runoff and Related Fire Impacts

Concentrations of several radionuclides in storm water runoff in 2000 after the Cerro Grande Fire were greater than Laboratory-wide prefire levels. Maximum prefire radionuclide concentrations in unfiltered runoff were exceeded for americium-241, cesium-137, gross alpha, gross beta, plutonium-238, plutonium-239,240, strontium-90, and tritium. However, the highest concentrations of americium-241, plutonium-238, and tritium were from locations that were not impacted by the fire (lower DP Canyon and TA-54, MDA-G-3 and TA-54, MDA-G-6, respectively) and probably are Laboratory-derived.

In contrast, higher concentrations of cesium-137, plutonium-239,240, and strontium-90 occurred in 2000 that were primarily related to runoff from areas impacted by the Cerro Grande Fire. The most pronounced increases in concentrations were observed for americium-241, cesium-137, and strontium-90, with samples exceeding the Laboratory-wide historical maximums by as much as 10 times. The increases in most of the radionuclide concentrations are attributable to two main factors: increased ash and sediment load in runoff and the enhanced constituent concentrations in the ash (see LANL 2000a; Katzman et al. 2001). There is a suggestion of possible fire-related impacts associated with uranium in runoff at upstream sites, however, the possible impacts are not conclusive due to the limited prefire data set with which to provide adequate comparison for postfire data.

The runoff data indicate that a total of approximately 9.6 mCi of strontium-90 entered the Laboratory from areas affected by the Cerro Grande Fire and a total of approximately 2.4 mCi left LANL in runoff at downstream locations. The data indicate that approximately 7.2 mCi of strontium-90 were deposited in canyon floor sediments at LANL, and most amounts were deposited in Water Canyon and Pajarito Canyon. The Los Alamos Reservoir in upper Los Alamos Canyon provided a catchment for runoff from burned areas in the upper watershed and may have trapped sediment and strontium-90 in the upper canyon, reducing the amount available to flow onto LANL.

Radionuclide concentrations were significantly lower in filtered samples than in unfiltered samples. About 75% to 95% of the radioactivity in a runoff sample was typically associated with the suspended sediments (ash, silt, clay, etc.) and carried by the runoff rather than dissolved in the water. An exception to this may be uranium, which was found in higher concentrations in the dissolved fraction after the fire.

Evidence for substantial fire impacts on runoff includes the following:

- The highest concentrations of some radionuclides, such as cesium-137 and strontium-90, were collected from locations located upstream of LANL or from Rendija and Guaje Canyons north of LANL.
- Gross alpha activities in unfiltered runoff upstream of LANL show that the storm water flowing onto the Laboratory after the fire contained about one order of magnitude higher levels than before the fire.
- Gross beta activities in unfiltered runoff upstream of LANL show that the storm water flowing onto the Laboratory after the fire contained about two orders of magnitude higher levels than before the fire.
- Cesium-137 and strontium-90 concentrations generally show a decline through the runoff season, presumably as the source of ash and muck on the hillsides upstream of LANL is depleted and the ash and muck in flood deposits are stabilized in bank deposits and/or flushed downstream.

The introduction of fire-derived radionuclides into most of the LANL watercourses apparently masked the impact of similar Laboratory-derived constituents. Essentially, the “background” levels for many constituents significantly changed as result of the addition of the ash in the runoff. For most of the canyon runoff samples collected in 2000, LANL impacts are not clearly discernible because of the higher radionuclide concentrations in the ash.

Consistent with prefire conditions, LANL impacts to storm water runoff are indicated in DP Canyon, around TA-54, MDA-G and in Los Alamos Canyon in early (June 2 and 3) runoff events. LANL impacts are identifiable in the first significant runoff events of the season in Los Alamos Canyon on June 2 and 3 (Johansen et al. 2001) and throughout the runoff season for plutonium-239,240. The concentrations of americium-241 and strontium-90 in lower DP Canyon and tritium in two samples from TA-54, MDA-G-6 have not previously been recorded and indicate LANL impacts. Higher concentrations in runoff at onsite and downstream locations of plutonium-238 in Los Alamos Canyon, Cañada del Buey, and Pajarito

Canyon and uranium in Los Alamos, Pajarito, and Water Canyons indicate a probable contribution from LANL activities.

In unfiltered samples, gross alpha concentrations were greater than public dose DCG levels (30 pCi/L) and State of New Mexico livestock watering standards (15 pCi/L) at many locations upstream and on the Laboratory. The gross alpha DCG is based on the most restrictive anthropogenic alpha emitters (plutonium-239,240 and americium-241) and is commonly exceeded by runoff laden with naturally derived alpha emitters (such as the uranium-decay series). The New Mexico livestock standard excludes radon and uranium from the gross alpha limit. The gross beta activity DCG for public dose (1000 pCi/L) was not exceeded in runoff samples from LANL, but was slightly exceeded in one sample collected on July 17, 2000, from Rendija Canyon, which contained 1054 pCi/L with an uncertainty of 64 pCi/L. Of the specific alpha and beta emitters measured, none occurred in runoff samples at levels above their respective DCGs for public exposure. However, the alpha-emitting radionuclides plutonium-239,240 and americium; 241 were measured in concentrations greater than 15 pCi/L (the NMWQCC livestock watering standard for gross alpha activity).

All filtered storm water runoff samples met EPA and DOE drinking water standards for specific radionuclides, except for one sample. The EPA primary drinking water standard for strontium-90 (8 pCi/L) was exceeded in one sample collected on July 21 from the Los Alamos Canyon weir construction site, where the concentration of strontium-90 was 26.6 pCi/L. The source of the dissolved strontium-90 in this sample could be fire-related or from historical Laboratory releases. Dissolved strontium-90 concentrations generally were the highest of the individual radionuclides, relative to the standards; more than 10 samples contained dissolved strontium-90 levels that were greater than one-half the EPA drinking water standard. Gross alpha activity dissolved in runoff samples was greater than the minimum standard (DOE drinking water DCG) of 1.2 pCi/L in 27 samples, but no samples contained concentrations greater than the EPA primary drinking water standard (15 pCi/L). Gross beta activity in filtered runoff was greater than the minimum standard (DOE drinking water DCG) of 40 pCi/L in four samples collected on June 28 during the high runoff event. Dissolved concentrations of americium-241, cesium-137, plutonium-238, and plutonium-239,240 were not detected in concentrations more than the minimum standard values.

Radionuclides that are observed in higher flow-weighted average concentrations in 2000 after the Cerro Grande Fire include cesium-137, plutonium-239,240, strontium-90, and uranium. Monthly flow-weighted average radionuclide concentrations in unfiltered runoff at downstream LANL shows that peak concentrations occurred in June and July, with 5- to 20-fold increases above prefire averages during these months for cesium-137, strontium-90, and uranium. Concentrations of these same constituents dropped considerably during August, September, and October. The decline in runoff concentrations is partly due to flushing of ash from the LANL drainages during June and July and the occurrence of less; intense, late season rainfall events in August, September, and October that largely missed the mountains west of the Laboratory.

The radionuclides that show significant increased total activity at downstream locations in 2000 are cesium-137, plutonium-239,240, strontium-90, and uranium. The activity in runoff that passed downstream stations at LANL in 2000 was 2.3 mCi of cesium-137, 0.607 mCi of plutonium-239,240, and 2.26 mCi of strontium-90. The mass of uranium that passed downstream was approximately 3 kg. However, most of the uranium (89%) and strontium-90 (68%), about half of the cesium-137 (47%), and a portion of plutonium-239,240 (13%) is attributable to natural background concentrations in canyon sediments. The portion of the activity of radionuclides not attributable to background concentrations in suspended sediment is largely attributable to the effects of the Cerro Grande Fire for cesium-137, plutonium-239,240, and strontium-90; however, the small increase in uranium not attributable to background concentrations is likely from LANL impacts.

4.5 Metals in Storm Water Runoff

4.5.1 Summary of Metals in Storm Water Runoff

The results of metals analyses of storm water runoff in 2000 are shown in Appendix Table B-5. Metals analyses were performed on a total of 85 unfiltered runoff samples and 57 filtered samples in 2000. Table 4-6 summarizes the number of analyses performed for each metal constituent and the numbers of detections and non-detections. Because duplicates of some samples were analyzed, results are available for more than 85 unfiltered and 57 filtered samples; the data in Table 4-6 represent the total number of results obtained for each metal constituent. On average, metals constituents were detected in 86% of unfiltered samples and in 68% of filtered samples.

Table 4-6. Summary of Metals Analyses in Storm Water Runoff in 2000.

	Unfiltered Samples				Filtered Samples			
Analyte	**No. Analyses**	**No. Non-Detects**	**No. Detects**	**% Detects**	**No. Analyses**	**No. Non-Detects**	**No. Detects**	**% Detects**
Ag	94	74	20	21%	56	49	7	13%
Al	94	0	94	100%	56	1	55	98%
As	94	14	80	85%	56	27	29	52%
B	90	1	89	99%	56	0	56	100%
Ba	94	0	94	100%	56	0	56	100%
Be	178	13	165	93%	112	62	50	45%
Cd	108	3	105	97%	70	51	19	27%
Co	94	0	94	100%	56	19	37	66%
Cr	94	2	92	98%	56	28	28	50%
Cu	94	0	94	100%	56	10	46	82%
Fe	102	0	102	100%	61	1	60	98%
Hg	74	51	23	31%	14	13	1	7%
Mn	94	0	94	100%	56	0	56	100%
Mo	94	40	54	57%	56	28	28	50%
Ni	94	0	94	100%	56	13	43	77%
Pb	110	0	110	100%	70	21	49	70%
Sb	108	33	75	69%	70	24	46	66%
Se	93	49	44	47%	24	20	4	17%
Sn	91	50	41	45%	57	42	15	26%
Sr	94	0	94	100%	56	0	56	100%
Ti	112	0	112	100%	70	4	66	94%
Tl	108	20	88	81%	70	41	29	41%
V	94	0	94	100%	56	0	56	100%
Zn	94	0	94	100%	56	7	49	88%
Totals/Avg.	2491	334	2157	86%	1461	458	1003	68%

The summary of metals concentrations in storm water runoff in 2000, including the minimum, maximum, median, and average concentrations of each metal detected in runoff samples are shown in Table 4-7. The results are shown graphically in box plots in Figures B-5a and b for unfiltered samples and in Figures B-6a and b for filtered samples.

Table 4-7. Summary of Detects of Metals in Storm Water Runoff in 2000.

	Unfiltered Samples				Filtered Samples			
Analyte	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Average (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Average (µg/L)
Ag	0.46	171.06	1.1	9.17	0.618	0.95	0.618	0.68
Al	73.4	995000	42200	81661	18	11500	323	871
As	2.98	137	13.9	24.2	2.96	12	4.35	5.30
B	5.58	317000	70.2	3726.7	8.28	190	43.7	59.0
Ba	24.8	20700	845	2483	7.81	550	76.2	102.3
Be	0.022	99.8	4.93	8.72	0.01	0.44	0.05	0.08
Cd	0.12	33.8	1.78	3.58	0.076	0.32	0.16	0.19
Co	0.761	475	25.2	43.4	1.02	11.3	3	3.75
Cr	1.09	510	21.5	47.8	0.39	5.73	1.01	1.24
Cu	2.68	607.1	45	80.3	1.64	9.8	3.49	4.26
Fe	283	560000	26400	59303	24.6	6910	201	492
Hg	0.016	1.333	0.16	0.294	0.011	0.011	0.011	0.011
Mn	60.5	102000	2680	10568	5.04	2000	140	374
Mo	1.47	82.793	3.4	7.9	1.71	16	5.4	6.6
Ni	1.9	826	31.2	59.5	1.04	10	2.54	3.61
Pb	0.085	1180	63.8	139.1	0.015	6.99	0.45	0.83
Sb	0.173	47.695	1.03	4.28	0.201	280	1.08	8.30
Se	2.19	56.693	6.97	12.73	2.94	4.1	3.85	3.69
Sn	2.38	561.977	3.73	47.56	2.38	3.45	2.38	2.47
Sr	17.5	6944.44	310	926	10.5	590	151	186
Ti	3.12	2980	419	637.4	1.12	157	7.09	11.61
Tl	0.019	47.595	0.54	3.26	0.019	4.1	0.09	0.30
V	1.6	654.24	48.4	95.1	0.97	12.2	3.1	3.6
Zn	2.94	3610	364	470	0.504	164	7.5	18.3

As with radionuclide constituents, the concentrations of metals in unfiltered runoff samples are typically higher than in the dissolved state. The metals constituents that were measured at much higher (about 200 times) concentrations in unfiltered samples compared with filtered samples include aluminum, lead, and iron. Most other metals were measured in concentrations in unfiltered runoff between about two times and 10 times higher in unfiltered samples compared with filtered samples. The increasing concentrations of most metals constituents in unfiltered runoff generally correspond with increasing TSS concentrations. Metals in unfiltered samples that do not have an apparent correlation with TSS concentrations include silver, mercury, molybdenum, and selenium; these constituents are usually measured at or near their respective detection limits in runoff.

4.5.2 Comparison with Historic Data

The metals concentrations measured in runoff in 2000 are compared with maximum historic concentrations to provide an assessment of metals in fire-related runoff with prefire maximum concentrations. Figure 4-23 shows the range of metals concentrations observed in unfiltered runoff in 2000 and the historic maximum metals concentrations observed from 1997 through 1999. The maximum concentrations of most metals constituents in unfiltered runoff in 2000 were higher than historically observed. Metals concentrations significantly higher (greater than an order of magnitude) in 2000 runoff include silver, boron, manganese, nickel, tin, strontium, and thallium. Metal constituents in unfiltered runoff that were not higher than historic maximums were mercury and selenium. Laboratory method detection limits for metals analyses in 2000 were lower than previous years, which likely influenced the results of metals that occur at or near detection limits such as mercury, antimony, and selenium.

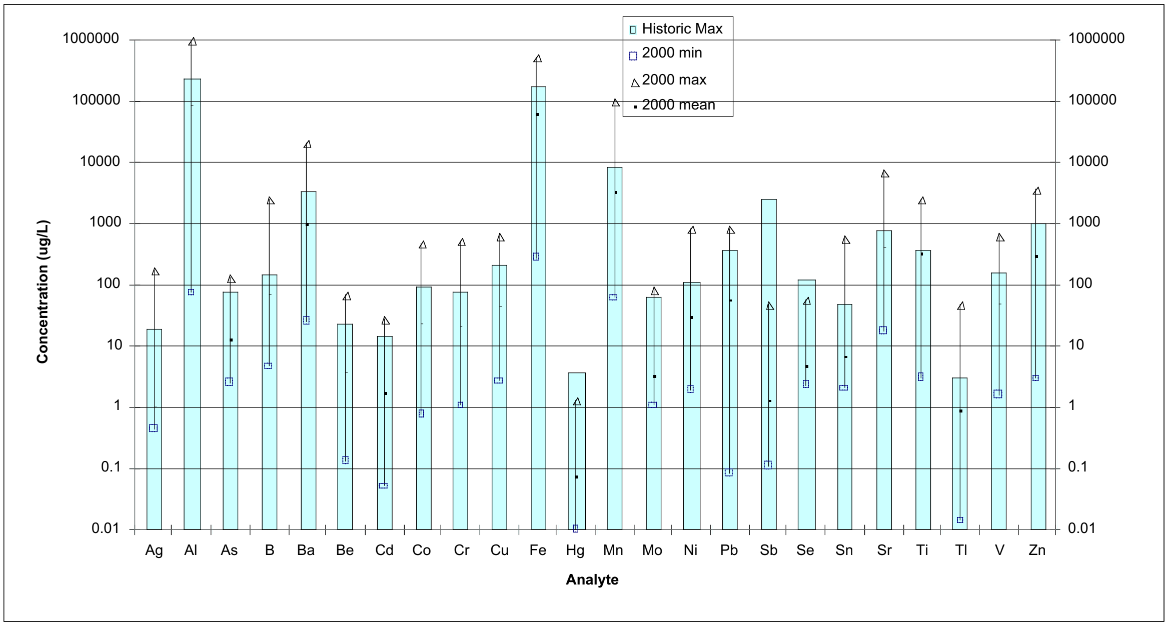


Figure 4-23. Metals concentrations in unfiltered runoff in 2000 compared with historic maximum concentrations.

Figure 4-24 shows the range of dissolved metals concentrations observed in runoff in 2000 and the historic maximum dissolved metals concentrations observed in filtered runoff from 1997 through 1999. The maximum concentrations of dissolved metals constituents in runoff in 2000 that were higher than historically observed include antimony, tin, titanium, and thallium. The concentrations of most metal constituents were lower than historically observed maximums, largely due to implementing laboratory methods utilizing lower detection limits in 2000. Dissolved mercury and selenium had not previously been detected in filtered historic runoff samples, but due to the lower detection methods used in 2000, dissolved mercury was detected in one sample and selenium was detected in four samples.

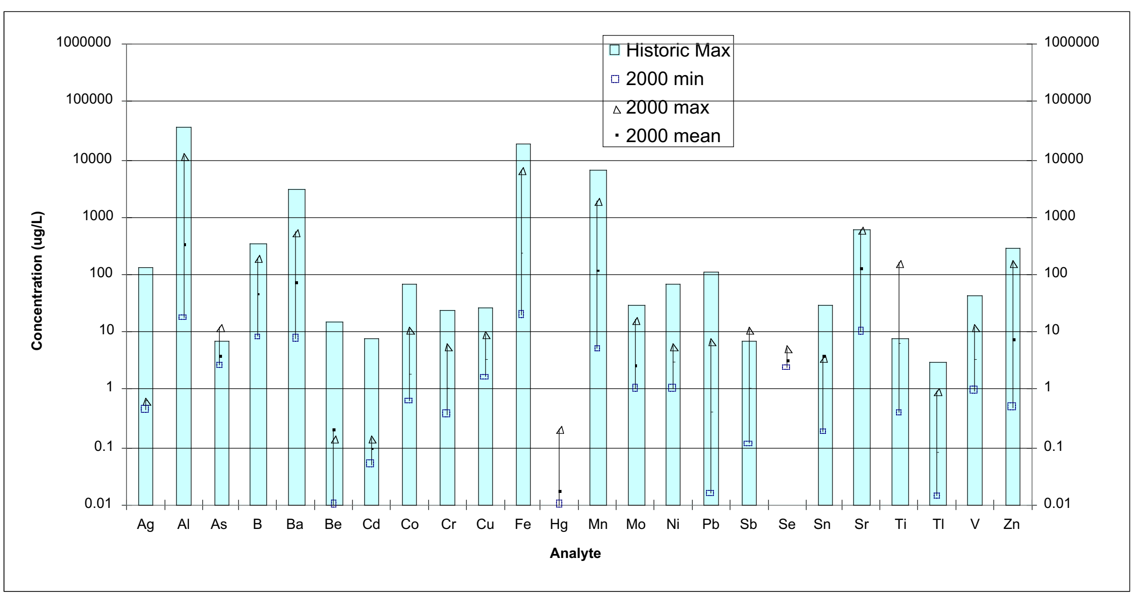


Figure 4-24. Dissolved metals concentrations in filtered runoff in 2000 compared with historic maximum concentrations.

4.5.3 Comparison with Standards

The concentrations of metal constituents in unfiltered storm water runoff may be compared with the NMWQCC livestock watering standards and the NMWQCC wildlife habitat standards. The quality of filtered storm water runoff may be compared against the NMWQCC groundwater standards because of the possibility of seepage of dissolved constituents from the streambed into underlying shallow groundwater. These standard values are included with the storm water data tables in Appendix Table B-5. Mercury and selenium concentrations in unfiltered runoff were greater than wildlife habitat standards (Figure 4-25).

Total mercury was measured above the wildlife habitat standard (0.77 µg/L) in 3 of 74 (4%) samples; all three were collected from storm water runoff in Pajarito and Water Canyons during the large runoff event of June 28. The highest concentration of mercury in unfiltered runoff was 1.33 µg/L from the upstream Pajarito Canyon stream gage (E240). The source(s) of the elevated mercury is not clear because it was found both onsite and above the Laboratory. There are recognized sources on LANL, natural soil mercury, as well as widespread atmospheric deposition from other sources distant from Los Alamos. Additional runoff and sediment testing in 2001 may provide more insight into this issue.

Total recoverable selenium was measured above the wildlife habitat standard of 5 µg/L in 21 of 79 (27%) samples, of which four were from upstream locations, five were from onsite locations, 10 were from downstream locations, and two were from Guaje and Rendija Canyons. The source(s) of the elevated selenium is not yet definitive. The distribution of these occurrences shows the presence of some natural selenium in the runoff. Selenium is commonly found in volcanic rich soils and rocks. LANL sources also may be present, in unknown quantities.

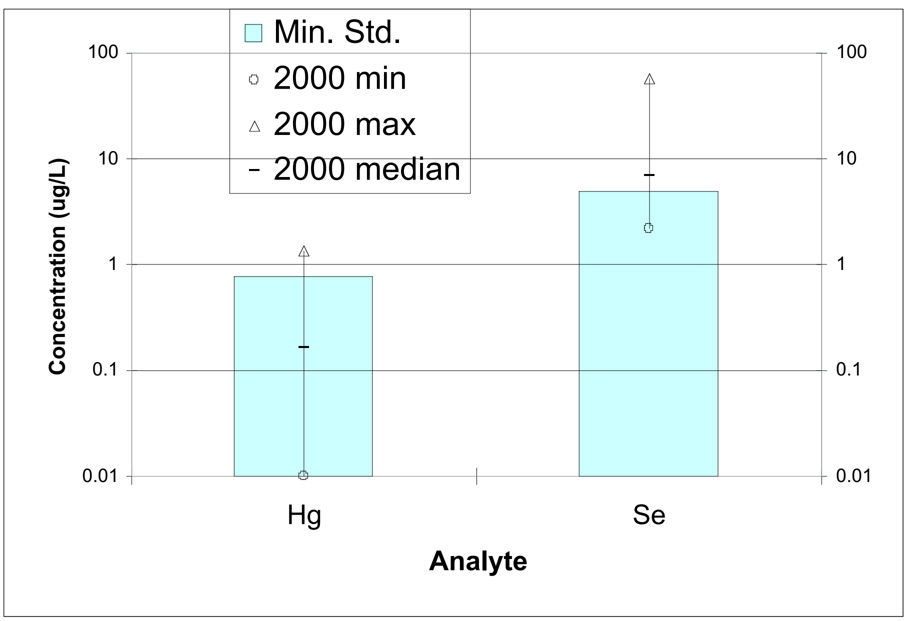


Figure 4-25. Mercury and selenium concentrations in unfiltered runoff in 2000 compared with minimum standard values.

Figure 4-26 shows the summary of metals dissolved in runoff and the comparison standards for filtered runoff. Dissolved metals that were measured in concentrations above minimum standard values were aluminum, iron, manganese, and antimony. All of these elevated levels are attributable to natural sources. Aluminum was measured above the New Mexico groundwater limit (5000 µg/L) in one sample collected from Starmer's Gulch above SR 501, an upstream location tributary to Pajarito Canyon, on October 23. Iron was measured above the groundwater limit (1000 µg/L) in six samples that included samples from three upstream locations, one onsite location, and two downstream locations. Most of the samples that contained dissolved iron above the standard were collected in October near the end of the runoff season.

Dissolved antimony was found in concentrations above the EPA primary drinking water standard (6 µg/L) in two samples. One sample collected from Rendija Canyon (ER3X site) on July 17 contained 10.7 µg/L and another sample collected from TA-54 MDA-G (gage E227) on August 18 contained 8.61 µg/L.

Dissolved manganese exceeded the New Mexico groundwater standard (200 µg/L) in nearly half of the filtered samples (26 of 56). Manganese has been shown to be present in runoff from fire-impacted areas in increased concentrations (e.g., Bitner et al. 2001, p. 7). Manganese is a natural component in plant tissue and surface soils. The substantial increase in dissolved levels after fires has been attributed to heat-induced physio-chemical breakdown of manganese complexed with organic matter (Chambers and Attiwill 1994). An increase of 279% in the concentrations of water-soluble manganese has been recorded after heating soil to 400˚C (Chambers and Attiwill 1994). At Los Alamos, samples containing the higher dissolved manganese concentrations were collected several hours or days after the runoff event.

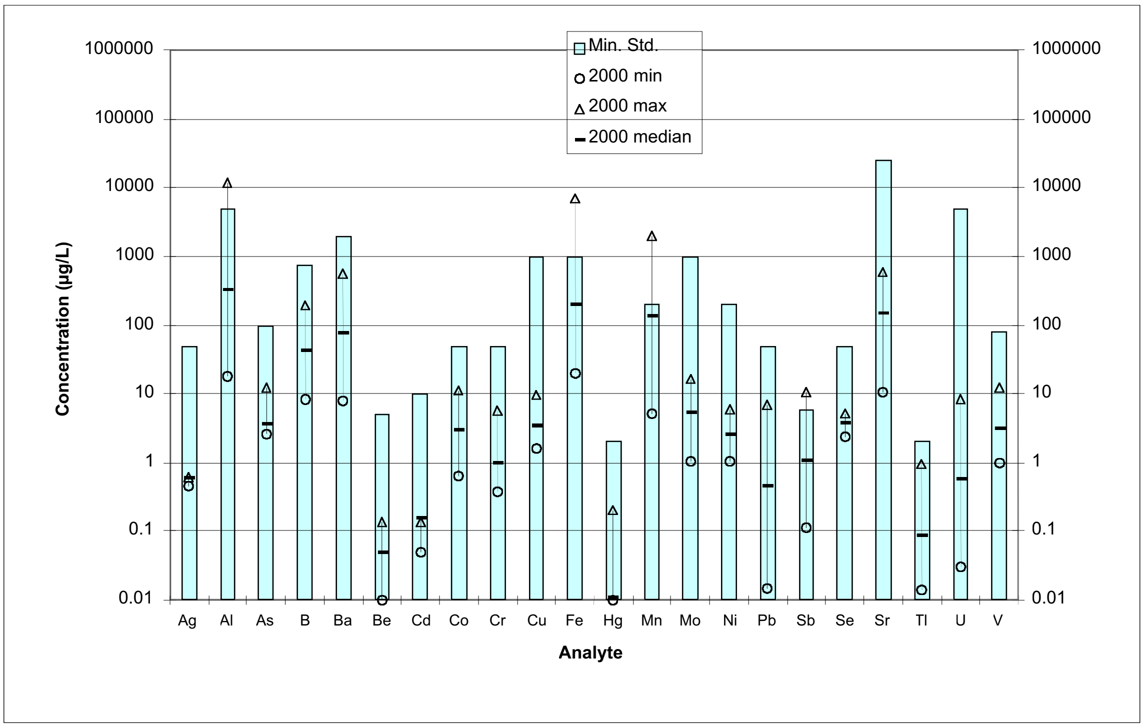


Figure 4-26. Dissolved metals concentrations in filtered runoff in 2000 compared with minimum standard values.

4.5.4 Metals in Suspended Sediment

Suspended solids comprise the major portion of the total metals load in the runoff samples and were therefore examined to determine if metals concentrations present in the suspended sediment were above screening levels. The concentrations of metals in the suspended sediment fraction of the runoff samples were calculated using the concentrations of metals in the unfiltered runoff and the TSS concentrations. Samples with TSS concentrations greater than 300 mg/L were used to calculate the suspended sediment concentrations, which comprised the majority of runoff events. These calculations did not consider dissolved concentrations in the filtered runoff; therefore, the results are considered maximum concentrations of metals in suspended sediment. Specific screening levels for storm water runoff are not available so relatively conservative screening levels for residential soil (EPA 2001) and sediment BVs (Ryti et al. 1998) were used to evaluate the metals concentrations in the suspended sediment fraction of the storm water runoff. The concentration of metals in stream sediments resulting from deposition from the runoff would be expected to be significantly lower than what is calculated for the suspended sediment.

Table 4-8 summarizes the results of the calculated metals concentrations in suspended sediment and shows the EPA screening levels and sediment BVs, and Figure 4-27 shows the summary of the results and the comparison with the screening levels. Metals with concentrations in the suspended sediment fraction of the runoff that were greater than screening levels include iron, manganese, and thallium. Of these, manganese and iron were most often encountered in concentrations above the screening levels and manganese was calculated in concentrations significantly higher than the screening level (see Figure 4-27). The majority of the runoff samples contain metals concentrations that meet the screening levels.

Table 4-8. Calculated Metals Concentrations in Suspended Sediment in Runoff in 2000.

Analyte	Number of Calculations	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	EPA Residential Soil SL [a] (mg/kg)	Number of Analyses > SL	Sediment Background Value [b]
Ag	60	0.012	13.16	0.24	390	0	1
Al	60	200.000	61787.56	10052.20	76000	0	15,400
As	60	0.170	18.54	2.99	22	0	3.98
B	60	0.845	321.83	15.64	5500	0	
Ba	60	25.360	2019.28	281.25	5400	0	127
Be	60	0.207	5.10	1.27	150	0	1.31
Cd	60	0.047	2.26	0.45	39	0	0.4
Co	60	0.324	25.25	6.20	3400	0	4.73
Cr	60	0.116	32.89	6.02	210	0	10.5
Cu	60	0.405	85.76	10.93	2900	0	11.2
Fe	60	510.204	42227.35	7555.43	23000	5	13,800
Hg	54	0.000	0.55	0.02	23	0	0.1
Mn	60	37.23	16991.67	973.47	3200	9	543
Mo	60	0.044	31.60	0.72	390	0	
Ni	60	0.378	43.12	8.47	1600	0	9.38
Pb	60	1.305	110.51	20.04	400	0	19.7
Sb	60	0.002	18.20	0.31	31	0	0.83
Se	58	0.098	19.20	1.04	390	0	0.3
Sn	59	0.044	214.50	1.50	47000	0	
Sr	60	31.373	2908.44	106.40	47000	0	
Ti	60	6.020	982.03	116.29			
Tl	60	0.003	18.17	0.24	6.3	2	0.73
V	60	0.351	67.55	14.38	550	0	19.7
Zn	60	2.514	877.19	74.18	23000	0	60.2

[a] EPA 2001; [b] Ryti et al. 1998

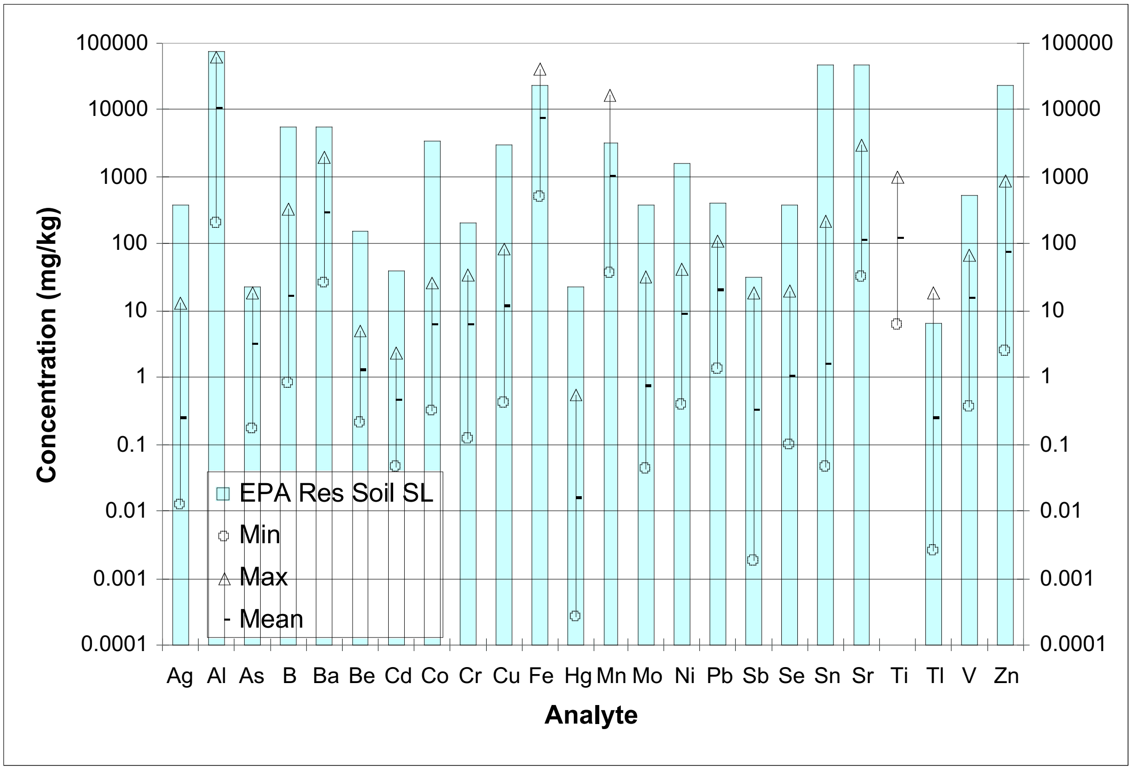


Figure 4-27. Summary of metals in suspended sediments compared with EPA residential soil screening level.

Iron was calculated to be above the screening level in 5 of 60 samples. The highest iron were in two samples collected during the high runoff event in lower Pajarito Canyon on June 28 at gage E250 and at the culvert at SR 4 (location E4SC), which contained calculated iron concentrations in suspended sediment of 33,125 and 44,227 mg/kg, respectively, about 1.4 and 1.8 times the screening level. Another runoff sample collected in lower Pajarito Canyon at gage E250 on October 23 contained 35,622 mg/kg, 1.55 times the screening level. Two other runoff samples containing iron in concentrations above the screening level were from TA-54, MDA-G-1 and G-2, collected on October 11, which contained iron in concentrations 1.16 and 1.20 times the screening level.

Manganese in suspended sediment was calculated in concentrations greater than the screening level in 9 of 60 runoff samples. Samples associated with storm water runoff (TSS >300 mg/L) that contained manganese concentrations above the screening level were collected on June 3 from upper Los Alamos Canyon at gage E025 (1.95 times the screening level), on June 28 in Pajarito Canyon at gages E242 (1.4x), E250 (3.7x), and ES4C (2.4x), Water Canyon at gages E252 (5.3x), E264 (1.4x), and E265 (1.1x), Cañon de Valle at gage E253 (2.9x), and on October 23 in upper Pajarito Canyon at gage E240 (1.4x). Manganese was identified as occurring in elevated concentrations in ash and muck after the fire (LANL 2000a), which is likely the source of elevated concentrations in the runoff suspended sediment.

Thallium in suspended sediment was calculated to be present in concentrations greater than the screening level in 2 of 60 samples. A sample collected on June 28 from Pajarito Canyon (gage E241) contained 2.8 times the screening level, and another sample collected on June 28 from upper Water Canyon (gage E252) contained 1.2 times the screening level.

The evaluation of metals in suspended sediment in runoff identified manganese as the metal likely to be of most concern from a public exposure perspective. The elevated concentrations commonly occurred in samples collected in Pajarito Canyon and Water Canyon both onsite and upstream of LANL, where the concentrations should be primarily derived from natural sources. Manganese concentrations calculated for suspended sediment in fire-related runoff samples were usually less than five times the screening level. Due to further downstream mixing, the concentrations in sediment found in deposits after the runoff events will likely be substantially lower than concentrations calculated for the runoff samples.

Figure 4-28 shows the summary of the calculated metals concentrations in suspended sediment compared with stream sediment BVs that have been derived for LANL (Ryti et al. 1998). Specific BVs for suspended sediments have not been determined and the concentrations of metals in suspended sediments in runoff is expected to be higher than in stream sediments due to the smaller particle sizes in runoff. The comparison with stream sediment BVs is shown here for evaluation purposes only. The concentration of metals in stream sediments resulting from deposition from the runoff would be expected to be significantly lower than what is calculated for the suspended sediment.

Maximum concentrations of all metals in suspended sediments are greater than sediment BVs, however, mean concentrations for most metals are less than the sediment BV. Metals with mean concentrations higher than the sediment BV include barium, cadmium, cobalt, manganese, lead, selenium, and zinc.

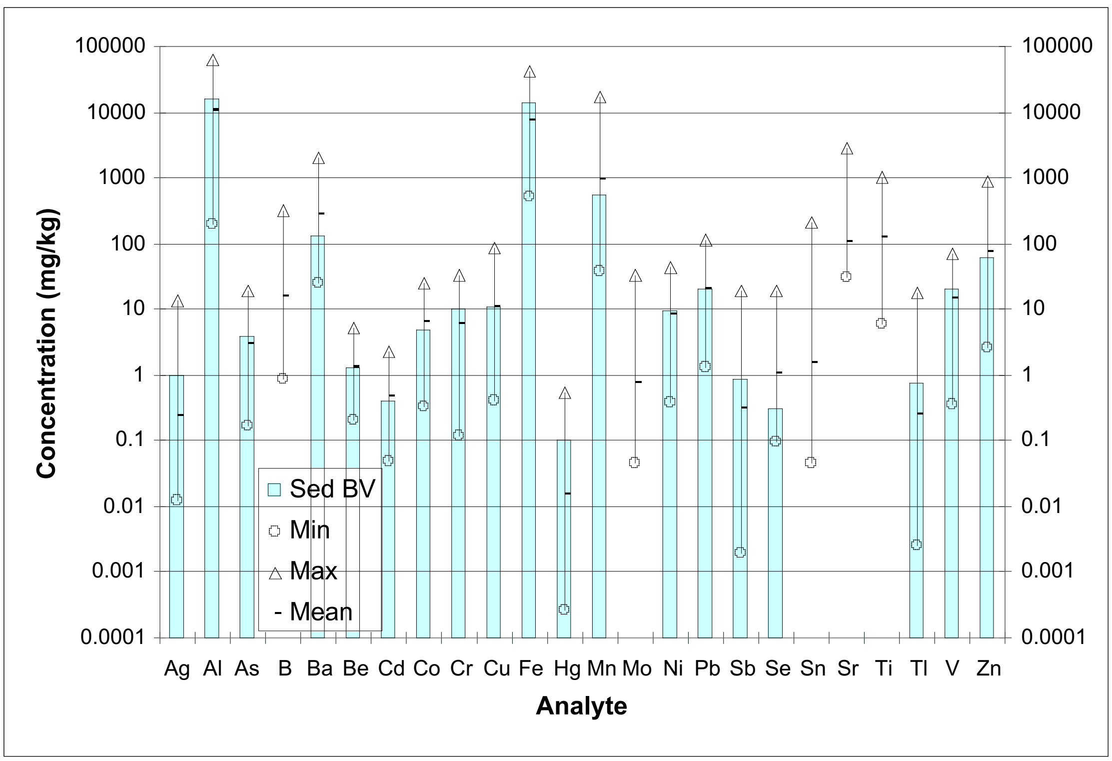


Figure 4-28. Summary of metals in suspended sediments compared with background values.

4.5.5 Transport of Metals in Storm Water Runoff

Figures 4-29a and b show the flow-weighted average annual concentrations of metals in storm water runoff at downstream LANL sites. Metals that have higher flow-weighted average concentrations in 2000 than previous years include silver, aluminum, arsenic, boron, barium, beryllium, cobalt, chromium, copper, iron, mercury, manganese, nickel, lead, antimony, tin, strontium, vanadium, and zinc. Metals that had higher flow-weighted concentrations in previous years include cadmium, molybdenum, and selenium. The higher flow-weighted average concentrations in 2000 are partially due to the higher flow volumes associated with runoff from fire areas and the higher concentrations of some metals observed in fire; related runoff.

Substantial increases occurred during 2000 in flow-weighted average metals concentrations of arsenic, boron, barium, chromium, copper, manganese, strontium, silver, vanadium, and zinc, compared to levels seen in the three years before the fire. Increases of 5 to 10 times above prefire levels were seen for most of these metals. In addition, concentrations of antimony, nickel, lead, and tin were twice the prefire concentrations in 2000.

The prefire average concentrations typically varied within about one-half an order of magnitude. Within these limited ranges, however, there is a suggestion of upward trends in some prefire metals concentrations over the three prefire years for which we have storm water runoff data. Average concentrations progressively increase for barium, beryllium, cobalt, nickel, lead, manganese, strontium, and zinc. The interpretation of this preliminary finding is not clear. Additional study is needed to determine if the indicated trends can be isolated to individual drainages.

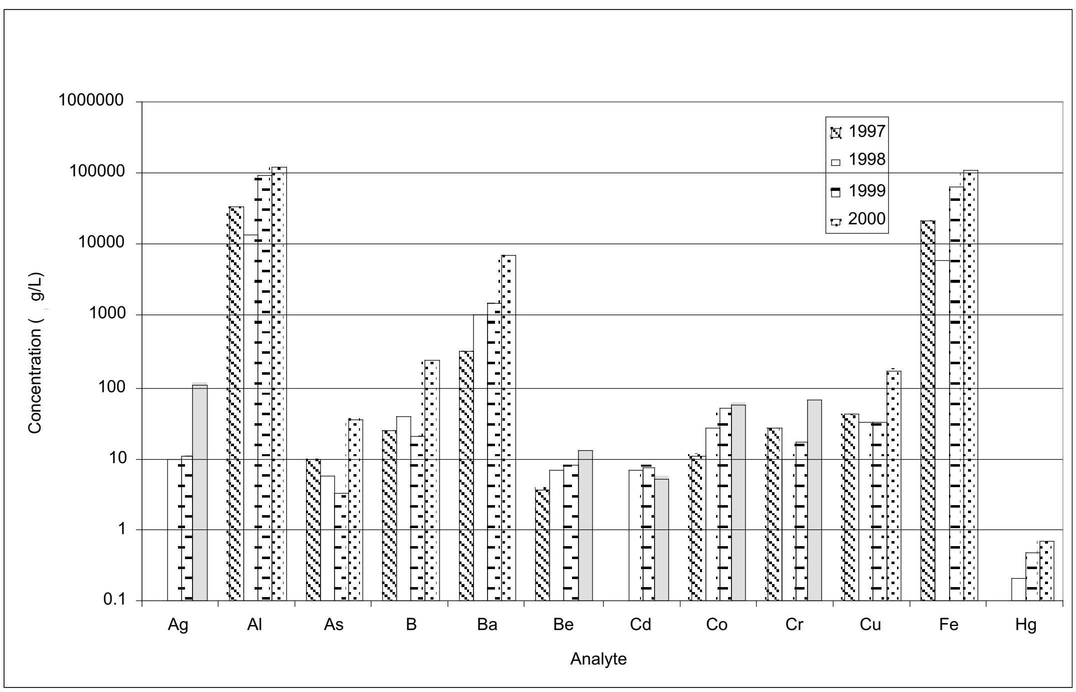


Figure 4-29a. Flow-weighted average annual concentrations of metals in unfiltered runoff at downstream sites.

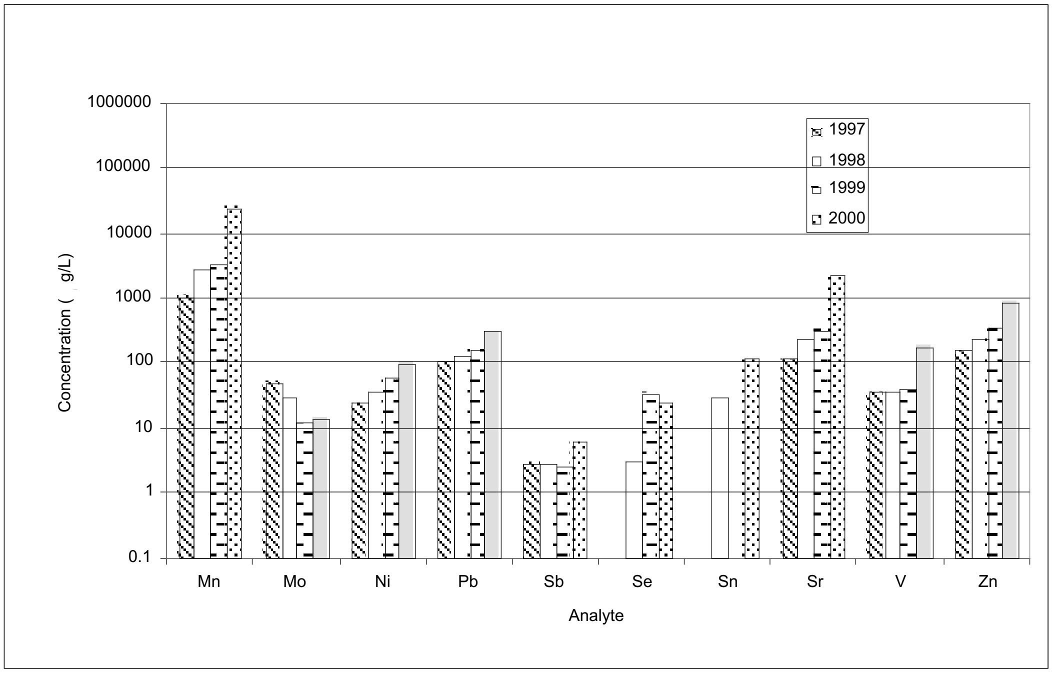


Figure 4-29b. Flow-weighted average annual concentrations of metals in unfiltered runoff at downstream sites (continued).

4.5.6 Summary of Metals in Runoff

The maximum concentrations of most metals constituents in unfiltered runoff in 2000 were higher than historically observed. Metals concentrations significantly higher (greater than an order of magnitude) in 2000 runoff include silver, boron, manganese, nickel, tin, strontium, and thallium. Metal constituents in unfiltered runoff that were not higher than historic maximums were mercury, antimony, and selenium. The maximum concentrations of dissolved metals constituents in runoff in 2000 that were higher than historically observed include antimony, tin, titanium, and thallium. The concentrations of most metal constituents were lower than historically observed maximums, largely due to implementing laboratory methods utilizing lower detection limits in 2000.

Maximum concentrations of metals constituents in unfiltered storm water runoff in 2000 that were greater than minimum standards include aluminum, barium, copper, mercury, lead, and selenium. Dissolved metals that were measured in concentrations above minimum standard values were aluminum, iron, and manganese.

Iron concentrations in unfiltered samples increased for a time in June and July immediately following the fire and decreased throughout the runoff season. However, dissolved iron concentrations in runoff in June and July were significantly lower than prefire concentrations, but increased throughout the runoff season, reflecting a geochemical change in the runoff created by the presence of ash and muck materials.

Manganese concentrations in unfiltered runoff were significantly higher in 2000 as the result of the presence of ash and muck from fire-impacted areas. Significantly higher dissolved manganese concentrations were noted in runoff samples collected several hours or days after the initial precipitation and runoff events, indicating that increased dissolved manganese concentrations were related to increased time that water was in contact with ash and muck materials.

Higher concentrations of silver in unfiltered runoff in 2000 are from relatively high runoff events generated from the fire-impacted areas. However, the higher silver concentrations tend to be from onsite and downstream locations and may be related to high-volume runoff transporting silver from historic LANL discharges in some canyons rather than to direct impacts from the Cerro Grande Fire. Strengthening the possibility that silver is Laboratory-derived is the observation that silver was largely not detected in samples from Guaje and Rendija Canyons, which showed high concentrations for most other metals and radionuclides.

Metal constituents that have higher flow-weighted average concentrations in 2000 than previous years include silver, aluminum, arsenic, boron, barium, beryllium, cobalt, chromium, copper, iron, mercury, manganese, nickel, lead, antimony, tin, strontium, vanadium, and zinc. The higher flow-weighted average concentrations in 2000 are principally due to the higher flow volumes associated with runoff from fire; impacted areas and to the higher concentrations of some metals observed in fire-related runoff.

Metals with concentrations in the suspended sediment fraction of the runoff that were greater than screening levels include iron, manganese, and thallium. Of these, manganese and iron were most often encountered in concentrations above the screening levels and manganese was calculated in concentrations significantly higher than the screening level. The majority of the runoff samples contain metals concentrations that meet the screening levels.

4.6 Organic Compounds in Storm Water Runoff

Table 4-9 summarizes the locations where we collected samples for organic analyses in 2000. (See Section 5.F.2.c. of the Environmental Surveillance report [LANL, 2001] for the analytical methods and analytes.) Samples were analyzed for VOCs and SVOCs. Some samples were also analyzed for HE constituents, PCBs, and dioxins/furans. Table 4-10 shows organic compounds detected in runoff in 2000 above the analytical laboratory's reporting level. PCBs and dioxins/furans were not found in runoff above analytical detection limits.

HE compounds detected include HMX, RDX, Tetryl, and several isomers of nitrobenzene and nitrotoluene. Except for HMX and RDX, these compounds were detected only in the large runoff event of June 28. When performing the analyses on the June 28 samples, however, the commercial analytical laboratory noted substantial matrix interferences because of the high ash content in these samples (Lab quality code = X, see Table 4-10), and these values are suspect. Most of these HE compounds were detected in samples collected upstream or in canyons north of the Laboratory. Trace (sub-part per billion) levels of HMX and RDX also were detected in a runoff sample collected in lower Water Canyon at SR 4 (gage E265) in late October. HMX and RDX have previously been detected in surface water and spring discharges in this drainage system at comparable levels (e.g., LANL 1998, p. 131).

Detections of SVOCS included bis(2-ethylhexyl)phthalate, benzoic acid, benzyl alcohol, 2; methylnapthalene, and pyridine. The benzoic acid, benzyl alcohol, and pyridine are thought to be products of combustion of forest fuels. Benzoic acid was detected throughout the runoff season in many fire-impacted drainages, and pyridine was detected in Guaje Canyon, north of the Laboratory. There is no definitive source for the bis(2-ethylhexyl)phthalate, but this compound is commonly recognized as introduced in analytical laboratory analysis.

The one VOC detected in runoff in 2000 was 1,4-Dichlorobenzene. The three detections of this compound were at levels very near the analytical detection limit, and samples were collected from locations upstream of the Laboratory. Detections of all of organic chemicals except one were at concentrations below the EPA Region 6 screening values for tap water (EPA 2001). One runoff sample from TA-54 MDA-G station G-4 contained bis(2-ethylhexyl)phthalate at a concentration approximately three times larger than the EPA screening level.

Table 4-9. Samples Collected for Analysis of Organic Compounds, HE Compounds, and PCBs.

Sample Date	Location Synonym	HEXP[a]	PEST/PCB	SVOC	VOC
6/2/00	E030		7	71	
6/2/00	E040		7	71	
6/3/00	E025		7	71	
6/3/00	E042		7	71	
6/28/00	E18C		7	81	
6/28/00	E240	28	7	101	
6/28/00	E241		7		
6/28/00	E242		7	81	
6/28/00	E250	28	7	91	
6/28/00	E252			10	
6/28/00	E253	28	7	81	
6/28/00	E264	28	7	91	
6/28/00	E265	28	7	91	
6/28/00	ES4C	28	7	91	
7/9/00	E042	28	7	81	
7/9/00	EGS4	28	7	81	
7/16/00	E122		7		
7/17/00	E223		7	81	
7/18/00	E025		7	71	
7/21/00	ELAW		7	70	
7/25/00	E039			70	
7/29/00	E227	14	7	70	
7/29/00	E230		7	70	
7/29/00	E248	14	7		
7/29/00	E265	14	7		
8/9/00	E221		7		
8/9/00	E227		7		
8/9/00	E248	14	7	10	
8/9/00	E248.5		7		
8/9/00	E267		7		
8/12/00	E265	14			
8/18/00	E248.5	14	7	80	31
8/18/00	E265	14	7	80	31
8/31/00	ELAR	14	7	80	
8/31/00	EULR	14	7	80	
9/8/00	E240	14	7	80	31
9/8/00	EGS4	14	7	80	31
9/12/00	E025	14	7	80	31
10/7/00	E223		8		
10/11/00	E247		8		
10/11/00	E248		8		
10/11/00	E248.5		8		
10/12/00	E249.5			74	
10/23/00	E042			10	
10/23/00	E230	14		10	
10/23/00	E240	14	7	80	31
10/23/00	E252	14	7	82	31
10/23/00	E253	14	7	81	31
10/23/00	E265	14	8	80	31
10/23/00	M2417	14		80	31
10/23/00	M2436	14	7	80	31
10/24/00	E250	14	8	80	31
10/27/00	E250	14			
10/27/00	E263	14		10	
10/28/00	E230	14			

[a]HEXP = high explosive compounds; PEST/PCB = pesticides/ polychlorinated biphenyls; SVOC = semivolatile organic compounds; VOC = volatile organic compounds

Table 4-10. Organic Compounds Detected in Runoff Samples in 2000[a].

Location Name	Date	Fld Prep	Lab Sample Type	Suite	Analyte	Result	MDL	Units	Lab Qual Code	Lab Code
Pajarito Canyon above SR 501	6/28	UF	CS	HEXP	2,4,6-Trinitrotoluene	0.44	0.035	µg/L	X	PARA
Indio Canyon at SR 4	6/28	UF	CS	HEXP	2,4,6-Trinitrotoluene	0.38	0.035	µg/L	X	PARA
Cañon del Valle above SR 501	6/28	UF	CS	HEXP	4-Amino-2,6-dinitrotoluene	1.3	0.08	µg/L	X	PARA
Water Canyon below SR 4	6/28	UF	CS	HEXP	4-Amino-2,6-dinitrotoluene	1.3	0.08	µg/L	X	PARA
Pajarito Canyon at SR 4 Culvert	6/28	UF	CS	HEXP	4-Amino-2,6-dinitrotoluene	1.9	0.08	µg/L	X	PARA
Indio Canyon at SR 4	6/28	UF	CS	HEXP	4-Amino-2,6-dinitrotoluene	1.2	0.08	µg/L	X	PARA
Pajarito Canyon above SR 501	6/28	UF	CS	HEXP	4-Amino-2,6-dinitrotoluene	2.8	0.08	µg/L	X	PARA
Indio Canyon at SR 4	6/28	UF	CS	HEXP	HMX	2.2	0.041	µg/L		PARA
Indio Canyon at SR 4	6/28	UF	RE	HEXP	HMX	2.2	0.041	µg/L		PARA:
Cañon del Valle above: SR 501	6/28	UF	CS	HEXP	2-Amino-4,6-dinitrotoluene	1	0.061	µg/L	X	PARA:
Pajarito Canyon above: SR 501	6/28	UF	CS	HEXP	2-Amino-4,6-dinitrotoluene	1.3	0.061	µg/L	X	PARA:
Cañon del Valle above: SR 501	6/28	UF	CS	HEXP	Tetryl	8.1	0.076	µg/L	X	PARA:
Indio Canyon at SR 4	6/28	UF	CS	HEXP	Tetryl	3.7	0.076	µg/L	X	PARA:
Pajarito Canyon at SR 4: Culvert	6/28	UF	CS	HEXP	Tetryl	18	0.076	µg/L	X	PARA:
Cañon del Valle above: SR 501	6/28	UF	CS	HEXP	2-nitrotoluene	1.4	0.069	µg/L	X	PARA:
Cañon del Valle above: SR 501	6/28	UF	CS	HEXP	Nitrobenzene	5.6	0.04	µg/L	X	PARA:
Pajarito Canyon above: SR 501	6/28	UF	CS	HEXP	Nitrobenzene	13	0.04	µg/L	X	PARA:
Indio Canyon at SR 4	6/28	UF	CS	HEXP	Nitrobenzene	4	0.04	µg/L	X	PARA:
Water Canyon below SR 4	6/28	UF	CS	HEXP	3-Nitrotoluene	2.7	0.031	µg/L	X	PARA:
Pajarito Canyon at SR 4: Culvert	6/28	UF	CS	HEXP	3-Nitrotoluene	3	0.031	µg/L	X	PARA:
Pajarito Canyon above: SR 4	6/28	UF	CS	HEXP	1,3,5-trinitrobenzene	2.6	0.049	µg/L	X	PARA:
Pajarito Canyon at SR 4: Culvert	6/28	UF	CS	HEXP	1,3,5-trinitrobenzene	4.2	0.049	µg/L	X	PARA:
Water Canyon below SR 4	6/28	UF	CS	HEXP	1,3,5-trinitrobenzene	5.7	0.049	µg/L	X	PARA
Water Canyon below SR 4	6/28	UF	CS	HEXP	1,3-Dinitrobenzene	1.9	0.078	µg/L	X	PARA
Guaje Canyon at SR 502	7/9	UF	CS	HEXP	1,3,5-trinitrobenzene	1.5	0.049	µg/L	X	PARA
Water Canyon at SR 4	10/27	UF	CS	HEXP	RDX	0.76	0.0221	µg/L		GELC
Water Canyon at SR 4	10/27	UF	CS	HEXP	HMX	0.52	0.0261	µg/L		GELC:
Los Alamos Canyon at: Los Alamos	6/3	UF	CS	SVOC	Benzoic Acid	690	40	µg/L		PARA:
Los Alamos Canyon at: Los Alamos	6/3	UF	CS	SVOC	Benzoic Acid	250	16	µg/L		PARA:
Pajarito Canyon at TA-18: Culvert	6/28	UF	CS	SVOC	Benzoic Acid	1900	120	µg/L		PARA:
Pajarito Canyon above: SR 501	6/28	UF	CS	SVOC	Benzoic Acid	1800	84	µg/L		PARA:
Starmer's Gulch at TA-22	6/28	UF	CS	SVOC	Benzoic Acid	1300	82	µg/L		PARA
Pajarito Canyon above SR 4	6/28	UF	CS	SVOC	Benzoic Acid	1300	95	µg/L		PARA
Guaje Canyon at SR 502	7/9	UF	CS	SVOC	Pyridine	16	3	µg/L		PARA
Los Alamos Canyon near Los Alamos	7/9	UF	CS	SVOC	Bis(2-ethylhexyl)phthalate	1.9	1.1	µg/L		PARA
Guaje Canyon at SR 502	7/9	UF	CS	SVOC	Benzoic Acid	67	5.2	µg/L		PARA
Los Alamos Canyon at Los Alamos	9/12	UF	CS	SVOC	Bis(2-ethylhexyl)phthalate	1.4	0.32	µg/L		GELC

Table 4-10 (Cont.)

Location Name	Date	Fld Prep	Lab Sample Type	Suite	Analyte	Result	MDL	Units	Lab Qual Code	Lab Code
G-4	10/12	UF	CS	SVOC	Bis(2-ethylhexyl)phthalate	5.3	0.32	µg/L		GELC
G-4	10/12	UF	CS	SVOC	Bis(2-ethylhexyl)phthalate	13.1	0.32	µg/L		GELC
G-4	10/12	UF	CS	SVOC	2-Methylnaphthalene	3.6	0.15	µg/L		GELC:
Starmer's Gulch above: SR 501	10/23	UF	CS	SVOC	Benzyl Alcohol	31.6	0.23	µg/L		GELC:
Starmer's Gulch above: SR 501	10/23	UF	CS	SVOC	Benzoic Acid	111	2.76	µg/L		GELC:
Water Canyon above: SR 501	10/23	UF	CS	SVOC	Benzoic Acid	43.8	2.76	µg/L		GELC:
Cañon del Valle above: SR 501	10/23	UF	CS	SVOC	Benzoic Acid	46.4	2.76	µg/L		GELC:
Two-mile Canyon above: SR 501	10/23	UF	CS	SVOC	Benzoic Acid	457	2.76	µg/L	D	GELC:
Pajarito Canyon above: SR 501	9/8	UF	CS	VOC	1,4-Dichlorobenzene	0.18	0.118	µg/L		GELC:
Guaje Canyon at SR 502	9/8	UF	CS	VOC	1,4-Dichlorobenzene	0.22	0.118	µg/L		GELC:
Los Alamos Canyon at: Los Alamos	9/12	UF	CS	VOC	1,4-Dichlorobenzene	0.12	0.118	µg/L		GELC:

HEXP = high explosive compounds; SVOC = semivolatile organic compounds; VOCs = volatile organic compounds; CS = client sample; UF = unfiltered sample; X = matrix interference from high ash content.; D = Sample diluted to facilitate analysis; PARA = Paragon Analytics, Inc.; GELC = General Engineering Laboratory

Oil and grease analyses were performed on seven storm water runoff samples collected in 2000. Table 4-11 lists the results of the analyses for oil and grease. Oil and grease were detected in estimated concentrations in four of the seven analyses. Three of the samples containing oil and grease in the storm water runoff were from TA-54 MDA-G and one sample from the Pajarito Canyon retention pond in middle Pajarito Canyon.

Table 4-11. Results of Oil and Grease Analysis of Runoff in 2000.

Sample Date	Sample Id	Fld Prep	Analyte	Sym	Result	Units	MDL	Lab Qual	Method
29-Jul-00	G-6	UF	Oil & Grease	<	1.95	mg/L	1.95	U	EPA:413.1
29-Jul-00	G-2	UF	Oil & Grease		3.53	mg/L	1.95	J	EPA:413.1
29-Jul-00	Water Canyon below SR 4	UF	Oil & Grease		3	mg/L	1.84	J	EPA:413.1
15-Aug-00	G-4	UF	Oil & Grease		3.05	mg/L	1.75	J	EPA:413.1
18-Aug-00	Cañada del Buey at SR 4	UF	Oil & Grease	<	1.73	mg/L	1.73	U	EPA:413.1
24-Aug-00	Pajarito Retention Structure	UF	Oil & Grease		2.99	mg/L	1.91	J	EPA:413.1
12-Oct-00	G-4	UF	Oil & Grease	<	3.39	mg/L	3.39	U	EPA:413.1

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Appendix A. Storm Water Runoff Samples Collected at LANL in 2000 after the Cerro Grande Fire.

Sample Date	Gage - Location	Sample ID	Sample Prep	Number of Analyses Results						
				General Water Chemistry	High Explosive Compounds	Metals	Pesticides - PCBs	Radio; nuclides	Semi-Volatile Organic Compounds (SVOCs)	Volatile Organic Compounds (VOCs)
6/2/00	E030	PS00061E030	UF	12		31	7	51	71	
6/2/00	E030	PS00062E030	UF	1						
6/2/00	E040	PS00061E040	UF	11		31	7	51	71	
6/2/00	E040	PS00062E040	UF	1						
6/2/00	E042	PS00061E042	UF	11		31		51		
6/2/00	E042	PS00062E042	UF	1						
6/3/00	E025	PF00061E025	F	4		31		51		
6/3/00	E025	PS00061E025	UF	12		31	7	51	71	
6/3/00	E025	PS00062E025	UF	1						
6/3/00	E042	PF00063E042	F	4		31		51		
6/3/00	E042	PS00063E042	UF	12		31	7	53	71	
6/3/00	E042	PS00064E042	UF	1						
6/28/00	E18C	PF00061E18C	F	8		55		51		
6/28/00	E18C	PS00061E18C	UF	13		26	7	130	81	
6/28/00	E18C	PS00062E18C	UF	3						
6/28/00	E240	PF00063E240	F	4		31		51		
6/28/00	E240	PS00063E240	UF	13	28	25	7	92	101	
6/28/00	E240	PS00064E240	UF	2						
6/28/00	E241	PF00061E241	F	4		31		51		
6/28/00	E241	PS00061E241	UF	14		26	7	96		
6/28/00	E241	PS00062E241	UF	2						
6/28/00	E242	PF00065E242	F	4		31		51		
6/28/00	E242	PS00065E242	UF	13		25	7	54	81	
6/28/00	E242	PS00066E242	UF	2						
6/28/00	E250	PF00061E250	F	4		31		52		
6/28/00	E250	PS00061E250	UF	13	28	27	7	92	91	
6/28/00	E250	PS00062E250	UF	2						
6/28/00	E252	PS00061E252	UF	13		26		95	10	
6/28/00	E252	PS00062E252	UF	3						
6/28/00	E253	PS00061E253	UF	13	28	25	7	92	81	
6/28/00	E253	PS00062E253	UF	2						
6/28/00	E263	PS00061E263	UF					3		
6/28/00	E264	PF00061E264	F					90		
6/28/00	E264	PS00061E264	UF	15	28	32	7	89	91	
6/28/00	E264	PS00062E264	UF	2						
6/28/00	E265	PF00061E265	F	4		31		90		
6/28/00	E265	PS00061E265	UF	13	28	25	7	92	91	
6/28/00	E265	PS00062E265	UF	2						
6/28/00	EPG1	PF00061EPG1	F					51		
6/28/00	EPG1	PS00061EPG1	UF	2				92		
6/28/00	EPG1	PS00062EPG1	UF	2						
6/28/00	ES4C	PF00065ES4C	F	4		31		53		
6/28/00	ES4C	PS00065ES4C	UF	15	28	25	7	92	91	
6/28/00	ES4C	PS00066ES4C	UF	2						
7/9/00	E042	PF00071E042	F	4		32		54		
7/9/00	E042	PS00071E042	UF	21	28	56	7	127	81	
7/9/00	E042	PS00072E042	UF	2						
7/9/00	EGS4	PF00071EGS4	F	4		32		51		
7/9/00	EGS4	PS00071EGS4	UF	13	28	32	7	125	81	
7/9/00	EGS4	PS00072EGS4	UF	2						
7/15/00	E223	GS00071E223	UF	3		8				
7/15/00	E223	PS00071E223	UF	12		24				
7/15/00	E223	PS00072E223	UF	2						
7/16/00	E122	PS00071E122	UF	2			7			
7/17/00	E122	GS00073E122	UF	2		8				
7/17/00	E122	PS00073E122	UF	11		24		57		
7/17/00	E122	PS00074E122	UF	2						
7/17/00	E196	GS00071E196	UF			8				
7/17/00	E196	PS00071E196	UF	11		24		52		
7/17/00	E196	PS00072E196	UF	2						

Sample Date	Gage - Location	Sample ID	Sample Prep	Number of Analyses Results: General Water Chemistry	High Explosive Compounds	Metals	Pesticides - PCBs	Radio-nuclides	Semi-Volatile Organic Compounds (SVOCs)	Volatile Organic Compounds (VOCs)
7/17/00	E223	GF00073E223	F			8:				
7/17/00	E223	GS00073E223	UF	2		8			10:	
7/17/00	E223	PS00073E223	UF	4			7	52	71:	
7/17/00	E223	PS00074E223	UF	2:						
7/17/00	ER3X	GF00071ER3X	F			8:				
7/17/00	ER3X	PF00071ER3X	F	4		24		51:		
7/17/00	ER3X	PS00071ER3X	UF	12		48		67:		
7/17/00	ER3X	PS00072ER3X	UF	3:						
7/18/00	E025	GF00071E025	F			8:				
7/18/00	E025	GS00071E025	UF	4		16:				
7/18/00	E025	PF00071E025	F	4		24		57:		
7/18/00	E025	PS00071E025	UF	11		24	7	57	71:	
7/18/00	E025	PS00073E025	UF	2				55:		
7/19/00	E025	PS00072E025	UF	2:						
7/19/00	E025	PS00074E025	UF	2:						
7/21/00	ELAW	GF00071ELAW	F	1		25		67:		
7/21/00	ELAW	GS00071ELAW	UF	8		52	7	120	70:	
7/21/00	ELAW	GS00072ELAW	UF	1:						
7/25/00	E039	GF00071E039	F	1		25:				
7/25/00	E039	GS00071E039	UF	5		26			70:	
7/25/00	E039	GS00072E039	UF	2:						
7/29/00	E227	GF00071E227	F	1		25		68:		
7/29/00	E227	GS00071E227	F	2:						
7/29/00	E227	GS00071E227	UF	10	14	26	7	66	70:	
7/29/00	E227	GS00072E227	UF	2:						
7/29/00	E230	GF00081E230	F	1		25:				
7/29/00	E230	GS00081E230	F	1:						
7/29/00	E230	GS00081E230	UF	13		26	7	1	70:	
7/29/00	E230	GS00082E230	UF	2:						
7/29/00	E248	GF00071E248	F	1		25		65:		
7/29/00	E248	GS00071E248	F	1:						
7/29/00	E248	GS00071E248	UF	13	14	26	7	63:		
7/29/00	E248	GS00072E248	UF	2:						
7/29/00	E248.5	GS000712485	F	1:						
7/29/00	E248.5	GS000712485	UF	11		26:				
7/29/00	E265	GF00081E265	F					62:		
7/29/00	E265	GS00081E265	UF	19	14	51	7	116:		
7/29/00	E265	GS00082E265	UF	2:						
8/9/00	E221	GS00081E221	F	2:						
8/9/00	E221	GS00081E221	UF	6		52	7:			
8/9/00	E221	GS00082E221	UF	2:						
8/9/00	E227	GS00081E227	F	1:						
8/9/00	E227	GS00081E227	UF	8			7:			
8/9/00	E227	GS00082E227	UF	2:						
8/9/00	E230	GS00083E230-1	UF	3				62:		
8/9/00	E230	GS00084E230-1	UF	2:						
8/9/00	E247	GS00081E247	F	1:						
8/9/00	E247	GS00081E247	UF	12:						
8/9/00	E247	GS00082E247	UF	2:						
8/9/00	E248	GF00081E248	F	1		24		71:		
8/9/00	E248	GS00081E248	UF	3	14	26	7	116	10:	
8/9/00	E248	GS00082E248	UF	2:						
8/9/00	E248.5	GS000812485	UF	2			7	62:		
8/9/00	E248.5	GS000822485	UF	2:						
8/9/00	E267	GS00081E267	UF	10		26	7	63:		
8/9/00	E267	GS00082E267	UF	2:						
8/12/00	E265	GS00083E265	UF	3	14	26		49:		
8/12/00	E265	GS00084E265	UF	2:						
8/15/00	E249.5	GS000812495	F	2:						
8/15/00	E249.5	GS000812495	UF	20		51		104:		
8/15/00	E249.5	GS000822495	UF	2:						
8/18/00	E227	GF00083E227	F	1		24		62:		
8/18/00	E227	GS00083E227	F	3:						

Sample Date	Gage - Location	Sample ID	Sample Prep	Number of Analyses Results						
				General Water Chemistry	High Explosive Compounds	Metals	Pesticides - PCBs	Radio-nuclides	Semi-Volatile Organic Compounds (SVOCs)	Volatile Organic Compounds (VOCs)
8/18/00	E227	GS00083E227	UF	20		33		70		
8/18/00	E227	GS00084E227	UF	3						
8/18/00	E230	GF00085E230	F	1		24		112		
8/18/00	E230	GS00083E230-2	F	2						
8/18/00	E230	GS00083E230-2	UF	15						
8/18/00	E230	GS00085E230	UF	6		26		68		
8/18/00	E230	GS00086E230	UF	3						
8/18/00	E248.5	GF000832485	F	1		24		17		
8/18/00	E248.5	GS000832485	F	2						
8/18/00	E248.5	GS000832485	UF	12	14	26	7	27	80	31
8/18/00	E248.5	GS000842485	UF	3						
8/18/00	E265	GF00085E265	F	1		24		20		
8/18/00	E265	GS00085E265	F	2						
8/18/00	E265	GS00085E265	UF	13	14	44	7	20	80	31
8/18/00	E265	GS00086E265	UF	5						
8/18/00	E273	GS00081E273	UF	4		26				
8/18/00	E273	GS00082E273	UF	3						
8/18/00	E275	GS00081E275	UF	5		51				
8/18/00	E275	GS00082E275	UF	3						
8/24/00	EPRP	GF00081EPRP	F	23		26		70		
8/24/00	EPRP	GF00081EPRP	UF	1						
8/24/00	EPRP	GS00081EPRP	F	3						
8/24/00	EPRP	GS00081EPRP	UF	19		26		125		
8/31/00	ELAR	GF00081ELAR	F	17		25		62		
8/31/00	ELAR	GF00081ELAR	UF	1						
8/31/00	ELAR	GS00081ELAR	UF	15	14	51	7	127	80	
8/31/00	EULR	GF00081EULR	F	15		25		62		
8/31/00	EULR	GS00081EULR	UF	11	14	26	7	61	80	
9/8/00	E240	GF00091E240	F	6		24		236		
9/8/00	E240	GS00091E240	F	6						
9/8/00	E240	GS00091E240	UF	14	14	51	7	174	80	31
9/8/00	E240	GS00092E240	UF	1						
9/8/00	EGS4	GF00091EGS4	F	6		24		124		
9/8/00	EGS4	GS00091EGS4	F	2						
9/8/00	EGS4	GS00091EGS4	UF	9	14	26	7	121	80	31
9/8/00	EGS4	GS00092EGS4	UF	1						
9/12/00	E025	GF00091E025	F	6		24		130		
9/12/00	E025	GS00091E025	F	2						
9/12/00	E025	GS00091E025	UF	12	14	26	7	123	80	31
9/12/00	E025	GS00092E025	UF	2						
10/7/00	E196	GF00101E196	F					59		
10/7/00	E196	GS00101E196	F	3						
10/7/00	E196	GS00101E196	UF	17		49		108		
10/7/00	E196	GS00102E196	UF	3						
10/7/00	E223	GS00101E223	F	3						
10/7/00	E223	GS00101E223	UF	13		25	8	53		
10/7/00	E223	GS00102E223	UF	3						
10/11/00	E227	GF00101E227	F	11		25		77		
10/11/00	E227	GS00101E227	F	6						
10/11/00	E227	GS00101E227	UF	17		51		78		
10/11/00	E227	GS00102E227	UF	3						
10/11/00	E230	GS00101E230	UF	11		26				
10/11/00	E230	GS00102E230	UF	3						
10/11/00	E247	GF00101E247	F	6		25				
10/11/00	E247	GS00101E247	F	3						
10/11/00	E247	GS00101E247	UF	12		26	8	72		
10/11/00	E247	GS00102E247	UF	3						
10/11/00	E248	GF00101E248	F	6		25		76		
10/11/00	E248	GS00101E248	F	3						
10/11/00	E248	GS00101E248	UF	12		26	8	72		
10/11/00	E248	GS00102E248	UF	3						
10/11/00	E248.5	GF001012485	F	6		25				
10/11/00	E248.5	GS001012485	F	3						

Sample Date	Gage - Location	Sample ID	Sample Prep	Number of Analyses Results						
				General Water Chemistry	High Explosive Compounds	Metals	Pesticides - PCBs	Radio-nuclides	Semi-Volatile Organic Compounds (SVOCs)	Volatile Organic Compounds (VOCs)
10/11/00	E248.5	GS001012485	UF	12		26	8	73		
10/11/00	E248.5	GS001022485	UF	4						
10/12/00	E040	GS00101E040-1	UF	3				71		
10/12/00	E040	GS00102E040-1	UF	2						
10/12/00	E249.5	GF001012495	F	6		25		75		
10/12/00	E249.5	GS001012495	F	4						
10/12/00	E249.5	GS001012495	UF	14		26		73	74	
10/12/00	E249.5	GS001022495	UF	3						
10/17/00	E042	GS00101E042	UF	2				71		
10/17/00	E042	GS00102E042	UF	3						
10/17/00	E122	GS00101E122	UF	2				81		
10/17/00	E122	GS00102E122	UF	2						
10/23/00	E030	GS00101E030	UF	9		25				
10/23/00	E038	GS00101E038	UF	3						
10/23/00	E039	GS00101E039	F	2						
10/23/00	E039	GS00101E039	UF	10		24				
10/23/00	E039	GS00102E039	UF	1						
10/23/00	E040	GS00101E040-2	F	2						
10/23/00	E040	GS00101E040-2	UF	12		24				
10/23/00	E040	GS00102E040-2	UF	1						
10/23/00	E042	GF00103E042	F	6		24		72		
10/23/00	E042	GS00103E042	F	2						
10/23/00	E042	GS00103E042	UF	9		26		72	10	
10/23/00	E042	GS00104E042	UF	3						
10/23/00	E060	GF00101E060	F	1		24				
10/23/00	E060	GS00101E060	F	2						
10/23/00	E060	GS00101E060	UF	11		25		71		
10/23/00	E060	GS00102E060	UF	2						
10/23/00	E218	GS00101E218	UF	4		25				
10/23/00	E218	GS00102E218	UF	1						
10/23/00	E230	GS00103E230	F	2						
10/23/00	E230	GS00103E230	UF	12	14	26		72	10	
10/23/00	E230	GS00104E230	UF	3						
10/23/00	E240	GF00101E240	F	6		24		76		
10/23/00	E240	GS00101E240	F	3						
10/23/00	E240	GS00101E240	UF	24		52		127		
10/23/00	E240	GS00102E240	UF	2						
10/23/00	E240	GS00103E240	UF	6	14		7		80	31
10/23/00	E249	GF00101E249	F	1		24				
10/23/00	E249	GS00101E249	F	2						
10/23/00	E249	GS00101E249	UF	13		26		72		
10/23/00	E249	GS00102E249	UF	3						
10/23/00	E252	GF00101E252	F	6		24		71		
10/23/00	E252	GS00101E252	F	2						
10/23/00	E252	GS00101E252	UF	13	14	26	7	74	82	31
10/23/00	E252	GS00102E252	UF	3						
10/23/00	E253	GF00101E253	F	6		24		71		
10/23/00	E253	GS00101E253	F	2						
10/23/00	E253	GS00101E253	UF	12	14	26	7	75	81	31
10/23/00	E253	GS00102E253	UF	3						
10/23/00	E265	GF00101E265	F	6		24				
10/23/00	E265	GS00101E265	F	2						
10/23/00	E265	GS00101E265	UF	15	14	51	8	2	80	31
10/23/00	E265	GS00102E265	UF	4						
10/23/00	E267	GF00101E267	F	6		24		5		
10/23/00	E267	GS00101E267	F	3						
10/23/00	E267	GS00101E267	UF	13		26		3		
10/23/00	E267	GS00102E267	UF	3						
10/23/00	E275	GS00101E275	F	1						
10/23/00	E275	GS00101E275	UF	18		26				
10/23/00	E275	GS00102E275	UF	3						
10/23/00	M2417	GF001012417	F	6		24		78		
10/23/00	M2417	GS001012417	F	2						

Sample Date	Gage - Location	Sample ID	Sample Prep	Number of Analyses Results						
				General Water Chemistry	High Explosive Compounds	Metals	Pesticides - PCBs	Radio-nuclides	Semi-Volatile Organic Compounds (SVOCs)	Volatile Organic Compounds (VOCs)
10/23/00	M2417	GS001012417	UF	15	14	26		72	80	31
10/23/00	M2417	GS001022417	UF	3						
10/23/00	Two-mile above Highway 501	GF001012436	F	9		24		74		
10/23/00	Two-mile above Highway 501	GS001012436	F	2						
10/23/00	Two-mile above Highway 501	GS001012436	UF	12	14	26	7	72	80	31
10/23/00	Two-mile above Highway 501	GS001022436	UF	3						
10/24/00	E250	GF00101E250	F	8		24		71		
10/24/00	E250	GS00101E250	F	3						
10/24/00	E250	GS00101E250	UF	13	14	25	8	76	80	31
10/24/00	E250	GS00102E250	UF	1						
10/25/00	E248.5	GF001032485	F	6		24				
10/25/00	E248.5	GS001032485	UF	9		25				
10/25/00	E248.5	GS001042485	UF	1						
10/27/00	E039	GF00103E039	F	7		48				
10/27/00	E039	GS00103E039	UF	5		24				
10/27/00	E040	GF00105E040	F	6		24		77		
10/27/00	E040	GS00105E040	F	2						
10/27/00	E040	GS00105E040	UF	6		25		1		
10/27/00	E040	GS00106E040	UF	3						
10/27/00	E042	GF00105E042	F	6		24				
10/27/00	E042	GS00105E042	UF	5				73		
10/27/00	E060	GF00103E060	F					71		
10/27/00	E060	GS00103E060	UF	4				72		
10/27/00	E060	GS00104E060	UF	2						
10/27/00	E250	GF00103E250	F	6		24		72		
10/27/00	E250	GS00103E250	F	2						
10/27/00	E250	GS00103E250	UF	13	14	26		72		
10/27/00	E263	GF00101E263	F	9		24				
10/27/00	E263	GS00101E263	F	2						
10/27/00	E263	GS00101E263	UF	17	14	50		1	10	
10/27/00	E265	GF00103E265	F	6		24		71		
10/27/00	E265	GS00103E265	UF	6		27		72		
10/27/00	E265	GS00104E265	UF	2						
10/28/00	E230	GF00105E230	F	6		24				
10/28/00	E230	GS00105E230	F	2						
10/28/00	E230	GS00105E230	UF	12	14	25				
10/28/00	E230	GS00106E230	UF	2						
10/28/00	E248.5	GF001052485	F	1		24		78		
10/28/00	E248.5	GS001052485	UF	4		1		72		
10/28/00	E248.5	GS001062485	UF	2						
10/28/00	E250	GS00104E250	UF	2						
10/28/00	E263	GS00102E263	UF	3						
10/28/00	E273	GF00101E273	F	5						
10/28/00	E273	GS00101E273	F	3						
10/28/00	E273	GS00101E273	UF	6		25				
10/28/00	E273	GS00102E273	UF	2						
10/28/00	E275	GS00103E275	F	2						
10/28/00	E275	GS00103E275	UF	6		25				
10/28/00	E275	GS00104E275	UF	2						
10/30/00	E042	GS00107E042	UF	6						

Appendix B. Analytic Results of Storm Water Runoff Sampling in 2000

Table B-1. Chemical Quality of Storm Water Runoff in 2000

Station name	Date	Codes[b]		SiO$_2$	Ca	Mg	K	Na	Cl	SO$_4$	CO$_3$ Alkalinity		Total Alkalinity		$_4$-P	$_3$-N		CN (amen)		CN(TOTAL)		[c]		TSS[d]		Lab pH[e]	Cond-uctance (uS/cm)
				Result	Result	Result	Result	Result	Result	Result	Sym	Result	Result	Result	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Result	Result
Los Alamos Canyon at Los Alamos	6/3	F	CS		42.0	6.2	12.0	6.7																			
Los Alamos Canyon at Los Alamos	6/3	UF	CS																						250		
Los Alamos Canyon at Los Alamos	6/3	UF	CS		59.0	7.1	13.0	6.8							1.80		0.07	<	0.0100		0.0180				240		
Los Alamos Canyon at Los Alamos	7/18	F	CS		58.0	11.0	18.0	4.0																			
Los Alamos Canyon at Los Alamos	7/18	UF	CS		240.0	20.0	30.0	5.0							0.94		0.67	<	0.0100						9800		
Los Alamos Canyon at Los Alamos	7/18	UF	TOTC																		0.1300						
Los Alamos Canyon at Los Alamos	7/18	UF	CS																						32000		
Los Alamos Canyon at Los Alamos	7/19	UF	CS																						35000		
Los Alamos Canyon at Los Alamos	7/19	UF	CS																						36000		
Los Alamos Canyon at Los Alamos	9/12	F	CS			10.9			3.6	8.5	<	1	186														
Los Alamos Canyon at Los Alamos	9/12	F	CS																				346				
Los Alamos Canyon at Los Alamos	9/12	F	DUP																				350				
Los Alamos Canyon at Los Alamos	9/12	UF	CS			12.0									0.84		0.06	<	0.0028	<	0.0028						320
Los Alamos Canyon at Los Alamos	9/12	UF	DUP															<	0.0028	<	0.0028						
Los Alamos Canyon at Los Alamos	9/12	UF	CS																						221		
Los Alamos Canyon at Los Alamos	9/12	UF	DUP																						226		
Los Alamos Canyon below TA-2	6/2	UF	CS		34.0	5.9	7.6	14.0							0.24		0.09			<	0.0100				4500		
Los Alamos Canyon below TA-2	6/2	UF	CS																						3400		
Los Alamos Canyon below TA-2	10/23	UF	CS			4.7									0.23	<	0.01	<	0.0028	<	0.0028						
Head of DP Canyon	10/23	UF	CS															<	0.0028	<	0.0028						
DP Canyon below Meadow at TA-21	7/25	F	CS			0.8																					
DP Canyon below Meadow at TA-21	7/25	UF	CS			1.7												<	0.0028	<	0.0028				302		
DP Canyon below Meadow at TA-21	7/25	UF	CS																						298		
DP Canyon below Meadow at TA-21	10/23	F	CS																				60				
DP Canyon below Meadow at TA-21	10/23	F	DUP																				66				
DP Canyon below Meadow at TA-21	10/23	UF	CS			4.0									0.23		0.12	<	0.0028	<	0.0028						70
DP Canyon below Meadow at TA-21	10/27	F	CS			0.5			1.4	2.1	<	1	19														
DP Canyon below Meadow at TA-21	10/27	F	DUP			0.5																					
DP Canyon below Meadow at TA-21	10/27	UF	CS			3.7												<	0.0028	<	0.0028				1700		
DP Canyon below Meadow at TA-21	10/27	UF	DUP																						1840		
DP Canyon at Mouth	6/2	UF	CS		35.0	3.0	6.4	6.7							0.81		0.29			<	0.0100				3300		
DP Canyon at Mouth	6/2	UF	CS																						5800		
DP Canyon at Mouth	10/12	UF	CS																						2750		
DP Canyon at Mouth	10/12	UF	DUP																						3550		
DP Canyon at Mouth	10/12	UF	CS																						1800		
DP Canyon at Mouth	10/12	UF	DUP																						4300		
DP Canyon at Mouth	10/23	F	CS																				66				
DP Canyon at Mouth	10/23	F	DUP																				68				
DP Canyon at Mouth	10/23	UF	CS			5.9									0.40		0.08	<	0.0028	<	0.0028						69
DP Canyon at Mouth	10/23	UF	DUP															<	0.0028	<	0.0028						
DP Canyon at Mouth	10/27	F	CS			0.7			2.4	2.8	<	1	25														
DP Canyon at Mouth	10/27	F	CS																				104				
DP Canyon at Mouth	10/27	F	DUP																				92				
DP Canyon at Mouth	10/27	UF	CS			9.0												<	0.0028	<	0.0028				4150		94
DP Canyon at Mouth	10/27	UF	DUP																						5320		
DP Canyon at Mouth	10/27	UF	CS																						4670		
DP Canyon at Mouth	10/27	UF	DUP																						5890		
DP Canyon at Mouth	10/27	UF	TRP																						6110		
Los Alamos Canyon near Los Alamos	6/2	UF	CS		61.0	7.7	11.0	11.0							0.82		0.34			<	0.0100				8800		
Los Alamos Canyon near Los Alamos	6/2	UF	CS																						23000		
Los Alamos Canyon near Los Alamos	6/3	F	CS		45.0	6.8	12.0	12.0																			
Los Alamos Canyon near Los Alamos	6/3	UF	CS																						1900		
Los Alamos Canyon near Los Alamos	6/3	UF	CS		96.0	9.5	15.0	12.0							3.70	<	0.05	<	0.0100		0.0280				2300		
Los Alamos Canyon near Los Alamos	7/9	UF	CS		410.0	23.0	32.0	13.0							1.30		1.00	<	0.0100						15000		
Los Alamos Canyon near Los Alamos	7/9	UF	DUP		409.0	22.8	31.6	12.8										<	0.0100						14800		
Los Alamos Canyon near Los Alamos	7/9	UF	TOTC																		0.0700						
Los Alamos Canyon near Los Alamos	7/9	F	CS		41.0	6.1	14.0	9.4																			
Los Alamos Canyon near Los Alamos	7/9	UF	CS																						12000		
Los Alamos Canyon near Los Alamos	10/17	UF	CS																						1680		
Los Alamos Canyon near Los Alamos	10/17	UF	DUP																						1820		
Los Alamos Canyon near Los Alamos	10/17	UF	CS																						1670		
Los Alamos Canyon near Los Alamos	10/17	UF	DUP																						1710		

Table B-1. (Cont.)

Station name	Date	Codes[b]		SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity		Total Alkalinity		$_4$-P	$_3$-N		CN (amen)		CN(TOTAL)		[c]		TSS[d]		Lab pH[e]	Conductance (uS/cm)
				Result	Result	Result	Result	Result	Result	Result	Sym	Result	Result	Result	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Result	Result
Los Alamos Canyon near Los Alamos	10/17	UF	TRP																						1790		
Los Alamos Canyon near Los Alamos	10/23	F	CS			1.0			4.8	1.6	<	1	29														
Los Alamos Canyon near Los Alamos	10/23	F	CS																				102				
Los Alamos Canyon near Los Alamos	10/23	F	DUP																				110				
Los Alamos Canyon near Los Alamos	10/23	UF	CS			6.5												<	0.0028		0.0038				2880		82
Los Alamos Canyon near Los Alamos	10/23	UF	DUP															<	0.0028		0.0051				3180		
Los Alamos Canyon near Los Alamos	10/23	UF	CS																						14000		
Los Alamos Canyon near Los Alamos	10/23	UF	DUP																						15100		
Los Alamos Canyon near Los Alamos	10/27	F	CS			2.6			7.9	4.1	<	1	49														
Los Alamos Canyon near Los Alamos	10/27	UF	CS															<	0.0028		0.0080				3340		
Los Alamos Canyon near Los Alamos	10/27	UF	DUP																						3480		
Los Alamos Canyon near Los Alamos	10/27	UF	TRP																						3660		
Los Alamos Canyon near Los Alamos	10/30	UF	CS															<	0.0028		0.0061				290		
Los Alamos Canyon near Los Alamos	10/30	UF	DUP															<	0.0028	<	0.0028				298		
Pueblo Canyon near Los Alamos	10/23	F	CS			5.1																					
Pueblo Canyon near Los Alamos	10/23	F	CS																				324				
Pueblo Canyon near Los Alamos	10/23	F	DUP																				332				
Pueblo Canyon near Los Alamos	10/23	UF	CS			20.8									4.38		0.64		0.0032		0.0033						308
Pueblo Canyon near Los Alamos	10/27	UF	CS															<	0.0028		0.0153				3910		
Pueblo Canyon near Los Alamos	10/27	UF	DUP																						5780		
Pueblo Canyon near Los Alamos	10/27	UF	CS																						4110		
Pueblo Canyon near Los Alamos	10/27	UF	DUP																						4120		
Sandia Canyon near TA-3	7/16	UF	CS																						270		
Sandia Canyon near TA-3	7/17	UF	CS																						740		
Sandia Canyon near TA-3	7/17	UF	CS		12.0	2.0	3.0	8.0							0.16		0.53	<	0.0100	<	0.0100				570		
Sandia Canyon near TA-3	10/17	UF	CS																						100		
Sandia Canyon near TA-3	10/17	UF	DUP																						90		
Sandia Canyon near TA-3	10/17	UF	CS																						100		
Sandia Canyon near TA-3	10/17	UF	DUP																						110		
TA-55	7/17	UF	CS																						250		
TA-55	7/17	UF	CS		8.0	0.8	1.0	1.0							0.14		0.71	<	0.0100	<	0.0100				150		
TA-55	10/7	F	CS																			<	6				
TA-55	10/7	UF	CS			0.6									0.08		0.58	<	0.0028	<	0.0028				57.7		28
TA-55	10/7	UF	DUP			0.6												<	0.0028	<	0.0028						28
TA-55	10/7	UF	CS																						111		
TA-55	10/7	UF	DUP																						113		
Cañada del Buey near TA-46	10/23	UF	CS			6.0												<	0.0028	<	0.0028						
TA-54, MDA-J	8/9	F	CS																				106				
TA-54, MDA-J	8/9	F	DUP																				106				
TA-54, MDA-J	8/9	UF	CS			18.0																			4290		45
TA-54, MDA-J	8/9	UF	DUP			17.8																					
TA-54, MDA-J	8/9	UF	CS																						2310		
TA-54, MDA-J	7/15	UF	CS																						50		
TA-54, MDA-J	7/15	UF	CS		18.0	1.0	1.0	1.0							0.09		1.00								70		93
TA-54, MDA-J	7/15	UF	DUP																						73		94
TA-54, MDA-J	7/17	UF	CS																						87		
TA-54, MDA-J	7/17	UF	CS															<	0.0100	<	0.0100				37		
TA-54, MDA-J	10/7	F	CS																				17				
TA-54, MDA-J	10/7	F	DUP																				19				
TA-54, MDA-J	10/7	UF	CS			0.5									0.10		0.81	<	0.0028	<	0.0028				31.7		34
TA-54, MDA-J	10/7	UF	DUP																						35		
TA-54, MDA-J	10/7	UF	CS																						75		
TA-54, MDA-J	10/7	UF	DUP																						90		
TA-54, MDA-G-6	7/29	F	CS			14.2																					
TA-54, MDA-G-6	7/29	F	CS																				254				
TA-54, MDA-G-6	7/29	F	DUP																				264				
TA-54, MDA-G-6	7/29	UF	CS			31.5									1.03		0.47								3810		306
TA-54, MDA-G-6	7/29	UF	CS																						4260		
TA-54, MDA-G-6	8/9	F	CS																				161				
TA-54, MDA-G-6	8/9	UF	CS															<	0.0028		0.0031				6230		22100
TA-54, MDA-G-6	8/9	UF	DUP															<	0.0028		0.0038						
TA-54, MDA-G-6	8/9	UF	CS																						5560		
TA-54, MDA-G-6	8/18	F	CS			7.9																					
TA-54, MDA-G-6	8/18	F	CS																				210				
TA-54, MDA-G-6	8/18	F	DUP																				205				

Table B-1. (Cont.)

Station name	Date	Codes[b]		SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity		Total Alkalinity		$_4$-P	$_3$-N		CN (amen)		CN(TOTAL)		[c]		TSS[d]		Lab pH[e]	Cond-uctance (uS/cm)
				Result	Result	Result	Result	Result	Result	Result	Sym	Result	Result	Result	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Result	Result
TA-54, MDA-G-6	10/11	F	CS			2.7			10.0	1.0	<	1	20														
TA-54, MDA-G-6	10/11	F	DUP						9.9	1.1	<	1	19														
TA-54, MDA-G-6	10/11	F	CS																				137				76
TA-54, MDA-G-6	10/11	F	DUP																				144				
TA-54, MDA-G-6	10/11	F	TRP																				142				
TA-54, MDA-G-6	10/11	UF	CS			10.1									0.43		0.07	<	0.0028	<	0.0028				3000		
TA-54, MDA-G-6	10/11	UF	DUP			10.0												<	0.0028	<	0.0028				3290		
TA-54, MDA-G-6	10/11	UF	TRP																						3100		
TA-54, MDA-G-6	10/11	UF	CS																						6020		
TA-54, MDA-G-6	10/11	UF	DUP																						7080		
Cañada del Buey at White Rock	7/29	F	CS																				312				
Cañada del Buey at White Rock	7/29	UF	CS			86.9									5.67		0.15	<	0.0028	<	0.0028				19600		10600
Cañada del Buey at White Rock	7/29	UF	DUP																								10600
Cañada del Buey at White Rock	7/29	F	CS			1.8																					
Cañada del Buey at White Rock	7/29	UF	CS																						38300		
Cañada del Buey at White Rock	8/9	UF	CS																						15300		
Cañada del Buey at White Rock	8/9	UF	DUP																						16700		
Cañada del Buey at White Rock	8/9	UF	CS																						18900		
Cañada del Buey at White Rock	8/18	F	CS																				210				
Cañada del Buey at White Rock	8/18	F	DUP																				214				
Cañada del Buey at White Rock	8/18	UF	CS												3.12		0.33	<	0.0028	<	0.0028				15700		125
Cañada del Buey at White Rock	8/18	UF	DUP																						16400		
Cañada del Buey at White Rock	8/18	UF	QUD																						16300		
Cañada del Buey at White Rock	8/18	UF	TRP																						10500		
Cañada del Buey at White Rock	8/18	F	CS			0.9																					
Cañada del Buey at White Rock	8/18	UF	CS			31.6												<	0.0028	<	0.0028				9160		
Cañada del Buey at White Rock	8/18	UF	DUP																						9910		
Cañada del Buey at White Rock	8/18	UF	CS																						14500		
Cañada del Buey at White Rock	8/18	UF	DUP																						8520		
Cañada del Buey at White Rock	10/11	UF	CS			20.7									2.31		0.11	<	0.0028	<	0.0028				13700		
Cañada del Buey at White Rock	10/11	UF	DUP																						15100		
Cañada del Buey at White Rock	10/11	UF	CS																						10600		
Cañada del Buey at White Rock	10/11	UF	DUP																						14800		
Cañada del Buey at White Rock	10/23	F	CS																				252				
Cañada del Buey at White Rock	10/23	F	DUP																				254				
Cañada del Buey at White Rock	10/23	UF	CS			24.8									1.45		0.09	<	0.0028		0.0036				11300		66
Cañada del Buey at White Rock	10/23	UF	DUP																						9500		
Cañada del Buey at White Rock	10/23	UF	CS																						19600		
Cañada del Buey at White Rock	10/23	UF	DUP																						25100		
Cañada del Buey at White Rock	10/28	F	CS			1.4			0.3	0.4	<	0.3	18														
Cañada del Buey at White Rock	10/28	F	CS																				240				
Cañada del Buey at White Rock	10/28	F	DUP																				252				
Cañada del Buey at White Rock	10/28	UF	CS			7.0									0.90		0.02	<	0.0028		0.0038				6360		57
Cañada del Buey at White Rock	10/28	UF	DUP																						6400		
Cañada del Buey at White Rock	10/28	UF	CS																						7080		
Cañada del Buey at White Rock	10/28	UF	DUP																						7930		
Pajarito Canyon above SR 501	6/28	F	CS		63.0	12.0	21.0	5.1																			
Pajarito Canyon above SR 501	6/28	UF	CS												2.50		0.38	<	0.0500						25000		
Pajarito Canyon above SR 501	6/28	UF	TOTC		1110.0	112.8	111.3	11.7													0.1460						
Pajarito Canyon above SR 501	6/28	UF	CS																						35000		
Pajarito Canyon above SR 501	9/8	F	CS			4.8			2.2	9.8	<	1	70														
Pajarito Canyon above SR 501	9/8	F	CS																				273				215
Pajarito Canyon above SR 501	9/8	F	DUP																				281				214
Pajarito Canyon above SR 501	9/8	UF	CS			30.9									8.45		0.85	<	0.0028		0.0218				9740		
Pajarito Canyon above SR 501	9/8	UF	DUP			31.4									8.70												
Pajarito Canyon above SR 501	9/8	UF	CS																						8200		
Pajarito Canyon above SR 501	10/23	F	CS			5.4			1.5	4.6	<	1	78														
Pajarito Canyon above SR 501	10/23	F	CS																				171				
Pajarito Canyon above SR 501	10/23	F	DUP																				349				
Pajarito Canyon above SR 501	10/23	UF	CS			7.8									1.71		0.31	<	0.0028		0.0072				414		182
Pajarito Canyon above SR 501	10/23	UF	DUP	20	35.9	7.7	11.3	3.2							1.81				0.0031		0.0078				470		182
Pajarito Canyon above SR 501	10/23	UF	TRP																						414		
Pajarito Canyon above SR 501	10/23	UF	CS																						442		
Pajarito Canyon above SR 501	10/23	UF	CS															<	0.0028		0.0173				7640		
Pajarito Canyon above SR 501	10/23	UF	DUP																						6380		

Table B-1. (Cont.)

Station name	Date	Codes[b]		SiO$_2$	Ca	Mg	K	Na	Cl	SO$_4$	CO$_3$ Alkalinity		Total Alkalinity		$_4$-P	$_3$-N		CN (amen)		CN(TOTAL)		[c]		TSS[d]		Lab pH[e]	Cond-uctance (uS/cm)
				Result	Result	Result	Result	Result	Result	Result	Sym	Result	Result	Result	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Result	Result
Pajarito Canyon at TA-22	6/28	UF	CS																						2000		
Starmers Gulch at TA-22	6/28	F	CS		62.0	10.0	22.0	8.6																			
Starmers Gulch at TA-22	6/28	UF	CS												5.90		0.52	<	0.0500						3100		
Starmers Gulch at TA-22	6/28	UF	TOTC		291.6	26.7	41.9	10.9													0.0840						
Starmers Gulch at TA-22	6/28	UF	CS																						2900		
TA-54, MDA-G-1	8/9	F	CS																				105				
TA-54, MDA-G-1	8/9	UF	CS												2.22		0.31								13300		15300
TA-54, MDA-G-1	8/9	UF	DUP												2.16		0.34										
TA-54, MDA-G-1	8/9	UF	CS																						12900		
TA-54, MDA-G-1	10/11	F	CS			0.6			0.5	0.5	<	1	8														
TA-54, MDA-G-1	10/11	F	CS																				84				
TA-54, MDA-G-1	10/11	F	DUP																				87				
TA-54, MDA-G-1	10/11	UF	CS			7.4									0.31		0.06	<	0.0028	<	0.0028				1040		29
TA-54, MDA-G-1	10/11	UF	DUP																						1090		
TA-54, MDA-G-1	10/11	UF	CS																						677		
TA-54, MDA-G-1	10/11	UF	DUP																						760		
TA-54, MDA-G-2	7/29	F	CS			39.3																					
TA-54, MDA-G-2	7/29	F	CS																				280				
TA-54, MDA-G-2	7/29	UF	CS			46.9									0.73		0.53	<	0.0028	<	0.0028				1640		573
TA-54, MDA-G-2	7/29	UF	DUP																						1730		
TA-54, MDA-G-2	7/29	UF	CS																						1490		
TA-54, MDA-G-2	8/9	F	CS			8.7																					
TA-54, MDA-G-2	8/9	UF	CS			23.9																			4830		
TA-54, MDA-G-2	8/9	UF	CS																						4860		
TA-54, MDA-G-2	10/11	F	CS			11.4			53.2	1.3	<	1	29														
TA-54, MDA-G-2	10/11	F	CS																				231				
TA-54, MDA-G-2	10/11	F	DUP																				232				
TA-54, MDA-G-2	10/11	UF	CS			17.7									0.22		0.20	<	0.0028	<	0.0028				570		159
TA-54, MDA-G-2	10/11	UF	DUP																						582		
TA-54, MDA-G-2	10/11	UF	CS																						510		
TA-54, MDA-G-2	10/11	UF	DUP																						514		
TA-54, MDA-G-3	7/29	F	CS																				346				
TA-54, MDA-G-3	7/29	UF	CS			33.6									2.14		0.87	<	0.0028	<	0.0028				10300		315
TA-54, MDA-G-3	8/9	UF	CS																						35800		
TA-54, MDA-G-3	8/9	UF	CS																						37800		
TA-54, MDA-G-3	8/18	F	CS			13.8																					
TA-54, MDA-G-3	8/18	F	CS																				333				
TA-54, MDA-G-3	8/18	F	DUP																				345				
TA-54, MDA-G-3	8/18	UF	CS			20.0									0.86		0.67	<	0.0028	<	0.0028				5560		357
TA-54, MDA-G-3	8/18	UF	DUP																						5270		
TA-54, MDA-G-3	8/18	UF	CS																						6040		
TA-54, MDA-G-3	8/18	UF	DUP																						7110		
TA-54, MDA-G-3	10/11	F	CS			3.0			13.0	3.9	<	1	25														
TA-54, MDA-G-3	10/11	F	CS																				162				
TA-54, MDA-G-3	10/11	F	DUP																				166				
TA-54, MDA-G-3	10/11	UF	CS			6.5									0.41		0.26	<	0.0028	<	0.0028				610		102
TA-54, MDA-G-3	10/11	UF	DUP																						638		
TA-54, MDA-G-3	10/11	UF	CS																						620		
TA-54, MDA-G-3	10/11	UF	DUP																						620		
TA-54, MDA-G-3	10/11	UF	TRP																						628		
TA-54, MDA-G-3	10/25	F	CS			2.1			6.7	2.5	<	1	22														
TA-54, MDA-G-3	10/25	UF	CS			11.1									0.18		0.81	<	0.0028	<	0.0028						
TA-54, MDA-G-3	10/28	F	CS			2.4																					
TA-54, MDA-G-3	10/28	UF	CS															<	0.0028	<	0.0028				392		
TA-54, MDA-G-3	10/28	UF	DUP																						402		
TA-54, MDA-G-3	10/28	UF	CS																						444		
TA-54, MDA-G-3	10/28	UF	DUP																						448		
TA-54, MDA-G-5	10/23	F	CS			0.5																					
TA-54, MDA-G-5	10/23	F	CS																				49				
TA-54, MDA-G-5	10/23	F	DUP																				50				
TA-54, MDA-G-5	10/23	UF	CS			1.5									0.13		0.08	<	0.0028	<	0.0028				214		22
TA-54, MDA-G-5	10/23	UF	DUP												0.15										270		
TA-54, MDA-G-5	10/23	UF	CS																						2640		
TA-54, MDA-G-5	10/23	UF	DUP																						2670		
TA-54, MDA-G-4	8/15	F	CS																				90				

Table B-1. (Cont.)

Station name	Date	Codes[b]		SiO$_2$	Ca	Mg	K	Na	Cl	SO$_4$	CO$_3$ Alkalinity		Total Alkalinity		$_4$-P	$_3$-N		CN (amen)		CN(TOTAL)		[c]		TSS[d]		Lab pH[e]	Conductance (uS/cm)
				Result	Result	Result	Result	Result	Result	Result	Sym	Result	Result	Result	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Result	Result
TA-54, MDA-G-4	10/12	F	CS																				146				
TA-54, MDA-G-4	10/12	F	DUP																				153				
TA-54, MDA-G-4	10/12	F	TRP																				153				
TA-54, MDA-G-4	10/12	UF	CS			3.4									0.20		0.15	<	0.0028	<	0.0028				80		139
TA-54, MDA-G-4	10/12	UF	DUP																						82		
TA-54, MDA-G-4	10/12	UF	CS																						70		
TA-54, MDA-G-4	10/12	UF	DUP																						75.6		
Pajarito Canyon above SR 4	6/28	F	CS		97.0	16.0	32.0	7.4																			
Pajarito Canyon above SR 4	6/28	UF	CS												0.98		0.11	<	0.0500						2400		
Pajarito Canyon above SR 4	6/28	UF	TOTC		706.0	52.9	65.6	10.4													0.0850						
Pajarito Canyon above SR 4	6/28	UF	CS																						6000		
Pajarito Canyon above SR 4	10/24	F	CS			4.6			6.7	11.0	<	1	85														
Pajarito Canyon above SR 4	10/24	F	DUP						6.6	10.7																	
Pajarito Canyon above SR 4	10/24	F	CS																				264				
Pajarito Canyon above SR 4	10/24	F	DUP																				276				
Pajarito Canyon above SR 4	10/24	F	TRP																				268				
Pajarito Canyon above SR 4	10/24	UF	CS			9.6									1.34		0.94	<	0.0028	<	0.0028						226
Pajarito Canyon above SR 4	10/27	F	CS			5.0			6.4	13.9	<	1	80														
Pajarito Canyon above SR 4	10/27	F	CS																				250				
Pajarito Canyon above SR 4	10/27	F	DUP																				252				
Pajarito Canyon above SR 4	10/27	UF	CS			10.5									0.97		0.41	<	0.0028		0.0072				752		210
Pajarito Canyon above SR 4	10/27	UF	DUP															<	0.0028		0.0070				772		
Pajarito Canyon above SR 4	10/28	UF	CS																						1700		
Pajarito Canyon above SR 4	10/28	UF	DUP																						1710		
Water Canyon above SR 501	6/28	UF	CS												0.74		0.60		0.0620						1000		
Water Canyon above SR 501	6/28	UF	TOTC		573.7	33.7	43.3	4.7													0.0660						
Water Canyon above SR 501	6/28	UF	CS																						1600		
Water Canyon above SR 501	10/23	F	CS			3.8			1.4	3.9	<	1	62														
Water Canyon above SR 501	10/23	F	CS																				436				
Water Canyon above SR 501	10/23	F	DUP																				438				
Water Canyon above SR 501	10/23	UF	CS			29.2									6.90		0.21	<	0.0028		0.0176				15600		253
Water Canyon above SR 501	10/23	UF	DUP																						16400		
Water Canyon above SR 501	10/23	UF	CS																						11100		
Water Canyon above SR 501	10/23	UF	DUP																						13100		
Cañon del Valle above SR 501	6/28	UF	CS												0.85		0.78	<	0.0500						3400		
Cañon del Valle above SR 501	6/28	UF	TOTC		666.0	46.4	55.8	7.0													0.0920						
Cañon del Valle above SR 501	6/28	UF	CS																						3100		
Cañon del Valle above SR 501	10/23	F	CS			3.4			1.2	4.0	<	1	65														
Cañon del Valle above SR 501	10/23	F	CS																				292				
Cañon del Valle above SR 501	10/23	F	DUP																				298				
Cañon del Valle above SR 501	10/23	UF	CS			17.0									7.40		0.36	<	0.0028		0.0145				4970		245
Cañon del Valle above SR 501	10/23	UF	DUP																						7610		
Cañon del Valle above SR 501	10/23	UF	CS																						2840		
Cañon del Valle above SR 501	10/23	UF	DUP																						5350		
Water Canyon at SR 4	6/28	UF	CS												0.72		0.69	<	0.0500						5000		
Water Canyon at SR 4	6/28	UF	TOTC		688.4	58.4	64.9	8.9													0.0720						
Water Canyon at SR 4	10/27	F	CS			5.4			2.4	7.1	<	1	39														
Water Canyon at SR 4	10/27	F	DUP								<	1	38														
Water Canyon at SR 4	10/27	F	CS																				486				
Water Canyon at SR 4	10/27	F	DUP																				492				
Water Canyon at SR 4	10/27	UF	CS			37.4									5.10		0.09	<	0.0028		0.0495				51400		357
Water Canyon at SR 4	10/27	UF	DUP			37.6									5.05										52800		355
Water Canyon at SR 4	10/27	UF	TRP																						53500		
Water Canyon at SR 4	10/28	UF	CS																						61900		
Water Canyon at SR 4	10/28	UF	DUP																						62400		
Water Canyon at SR 4	10/28	UF	TRP																						65800		
Indio Canyon at SR 4	6/28	UF	CS																						12000		
Water Canyon below SR 4	6/28	F	CS		80.0	14.0	28.0	5.9																			
Water Canyon below SR 4	6/28	UF	CS												0.63		0.56	<	0.0500						13000		
Water Canyon below SR 4	6/28	UF	TOTC		971.7	87.3	95.2	11.1													0.1030						
Water Canyon below SR 4	6/28	UF	CS																						5800		
Water Canyon below SR 4	7/29	UF	CS			55.0									14.40	<	0.01		0.0393		0.0639				20300		
Water Canyon below SR 4	7/29	UF	DUP			61.4									14.50	<	0.01		0.0457		0.0738						
Water Canyon below SR 4	7/29	UF	CS																						21300		
Water Canyon below SR 4	8/12	UF	CS			37.5																			59600		

Table B-1. (Cont.)

Station name	Date	Codes[b]		SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity		Total Alkalinity		$_4$-P	$_3$-N		CN (amen)		CN(TOTAL)		[c]		TSS[d]		Lab pH[e]	Cond-uctance (uS/cm)
				Result	Result	Result	Result	Result	Result	Result	Sym	Result	Result	Result	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Result	Result
Water Canyon below SR 4	8/18	UF	DUP			3.9																			294		
Water Canyon below SR 4	8/18	UF	CS																						334		
Water Canyon below SR 4	8/18	UF	DUP																						322		
Water Canyon below SR 4	8/18	UF	QUD																						332		
Water Canyon below SR 4	8/18	UF	TRP																						344		
Water Canyon below SR 4	10/23	F	CS			4.9			5.0	6.8	<	1	85														
Water Canyon below SR 4	10/23	F	CS																				362				
Water Canyon below SR 4	10/23	F	DUP																				372				
Water Canyon below SR 4	10/23	UF	CS			28.6									5.10		0.06	<	0.0028	<	0.0028				23500		288
Water Canyon below SR 4	10/23	UF	DUP			29.0												<	0.0028	<	0.0028				24100		
Water Canyon below SR 4	10/23	UF	CS																						54700		
Water Canyon below SR 4	10/23	UF	DUP																						54700		
Water Canyon below SR 4	10/23	UF	TRP																						71400		
Water Canyon below SR 4	10/27	F	CS			3.1			1.8	6.8	<	1	48														
Water Canyon below SR 4	10/27	UF	CS			22.0												<	0.0028		0.0352				11200		
Water Canyon below SR 4	10/27	UF	DUP																						13700		
Water Canyon below SR 4	10/27	UF	TRP																						13900		
Water Canyon below SR 4	10/27	UF	CS																						9340		
Water Canyon below SR 4	10/27	UF	DUP																						9860		
Potrillo Canyon near White Rock	8/9	UF	CS			19.7									1.72		0.44	<	0.0028		0.0037				6970		
Potrillo Canyon near White Rock	8/9	UF	CS																						14000		
Potrillo Canyon near White Rock	10/23	F	CS			0.7			0.4	0.5	<	1	26														
Potrillo Canyon near White Rock	10/23	F	CS																				194				
Potrillo Canyon near White Rock	10/23	F	DUP																				390				
Potrillo Canyon near White Rock	10/23	UF	CS			9.0									0.58		0.10	<	0.0028	<	0.0028				5170		25
Potrillo Canyon near White Rock	10/23	UF	DUP																						5610		
Potrillo Canyon near White Rock	10/23	UF	CS																						13500		
Potrillo Canyon near White Rock	10/23	UF	DUP																						9760		
Ancho Canyon at TA-39	8/18	UF	CS			73.5																			19400		
Ancho Canyon at TA-39	8/18	UF	DUP																						20600		
Ancho Canyon at TA-39	8/18	UF	CS																						30000		
Ancho Canyon at TA-39	8/18	UF	DUP																						30200		
Ancho Canyon at TA-39	10/28	F	CS						0.9	1.4	<	1	13														
Ancho Canyon at TA-39	10/28	F	CS																				170				
Ancho Canyon at TA-39	10/28	F	DUP																				196				
Ancho Canyon at TA-39	10/28	F	TRP																				187				
Ancho Canyon at TA-39	10/28	UF	CS			17.0												<	0.0028	<	0.0028				2750		57
Ancho Canyon at TA-39	10/28	UF	DUP																						2790		
Ancho Canyon at TA-39	10/28	UF	CS																						1990		
Ancho Canyon at TA-39	10/28	UF	DUP																						2000		
Ancho Canyon near Bandelier NP	8/18	UF	CS			52.7																			7420		
Ancho Canyon near Bandelier NP	8/18	UF	DUP			51.6																			8610		
Ancho Canyon near Bandelier NP	8/18	UF	CS																						10500		
Ancho Canyon near Bandelier NP	8/18	UF	DUP																						11500		
Ancho Canyon near Bandelier NP	10/23	F	CS																				152				
Ancho Canyon near Bandelier NP	10/23	UF	CS			12.4			0.4	1.1	<	1	22		0.55		0.14	<	0.0028	<	0.0028				4230		53
Ancho Canyon near Bandelier NP	10/23	UF	DUP																						5300		
Ancho Canyon near Bandelier NP	10/23	UF	CS																						4220		
Ancho Canyon near Bandelier NP	10/23	UF	DUP																						4840		
Ancho Canyon near Bandelier NP	10/28	F	CS																				138				
Ancho Canyon near Bandelier NP	10/28	F	DUP																				141				
Ancho Canyon near Bandelier NP	10/28	UF	CS			9.3												<	0.0028		0.0036				2540		45
Ancho Canyon near Bandelier NP	10/28	UF	DUP																						2700		
Ancho Canyon near Bandelier NP	10/28	UF	CS																						2870		
Ancho Canyon near Bandelier NP	10/28	UF	DUP																						2880		
Upper Los Alamos Reservoir	8/31	F	CS	38	62.3	12.7	14.7	7.8	3.1	3.0		1	102	0.10	0.16		0.15						180				196
Upper Los Alamos Reservoir	8/31	F	DUP																				187				
Upper Los Alamos Reservoir	8/31	UF	CS			7.8									0.18		0.10	<	0.0028	<	0.0028			<	6.99		
Upper Los Alamos Reservoir	8/31	UF	DUP																					<	7.44		
Los Alamos Reservoir	8/31	F	CS	42	26.7	7.6	5.6	6.6	3.4	0.6	<	1	230	0.10	0.42		0.08						333				365
Los Alamos Reservoir	8/31	F	DUP																				335				364
Los Alamos Reservoir	8/31	F	TRP																				359				
Los Alamos Reservoir	8/31	UF	CS																							7.2	
Los Alamos Reservoir	8/31	UF	CS			12.4									0.60		0.02	<	0.0028	<	0.0028				38.2	7.2	
Los Alamos Reservoir	8/31	UF	DUP			12.5												<	0.0028	<	0.0028						

Table B-1. (Cont.)

Station name	Date	Codes[b]		SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity		Total Alkalinity		$_4$-P	$_3$-N		CN (amen)		CN(TOTAL)		[c]		TSS[d]		Lab pH[e]	Cond-uctance (uS/cm)
				Result	Result	Result	Result	Result	Result	Result	Sym	Result	Result	Result	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Sym	Result	Result	Result
Rendija Canyon at 3rd Crossing	7/17	F	CS		36.0	6.0	10.0	2.0																			
Rendija Canyon at 3rd Crossing	7/17	UF	CS		250.0	22.0	25.0	3.0							0.58		0.50										
Rendija Canyon at 3rd Crossing	7/17	UF	DUP		300.0	26.0	30.0	4.0																			
Guaje Canyon at SR-502	7/9	F	CS		51.0	9.0	14.0	4.1																			
Guaje Canyon at SR-502	7/9	UF	CS		620.0	39.0	38.0	7.3							0.71		0.93	<	0.0100						37000		
Guaje Canyon at SR-502	7/9	UF	TOTC																		0.1760						
Guaje Canyon at SR-502	7/9	UF	CS																						33000		
Guaje Canyon at SR-502	9/8	F	CS			7.1			2.4	16.7	<	1	118														
Guaje Canyon at SR-502	9/8	F	CS																				570				
Guaje Canyon at SR-502	9/8	UF	CS			188.0									8.60		0.39	<	0.0028		0.0196						427
Guaje Canyon at SR-502	9/8	UF	CS																						76000		
Starmer's Gulch above SR 501	10/23	F	CS			4.7			2.0	4.3	<	1	51														
Starmer's Gulch above SR 501	10/23	F	CS																				426				
Starmer's Gulch above SR 501	10/23	F	DUP																				436				
Starmer's Gulch above SR 501	10/23	UF	CS			19.4									7.26		0.10	<	0.0028		0.0103				6240		274
Starmer's Gulch above SR 501	10/23	UF	DUP												7.35		0.10								6260		
Starmer's Gulch above SR 501	10/23	UF	TRP																						8930		
Starmer's Gulch above SR 501	10/23	UF	CS																						1740		
Starmer's Gulch above SR 501	10/23	UF	DUP																						2590		
Twomile Canyon at SR 501	10/23	F	CS			2.8			1.8	4.2	<	1	63														
Twomile Canyon at SR 501	10/23	F	DUP								<	1	64														
Twomile Canyon at SR 501	10/23	F	CS																				312				
Twomile Canyon at SR 501	10/23	F	DUP																				314				
Twomile Canyon at SR 501	10/23	UF	CS			19.4									8.15		0.14	<	0.0028		0.0111				8080		270
Twomile Canyon at SR 501	10/23	UF	DUP																						7080		
Twomile Canyon at SR 501	10/23	UF	CS																						10900		
Twomile Canyon at SR 501	10/23	UF	DUP																						9980		
Pajarito Canyon at TA-18 Culvert	6/28	F	CS		85.0	14.0	29.0	7.0																			
Pajarito Canyon at TA-18 Culvert	6/28	F	DUP		84.7	14.2	28.7	7.0																			
Pajarito Canyon at TA-18 Culvert	6/28	UF	CS												0.98		0.52	<	0.0500						16000		
Pajarito Canyon at TA-18 Culvert	6/28	UF	TOTC		877.3	81.1	96.2	11.8													0.1750						
Pajarito Canyon at TA-18 Culvert	6/28	UF	CS																						18000		
Pajarito Canyon at TA-18 Culvert	6/28	UF	DUP																						27500		
Pajarito Canyon at G-1	6/28	UF	CS																						3200		
Pajarito Canyon at G-1	6/28	UF	CS																						21000		
Pajarito Canyon at SR-4 Culvert	6/28	F	CS		99.0	17.0	32.0	7.8																			
Pajarito Canyon at SR-4 Culvert	6/28	UF	CS												3.70		0.67	<	0.0500						5700		
Pajarito Canyon at SR-4 Culvert	6/28	UF	TOTC		774.9	73.4	91.5	11.8													0.0970						
Pajarito Canyon at SR-4 Culvert	6/28	UF	CS																						1600		
Water Quality Standards[g]																											
EPA Primary Drinking Water Standard										500				4.0			10				0.2000						
EPA Secondary Drinking Water Standard									250	250													500			6.8-8.5	
EPA Health Advisory								20																			
NMWQCC Groundwater Limit									250	600				1.6			10				0.2000		1000			6-9	
NMWQCC Wildlife Habitat Standard																			0.0052								

[a]Except where noted.
[b]Codes: UF- unfiltered; F- filtered; CS- customer sample; DUP- laboratory duplicate; TRP- laboratory triplicate.
[c]Total dissolved solids.
[d]Total suspended solids.
[e]Standard units.
[f]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[g]Standards given here for comparison only, see Appendix A.

Table B-2 Radiochemical Analysis of Runoff Samples for 2000 (pCi/L[a])

Station Name	Date	Codes[b]		H-3			Sr-90				Cs-137			U-234			U-235,236			U-238			U (ug/L)
				Result	Uncert	MDA	Result	Uncert	MDA	Sym[c]	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result
Los Alamos Canyon at Los Alamos	6/3	F	CS	80	30	190	3.04	0.15	0.29		-0.10	0.73	5.00	1.040	0.053	0.058	0.041	0.008	0.016	1.090	0.055	0.033	3.50
Los Alamos Canyon at Los Alamos	6/3	UF	CS	120	30	190	4.34	0.21	0.33		5.00	0.58	2.30	1.450	0.065	0.048	0.067	0.011	0.057	1.580	0.070	0.041	4.48
Los Alamos Canyon at Los Alamos	7/18	F	CS																				4.74
Los Alamos Canyon at Los Alamos	7/18	UF	CS																				21.50
Los Alamos Canyon at Los Alamos	7/18	UF	DUP																				26.00
Los Alamos Canyon at Los Alamos	7/18	F	CS		4		.24	0.43	0.39		0.00	2.00	3.00	2.000	0.000	0.000	0.460	0.000	0.000	2.000	0.000	0.000	
Los Alamos Canyon at Los Alamos	7/18	F	DUP											2.000	0.000	0.000	0.203	0.000	0.000	1.000	0.000	0.000	
Los Alamos Canyon at Los Alamos	7/18	UF	CS	20	55	180	16.80	1.55	0.40														
Los Alamos Canyon at Los Alamos	7/18	UF	TOTC								34.00	3.00		16.000	1.000		2.000	0.000		18.000	1.000		
Los Alamos Canyon at Los Alamos	7/18	UF	TOTC				38.90				102.00	10.00		47.000	3.500		4.000	0.500		52.000	4.000		
Los Alamos Canyon at Los Alamos	9/12	F	CS		3		.40	0.36	0.21		1.75	1.93	7.06	0.661	0.100	0.101	0.011	0.011	0.030	0.634	0.097	0.080	1.51
Los Alamos Canyon at Los Alamos	9/12	F	DUP				3.33	0.13	0.24					0.730	0.105	0.110	0.026	0.023	0.110	0.603	0.093	0.095	
Los Alamos Canyon at Los Alamos	9/12	UF	CS	-91	57	199	2.98	0.20	0.40		5.42	2.81	7.49	1.940	0.183	0.097	0.072	0.029	0.091	1.780	0.171	0.051	2.82
Los Alamos Canyon at Los Alamos	9/12	UF	DUP	-122	56	201																	
Los Alamos Canyon below TA-2	6/2	UF	CS	100	30	190	1.63	0.09	0.33		0.00	0.35	2.50	3.830	0.150	0.063	0.360	0.025	0.034	3.460	0.138	0.056	6.94
Los Alamos Canyon below TA-2	10/23	UF	CS																				0.99
DP Canyon below Meadow at TA-21	7/25	F	CS																				0.08
DP Canyon below Meadow at TA-21	7/25	UF	CS																				0.67
DP Canyon below Meadow at TA-21	10/23	UF	CS																				1.62
DP Canyon below Meadow at TA-21	10/27	F	CS																				0.08
DP Canyon below Meadow at TA-21	10/27	F	DUP																				0.05
DP Canyon below Meadow at TA-21	10/27	UF	CS																				2.05
DP Canyon at Mouth	6/2	UF	CS	140	30	190	23.90	1.08	0.35		14.20	1.23	5.50	3.540	0.145	0.053	0.258	0.022	0.018	2.280	0.100	0.038	4.82
DP Canyon at Mouth	10/12	UF	CS				23.80	1.04	0.55		6.21	1.90	4.58	4.320	0.423	0.106	0.115	0.042	0.039	2.700	0.292	0.133	
DP Canyon at Mouth	10/23	UF	CS																				2.62
DP Canyon at Mouth	10/27	F	CS		7		.33	0.31	0.48		0.41	1.56	2.19	0.052	0.022	0.075	0.000	0.009	0.065	0.017	0.013	0.051	0.05
DP Canyon at Mouth	10/27	F	DUP																				
DP Canyon at Mouth	10/27	UF	CS	-29	57	193																	5.40
Los Alamos Canyon near Los Alamos	6/2	UF	CS	130	30	190	25.20	1.15	0.42		13.90	0.88	4.30	7.900	0.325	0.110	0.560	0.040	0.092	6.200	0.250	0.087	10.20
Los Alamos Canyon near Los Alamos	6/3	F	CS	30	28	190	3.54	0.17	0.32		0.20	0.75	5.20	1.060	0.053	0.066	0.099	0.013	0.052	1.120	0.055	0.066	3.44
Los Alamos Canyon near Los Alamos	6/3	UF	CS	150	30	190	6.80	0.33	0.33		21.80	1.95	6.00	2.550	0.108	0.057	0.235	0.021	0.057	2.610	0.110	0.061	6.35
Los Alamos Canyon near Los Alamos	6/3	UF	DUP																				
Los Alamos Canyon near Los Alamos	7/9	F	CS								-1.00	1.55	2.60	1.040	0.080	0.023	0.096	0.017	0.018	1.320	0.100	0.026	4.05
Los Alamos Canyon near Los Alamos	7/9	F	DUP											1.140	0.085	0.006	0.061	0.015	0.033	1.340	0.100	0.006	
Los Alamos Canyon near Los Alamos	7/9	UF	CS	-100	55	190																	68.40
Los Alamos Canyon near Los Alamos	7/9	UF	DUP	-90	55	190																	
Los Alamos Canyon near Los Alamos	7/9	UF	TOTC								106.58			26.042			1.731			36.411			
Los Alamos Canyon near Los Alamos	10/17	UF	CS				10.90	0.63	0.88		4.25	2.10	4.50	0.771	0.096	0.071	0.054	0.021	0.021	0.500	0.073	0.082	
Los Alamos Canyon near Los Alamos	10/23	F	CS		4		.60	0.47	1.23		3.33	1.46	2.52	0.045	0.021	0.069	0.000	1.000	0.020	0.015	0.011	0.020	0.03
Los Alamos Canyon near Los Alamos	10/23	F	DUP																				
Los Alamos Canyon near Los Alamos	10/23	UF	CS	30	59	194	9.94	1.29	0.56		18.80	1.99	3.47	5.860	0.471	0.084	0.214	0.042	0.052	5.770	0.465	0.019	2.98
Los Alamos Canyon near Los Alamos	10/27	F	CS																				0.22
Los Alamos Canyon near Los Alamos	10/27	UF	CS	-29	56	190	11.20	0.44	0.54		15.00	2.25	4.23	8.720	0.951	0.312	0.851	0.216	0.511	8.920	0.967	0.115	
Los Alamos Canyon near Los Alamos	10/27	UF	DUP	-29	56	191																	
Pueblo Canyon near Los Alamos	10/23	F	CS																				1.34
Pueblo Canyon near Los Alamos	10/23	UF	CS				10.80	0.52	0.99		9.14	1.58	3.81	14.100	1.280	0.254	0.673	0.148	0.202	15.700	1.410	0.386	9.78
Pueblo Canyon near Los Alamos	10/23	UF	DUP																				
Pueblo Canyon near Los Alamos	10/27	F	CS		1		.62	0.18	0.54		1.12	0.84	3.10	0.297	0.057	0.102	0.013	0.013	0.063	0.276	0.053	0.063	
Pueblo Canyon near Los Alamos	10/27	UF	CS	-89	56	195	5.40	0.31	0.55		4.43	2.06	3.22	17.000	1.760	0.418	1.080	0.265	0.155	18.000	1.850	0.528	
Sandia Canyon at TA-3	7/17	UF	CS																				0.87
Sandia Canyon at TA-3	7/17	UF	CS	100	55	180	0.15	0.12	0.39		0.00	2.50	4.00	0.760	0.000	0.000	0.064	0.000	0.000	0.860	0.000	0.000	
Sandia Canyon at TA-3	7/17	UF	DUP																				
Sandia Canyon at TA-3	10/17	UF	CS				0.51	0.18	0.58		0.58	1.62	5.01	0.058	0.023	0.074	0.017	0.012	0.051	0.051	0.020	0.050	
Sandia Canyon at TA-3	10/17	UF	DUP											0.055	0.018	0.015	-0.003	0.007	0.060	0.042	0.016	0.041	
TA-55	7/17	UF	CS																				0.46
TA-55	7/17	UF	CS	10	55	180	0.00	0.12	0.40		2.00	2.50	4.00	0.205	0.000	0.000	0.075	0.000	0.000	0.286	0.000	0.000	
TA-55	10/7	F	CS								4.23	1.53	2.06										
TA-55	10/7	F	DUP											0.053	0.031	0.147	-0.018	0.015	0.118	0.000	0.012	0.085	
TA-55	10/7	UF	CS	-69	47	161					0.39	0.72	2.69										0.15
TA-55	10/7	UF	DUP				0.32	0.21	0.69		0.53	0.87	3.34										0.15

Table B-2. (Cont.)

Station Name	Date	Codes[b]		H-3			Sr-90			Sym[c]	Cs-137			U-234			U-235,236			U-238			U (ug/L)
				Result	Uncert	MDA	Result	Uncert	MDA		Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result
Cañada del Buey near TA-46	10/23	UF	CS																				18.00
TA-54, MDA-J	8/9	UF	CS																				3.21
TA-54, MDA-J	8/9	UF	DUP																				3.33
TA-54, MDA-L	7/15	UF	CS																				0.21
TA-54, MDA-L	7/17	F	CS																				0.04
TA-54, MDA-L	7/17	UF	CS																				0.15
TA-54, MDA-L	7/17	UF	CS	110	55	180	0.04	0.12	0.40		0.00	2.00	3.00	0.910	0.000	0.000	0.010	0.000	0.000	0.059	0.000	0.000	
TA-54, MDA-L	10/7	UF	CS	-79	51	175					1.12	1.61	2.21										0.11
TA-54, MDA-G-6	7/29	F	CS				0.21	0.10	0.16		0.25	0.62	2.24	0.069	0.021	0.016	-0.003	0.008	0.054	0.021	0.014	0.054	0.20
TA-54, MDA-G-6	7/29	F	DUP											0.094	0.023	0.014	0.016	0.009	0.014	0.047	0.016	0.014	
TA-54, MDA-G-6	7/29	UF	CS	500	67	183	0.75	0.39	0.63		0.00	0.76	2.95	7.770	0.580	0.044	0.365	0.050	0.044	7.920	0.591	0.044	5.37
TA-54, MDA-G-6	7/29	UF	DUP	388	64	182																	
TA-54, MDA-G-6	8/18	F	CS				0.27	0.20	0.33		0.12	0.93	3.26	0.029	0.025	0.128	0.000	0.013	0.089	0.048	0.022	0.079	0.14
TA-54, MDA-G-6	8/18	UF	CS	1730	147	369	0.26	0.17	0.27		7.05	1.64	3.40	0.584	0.078	0.130	0.026	0.019	0.092	0.662	0.082	0.078	2.61
TA-54, MDA-G-6	8/18	UF	DUP	1710	141	349																	2.61
TA-54, MDA-G-6	10/11	F	CS				3.34	0.46	0.50		0.55	0.62	2.29	0.073	0.026	0.098	-0.003	0.008	0.063	0.041	0.017	0.055	0.11
TA-54, MDA-G-6	10/11	F	DUP											0.045	0.018	0.044	-0.003	0.003	0.045	0.060	0.021	0.056	
TA-54, MDA-G-6	10/11	UF	CS	1870	101	209	0.17	0.18	0.59		5.70	2.03	3.65	9.160	1.140	0.839	0.544	0.226	0.246	7.650	1.010	0.665	2.50
TA-54, MDA-G-6	10/11	UF	DUP											10.700	1.260	0.667	0.191	0.165	0.978	10.600	1.260	0.975	2.54
Cañada del Buey at White Rock	7/29	F	CS																				0.31
Cañada del Buey at White Rock	7/29	UF	CS	-112	52	185																	15.70
Cañada del Buey at White Rock	8/9	UF	CS				-0.14	0.27	0.46		0.79	0.91	3.25	25.900	2.320	0.414	1.450	0.308	0.415	26.900	2.400	0.522	
Cañada del Buey at White Rock	8/18	F	CS				0.30	0.24	0.39		-0.72	0.81	2.70	0.003	0.016	0.101	-0.022	0.008	0.091	0.036	0.017	0.056	0.07
Cañada del Buey at White Rock	8/18	F	DUP								0.83	0.83	2.91										
Cañada del Buey at White Rock	8/18	UF	CS	-69	103	351	0.34	0.19	0.30		-0.14	1.20	4.19	9.840	0.977	0.487	0.430	0.126	0.286	10.400	1.020	0.226	9.58
Cañada del Buey at White Rock	8/18	UF	DUP				0.89	0.25	0.38														
Cañada del Buey at White Rock	10/11	UF	CS																				2.80
Cañada del Buey at White Rock	10/23	UF	CS	-61	57	196	0.63	0.31	1.03		4.39	1.89	3.33	14.400	1.200	0.204	0.942	0.152	0.140	14.200	1.190	0.140	4.01
Cañada del Buey at White Rock	10/28	F	CS																				0.11
Cañada del Buey at White Rock	10/28	UF	CS																				1.76
Pajarito Canyon above SR 501	6/28	F	CS				3.42	0.35	0.41		-0.20	2.65	4.50	1.370	0.155	0.033	0.161	0.046	0.076	1.320	0.155	0.057	3.74
Pajarito Canyon above SR 501	6/28	UF	CS	-10	60	190																	
Pajarito Canyon above SR 501	6/28	UF	TOTC				59.20	4.50			109.00			31.200	2.150		1.982			33.104			
Pajarito Canyon above SR 501	9/8	F	CS				1.53	0.14	0.32		2.34	1.93	7.03	0.249	0.046	0.086	0.036	0.019	0.066	0.173	0.040	0.097	0.43
Pajarito Canyon above SR 501	9/8	F	DUP								0.94	2.05	7.35										
Pajarito Canyon above SR 501	9/8	UF	CS	-120	56	198	6.09	0.67	0.29		31.60	5.93	7.71	8.030	0.679	0.150	0.245	0.065	0.129	7.910	0.671	0.167	12.70
Pajarito Canyon above SR 501	9/8	UF	DUP								30.50	2.62	3.00										13.90
Pajarito Canyon above SR 501	10/23	F	CS				1.36	0.24	0.71		-0.90	0.50	1.67	0.167	0.047	0.144	0.014	0.019	0.103	0.134	0.039	0.089	0.41
Pajarito Canyon above SR 501	10/23	F	DUP				1.95	0.17	0.46														
Pajarito Canyon above SR 501	10/23	UF	CS	-30	57	194	2.93	0.32	0.87		0.00	1.68	3.50	0.408	0.079	0.093	0.000	0.016	0.117	0.352	0.074	0.117	1.21
Pajarito Canyon above SR 501	10/23	UF	DUP								1.87	2.82	3.90										1.20
Pajarito Canyon at TA-22	6/28	F	CS				2.42	0.25	0.34		0.30	2.65	4.40	1.010	0.110	0.058	0.148	0.037	0.058	0.790	0.095	0.058	2.60
Pajarito Canyon at TA-22	6/28	UF	CS	0	60	190					1.10	2.55	4.20										
Pajarito Canyon at TA-22	6/28	UF	DUP	60	60	190					-0.30	1.35	2.30										
Pajarito Canyon at TA-22	6/28	UF	TOTC				8.11	0.67						5.120	0.300		0.387			4.509			
Starmers Gulch at TA-22	6/28	F	CS				3.18	0.32	0.36		1.20	2.70	4.40	1.060	0.115	0.052	0.260	0.049	0.043	0.950	0.105	0.052	3.24
Starmers Gulch at TA-22	6/28	UF	CS	-10	60	190					-2.00	3.00	4.90										
Starmers Gulch at TA-22	6/28	UF	TOTC				15.33	1.25						4.540	0.280		0.619			5.037			
TA-54, MDA-G-1	10/11	F	CS																				0.06
TA-54, MDA-G-1	10/11	UF	CS	-180	57	209	0.59	0.18	0.60		0.68	1.03	3.68	0.364	0.060	0.072	0.043	0.020	0.057	0.441	0.068	0.093	1.91
TA-54, MDA-G-2	7/29	F	CS				0.38	0.16	0.25		0.04	0.64	2.28	0.108	0.025	0.043	0.028	0.012	0.013	0.061	0.018	0.034	0.16
TA-54, MDA-G-2	7/29	F	DUP																				
TA-54, MDA-G-2	7/29	UF	CS	303	62	182	1.00	0.22	0.32		0.00	0.98	3.76	4.240	0.353	0.111	0.261	0.052	0.111	4.370	0.363	0.122	2.95
TA-54, MDA-G-2	8/9	F	CS				0.31	0.24	0.39		-0.57	0.82	2.80	0.038	0.024	0.100	-0.007	0.005	0.127	0.079	0.034	0.100	0.13
TA-54, MDA-G-2	8/9	F	DUP											0.140	0.048	0.187	-0.006	0.005	0.124	0.090	0.036	0.098	
TA-54, MDA-G-2	8/9	UF	CS	0	54	180	0.87	0.29	0.46		-1.85	1.21	3.86	12.400	1.300	0.169	0.251	0.127	0.170	12.900	1.340	0.169	5.35
TA-54, MDA-G-2	8/9	UF	DUP				0.10	0.32	0.53		-0.40	0.97	3.35										
TA-54, MDA-G-2	10/11	F	CS				1.14	0.23	0.72		62.40	2.33	2.33	0.056	0.028	0.113	0.000	0.017	0.114	0.064	0.029	0.113	0.20
TA-54, MDA-G-2	10/11	UF	CS	864	81	207	0.78	0.17	0.55		2.92	1.15	4.25	0.344	0.070	0.138	0.017	0.017	0.085	0.327	0.068	0.124	1.61
TA-54, MDA-G-3	7/29	UF	CS																				11.10
TA-54, MDA-G-3	8/9	UF	CS				2.11	0.33	0.45		1.18	0.85	3.05	77.700	6.910	0.935	3.360	0.549	1.040	72.900	6.500	0.380	
TA-54, MDA-G-3	8/18	F	CS				0.21	0.21	0.34		4.15	1.51	3.13	0.099	0.032	0.109	0.005	0.017	0.109	0.109	0.032	0.087	0.26
TA-54, MDA-G-3	8/18	F	DUP																				
TA-54, MDA-G-3	8/18	UF	CS	493	0	371	0.80	0.24	0.36			1.01	3.50	21.100	1.940	0.418	0.819	0.189	0.375	19.400	1.800	0.741	1.16

Table B-2. (Cont.)

Station Name	Date	Codes[b]		H-3													,236			U-238			U (ug/L)
				Result	Uncert	MDA	Result	Uncert	MDA	Sym[c]	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result
TA-54, MDA-G-3	8/18	UF	DUP																				
TA-54, MDA-G-3	10/11	F	CS																				0.50
TA-54, MDA-G-3	10/11	UF	CS	603	77	209	0.79	0.19	0.58		0.46	1.15	4.11	0.515	0.076	0.095	0.032	0.019	0.074	0.460	0.071	0.112	1.58
TA-54, MDA-G-3	10/25	F	CS																				0.15
TA-54, MDA-G-3	10/25	UF	CS																				1.19
TA-54, MDA-G-3	10/28	F	CS				0.01	0.20	0.69		0.75	0.77	2.86	0.068	0.022	0.057	0.025	0.012	0.017	0.025	0.015	0.057	0.11
TA-54, MDA-G-3	10/28	F	DUP											0.075	0.023	0.018	0.027	0.014	0.018	0.010	0.010	0.050	
TA-54, MDA-G-3	10/28	UF	CS	292	65	192	0.08	0.21	0.72		-1.39	1.11	3.63	0.335	0.067	0.084	0.000	0.014	0.106	0.176	0.048	0.084	
TA-54, MDA-G-5	10/23	F	CS																				0.03
TA-54, MDA-G-5	10/23	UF	CS	179	62	191	0.83	0.20	0.54		-0.45	1.03	3.49	0.263	0.051	0.074	0.004	0.009	0.059	0.179	0.041	0.059	0.37
TA-54, MDA-G-4	8/15	UF	CS	-68	133	454					1.09	1.17	3.73										1.15
TA-54, MDA-G-4	8/15	UF	DUP	86	154	510					-0.63	1.10	3.79										1.16
TA-54, MDA-G-4	10/12	F	CS				1.28	0.20	0.59		0.00	1.44	6.05	0.089	0.025	0.055	0.057	0.020	0.044	0.065	0.020	0.016	0.18
TA-54, MDA-G-4	10/12	F	DUP																				
TA-54, MDA-G-4	10/12	UF	CS	440	71	204	1.28	0.29	0.62		2.02	0.90	3.05	0.174	0.038	0.086	-0.010	0.010	0.087	0.220	0.044	0.099	0.36
TA-54, MDA-G-4	10/12	UF	DUP	122	66	211																	
Pajarito Canyon above SR 4	6/28	F	CS				6.10	0.60	0.35		0.10	2.75	4.60	2.240	0.175	0.058	0.253	0.040	0.055	2.120	0.170	0.040	6.65
Pajarito Canyon above SR 4	6/28	F	DUP				6.00	0.55	0.32														
Pajarito Canyon above SR 4	6/28	UF	CS	-100	55	190																	
Pajarito Canyon above SR 4	6/28	UF	TOTC				43.90	3.75			15.98			5.320	0.290		0.325			5.454			2.48
Pajarito Canyon above SR 4	10/24	F	CS				1.49	0.21	0.62	<	0.67	0.52	1.92	0.650	0.101	0.086	0.012	0.018	0.109	0.844	0.120	0.141	2.19
Pajarito Canyon above SR 4	10/24	UF	CS		2		.44	0.35	1.03	<	2.07	1.74	3.34	1.340	0.152	0.103	0.092	0.032	0.071	1.610	0.174	0.089	4.64
Pajarito Canyon above SR 4	10/24	UF	DUP	-148	55	200								1.320	0.146	0.065	0.079	0.027	0.024	1.380	0.150	0.082	
Pajarito Canyon above SR 4	10/27	F	CS				2.30	0.19	0.51		-0.15	0.75	2.69	0.855	0.097	0.048	0.032	0.017	0.060	0.968	0.106	0.078	3.63
Pajarito Canyon above SR 4	10/27	UF	CS	-58	56	192	2.28	0.27	0.60		0.72	0.88	3.11	2.120	0.216	0.106	0.128	0.037	0.027	3.060	0.288	0.073	11.40
Water Canyon above SR 501	6/28	UF	CS	-40	55	190																	
Water Canyon above SR 501	6/28	UF	TOTC				38.80	3.50			7.30			2.749	0.153		0.338			2.739			
Water Canyon above SR 501	10/23	F	CS				5.07	0.55	1.35		1.26	1.48	1.97	0.336	0.054	0.050	0.020	0.017	0.082	0.234	0.046	0.089	0.75
Water Canyon above SR 501	10/23	UF	CS	-60	56	193	13.30	0.96	1.59		14.30	2.38	3.48	32.300	3.010	0.790	1.450	0.319	0.691	29.800	2.800	0.143	1.54
Water Canyon above SR 501	10/23	UF	DUP																				
Cañon del Valle above SR 501	6/28	UF	CS	20	60	190																	
Cañon del Valle above SR 501	6/28	UF	TOTC				48.20	4.20			15.38			4.380	0.295		0.276			4.511			
Cañon del Valle above SR 501	10/23	F	CS				2.77	0.46	1.38		0.71	0.78	2.82	0.233	0.044	0.064	0.010	0.013	0.074	0.182	0.038	0.051	0.40
Cañon del Valle above SR 501	10/23	UF	CS	0	57	192	10.00	0.80	0.60		11.70	2.31	3.44	10.400	0.930	0.144	0.441	0.101	0.144	11.900	1.040	0.182	2.99
Water Canyon at SR 4	6/28	UF	TOTC								26.55						0.454			10.791			
Water Canyon at SR 4	10/27	F	CS																				3.06
Water Canyon at SR 4	10/27	UF	CS	0	57	192																	12.40
Water Canyon at SR 4	10/27	UF	DUP																				12.90
Indio Canyon at SR 4	6/28	F	CS				5.01	0.49	0.36		-2.10	3.05	5.00	1.510	0.150	0.057	0.178	0.042	0.048	1.480	0.150	0.025	
Indio Canyon at SR 4	6/28	F	DUP								-0.80	2.80	4.70										
Indio Canyon at SR 4	6/28	UF	CS	40	60	190																	3.87
Indio Canyon at SR 4	6/28	UF	TOTC				30.90	2.25						9.940	0.565								
Water Canyon below SR 4	6/28	F	CS				5.40	0.55	0.38		0.10	2.70	4.60	1.500	0.150	0.073	0.124	0.036	0.078	1.290	0.135	0.062	4.13
Water Canyon below SR 4	6/28	F	DUP								-0.10	1.35	2.20										
Water Canyon below SR 4	6/28	UF	CS	100	60	190																	
Water Canyon below SR 4	6/28	UF	TOTC				62.10	4.45			61.36			18.630	1.305		1.540			20.581			
Water Canyon below SR 4	7/29	F	CS				2.26	0.57	0.80		-0.37	0.89	2.96	3.800	0.309	0.054	0.205	0.038	0.043	4.970	0.393	0.016	
Water Canyon below SR 4	7/29	UF	CS	-84	52	184	13.30	1.03	0.31		4.71	1.62	2.58	45.900	3.830	0.154	2.740	0.310	0.155	63.100	5.220	0.122	115.00
Water Canyon below SR 4	7/29	UF	DUP				13.00	1.27	0.58		2.03	1.11	2.14										146.00
Water Canyon below SR 4	8/12	UF	CS								1.09	1.17	4.22										7.82
Water Canyon below SR 4	8/18	F	CS				1.05	0.33	0.51			0.84	2.83	0.139	0.041	0.126	-0.005	0.019	0.127	0.126	0.037	0.101	0.55
Water Canyon below SR 4	8/18	F	DUP											0.199	0.042	0.085	-0.004	0.010	0.077	0.192	0.040	0.066	
Water Canyon below SR 4	8/18	UF	CS	223	0	374	1.01	0.19	0.24			1.49	5.15	0.359	0.068	0.165	0.009	0.018	0.106	0.337	0.067	0.182	1.42
Water Canyon below SR 4	10/23	F	CS																				0.92
Water Canyon below SR 4	10/23	UF	CS																				4.37
Water Canyon below SR 4	10/23	UF	DUP																				4.47
Water Canyon below SR 4	10/27	F	CS				0.61	0.18	0.52		0.71	0.95	3.06	0.359	0.057	0.086	0.010	0.017	0.099	0.428	0.062	0.061	1.35
Water Canyon below SR 4	10/27	UF	CS	-30	58	197	8.59	0.52	0.54		8.62	2.77	3.11	43.100	3.940	0.137	1.890	0.351	0.372	53.600	4.830	0.137	29.60
Potrillo Canyon near White Rock	8/9	UF	CS	-138	50	182	1.91	0.37	0.54		-0.33	0.86	2.92	9.380	0.877	0.366	0.344	0.093	0.155	10.300	0.947	0.253	5.83
Potrillo Canyon near White Rock	10/23	F	CS																				0.07
Potrillo Canyon near White Rock	10/23	F	DUP																				
Potrillo Canyon near White Rock	10/23	UF	CS	30	57	189																	2.37
Ancho Canyon at TA-39	8/18	UF	CS																				18.50
Ancho Canyon at TA-39	10/28	UF	CS																				3.57

Table B-2. (Cont.)

Station Name	Date		Codes[b]	H-3			Sr-90				Cs-137			U-234			U-235,236			U-238			U (ug/L)
				Result	Uncert	MDA	Result	Uncert	MDA	Sym[c]	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result
Ancho Canyon near Bandelier NP	8/18	UF	CS																				14.40
Ancho Canyon near Bandelier NP	8/18	UF	DUP																				15.40
Ancho Canyon near Bandelier NP	10/23	UF	CS																				3.17
Ancho Canyon near Bandelier NP	10/28	UF	CS																				3.06
Upper Los Alamos Reservoir	8/31	F	CS				0.87	0.29	0.33		1.16	1.15	4.18	0.290	0.049	0.070	0.006	0.013	0.079	0.143	0.033	0.061	0.40
Upper Los Alamos Reservoir	8/31	F	DUP											0.195	0.041	0.081	0.007	0.011	0.063	0.141	0.034	0.063	
Upper Los Alamos Reservoir	8/31	UF	CS				0.92	0.30	0.44		-0.80	1.01	3.44	0.214	0.044	0.110	-0.010	0.013	0.099	0.178	0.038	0.061	0.37
Upper Los Alamos Reservoir	8/31	UF	DUP	-57	54	186																	
Los Alamos Reservoir	8/31	F	CS				3.20	0.43	0.38		0.00	1.12	4.23	0.453	0.070	0.122	0.031	0.018	0.072	0.234	0.046	0.057	0.88
Los Alamos Reservoir	8/31	UF	CS				3.63	0.41	0.37		0.79	1.02	3.57	0.452	0.076	0.157	0.082	0.032	0.109	0.339	0.062	0.097	1.10
Los Alamos Reservoir	8/31	UF	DUP								0.27	0.97	3.43										1.11
Los Alamos at SR 4 Weir	7/21	F	CS				26.60	4.42	2.69		1.14	0.67	2.51	2.060	0.172	0.037	0.088	0.020	0.011	1.920	0.162	0.037	6.01
Los Alamos at SR 4 Weir	7/21	F	DUP																				
Los Alamos at SR 4 Weir	7/21	UF	CS	0	40	136	1.95	1.21	1.96		0.00	1.54	2.38	2.950	0.295	0.101	0.131	0.041	0.101	2.430	0.253	0.080	8.23
Los Alamos at SR 4 Weir	7/21	UF	DUP	-60	39	136					1.58	0.80	2.96	2.890	0.278	0.069	0.132	0.038	0.087	2.440	0.243	0.025	8.25
Rendija Canyon at 3rd Crossing	7/17	F	CS																				2.74
Rendija Canyon at 3rd Crossing	7/17	F	CS				4.50	0.45	0.38		0.00	2.50	4.00	0.730	0.000	0.000	0.037	0.000	0.000	0.920	0.000	0.000	
Rendija Canyon at 3rd Crossing	7/17	UF	CS	100	55	180	72.00	6.50	0.39														
Rendija Canyon at 3rd Crossing	7/17	UF	DUP	60	55	180																	
Rendija Canyon at 3rd Crossing	7/17	UF	TOTC								267.00	18.50		87.000	6.000		10.000	1.000		94.000	7.000		
Rendija Canyon at 3rd Crossing	7/17	UF	TOTCD				73.00																
Guaje Canyon at SR 502	7/9	F	CS								-0.40	1.45	2.40	1.490	0.110	0.022	0.101	0.017	0.022	1.960	0.140	0.007	5.89
Guaje Canyon at SR 502	7/9	UF	CS	-50	55	190																	92.70
Guaje Canyon at SR 502	7/9	UF	TOTC								359.29			103.070			8.456			118.436			
Guaje Canyon at SR 502	9/8	F	CS		2		.92	0.18	0.27		2.44	2.00	7.33	0.937	0.100	0.079	0.023	0.017	0.067	1.040	0.106	0.041	2.48
Guaje Canyon at SR 502	9/8	UF	CS	-120	56	198	80.80	9.49	9.19		221.78	14.63	8.50	136.000	24.800	2.070	3.800	1.140	0.606	134.000	24.300	0.604	10.00
Starmer's Gulch above SR 501	10/23	F	CS				1.47	0.42	1.23		0.04	0.45	1.57	0.205	0.040	0.058	0.009	0.012	0.067	0.205	0.039	0.017	0.76
Starmer's Gulch above SR 501	10/23	F	DUP											0.167	0.038	0.094	-0.014	0.007	0.081	0.214	0.042	0.062	
Starmer's Gulch above SR 501	10/23	UF	CS	-61	56	194	12.10	0.77	0.83		17.10	2.32	3.48	18.700	1.560	0.148	0.695	0.131	0.148	19.800	1.650	0.148	2.67
Twomile Canyon at SR 501	10/23	F	CS				2.70	0.66	1.80		-0.78	0.79	2.70	0.067	0.042	0.134	0.067	0.031	0.089	0.133	0.033	0.020	0.42
Twomile Canyon at SR 501	10/23	F	DUP											0.095	0.040	0.116	0.022	0.016	0.054	0.029	0.025	0.088	
Twomile Canyon at SR 501	10/23	UF	CS	-30	56	189	15.10	0.72	0.70		511.00	10.80	4.35	10.300	0.892	0.233	0.446	0.098	0.166	11.600	0.989	0.282	4.23
Pajarito Canyon at TA-18 Culvert	6/28	F	CS				5.40	0.50	0.34		0.10	2.25	3.80	2.280	0.175	0.051	0.182	0.030	0.028	2.370	0.180	0.028	6.34
Pajarito Canyon at TA-18 Culvert	6/28	UF	CS	40	60	190																	
Pajarito Canyon at TA-18 Culvert	6/28	UF	TOTC				75.40	5.40			95.73			24.480	1.425		1.186			26.184			
Pajarito Canyon at G-1	6/28	F	CS				5.60	0.55	0.34		1.40	2.80	4.60	2.360	0.185	0.035	0.165	0.032	0.015	2.210	0.175	0.043	
Pajarito Canyon at G-1	6/28	UF	CS	-20	60	190																	
Pajarito Canyon at G-1	6/28	UF	TOTC				51.20	4.35			13.47			12.640	0.630		0.676			13.265			
Pajarito Canyon at SR 4 Culvert	6/28	F	CS				6.30	0.60	0.37		0.80	2.60	4.30	2.520	0.190	0.028	0.288	0.041	0.040	2.480	0.185	0.035	8.37
Pajarito Canyon at SR 4 Culvert	6/28	F	DUP																				
Pajarito Canyon at SR 4 Culvert	6/28	UF	CS	0	60	190																	
Pajarito Canyon at SR 4 Culvert	6/28	UF	TOTC				36.80	2.65			38.09			11.020	0.695		0.631			11.318			
Water Quality Standards[d]																							
DOE DCG for Public Dose				2,000,000			1,000				3,000			500			600			600			800
DOE Drinking Water System DCG				80,000			40				120			2 0			2 4			2 4			3 0
EPA Primary Drinking Water Standard				20,000			8																30
EPA Screening Level																							
NMWQCC Groundwater Limit																							5,000
NMWQCC Livestock Watering				20,000,000																			
Historical Maximum for UF data				1,120			2 5			4	2.3												170
Historical Maximum for F data							15.9				29.4												3.01

a Except where noted. Three columns are listed: the first is the analytical result, the second is the radioactive counting uncertainty (1 standard deviation), and the third is the analytic laboratory measurement-specific minimum detectable activity.
b Codes: UF - unfiltered sample; F - Filttered Sample; CS - Customer Sample; DUP - laboratory duplicate; TOTC - Total concentration calculated from laboratory data; TOTC D - Total concentration calculated from laboratory duplicate
c Less than symbol (<) means measurement was below the specified limit of detection of the anytical method
d Standards given here for comparison only, see Apendix A.

Table B-2. (Cont.)

Station Name	Date	Codes[b]		Pu-239			Pu-239,240			Am-241			Gross Alpha			Gross Beta			Gross Gamma		
				Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA
Los Alamos Canyon at Los Alamos	6/3	F	CS	0.003	0.003	0.024	0.011	0.004	0.024				1.7	0.3	1.9	18.3	0.9	3.0			
Los Alamos Canyon at Los Alamos	6/3	UF	CS	-0.006	0.003	0.044	0.194	0.016	0.012				13.8	0.7	1.9	44.8	1.6	2.5			
Los Alamos Canyon at Los Alamos	7/18	F	CS																		
Los Alamos Canyon at Los Alamos	7/18	UF	CS																		
Los Alamos Canyon at Los Alamos	7/18	UF	DUP																		
Los Alamos Canyon at Los Alamos	7/18	F	CS	0.009	0.000	0.000	0.004	0.000	0.000	0.008	0.000	0.000	3.0	0.5	2.0	26.0	2.0	2.0			
Los Alamos Canyon at Los Alamos	7/18	F	DUP	0.009	0.000	0.000	0.004	0.000	0.000	0.008	0.000	0.000									
Los Alamos Canyon at Los Alamos	7/18	UF	CS																		
Los Alamos Canyon at Los Alamos	7/18	UF	TOTC	0.001	0.000		1.000	0.000		1.000	0.000		118.0	8.5		192.0	10.5		383.0	18.5	
Los Alamos Canyon at Los Alamos	7/18	UF	TOTC	0.300	0.000		5.000	0.500		1.000	0.000		324.0	27.5		447.0	29.0		746.0	43.5	
Los Alamos Canyon at Los Alamos	9/12	F	CS	0.017	0.010	0.015	0.006	0.006	0.015				3.3	0.5	0.7	21.5	1.6	1.5			
Los Alamos Canyon at Los Alamos	9/12	F	DUP																		
Los Alamos Canyon at Los Alamos	9/12	UF	CS	0.032	0.019	0.029	0.116	0.039	0.029				21.8	27.1	16.0	52.4	64.5	32.5			
Los Alamos Canyon at Los Alamos	9/12	UF	DUP																		
Los Alamos Canyon below TA-2	6/2	UF	CS	0.080	0.011	0.046	13.500	0.475	0.014				268.0	10.8	21.0	310.0	11.8	27.0			
Los Alamos Canyon below TA-2	10/23	UF	CS																		
DP Canyon below Meadow at TA-21	7/25	F	CS																		
DP Canyon below Meadow at TA-21	7/25	UF	CS																		
DP Canyon below Meadow at TA-21	10/23	UF	CS																		
DP Canyon below Meadow at TA-21	10/27	F	CS																		
DP Canyon below Meadow at TA-21	10/27	F	DUP																		
DP Canyon below Meadow at TA-21	10/27	UF	CS																		
DP Canyon at Mouth	6/2	UF	CS	0.640	0.035	0.039	3.300	0.125	0.026				328.0	13.3	24.0	403.0	15.0	32.0			
DP Canyon at Mouth	10/12	UF	CS	0.878	0.133	0.008	3.720	0.530	0.008	20.700	1.420	0.069	14.4	2.1	1.4	67.4	4.8	2.3			
DP Canyon at Mouth	10/23	UF	CS																		
DP Canyon at Mouth	10/27	F	CS	0.004	0.007	0.030	0.012	0.009	0.030	0.044	0.014	0.031	0.6	0.4	1.3	16.3	1.3	2.2			
DP Canyon at Mouth	10/27	F	DUP	0.004	0.004	0.011	0.016	0.008	0.011	0.069	0.015	0.008	0.5	0.5	1.6	17.5	1.5	2.7			
DP Canyon at Mouth	10/27	UF	CS																		
Los Alamos Canyon near Los Alamos	6/2	UF	CS	0.780	0.043	0.040	10.900	0.400	0.016				570.0	23.8	50.0	930.0	35.0	70.0			
Los Alamos Canyon near Los Alamos	6/3	F	CS	0.018	0.005	0.012	0.015	0.005	0.031				1.9	0.3	1.9	19.1	0.9	2.5			
Los Alamos Canyon near Los Alamos	6/3	UF	CS	0.074	0.010	0.025	1.260	0.055	0.025				109.0	4.5	9.7	177.0	6.5	11.0			
Los Alamos Canyon near Los Alamos	6/3	UF	DUP										81.0	3.3	7.6	157.0	5.8	12.0			
Los Alamos Canyon near Los Alamos	7/9	F	CS	0.016	0.009	0.028	0.055	0.015	0.031	0.027	0.012	0.014									
Los Alamos Canyon near Los Alamos	7/9	F	DUP	0.007	0.007	0.026	0.070	0.016	0.023	0.025	0.013	0.017									
Los Alamos Canyon near Los Alamos	7/9	UF	CS	0.018	0.010	0.032															
Los Alamos Canyon near Los Alamos	7/9	UF	DUP																		
Los Alamos Canyon near Los Alamos	7/9	UF	TOTC	0.346			24.773			3.257											
Los Alamos Canyon near Los Alamos	10/17	UF	CS	0.814	0.167	0.048	7.370	1.120	0.048	1.680	0.129	0.012	10.3	1.5	1.6	31.2	2.8	3.3			
Los Alamos Canyon near Los Alamos	10/23	F	CS	0.004	0.007	0.028	0.027	0.013	0.036	0.043	0.013	0.024	0.6	0.4	1.1	9.5	1.0	1.9			
Los Alamos Canyon near Los Alamos	10/23	F	DUP							0.051	0.017	0.041									
Los Alamos Canyon near Los Alamos	10/23	UF	CS	0.293	0.039	0.012	2.920	0.195	0.074	3.320	0.219	0.009	139.0	43.5	4.4	207.0	63.0	6.6			
Los Alamos Canyon near Los Alamos	10/27	F	CS																		
Los Alamos Canyon near Los Alamos	10/27	UF	CS	0.362	0.045	0.039	3.610	0.231	0.031	3.440	0.228	0.027	25.7	4.7	2.0	39.8	2.3	2.6			
Los Alamos Canyon near Los Alamos	10/27	UF	DUP																		
Pueblo Canyon near Los Alamos	10/23	F	CS																		
Pueblo Canyon near Los Alamos	10/23	UF	CS	0.210	0.052	0.081	22.800	1.410	0.081	0.748	0.087	0.055									
Pueblo Canyon near Los Alamos	10/23	UF	DUP	0.132	0.035	0.068	20.700	1.200	0.068												
Pueblo Canyon near Los Alamos	10/27	F	CS	0.111	0.030	0.016	0.169	0.041	0.043	0.024	0.009	0.009	1.2	0.5	1.0	10.2	1.1	2.4			
Pueblo Canyon near Los Alamos	10/27	UF	CS	0.163	0.027	0.027	15.100	0.836	0.010	0.749	0.068	0.027	22.4	4.3	1.8	24.9	1.6	2.4			
Sandia Canyon at TA-3	7/17	UF	CS																		
Sandia Canyon at TA-3	7/17	UF	CS	0.013	0.000	0.000	0.022	0.000	0.000	0.012	0.000	0.000	3.0	0.5	2.0	17.0	1.5	2.0			
Sandia Canyon at TA-3	7/17	UF	DUP										3.0	0.5	2.0	17.0	1.5	2.0			
Sandia Canyon at TA-3	10/17	UF	CS	0.000	1.010	0.012	0.027	0.011	0.012	0.009	0.006	0.012	1.2	0.5	1.4	4.2	1.0	2.9			
Sandia Canyon at TA-3	10/17	UF	DUP										0.1	0.3	1.1	5.1	0.8	1.9			
TA-55	7/17	UF	CS																		
TA-55	7/17	UF	CS	0.019	0.000	0.000	0.024	0.000	0.000	0.084	0.000	0.000	2.0	0.5	2.0	14.0	1.0	2.0			
TA-55	10/7	F	CS										0.6	0.3	0.9	3.9	0.6	1.6			
TA-55	10/7	F	DUP	0.007	0.011	0.041	0.017	0.012	0.037	0.047	0.016	0.039									
TA-55	10/7	UF	CS				0.004	0.008	0.034				1.1	0.4	0.9	9.9	1.6	1.8			
TA-55	10/7	UF	DUP				0.025	0.011	0.026				0.6	0.4	1.4	7.4	0.9	2.0			

Table B-2. (Cont.)

Station Name	Date	Codes[b]		Pu-238			Pu-239,240			Am-241			Gross Alpha			Gross Beta			Gross Gamma		
				Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA
Cañada del Buey near TA-46	10/23	UF	CS																		
TA-54, MDA-J	8/9	UF	CS																		
TA-54, MDA-J	8/9	UF	DUP																		
TA-54, MDA-L	7/15	UF	CS																		
TA-54, MDA-L	7/17	F	CS																		
TA-54, MDA-L	7/17	UF	CS																		
TA-54, MDA-L	7/17	UF	CS	0.003	0.000	0.000	0.007	0.000	0.000	0.012	0.000	0.000	1.0	0.5	2.0	8.0	1.0	2.0			
TA-54, MDA-L	10/7	UF	CS										1.0	0.4	1.0	10.8	1.1	2.1			
TA-54, MDA-G-6	7/29	F	CS	0.008	0.006	0.021	0.008	0.009	0.030	0.102	0.022	0.012	1.2	0.5	1.3	5.2	0.8	1.9			
TA-54, MDA-G-6	7/29	F	DUP																		
TA-54, MDA-G-6	7/29	UF	CS	0.150	0.032	0.032	0.422	0.070	0.025	3.980	0.290	0.046	236.0	153.0	11.9	271.0	165.0	21.9			
TA-54, MDA-G-6	7/29	UF	DUP										239.0	182.0	11.1	284.0	181.0	21.0			
TA-54, MDA-G-6	8/18	F	CS	0.036	0.015	0.014	0.005	0.005	0.014	0.028	0.010	0.010	0.6	0.2	0.5	5.4	0.6	1.3			
TA-54, MDA-G-6	8/18	UF	CS	0.173	0.034	0.028	0.188	0.036	0.022	0.082	0.021	0.047	14.4	3.7	1.2	23.5	1.7	1.7			
TA-54, MDA-G-6	8/18	UF	DUP																		
TA-54, MDA-G-6	10/11	F	CS	0.009	0.008	0.028	0.024	0.009	0.008	0.023	0.012	0.035	1.1	0.3	0.8	2.6	0.4	1.3			
TA-54, MDA-G-6	10/11	F	DUP																		
TA-54, MDA-G-6	10/11	UF	CS	0.208	0.072	0.149	0.400	0.105	0.172	0.150	0.037	0.058	172.0	55.3	3.8	196.0	47.9	5.9			
TA-54, MDA-G-6	10/11	UF	DUP																		
Cañada del Buey at White Rock	7/29	F	CS																		
Cañada del Buey at White Rock	7/29	UF	CS																		
Cañada del Buey at White Rock	8/9	UF	CS	2.860	0.419	0.049	0.325	0.061	0.049	0.200	0.064	0.054	71.3	20.0	3.6	90.7	13.2	4.7			
Cañada del Buey at White Rock	8/18	F	CS	0.004	0.004	0.012	0.009	0.006	0.012	0.012	0.009	0.028	-0.1	0.3	1.0	2.8	0.5	1.6			
Cañada del Buey at White Rock	8/18	F	DUP																		
Cañada del Buey at White Rock	8/18	UF	CS	0.142	0.035	0.045	0.152	0.035	0.036	0.060	0.030	0.041	78.9	49.1	8.2	91.3	56.0	18.9			
Cañada del Buey at White Rock	8/18	UF	DUP																		
Cañada del Buey at White Rock	10/11	UF	CS																		
Cañada del Buey at White Rock	10/23	UF	CS	0.116	0.039	0.035	0.308	0.066	0.035	0.137	0.040	0.072	194.0	90.6	7.7	248.0	101.0	9.8			
Cañada del Buey at White Rock	10/28	F	CS																		
Cañada del Buey at White Rock	10/28	UF	CS																		
Pajarito Canyon above SR 501	6/28	F	CS	0.005	0.005	0.020	0.009	0.007	0.025	0.044	0.014	0.035	3.6	0.8	1.9	28.8	2.3	2.6			
Pajarito Canyon above SR 501	6/28	UF	CS										18.8	2.1	4.1	122.0	8.5	4.9			
Pajarito Canyon above SR 501	6/28	UF	TOTC	0.224	0.106		4.400	0.525		1.610	0.375		221.0	27.5		670.0	47.0				
Pajarito Canyon above SR 501	9/8	F	CS	0.029	0.011	0.010	0.014	0.008	0.010				0.7	0.3	0.8	11.8	1.0	1.6			
Pajarito Canyon above SR 501	9/8	F	DUP	0.006	0.010	0.042	0.035	0.015	0.016												
Pajarito Canyon above SR 501	9/8	UF	CS	0.079	0.024	0.041	1.050	0.163	0.032				33.2	40.8	10.5	75.7	92.5	30.0			
Pajarito Canyon above SR 501	9/8	UF	DUP										35.1	43.7	10.3	91.8	113.0	27.8			
Pajarito Canyon above SR 501	10/23	F	CS	0.004	0.004	0.011	0.013	0.007	0.011	0.030	0.011	0.024	0.5	0.4	1.4	10.1	1.2	2.3			
Pajarito Canyon above SR 501	10/23	F	DUP	0.004	0.004	0.012	0.000	1.000	0.033												
Pajarito Canyon above SR 501	10/23	UF	CS	0.009	0.016	0.068	0.174	0.043	0.067	0.056	0.016	0.012	13.4	3.0	1.6	32.7	2.9	2.7			
Pajarito Canyon above SR 501	10/23	UF	DUP																		
Pajarito Canyon at TA-22	6/28	F	CS	0.009	0.005	0.008	0.017	0.007	0.008	0.032	0.011	0.022	3.4	0.8	2.3	24.4	2.0	2.7			
Pajarito Canyon at TA-22	6/28	UF	CS										7.9	1.0	1.9	53.3	3.8	2.3			
Pajarito Canyon at TA-22	6/28	UF	DUP										7.8	1.0	1.9	56.5	4.0	2.3			
Pajarito Canyon at TA-22	6/28	UF	TOTC	0.053	0.018		0.694	0.067		0.313	0.041		56.5	4.8		104.7	5.7				
Starmers Gulch at TA-22	6/28	F	CS	0.009	0.009	0.034	0.028	0.010	0.025	0.029	0.010	0.010	3.0	0.7	1.9	29.6	2.4	2.6			
Starmers Gulch at TA-22	6/28	UF	CS										11.7	1.3	2.3	83.0	6.0	3.3			
Starmers Gulch at TA-22	6/28	UF	TOTC	0.032	0.017		0.932	0.087		0.423	0.051		95.7	8.3		228.9	12.6				
TA-54, MDA-G-1	10/11	F	CS																		
TA-54, MDA-G-1	10/11	UF	CS	0.160	0.037	0.036	0.063	0.020	0.013	0.030	0.012	0.012	35.5	5.1	1.5	59.8	3.8	1.4			
TA-54, MDA-G-2	7/29	F	CS	-0.010	0.007	0.039	0.003	0.003	0.009	0.027	0.011	0.012	0.8	0.4	1.2	6.1	0.7	1.9			
TA-54, MDA-G-2	7/29	F	DUP	0.003	0.003	0.008	0.017	0.007	0.008	0.058	0.016	0.029									
TA-54, MDA-G-2	7/29	UF	CS	0.524	0.085	0.025	1.360	0.202	0.009	0.695	0.068	0.012	36.3	13.2	2.1	48.0	3.4	3.0			
TA-54, MDA-G-2	8/9	F	CS	0.005	0.006	0.015	0.011	0.008	0.015	0.052	0.016	0.013	0.3	0.4	1.2	4.8	0.9	2.5			
TA-54, MDA-G-2	8/9	F	DUP	0.006	0.006	0.017	-0.004	0.004	0.045	0.033	0.012	0.011									
TA-54, MDA-G-2	8/9	UF	CS	0.211	0.044	0.034	0.232	0.047	0.050	0.204	0.063	0.050	123.0	71.9	3.1	151.0	34.9	4.3			
TA-54, MDA-G-2	8/9	UF	DUP										131.0	57.3	2.5	141.0	26.8	4.3			
TA-54, MDA-G-2	10/11	F	CS	0.025	0.010	0.023	0.028	0.010	0.008	0.020	0.012	0.037	0.7	0.3	0.8	3.3	0.5	1.4			
TA-54, MDA-G-2	10/11	UF	CS	0.020	0.012	0.036	0.026	0.011	0.024	0.087	0.020	0.011	34.8	3.6	1.4	41.7	2.7	1.3			
TA-54, MDA-G-3	7/29	UF	CS																		
TA-54, MDA-G-3	8/9	UF	CS	7.610	1.110	0.051	1.670	0.260	0.019	0.250	0.083	0.167	166.0	53.4	3.8	157.0	20.9	4.7			
TA-54, MDA-G-3	8/18	F	CS	0.034	0.017	0.041	0.017	0.015	0.052	0.006	0.004	0.008	0.7	0.3	0.6	5.1	0.6	1.3			
TA-54, MDA-G-3	8/18	F	DUP	0.016	0.008	0.011	0.004	0.004	0.011	0.010	0.014	0.050									
TA-54, MDA-G-3	8/18	UF	CS	0.179	0.043	0.081	0.326	0.061	0.048	0.324	0.088	0.149	194.0	69.3	194.0	176.0	54.3	176.0			

Table B-2. (Cont.)

Station Name	Date	Codes[b]		Pu-238			Pu-239,240			Am-241			Gross Alpha			Gross Beta			Gross Gamma		
				Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA
TA-54, MDA-G-3	8/18	UF	DUP										192.0	78.0	6.0	166.0	50.7	10.1			
TA-54, MDA-G-3	10/11	F	CS																		
TA-54, MDA-G-3	10/11	UF	CS	0.022	0.011	0.027	0.241	0.045	0.027	0.242	0.035	0.030	41.5	13.5	0.9	48.5	3.8	1.5			
TA-54, MDA-G-3	10/25	F	CS																		
TA-54, MDA-G-3	10/25	UF	CS																		
TA-54, MDA-G-3	10/28	F	CS	0.000	1.000	0.024	-0.003	0.006	0.031	0.043	0.013	0.024	0.4	0.3	0.9	3.6	0.7	2.1			
TA-54, MDA-G-3	10/28	F	DUP																		
TA-54, MDA-G-3	10/28	UF	CS	0.032	0.012	0.030	0.181	0.026	0.024	0.149	0.026	0.011	12.4	3.1	2.1	17.9	1.8	2.5			
TA-54, MDA-G-5	10/23	F	CS																		
TA-54, MDA-G-5	10/23	UF	CS	0.023	0.011	0.013	0.080	0.020	0.013	0.035	0.012	0.023	35.9	10.5	1.9	45.9	4.6	2.8			
TA-54, MDA-G-4	8/15	UF	CS										6.7	1.1	0.7	20.1	1.1	1.6			
TA-54, MDA-G-4	8/15	UF	DUP										5.6	0.7	0.7	17.7	1.0	1.6			
TA-54, MDA-G-4	10/12	F	CS	0.006	0.005	0.009	0.048	0.014	0.009	0.863	0.074	0.026	2.0	0.4	0.8	5.4	0.5	1.3			
TA-54, MDA-G-4	10/12	F	DUP	0.022	0.012	0.032	0.052	0.017	0.012	0.851	0.076	0.011									
TA-54, MDA-G-4	10/12	UF	CS	0.017	0.008	0.009	0.118	0.026	0.009	1.340	0.105	0.048	9.2	2.6	1.0	15.4	1.1	1.4			
TA-54, MDA-G-4	10/12	UF	DUP																		
Pajarito Canyon above SR 4	6/28	F	CS	-0.001	0.004	0.022	0.022	0.009	0.022	0.024	0.012	0.030	4.5	0.7	1.4	45.0	3.2	1.8			
Pajarito Canyon above SR 4	6/28	F	DUP																		
Pajarito Canyon above SR 4	6/28	UF	CS										28.8	2.9	4.7	173.0	12.0	4.6			
Pajarito Canyon above SR 4	6/28	UF	TOTC	0.042	0.017		1.163	0.094		0.466	0.058		71.5	5.2		239.2	13.1				
Pajarito Canyon above SR 4	10/24	F	CS	0.000	1.010	0.009	0.017	0.008	0.009	0.000	1.000	0.034									
Pajarito Canyon above SR 4	10/24	UF	CS	0.011	0.009	0.033	0.169	0.027	0.033	0.072	0.018	0.012									
Pajarito Canyon above SR 4	10/24	UF	DUP																		
Pajarito Canyon above SR 4	10/27	F	CS	0.087	0.022	0.011	0.064	0.019	0.029	0.031	0.012	0.026	2.1	0.7	1.8	12.5	1.3	2.5			
Pajarito Canyon above SR 4	10/27	UF	CS	0.014	0.011	0.037	0.096	0.021	0.037	0.052	0.017	0.032	14.4	4.7	1.2	17.6	2.7	2.3			
Water Canyon above SR 501	6/28	UF	CS										18.4	2.3	4.9	151.0	11.0	7.9			
Water Canyon above SR 501	6/28	UF	TOTC	0.039	0.011		0.840	0.060		0.594	0.057		46.6	3.5		211.8	11.9				
Water Canyon above SR 501	10/23	F	CS	0.000	0.006	0.030	0.008	0.008	0.030	0.015	0.008	0.023	2.4	0.8	1.4	14.5	1.6	2.3			
Water Canyon above SR 501	10/23	UF	CS	0.113	0.051	0.061	1.150	0.180	0.166	0.425	0.088	0.044	337.0	432.0	14.9	580.0	710.0	30.6			
Water Canyon above SR 501	10/23	UF	DUP							0.465	0.088	0.039									
Cañon del Valle above SR 501	6/28	UF	CS										25.0	2.9	5.7	161.0	11.5	5.8			
Cañon del Valle above SR 501	6/28	UF	TOTC	0.042	0.020		0.808	0.081		0.311	0.048		118.1	9.5		306.0	16.0				
Cañon del Valle above SR 501	10/23	F	CS	-0.010	0.007	0.048	0.015	0.012	0.038	0.009	0.007	0.023	0.5	0.4	1.2	9.5	1.1	2.4			
Cañon del Valle above SR 501	10/23	UF	CS	0.360	0.111	0.089	2.450	0.331	0.089	0.412	0.060	0.019	273.0	332.0	19.7	514.0	624.0	29.1			
Water Canyon at SR 4	6/28	UF	TOTC																		
Water Canyon at SR 4	10/27	F	CS																		
Water Canyon at SR 4	10/27	UF	CS																		
Water Canyon at SR 4	10/27	UF	DUP																		
Indio Canyon at SR 4	6/28	F	CS	0.014	0.008	0.021	0.013	0.007	0.009	0.020	0.011	0.034	3.0	0.8	2.1	34.6	2.7	2.5			
Indio Canyon at SR 4	6/28	F	DUP																		
Indio Canyon at SR 4	6/28	UF	CS										13.2	1.6	3.2	107.0	7.5	4.7			
Indio Canyon at SR 4	6/28	UF	TOTC	0.044	0.029		1.223	0.127		0.420	0.075		80.2	7.7		244.2	13.3				
Water Canyon below SR 4	6/28	F	CS	0.006	0.008	0.034	0.025	0.009	0.009	0.022	0.014	0.041	3.1	0.8	2.2	40.9	3.1	3.0			
Water Canyon below SR 4	6/28	F	DUP																		
Water Canyon below SR 4	6/28	UF	CS										12.6	2.5	6.8	170.0	12.0	8.5			
Water Canyon below SR 4	6/28	UF	TOTC	0.243	0.079		3.220	0.340		0.818	0.158		214.0	21.5		483.0	28.5				
Water Canyon below SR 4	7/29	F	CS	0.011	0.007	0.010	0.023	0.010	0.010	0.053	0.016	0.012	6.1	1.0	1.4	17.6	1.6	2.9			
Water Canyon below SR 4	7/29	UF	CS	0.296	0.057	0.014	2.950	0.434	0.047	4.200	0.365	0.033	63.3	18.5	8.6	121.0	12.1	12.2			
Water Canyon below SR 4	7/29	UF	DUP										69.6	21.1	8.7	148.0	14.3	10.1			
Water Canyon below SR 4	8/12	UF	CS																		
Water Canyon below SR 4	8/18	F	CS	0.025	0.015	0.046	0.005	0.009	0.037	0.019	0.010	0.030	1.1	0.4	0.7	7.2	0.7	1.5			
Water Canyon below SR 4	8/18	F	DUP										0.4	0.3	0.8	6.6	0.9	1.3			
Water Canyon below SR 4	8/18	UF	CS	0.011	0.013	0.050	0.075	0.026	0.058	0.033	0.013	0.031	8.3	1.9	1.0	19.2	1.4	1.5			
Water Canyon below SR 4	10/23	F	CS																		
Water Canyon below SR 4	10/23	UF	CS										212.0	99.3	9.4	303.0	123.0	10.5			
Water Canyon below SR 4	10/23	UF	DUP																		
Water Canyon below SR 4	10/27	F	CS	0.069	0.020	0.012	0.017	0.009	0.012	0.032	0.011	0.024	0.6	0.4	1.3	8.1	1.0	2.4			
Water Canyon below SR 4	10/27	UF	CS	0.064	0.015	0.009	0.465	0.047	0.025	0.211	0.037	0.053	457.0	558.0	18.9	675.0	821.0	39.1			
Potrillo Canyon near White Rock	8/9	UF	CS	0.017	0.010	0.030	0.139	0.031	0.030	0.160	0.057	0.054	40.7	7.4	2.1	55.8	7.2	4.0			
Potrillo Canyon near White Rock	10/23	F	CS										0.9	0.3	0.9	3.4	0.6	1.5			
Potrillo Canyon near White Rock	10/23	F	DUP										1.6	0.7	0.8	2.8	0.7	1.6			
Potrillo Canyon near White Rock	10/23	UF	CS										148.0	65.0	3.9	171.0	52.8	7.3			
Ancho Canyon at TA-39	8/18	UF	CS																		
Ancho Canyon at TA-39	10/28	UF	CS																		

Table B-2. (Cont.)

Station Name	Date	Codes[b]		Pu-238			Pu-239,240			Am-241			Gross Alpha			Gross Beta			Gross Gamma		
				Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA	Result	Uncert	MDA
Ancho Canyon near Bandelier NP	8/18	UF	CS																		
Ancho Canyon near Bandelier NP	8/18	UF	DUP																		
Ancho Canyon near Bandelier NP	10/23	UF	CS																		
Ancho Canyon near Bandelier NP	10/28	UF	CS																		
Upper Los Alamos Reservoir	8/31	F	CS	0.036	0.012	0.010	0.004	0.006	0.026	0.004	0.008	0.035									
Upper Los Alamos Reservoir	8/31	F	DUP																		
Upper Los Alamos Reservoir	8/31	UF	CS	0.004	0.004	0.011	0.008	0.009	0.031	0.022	0.009	0.010									
Upper Los Alamos Reservoir	8/31	UF	DUP																		
Los Alamos Reservoir	8/31	F	CS	0.038	0.015	0.031	0.013	0.008	0.011	0.026	0.009	0.009									
Los Alamos Reservoir	8/31	UF	CS	0.000	1.010	0.014	0.005	0.009	0.039	0.020	0.010	0.025									
Los Alamos Reservoir	8/31	UF	DUP																		
Los Alamos at SR 4 Weir	7/21	F	CS	0.125	0.027	0.009	0.028	0.011	0.009	0.084	0.019	0.028	5.7	1.1	1.2	33.5	2.4	2.3			
Los Alamos at SR 4 Weir	7/21	F	DUP										4.2	0.7	1.4	37.0	2.6	2.1			
Los Alamos at SR 4 Weir	7/21	UF	CS	0.042	0.016	0.031	0.386	0.068	0.031	0.180	0.029	0.034	27.1	9.5	5.0	69.1	21.5	11.6			
Los Alamos at SR 4 Weir	7/21	UF	DUP	0.062	0.017	0.009	0.455	0.075	0.025	0.179	0.027	0.009									
Rendija Canyon at 3rd Crossing	7/17	F	CS																		
Rendija Canyon at 3rd Crossing	7/17	F	CS	0.007	0.000	0.000	0.030	0.000	0.000	0.020	0.000	0.000	1.0	0.5	2.0	19.0	1.5	2.0			
Rendija Canyon at 3rd Crossing	7/17	UF	CS																		
Rendija Canyon at 3rd Crossing	7/17	UF	DUP																		
Rendija Canyon at 3rd Crossing	7/17	UF	TOTC	1.000	0.000		15.000	1.500		2.000	0.000		480.0	38.0		1054.0	64.0		1249.0	36.0	
Rendija Canyon at 3rd Crossing	7/17	UF	TOTCD																		
Guaje Canyon at SR 502	7/9	F	CS	0.003	0.005	0.024	0.022	0.008	0.008	0.038	0.017	0.044									
Guaje Canyon at SR 502	7/9	UF	CS																		
Guaje Canyon at SR 502	7/9	UF	TOTC	1.228			17.727			5.552											
Guaje Canyon at SR 502	9/8	F	CS	0.004	0.009	0.036	0.015	0.010	0.028				3.3	0.6	0.6	14.9	1.2	1.5			
Guaje Canyon at SR 502	9/8	UF	CS	0.354	0.127	0.237	7.630	1.220	0.237				367.0	2230.0	81.2	685.0	4160.0	153.0			
Starmer's Gulch above SR 501	10/23	F	CS	0.008	0.010	0.039	0.025	0.012	0.031	0.020	0.012	0.037	2.9	0.7	0.6	20.1	1.2	1.4			
Starmer's Gulch above SR 501	10/23	F	DUP																		
Starmer's Gulch above SR 501	10/23	UF	CS	0.219	0.079	0.074	3.070	0.338	0.074	0.373	0.058	0.021	161.0	72.1	7.1	268.0	109.0	10.2			
Twomile Canyon at SR 501	10/23	F	CS	0.015	0.009	0.014	0.025	0.013	0.037	0.028	0.015	0.041	3.3	0.8	1.3	21.2	1.5	2.0			
Twomile Canyon at SR 501	10/23	F	DUP																		
Twomile Canyon at SR 501	10/23	UF	CS	0.078	0.032	0.035	1.090	0.135	0.035	0.473	0.070	0.023	246.0	315.0	14.5	443.0	542.0	28.7			
Pajarito Canyon at TA-18 Culvert	6/28	F	CS	0.005	0.005	0.020	0.013	0.007	0.009	0.040	0.015	0.030	5.7	0.7	1.3	38.6	2.8	1.8			
Pajarito Canyon at TA-18 Culvert	6/28	UF	CS										11.6	4.0	13.0	171.0	13.0	14.0			
Pajarito Canyon at TA-18 Culvert	6/28	UF	TOTC	0.197	0.097		3.760	0.430		1.180	0.235		203.0	22.5		593.0	36.0				
Pajarito Canyon at G-1	6/28	F	CS	0.015	0.007	0.008	0.016	0.007	0.018	0.040	0.013	0.024	4.1	0.7	1.5	47.2	3.4	1.7			
Pajarito Canyon at G-1	6/28	UF	CS										16.5	3.0	8.0	180.0	13.0	8.2			
Pajarito Canyon at G-1	6/28	UF	TOTC	0.075	0.024		0.837	0.091		0.259	0.053		48.2	4.9		254.2	14.4				
Pajarito Canyon at SR 4 Culvert	6/28	F	CS	-0.004	0.008	0.039	0.016	0.007	0.009	0.009	0.007	0.024	5.6	0.8	1.6	44.5	3.2	1.9			
Pajarito Canyon at SR 4 Culvert	6/28	F	DUP										7.0	0.9	1.9	47.3	3.4	1.9			
Pajarito Canyon at SR 4 Culvert	6/28	UF	CS										16.9	2.0	4.1	135.0	9.5	6.1			
Pajarito Canyon at SR 4 Culvert	6/28	UF	TOTC	0.117	0.044		2.250	0.200		0.975	0.131		125.1	11.3		339.0	18.5				
Water Quality Standards[d]																					
DOE DCG for Public Dose				40			30			30			30			1,000					
DOE Drinking Water System DCG				1.6			1.2			1.2			1.2			40					
EPA Primary Drinking Water Standard													15								
EPA Screening Level																50					
NMWQCC Groundwater Limit																					
NMWQCC Livestock Watering													15								
Historical Maximum for UF data				1.531			15.778			15.168			640.8			1,637			623		
Historical Maximum for F data				0.105			0.99			3.509			27.5			40.0			499.2		

a Except where noted. Three columns are listed: the first is the analy

b Codes: UF - unfiltered sample; F - Filttered Sample; CS - Custom

c Less than symbol (<) means measurement was below the specifie

d Standards given here for comparison only, see Apendix A.

Table B-3. Comparison of Radionuclides in Unfiltered Runoff Water Samples for 2000 to Standards

Location Name	Sample Date	Codes[a]		Analyte	Result[b]	Uncert[c]	MDA	Units	Lab Qual Code[d]	val/min std[e]	min std	min std type	DOE DCG Screening Level	DOE DCG Ratio: Result / Scrn Lvl
Los Alamos Canyon at Los Alamos	6/3	UF	CS	GROSSA	13.8	0.7	1.9	pCi/L		0.92	15	0		
Los Alamos Canyon at Los Alamos	7/18	UF	TOTC	GROSSA	118.0	8.5		pCi/L		7.87	15	0	30	3.93
Los Alamos Canyon at Los Alamos	7/18	UF	TOTC	GROSSA	324.0	27.5		pCi/L		21.60	15	0	30	10.80
Los Alamos Canyon below TA-2	6/2	UF	CS	GROSSA	268.0	10.8	21.0	pCi/L		17.87	15	0	30	8.93
DP Canyon at Mouth	10/12	UF	CS	Am-241	20.700	1.420	0.069	pCi/L		0.69	30	0		
DP Canyon at Mouth	10/12	UF	CS	GROSSA	14.4	2.1	1.4	pCi/L		0.96	15	0		
DP Canyon at Mouth	6/2	UF	CS	GROSSA	328.0	13.3	24.0	pCi/L		21.87	15	0	30	10.93
Los Alamos Canyon near Los Alamos	10/17	UF	CS	GROSSA	10.3	1.5	1.6	pCi/L		0.69	15	0		
Los Alamos Canyon near Los Alamos	10/23	UF	CS	GROSSA	139.0	43.5	4.4	pCi/L		9.27	15	0	30	4.63
Los Alamos Canyon near Los Alamos	10/27	UF	CS	GROSSA	25.7	4.7	2.0	pCi/L		1.71	15	0		
Los Alamos Canyon near Los Alamos	6/2	UF	CS	GROSSA	570.0	23.8	50.0	pCi/L		38.00	15	0	30	19.00
Los Alamos Canyon near Los Alamos	6/2	UF	CS	GROSSB	930.0	35.0	70.0	pCi/L		0.93	1000	0		
Los Alamos Canyon near Los Alamos	6/3	UF	CS	GROSSA	109.0	4.5	9.7	pCi/L		7.27	15	0	30	3.63
Los Alamos Canyon near Los Alamos	6/3	UF	DUP	GROSSA	81.0	3.3	7.6	pCi/L		5.40	15	0	30	2.70
Los Alamos Canyon near Los Alamos	7/9	UF	TOTC	Pu-239,240	24.773			pCi/L		0.83	30	0		
Pueblo Canyon near Los Alamos	10/23	UF	CS	Pu-239,240	22.800	1.410	0.081	pCi/L		0.76	30	0		
Pueblo Canyon near Los Alamos	10/23	UF	DUP	Pu-239,240	20.700	1.200	0.068	pCi/L		0.69	30	0		
Pueblo Canyon near Los Alamos	10/27	UF	CS	GROSSA	22.4	4.3	1.8	pCi/L		1.49	15	0		
Pueblo Canyon near Los Alamos	10/27	UF	CS	Pu-239,240	15.100	0.836	0.010	pCi/L		0.50	30	0		
TA-54, MDA-G-6	8/18	UF	CS	GROSSA	14.4	3.7	1.2	pCi/L		0.96	15	0		
TA-54, MDA-G-6	10/11	UF	CS	GROSSA	172.0	55.3	3.8	pCi/L		11.47	15	0	30	5.73
Cañada del Buey at White Rock	8/9	UF	CS	GROSSA	71.3	20.0	3.6	pCi/L		4.75	15	0	30	2.38
Pajarito Canyon above SR 501	10/23	UF	CS	GROSSA	13.4	3.0	1.6	pCi/L		0.89	15	0		
Pajarito Canyon above SR 501	6/28	UF	CS	GROSSA	18.8	2.1	4.1	pCi/L		1.25	15	0		
Pajarito Canyon above SR 501	6/28	UF	TOTC	GROSSA	221.0	27.5		pCi/L		14.73	15	0	30	7.37
Pajarito Canyon above SR 501	6/28	UF	TOTC	GROSSB	670.0	47.0		pCi/L		0.67	1000	0		
Pajarito Canyon at TA-22	6/28	UF	CS	GROSSA	7.9	1.0	1.9	pCi/L		0.53	15	0		
Pajarito Canyon at TA-22	6/28	UF	DUP	GROSSA	7.8	1.0	1.9	pCi/L		0.52	15	0		
Pajarito Canyon at TA-22	6/28	UF	TOTC	GROSSA	56.5	4.8		pCi/L		3.77	15	0	30	1.88
Starmers Gulch at TA-22	6/28	UF	CS	GROSSA	11.7	1.3	2.3	pCi/L		0.78	15	0		
Starmers Gulch at TA-22	6/28	UF	TOTC	GROSSA	95.7	8.3		pCi/L		6.38	15	0	30	3.19
TA-54, MDA-G-1	10/11	UF	CS	GROSSA	35.5	5.1	1.5	pCi/L		2.37	15	0	30	1.18
TA-54, MDA-G-2	10/11	UF	CS	GROSSA	34.8	3.6	1.4	pCi/L		2.32	15	0	30	1.16
TA-54, MDA-G-3	8/9	UF	CS	GROSSA	166.0	53.4	3.8	pCi/L		11.07	15	0	30	5.53
TA-54, MDA-G-3	10/11	UF	CS	GROSSA	41.5	13.5	0.9	pCi/L		2.77	15	0	30	1.38
TA-54, MDA-G-3	10/28	UF	CS	GROSSA	12.4	3.1	2.1	pCi/L		0.83	15	0		
TA-54, MDA-G-5	10/23	UF	CS	GROSSA	35.9	10.5	1.9	pCi/L		2.39	15	0	30	1.20
TA-54, MDA-G-4	10/12	UF	CS	GROSSA	9.2	2.6	1.0	pCi/L		0.62	15	0		
Pajarito Canyon above SR 4	10/27	UF	CS	GROSSA	14.4	4.7	1.2	pCi/L		0.96	15	0		
Pajarito Canyon above SR 4	6/28	UF	CS	GROSSA	28.8	2.9	4.7	pCi/L		1.92	15	0		
Pajarito Canyon above SR 4	6/28	UF	TOTC	GROSSA	71.5	5.2		pCi/L		4.77	15	0	30	2.38
Water Canyon above SR 501	6/28	UF	CS	GROSSA	18.4	2.3	4.9	pCi/L		1.23	15	0		
Water Canyon above SR 501	6/28	UF	TOTC	GROSSA	46.6	3.5		pCi/L		3.11	15	0	30	1.55
Cañon del Valle above SR 501	6/28	UF	CS	GROSSA	25.0	2.9	5.7	pCi/L		1.67	15	0		

Table B-3. (Cont.)

Location Name	Sample Date	Codes[a]		Analyte	Result[b]	Uncert[c]	MDA	Units	Lab Qual Code[d]	val/min std[e]	min std	min std type	DOE DCG Screening Level	DOE DCG Ratio: Result / Scrn Lvl
Cañon del Valle above SR 501	6/28	UF	TOTC	GROSSA	118.1	9.5		pCi/L		7.87	15	0	30	3.94
Water Canyon at SR 4	6/28	UF	CS	GROSSA	13.2	1.6	3.2	pCi/L		0.88	15	0		
Water Canyon at SR 4	6/28	UF	TOTC	GROSSA	80.2	7.7		pCi/L		5.35	15	0	30	2.67
Water Canyon below SR 4	7/29	UF	CS	GROSSA	63.3	18.5	8.6	pCi/L		4.22	15	0	30	2.11
Water Canyon below SR 4	7/29	UF	DUP	GROSSA	69.6	21.1	8.7	pCi/L		4.64	15	0	30	2.32
Water Canyon below SR 4	8/18	UF	CS	GROSSA	8.3	1.9	1.0	pCi/L		0.55	15	0		
Water Canyon below SR 4	6/28	UF	CS	GROSSA	12.6	2.5	6.8	pCi/L		0.84	15	0		
Water Canyon below SR 4	6/28	UF	TOTC	GROSSA	214.0	21.5		pCi/L		14.27	15	0	30	7.13
Potrillo Canyon near White Rock, NM	8/9	UF	CS	GROSSA	40.7	7.4	2.1	pCi/L		2.71	15	0	30	1.36
Rendija Canyon at 3rd Crossing	7/17	UF	TOTC	GROSSA	480.0	38.0		pCi/L		32.00	15	0	30	16.00
Rendija Canyon at 3rd Crossing	7/17	UF	TOTC	GROSSB	1054.0	64.0		pCi/L		1.05	1000	0	1000	1.05
Rendija Canyon at 3rd Crossing	7/17	UF	TOTC	Pu-239,240	15.000	1.500		pCi/L		0.50	30	0		
Guaje Canyon at SR 502	7/9	UF	TOTC	Pu-239,240	17.727			pCi/L		0.59	30	0		
Pajarito Canyon at TA-18 Culvert	6/28	UF	TOTC	GROSSA	203.0	22.5		pCi/L		13.53	15	0	30	6.77
Pajarito Canyon at TA-18 Culvert	6/28	UF	TOTC	GROSSB	593.0	36.0		pCi/L		0.59	1000	0		
Pajarito Canyon at G-1	6/28	UF	CS	GROSSA	16.5	3.0	8.0	pCi/L		1.10	15	0		
Pajarito Canyon at G-1	6/28	UF	TOTC	GROSSA	48.2	4.9		pCi/L		3.21	15	0	30	1.61
Pajarito Canyon at SR 4 Culvert	6/28	UF	CS	GROSSA	16.9	2.0	4.1	pCi/L		1.13	15	0		
Pajarito Canyon at SR 4 Culvert	6/28	UF	TOTC	GROSSA	125.1	11.3		pCi/L		8.34	15	0	30	4.17

[a]Codes: UF - unfiltered sample; F - filtered samples; CS- customer sample; DUP.- duplicate; TOTC- value calculated from other results; TOTCD- duplicate calculated value.

[b]Values shown in the results column are >50% of the referenced standards. Not all data are shown.

[c]One standard deviation radioactivity counting uncertainty.

[d]Codes: B- analyte found in lab blank; U- analyte not detected.

[e] Values shown in the val/min std column are greater than 50% of the minimum standard used for comparison purposes. The minimum standard is either the DOE DCG or the New Mexico Livestock Watering Standard, which contain applicable radionuclide standards for unfiltered stormwater runoff.

Table B-4. Comparison of Radionuclides in Filtered Runoff Water Samples for 2000 to Standards

Location Name	Sample Date	Codes[a]		Analyte	Result[b]	Uncert[c]	MDA	Units	Lab Qual Code[d]	val/min std[e]	min std	min std type[b]	DOE DCG Screening Level	DOE DCG Ratio: Result / Scrn Lvl
Los Alamos Canyon at Los Alamos	7/18/00	F	CS	Sr-90	4.24	0.43	0.39	pCi/L		0.53	8	EPA PRIM DW STD		
DP Canyon at Mouth	10/27/00	F	CS	Sr-90	7.33	0.31	0.48	pCi/L		0.92	8	EPA PRIM DW STD	1000	0.007
Los Alamos Canyon near Los Alamos	10/23/00	F	CS	Sr-90	4.60	0.47	1.23	pCi/L		0.58	8	EPA PRIM DW STD	1000	0.005
TA-54, MDA-G-2	10/11/00	F	CS	Cs-137	62.40	2.33	2.33	pCi/L		0.52	120	DOE DW DCG	3000	0.021
TA-54, MDA-G-4	10/12/00	F	CS	Am-241	0.863	0.074	0.026	pCi/L		0.72	1.2	DOE DW DCG	30	0.029
TA-54, MDA-G-4	10/12/00	F	DUP	Am-241	0.851	0.076	0.011	pCi/L		0.71	1.2	DOE DW DCG	30	0.028
Pajarito Canyon above SR 4	6/28/00	F	CS	Sr-90	6.10	0.60	0.35	pCi/L		0.76	8	EPA PRIM DW STD	1000	0.006
Pajarito Canyon above SR 4	6/28/00	F	DUP	Sr-90	6.00	0.55	0.32	pCi/L		0.75	8	EPA PRIM DW STD	1000	0.006
Water Canyon above SR 501	10/23/00	F	CS	Sr-90	5.07	0.55	1.35	pCi/L		0.63	8	EPA PRIM DW STD	1000	0.005
Indio Canyon at SR 4	6/28/00	F	CS	Sr-90	5.01	0.49	0.36	pCi/L		0.63	8	EPA PRIM DW STD	1000	0.005
Water Canyon below SR 4	6/28/00	F	CS	Sr-90	5.40	0.55	0.38	pCi/L		0.68	8	EPA PRIM DW STD	1000	0.005
Los Alamos Canyon at SR 4 Weir	7/21/00	F	CS	Sr-90	26.60	4.42	2.69	pCi/L		3.33	8	EPA PRIM DW STD	1000	0.027
Rendija Canyon at 3rd Crossing	7/17/00	F	CS	Sr-90	4.50	0.45	0.38	pCi/L		0.56	8	EPA PRIM DW STD	1000	0.005
Pajarito Canyon at TA-18 Culvert	6/28/00	F	CS	Sr-90	5.40	0.50	0.34	pCi/L		0.68	8	EPA PRIM DW STD	1000	0.005
Pajarito Canyon at G-1	6/28/00	F	CS	Sr-90	5.60	0.55	0.34	pCi/L		0.70	8	EPA PRIM DW STD	1000	0.006
Pajarito Canyon at SR 4 Culvert	6/28/00	F	CS	Sr-90	6.30	0.60	0.37	pCi/L		0.79	8	EPA PRIM DW STD	1000	0.006

[a]Codes: UF - unfiltered sample; F - filtered samples; CS- customer sample; DUP.- duplicate.

[b]Values shown in the results column are >50% of the referenced standards. Not all data are shown.

[c]One standard deviation radioactivity counting uncertainty.

[d]Codes: B- analyte found in lab blank; U- analyte not detected.

[e] Values shown in the val/min std column are greater than 50% of the minimum standard used for comparison purposes. The minimum standard is either the DOE DCG, the DOE DW DCG, the EPA primary DW standard, or the New Mexico ground water limit, which contain applicable radionuclide standards for filtered stormwater runoff.

Table B-5. Trace Metals in Storm Water Runoff Samples in 2000

Location Name	Date	Codes[a]			Ag		Al		As		B		Ba		Be		Cd		Co		Cr		Cu		Fe		Hg
Los Alamos Canyon at Los Alamos	6/3	F	CS	<[b]	0.9		89.0		3.4		67.0		120.0		0.06		0.3		3.9	<	0.4		2.5		87	<	0.01
Los Alamos Canyon at Los Alamos	6/3	UF	CS	<	0.9		2900.0		7.1		74.0		370.0		1.02		0.8		6.1		1.4		6.8		2000	<	0.01
Los Alamos Canyon at Los Alamos	7/18	F	CS												0.04	<	0.1								332		
Los Alamos Canyon at Los Alamos	7/18	UF	CS												17.60		8.5								121000		
Los Alamos Canyon at Los Alamos	7/18	UF	DUP												20.70		9.1								166000		
Los Alamos Canyon at Los Alamos	7/18	F	CS		10.0		220.0		4.4		87.0		170.0	<	5.00	<	5.0		6.7		0.8		6.9		130	<	0.20
Los Alamos Canyon at Los Alamos	7/18	UF	CS		1.1		18000.0		14.0		317000.0		2000.0		9.10		3.7		43.0		4.3		17.0		5000		0.02
Los Alamos Canyon at Los Alamos	9/12	F	CS	<	0.5		377.0		5.0		54.1		157.0		0.51	<	0.1		6.4	<	1.1		1.6		375		
Los Alamos Canyon at Los Alamos	9/12	UF	CS	<	0.5		8660.0		7.2		48.7		287.0		1.35		0.7		8.1		2.6		9.2		4560	<	0.06
Los Alamos Canyon below TA- 2	6/2	UF	CS	<	0.9		4300.0		6.6		31.0		530.0		9.94		4.1		17.0		6.8		64.0		5200	<	0.01
Los Alamos Canyon below TA- 2	10/23	UF	CS	<	0.5		6090.0	<	2.6		23.9		98.7		0.86		0.3		0.8		3.1		5.6		3830		
DP Canyon below Meadow at TA-21	7/25	F	CS	<	0.5		85.9	<	2.6		24.9		16.7		0.52		0.2	<	0.6	<	1.1		9.5		75		
DP Canyon below Meadow at TA-21	7/25	UF	CS	<	0.5		5090.0	<	2.6		19.6		75.3		0.94		0.5		3.6		6.2		25.9		3860	<	0.06
DP Canyon below Meadow at TA-21	10/23	UF	CS	<	0.5		20400.0		5.7				230.0		2.67		1.2		6.3		20.9		55.4		17000		
DP Canyon below Meadow at TA-21	10/27	F	CS	<	0.5		679.0		3.8		11.2		16.6		0.52	<	0.1	<	0.6		1.7		3.1		401		
DP Canyon below Meadow at TA-21	10/27	F	DUP	<	0.5		665.0	<	2.6		10.6		16.4		0.52	<	0.1	<	0.6		1.6		2.7		397		
DP Canyon below Meadow at TA-21	10/27	UF	CS		0.7		18600.0		4.4		18.7		293.0		3.85		1.4		9.0		15.8		48.8		13000		
DP Canyon at Mouth	6/2	UF	CS	<	0.9		5400.0		5.3		28.0		510.0		11.76		4.3		17.0		6.3		58.0		3600	<	0.01
DP Canyon at Mouth	10/23	UF	CS	<	0.5		33000.0		10.1				363.0		6.27		2.0		10.1		28.8		64.0		26900		
DP Canyon at Mouth	10/27	F	CS	<	0.5		1040.0	<	2.6		15.2		22.9		0.59	<	0.1	<	0.6		1.0		2.1		584		
DP Canyon at Mouth	10/27	UF	CS		0.8		48800.0		10.4		40.4		760.0		14.22		3.5		25.2		41.9		108.0		37500		
Los Alamos Canyon near Los Alamos	6/2	UF	CS	<	0.9		8800.0		6.4		40.0		890.0		20.50		8.0		30.0		11.0		95.0		5900	<	0.01
Los Alamos Canyon near Los Alamos	6/3	F	CS	<	0.9		59.0	<	3.0		66.0		110.0		0.06		0.3		1.1	<	0.4		2.0		76	<	0.01
Los Alamos Canyon near Los Alamos	6/3	UF	CS	<	0.9		8700.0		8.1		81.0		830.0		4.97		3.5		15.0		4.6		13.0		4700	<	0.01
Los Alamos Canyon near Los Alamos	7/9	UF	CS	<	0.5		29000.0		22.0		220.0		3600.0		32.60		24.1		28.0		12.0		35.0		240000	<	0.01
Los Alamos Canyon near Los Alamos	7/9	UF	DUP	<	0.4		28600.0		22.0		215.0		3540.0		6.72		5.2		27.6		11.4		34.9		13300	<	0.01
Los Alamos Canyon near Los Alamos	7/9	F	CS	<	0.5		220.0		5.7		93.0		110.0		0.21		0.2		3.3		1.1		6.7		407	<	0.01
Los Alamos Canyon near Los Alamos	10/23	F	CS		0.6		617.0	<	2.6		13.5		17.3		0.53	<	0.1		11.3		1.1	<	1.8		368		
Los Alamos Canyon near Los Alamos	10/23	UF	CS		0.6		30900.0		8.6		21.0		513.0		7.77		2.1		28.9		23.0		50.9		25000	<	0.06
Los Alamos Canyon near Los Alamos	10/27	F	CS	<	0.5		772.0	<	2.6		18.4		41.7		0.51		0.1	<	0.6	<	1.1	<	1.8		415		
Pueblo Canyon near Los Alamos	10/23	F	CS	<	0.5		2700.0		4.6		91.9		99.1		0.66		0.1		1.9		0.9		4.4		1680		
Pueblo Canyon near Los Alamos	10/23	UF	CS	<	0.5		90600.0		29.1				2360.0		19.39		6.0		54.5		43.8		84.7		64900		0.25
Sandia Canyon at TA-3	7/17	UF	CS												0.89		1.5								12700		
Sandia Canyon at TA-3	7/17	UF	CS		0.8		5000.0		4.3		38.0		140.0		0.42		1.0		8.5		9.5		45.0		5000		0.08
TA-55	7/17	UF	CS												0.30		1.6								4120		
TA-55	7/17	UF	CS		0.8		1000.0	<	10.0		100.0		44.0	<	5.00		0.4		6.2		2.3		84.0		1000		0.03
TA-55	10/7	UF	CS	<	0.5		1940.0	<	2.6		16.2		25.3		0.57		0.3		4.6		2.0		57.5		1310	<	0.06
TA-55	10/7	UF	DUP	<	0.5		1880.0	<	2.6		15.5		24.8		0.57		0.3		4.5		2.0		56.9		1260		
Cañada del Buey near TA-46	10/23	UF	CS		0.7		19900.0		3.8		16.3		147.0		5.39		2.3		3.0		14.5		25.2		13200		
TA-54, MDA-J	8/9	UF	CS	<	0.5		102000.0		16.4		20.9		1030.0		14.15		1.0		33.0		59.3		49.4		64200	<	0.06
TA-54, MDA-J	8/9	UF	DUP	<	0.5		103000.0		17.1		24.3		1010.0		14.09		1.0		32.5		59.9		47.9		64600	<	0.06
TA-54, MDA-J	7/15	UF	CS												0.15		1.0								1630		
TA-54, MDA-J	7/15	UF	CS		0.6		1000.0	<	10.0		620.0		71.0	<	5.00		0.8		9.1		3.2		22.0		920		0.06
TA-54, MDA-J	7/17	F	CS												0.05		0.1				4				5		
TA-54, MDA-J	7/17	UF	CS												0.13		0.9								1350		
TA-54, MDA-J	10/7	UF	CS	<	0.5		1130.0	<	2.6		21.1		43.1		0.54		0.4		1.3		2.0		13.1		792	<	0.06
TA-54, MDA-G-6	7/29	F	CS	<	0.5		18.0	<	2.6		73.0		51.3		0.49		0.1		1.2	<	1.1		2.4		25		
TA-54, MDA-G-6	7/29	UF	CS	<	0.5		59200.0		13.8		82.5		509.0		8.89		1.3		16.6		36.8		46.6		38800	<	0.06
TA-54, MDA-G-6	8/18	F	CS	<	0.5		143.0	<	2.6		72.8		45.2		0.51	<	0.1		1.0	<	1.1		4.7		66		
TA-54, MDA-G-6	8/18	UF	CS	<	0.5		34800.0		7.9		113.0		257.0		4.54		0.7		19.9		21.0		26.5		24300	<	0.06
TA-54, MDA-G-6	8/18	UF	DUP												2.34		0.6										
TA-54, MDA-G-6	10/11	F	CS	<	0.5		531.0	<	2.6		24.5		23.9		0.51	<	0.1	<	0.6	<	1.1	<	1.8		301		
TA-54, MDA-G-6	10/11	UF	CS	<	0.5		23400.0	<	2.6		55.8		339.0		6.68		0.6		7.7		16.3		21.4		15800	<	0.06
TA-54, MDA-G-6	10/11	UF	DUP	<	0.5		23000.0	<	2.6		53.1		334.0		5.46		0.7		7.6		14.1		19.7		14800		
Cañada del Buey at White Rock	7/29	UF	CS	<	0.5		417000.0		64.1		90.4		5180.0		72.30		5.3		150.0		247.0		270.0		285000	<	0.06
Cañada del Buey at White Rock	7/29	F	CS	<	0.5		232.0		3.0		29.1		49.0		0.53	<	0.1		2.7	<	1.1		2.4		116		
Cañada del Buey at White Rock	8/18	F	CS		0.9		264.0	<	2.6		19.9		32.3		0.51	<	0.1		2.8	<	1.1	<	1.8		97		
Cañada del Buey at White Rock	8/18	UF	CS	<	0.5		164000.0		27.0		50.7		2520.0		29.80		3.1		89.0		85.7		100.0		103000	<	0.06
Cañada del Buey at White Rock	10/11	UF	CS	<	0.5		67900.0	<	2.6		51.3		3140.0		33.50		2.9		62.9		25.5		32.2		33700	<	0.06
Cañada del Buey at White Rock	10/23	UF	CS		0.6		118000.0		17.8		32.2		2010.0		25.60		2.9		56.3		66.1		52.6		77000	<	0.06

Table B-5. (Cont.)

Location Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Cañada del Buey at White Rock	10/28	F	CS	< 0.5	4830.0	< 2.6	8.3	40.7	0.72	< 0.1	< 0.6	1.9	1.9	2510	
Cañada del Buey at White Rock	10/28	UF	CS	< 0.5	21000.0	3.2	19.2	1190.0	13.82	1.7	26.0	6.3	14.3	8010	
Pajarito Canyon above SR 501	6/28	F	CS	< 0.9	300.0	4.2	130.0	210.0	0.06	0.4	6.0	0.5	7.2	190	< 0.01
Pajarito Canyon above SR 501	6/28	UF	TOTC	6.1	375946.7	99.9	600.4	16116.7	25.06	6.7	206.8	301.9	607.1	375572	1.33
Pajarito Canyon above SR 501	9/8	F	CS	< 0.5	427.0	4.1	27.4	80.5	0.50	< 0.1	4.2	< 1.1	3.5	444	
Pajarito Canyon above SR 501	9/8	UF	CS	< 0.5	166000.0	35.9	57.0	3890.0	14.96	5.9	71.9	88.7	135.0	103000	< 0.06
Pajarito Canyon above SR 501	9/8	UF	DUP	< 0.5	170000.0	37.6	67.9	3930.0	14.97	5.7	72.7	89.8	139.0	101000	
Pajarito Canyon above SR 501	10/23	F	CS	0.6	99.8	< 2.6	23.9	67.3	0.51	< 0.1	< 0.6	< 1.1	< 1.8	136	
Pajarito Canyon above SR 501	10/23	UF	CS	0.6	13400.0	4.7	32.0	433.0	1.09	0.4	8.7	6.9	11.5	9620	0.26
Pajarito Canyon above SR 501	10/23	UF	DUP	< 0.5	12800.0	3.9	32.3	429.0	0.94	0.4	8.6	6.7	11.1	9120	
Pajarito Canyon at TA-22	6/28	F	CS	< 0.9	420.0	< 3.0	98.0	190.0	0.05	0.4	5.7	1.1	7.3	260	< 0.01
Pajarito Canyon at TA-22	6/28	UF	TOTC	12.0	70784.1	48.6	274.6	2520.1	2.74	3.6	32.1	61.9	106.4	57392	0.45
Starmer's Gulch at TA-22	6/28	F	CS	< 0.9	280.0	3.8	120.0	180.0	0.06	0.4	3.0	0.4	6.6	180	< 0.01
Starmer's Gulch at TA-22	6/28	UF	TOTC	6.8	64574.2	35.2	252.4	3188.8	4.27	3.0	47.9	41.4	99.8	61296	0.18
TA 54 MDA G-1	10/11	F	CS	< 0.5	859.0	< 2.6	13.7	12.8	0.53	< 0.1	1.1	0.7	< 1.8	470	
TA 54 MDA G-1	10/11	UF	CS	< 0.5	42200.0	8.9	35.8	367.0	5.52	0.4	13.1	26.2	19.8	29200	< 0.06
TA-54, MDA-G-2	7/29	F	CS	< 0.5	< 23.4	< 2.6	139.0	95.8	0.49	0.2	1.9	< 1.1	3.4	< 20	
TA-54, MDA-G-2	7/29	UF	CS	< 0.5	30900.0	8.6	127.0	334.0	3.88	0.8	8.2	19.6	24.9	19700	< 0.06
TA-54, MDA-G-2	8/9	F	CS	< 0.5	51.2	< 2.6	49.8	40.5	0.48	< 0.1	3.0	< 1.1	2.9	30	
TA-54, MDA-G-2	8/9	UF	CS	< 0.5	56400.0	11.7	60.0	596.0	10.43	1.3	17.6	30.7	43.7	36600	< 0.06
TA-54, MDA-G-2	10/11	F	CS	< 0.5	126.0	< 2.6	71.7	54.6	0.51	< 0.1	3.5	< 1.1	4.2	103	
TA-54, MDA-G-2	10/11	UF	CS	< 0.5	21500.0	5.7	80.3	193.0	2.91	0.2	7.1	12.7	15.9	16000	< 0.06
TA-54, MDA-G-3	7/29	UF	CS	2.9	130000.0	26.4	74.7	1470.0	27.70	3.0	40.8	81.7	76.8	77600	< 0.06
TA-54, MDA-G-3	8/18	F	CS	< 0.5	135.0	< 2.6	92.3	75.0	0.51	< 0.1	3.0	1.4	3.8	37	
TA-54, MDA-G-3	8/18	UF	CS	< 0.5	13700.0	3.5	136.0	141.0	2.20	0.3	2.3	6.2	9.9	5700	< 0.06
TA-54, MDA-G-3	10/11	F	CS	< 0.5	516.0	< 2.6	37.8	27.8	0.52	< 0.1	< 0.6	2.3	4.6	291	
TA-54, MDA-G-3	10/11	UF	CS	0.7	17700.0	4.4	43.2	166.0	2.89	0.1	10.8	13.2	12.1	12400	< 0.06
TA-54, MDA-G-3	10/25	F	CS	< 0.5	195.0	< 2.6	21.4	25.4	0.49	0.2	< 0.6	1.2	2.3	116	
TA-54, MDA-G-3	10/25	UF	CS	< 0.5	54700.0	12.7	20.2	845.0	6.18	1.5	26.0	30.5	48.6	42200	
TA-54, MDA-G-3	10/28	F	CS	< 0.5	206.0	< 2.6	26.8	29.0	0.51	< 0.1	< 0.6	1.9	< 1.8	120	
TA-54, MDA-G-3	10/28	UF	CS												< 0.06
TA-54, MDA-G-5	10/23	F	CS	0.6	362.0	< 2.6	27.0	7.8	0.52	< 0.1	< 0.6	< 1.1	< 1.8	201	
TA-54, MDA-G-5	10/23	UF	CS	0.6	6940.0	< 2.6	22.2	46.6	0.91	< 0.1	2.2	4.3	3.6	4590	< 0.06
TA-54, MDA-G-4	8/15	UF	CS	< 0.5	11700.0	< 2.6	31.8	146.0	2.15	0.6	5.6	5.6	18.6	7860	< 0.06
TA-54, MDA-G-4	8/15	UF	DUP	< 0.5	11000.0	< 2.6	30.1	142.0	2.07	0.6	5.7	5.3	18.1	6920	
TA-54, MDA-G-4	10/12	F	CS	< 0.5	586.0	< 2.6	29.5	56.1	0.53	< 0.1	1.8	< 1.1	4.3	410	
TA-54, MDA-G-4	10/12	UF	CS	< 0.5	4660.0	3.6	32.7	83.9	0.76	0.1	4.1	2.6	8.9	2940	< 0.06
Pajarito Canyon above SR 4	6/28	F	CS	< 0.9	140.0	8.3	190.0	310.0	0.08	0.5	3.9	0.7	6.0	130	< 0.01
Pajarito Canyon above SR 4	6/28	UF	CS						0.24	1.0					
Pajarito Canyon above SR 4	6/28	UF	TOTC	6.2	80068.8	40.5	407.1	4817.7	5.55	3.2	52.4	62.0	150.9	79500	0.20
Pajarito Canyon above SR 4	10/24	F	CS	< 0.5	1070.0	3.6	32.1	73.8	0.59	< 0.1	< 0.6	1.6	3.1	605	
Pajarito Canyon above SR 4	10/24	UF	CS	1.7	43300.0	11.2		690.0	5.99	1.7	9.4	20.0	27.7	25900	< 0.06
Pajarito Canyon above SR 4	10/27	F	CS	< 0.5	323.0	< 2.6	39.7	76.7	0.61	0.1	< 0.6	< 1.1	1.6	192	
Pajarito Canyon above SR 4	10/27	UF	CS	1.4	47700.0	11.9	63.0	529.0	7.70	1.6	11.1	20.6	31.3	27500	< 0.06
Water Canyon above SR 501	6/28	UF	TOTC	1.1	19099.4	16.0	321.8	2019.3	1.35	0.6	16.5	13.7	34.1	18200	0.05
Water Canyon above SR 501	10/23	F	CS	0.6	3510.0	4.3	29.3	80.5	0.65	< 0.1	< 0.6	1.3	3.1	1820	
Water Canyon above SR 501	10/23	UF	CS	0.6	116000.0	20.4	81.5	4880.0	37.10	1.2	79.6	50.2	56.7	63900	< 0.06
Cañon del Valle above SR 501	6/28	UF	TOTC	2.6	51898.3	24.4	286.7	3827.8	3.78	1.1	38.2	39.4	86.6	58119	0.21
Cañon del Valle above SR 501	10/23	F	CS	0.6	165.0	4.4	31.7	56.8	0.51	< 0.1	3.7	< 1.1	2.0	162	
Cañon del Valle above SR 501	10/23	UF	CS	0.6	70300.0	15.8	74.5	3440.0	14.34	4.9	65.0	26.9	34.9	35700	< 0.06
Water Canyon at SR 4	6/28	UF	TOTC	39.4	85528.5	41.0	359.2	7192.2	6.68	2.1	50.9	61.3	150.6	95249	0.45
Water Canyon at SR 4	10/27	F	CS	< 0.5	3700.0	< 2.6	34.9	134.0	0.65	0.1	1.4	< 1.1	3.7	1820	
Water Canyon at SR 4	10/27	UF	CS	3.0	142000.0	24.0	105.0	5450.0	32.40	5.9	68.0	50.5	71.9	74200	
Water Canyon at SR 4	10/27	UF	DUP	2.8	143000.0	22.8	106.0	5430.0	32.40	6.1	67.9	51.1	73.9	74900	
Indio Canyon at SR 4	6/28	UF	CS						0.17	0.5					
Water Canyon below SR 4	6/28	F	CS	< 0.9	140.0	8.9	130.0	550.0	0.07	0.5	3.0	0.4	6.2	110	0.01
Water Canyon below SR 4	6/28	UF	TOTC	171.1	208933.2	73.6	470.6	17368.2	15.82	5.0	121.2	144.8	370.0	234477	1.06
Water Canyon below SR 4	7/29	UF	CS	12.0	251000.0	77.0	226.0	7520.0	43.40	11.7	108.0	130.0	290.0	173000	< 0.06
Water Canyon below SR 4	7/29	UF	DUP	14.0	299000.0	86.5	224.0	8180.0	51.00	14.2	121.0	157.0	337.0	205000	
Water Canyon below SR 4	8/12	UF	CS	1.4	98000.0	25.3	160.0	5120.0	23.00	4.5	76.4	41.5	54.8	65700	< 0.06
Water Canyon below SR 4	8/18	F	CS	< 0.5	424.0	3.3	41.2	41.8	0.49	< 0.1	1.3	< 1.1	2.0	166	
Water Canyon below SR 4	8/18	UF	CS	< 0.5	17600.0	3.4	27.5	292.0	1.94	0.3	4.3	8.3	12.2	9280	0.09
Water Canyon below SR 4	8/18	UF	DUP	< 0.5	17600.0	3.0	28.6	297.0	0.94		4.3	8.5	12.5	9350	
Water Canyon below SR 4	10/23	F	CS	< 0.5	862.0	4.0	30.6	97.2	0.52	< 0.1	2.3	< 1.1	2.5	499	

Table B-5. (Cont.)

Location Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Water Canyon below SR 4	10/23	UF	CS	< 0.5	54400.0	13.4	69.4	5300.0	27.00	6.1	79.5	13.7	26.2	25400	< 0.06
Water Canyon below SR 4	10/23	UF	DUP	< 0.5	54900.0	14.3	67.5	5310.0	27.20	5.9	80.5	13.4	26.1	25700	
Water Canyon below SR 4	10/27	F	CS	< 0.5	1560.0	< 2.6	27.8	96.1	0.53	< 0.1	< 0.6	< 1.1	1.9	816	
Water Canyon below SR 4	10/27	UF	CS	3.9	96000.0	22.2	80.8	4040.0	27.80	6.1	63.0	42.9	69.9	60800	< 0.06
Potrillo Canyon near White Rock	8/9	UF	CS	< 0.5	99600.0	17.1	22.7	1710.0	23.40	2.8	48.8	49.9	56.5	59300	< 0.06
Potrillo Canyon near White Rock	10/23	F	CS	< 0.5	1620.0	< 2.6	11.3	18.1	0.61	< 0.1	< 0.6	0.8	< 1.8	881	
Potrillo Canyon near White Rock	10/23	UF	CS	< 0.5	36200.0	7.7	< 4.7	869.0	12.75	1.9	27.5	17.5	23.6	22900	< 0.06
Ancho Canyon at TA-39	8/18	UF	CS	< 0.5	319000.0	63.0	80.8	3430.0	65.10	7.2	135.0	201.0	218.0	229000	< 0.06
Ancho Canyon at TA-39	10/28	UF	CS	< 0.5	93500.0	13.5	35.9	652.0	12.36	1.2	27.3	57.7	76.6	63500	
Ancho Canyon near Bandelier NP	8/18	UF	CS	< 0.5	278000.0	48.9	81.5	2250.0	41.70	6.3	86.0	162.0	165.0	185000	0.11
Ancho Canyon near Bandelier NP	8/18	UF	DUP	< 0.5	262000.0	43.7	71.0	2280.0	44.00	7.9	84.7	148.0	161.0	169000	
Ancho Canyon near Bandelier NP	10/23	UF	CS	< 0.5	60700.0	9.6	5.6	771.0	12.93	2.4	22.0	30.6	35.9	38200	< 0.06
Ancho Canyon near Bandelier NP	10/28	UF	CS	< 0.5	49100.0	5.8	26.9	526.0	9.59	1.2	17.2	24.8	26.7	28600	
Upper Los Alamos Reservoir	8/31	F	CS	< 0.5	2720.0	3.1	52.3	227.0	0.51	< 0.1	2.3	0.9	4.0	1660	
Upper Los Alamos Reservoir	8/31	UF	CS	< 0.5	73.4	< 2.6	24.6	61.6	0.50	< 0.1	2.6	< 1.1	2.7	283	0.05
Los Alamos Reservoir	8/31	F	CS	< 0.5	19.1	3.2	19.4	58.9	0.53	< 0.1	2.5	< 1.1	< 1.8	186	
Los Alamos Reservoir	8/31	UF	CS	< 0.5	2540.0	3.0	58.3	222.0	0.70	0.2	4.1	1.1	3.7	1630	0.05
Los Alamos Reservoir	8/31	UF	DUP	< 0.5	2260.0	4.2	58.3	220.0	0.66	0.2	3.7	< 1.1	3.5	1480	
Los Alamos Canyon at SR 4 Weir	7/21	F	CS	< 0.5	95.5	3.2	71.6	191.0	0.54	< 0.1	4.4	< 1.1	3.4	267	
Los Alamos Canyon at SR 4 Weir	7/21	UF	CS	< 0.5	39400.0	10.4	80.0	856.0	5.49	1.3	14.1	16.2	41.0	19400	0.07
Los Alamos Canyon at SR 4 Weir	7/21	UF	DUP	< 0.5	39800.0	8.9	80.7	863.0	5.45	1.4	14.2	16.6	41.6	19900	0.06
Rendija Canyon 3rd Crossing	7/17	F	CS						0.06	0.3				139	
Rendija Canyon 3rd Crossing	7/17	F	CS	0.9	280.0	12.0	75.0	77.0	< 5.00	< 5.0	9.7	0.7	2.9	160	< 0.20
Rendija Canyon 3rd Crossing	7/17	UF	CS	0.5	24000.0	44.0	2300.0	2000.0	13.00	5.9	56.0	5.7	7.8	3000	< 0.20
Rendija Canyon 3rd Crossing	7/17	UF	DUP	1.0	28000.0	50.9	2700.0	2000.0	15.60	7.0	65.9	7.1	9.1	4000	< 0.20
Guaje Canyon at SR 502	7/9	F	CS	< 0.5	110.0	11.0	120.0	86.0	0.14	0.2	8.6	0.7	4.5	341	< 0.01
Guaje Canyon at SR 502	7/9	UF	CS	< 0.5	7400.0	24.0	290.0	1700.0	59.40	34.0	12.0	4.3	15.0	192900	< 0.01
Guaje Canyon at SR 502	9/8	F	CS	< 0.5	463.0	6.5	46.1	108.0	0.52	< 0.1	1.9	< 1.1	4.4	273	
Guaje Canyon at SR 502	9/8	UF	CS	< 0.5	995000.0	137.0	136.0	20700.0	136.20	27.3	475.0	510.0	605.0	560000	< 0.06
Starmer's Gulch above SR 501	10/23	F	CS	0.6	11500.0	6.7	47.9	179.0	0.69	0.1	2.9	5.7	7.6	6910	
Starmer's Gulch above SR 501	10/23	UF	CS	0.6	63700.0	14.2	71.0	3840.0	16.01	4.3	65.6	22.0	26.3	32700	< 0.06
Two-mile Canyon at SR 501	10/23	F	CS	0.6	363.0	4.0	54.1	75.7	0.50	< 0.1	< 0.6	< 1.1	3.4	261	
Two-mile Canyon at SR 501	10/23	UF	CS	0.6	82500.0	23.0	90.5	3940.0	13.00	4.7	53.3	35.2	51.6	49400	< 0.06
Pajarito Canyon at TA-18 Culvert	6/28	F	CS	< 0.9	140.0	4.4	150.0	230.0	0.05	0.5	5.7	1.0	9.8	130	< 0.01
Pajarito Canyon at TA-18 Culvert	6/28	F	DUP	< 0.9	138.0	7.3	152.0	227.0	< 0.03	< 0.2	5.7	0.8	9.5	136	< 0.01
Pajarito Canyon at TA-18 Culvert	6/28	UF	TOTC	13.1	241784.0	74.9	495.4	11528.4	16.39	10.4	140.9	194.2	455.4	256436	1.19
Pajarito Canyon at SR 4 Culvert	6/28	F	CS	< 0.9	380.0	8.0	180.0	290.0	0.14	0.2	4.4	0.4	9.1	260	< 0.01
Pajarito Canyon at SR 4 Culvert	6/28	UF	TOTC	16.9	252358.8	90.0	480.0	10615.3	17.98	12.9	143.9	187.5	447.0	240696	0.38
Water Quality Standards[c]															
EPA Primary Drinking Water Standard						50		2,000	4	5		100			2
EPA Secondary Drinking Water Standard					50-200									300	
EPA Action Limit													1,300		
EPA Health Advisory															
NMWQCC Livestock Watering Standard					5,000	200	5,000			50	1,000	1,000	500		10
NMWQCC Groundwater Limit				50	5,000	100	750	1,000		10	50	50	1,000	1,000	2
NMWQCC Wildlife Habitat Standard															0.77

[a]Codes: UF- unfiltered; F- filtered; CS - customer sample; DUP - laboratory duplicate; TOTC - total concentration calculated from laboratory data.

[b]Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.

[c]Standards given here for comparison only, see Appendix A. Note that New Mexico Livestock Watering and Groundwater limits are based on dissolved concentrations, whereas many of these analyses are of unfiltered samples; thus, concentration may include suspended sediment quantities.

Table B-5. (Cont.)

Location Name	Date		Codes[a]	Mn		Mo		Ni		Pb		Sb		Se		Sn	Sr		Tl	V		Zn
Los Alamos Canyon at Los Alamos	6/3	F	CS	340	<	4.8		2.9		1.08		4.32	<	3.5	<	16.0	230.0		3.41	3.3		2.9
Los Alamos Canyon at Los Alamos	6/3	UF	CS	1500	<	4.8		6.8		45.80		4.53	<	3.5	<	16.0	310.0		3.62	8.7		54.0
Los Alamos Canyon at Los Alamos	7/18	F	CS							0.05		1.06							0.81			
Los Alamos Canyon at Los Alamos	7/18	UF	CS							319.00		1.55							3.71			
Los Alamos Canyon at Los Alamos	7/18	UF	DUP							409.00		1.35							3.86			
Los Alamos Canyon at Los Alamos	7/18	F	CS	1000		7.2		6.0	<	3.00		20.00	<	5.0	<	50.0	320.0	<	10.00	4.7		10.0
Los Alamos Canyon at Los Alamos	7/18	UF	CS	20000	<	10.0		40.0		54.00	<	20.00		9.3	<	50.0	1000.0	<	20.00	40.0		480.0
Los Alamos Canyon at Los Alamos	9/12	F	CS	1670		2.5		4.8		1.09		0.68			<	2.0	329.0		0.24	2.1		4.5
Los Alamos Canyon at Los Alamos	9/12	UF	CS	2160		1.8		9.4		14.80		0.69	<	2.4	<	2.0	361.0		0.24	8.8		35.6
Los Alamos Canyon below TA- 2	6/2	UF	CS	2500	<	4.8		19.0		381.00		3.93	<	3.5	<	16.0	190.0		4.08	33.0		430.0
Los Alamos Canyon below TA- 2	10/23	UF	CS	215	<	1.1		3.8		8.21		0.22	<	2.4	<	2.0	131.0		0.03	7.0		64.2
DP Canyon below Meadow at TA-21	7/25	F	CS	5		1.7		1.4		0.48	<	0.68	<	2.4	<	3.1	46.8	<	0.01	3.3		48.6
DP Canyon below Meadow at TA-21	7/25	UF	CS	188		1.8		5.4		29.70		1.12	<	2.4	<	3.1	56.4		0.05	10.5		200.0
DP Canyon below Meadow at TA-21	10/23	UF	CS	652	<	1.1		15.8		81.50		1.29	<	2.4		3.0	79.2		0.17	28.7		508.0
DP Canyon below Meadow at TA-21	10/27	F	CS	5	<	1.1	<	3.1		0.89		0.42			<	2.0	24.5		0.11	2.3		17.9
DP Canyon below Meadow at TA-21	10/27	F	DUP	5	<	1.1	<	3.1		0.90		0.36			<	2.0	24.3	<	0.01	2.0		17.7
DP Canyon below Meadow at TA-21	10/27	UF	CS	779	<	1.1		14.3		101.00		1.12				2.4	81.1		0.17	29.7		546.0
DP Canyon at Mouth	6/2	UF	CS	1900	<	4.8		18.0		395.00		4.43	<	3.5	<	16.0	150.0		3.88	33.0		620.0
DP Canyon at Mouth	10/23	UF	CS	1240	<	1.1		22.8		123.00		1.71	<	2.4	<	2.0	110.0		0.19	44.6		554.0
DP Canyon at Mouth	10/27	F	CS	9	<	1.1	<	3.1		1.50		0.54				2.7	34.8	<	0.01	2.3		19.9
DP Canyon at Mouth	10/27	UF	CS	2610		2.8		39.1		246.00		1.40		3.4		2.4	188.0		0.42	75.1		1070.0
Los Alamos Canyon near Los Alamos	6/2	UF	CS	4100	<	4.8		33.0		591.00		4.53	<	3.5	<	16.0	300.0		4.51	55.0		850.0
Los Alamos Canyon near Los Alamos	6/3	F	CS	390		6.7		3.0		1.03		4.38	<	3.5	<	16.0	240.0		3.41	3.0		4.6
Los Alamos Canyon near Los Alamos	6/3	UF	CS	4800	<	4.8		18.0		164.00		4.35		4.3	<	16.0	480.0		3.94	21.0		210.0
Los Alamos Canyon near Los Alamos	7/9	UF	CS	25000		5.4		31.0		1110.00		6.21		12.0	<	20.0	1700.0		20.42	40.0		810.0
Los Alamos Canyon near Los Alamos	7/9	UF	DUP	24600	<	4.2		30.4		101.00	<	2.79		12.2	<	20.4	1650.0	<	11.00	40.0		811.0
Los Alamos Canyon near Los Alamos	7/9	F	CS	390		9.4		4.2		2.45		4.05	<	2.6	<	20.0	190.0		3.77	4.7		7.6
Los Alamos Canyon near Los Alamos	10/23	F	CS	9	<	1.1		3.2		0.68		0.41				2.4	33.9		0.02	1.9		4.8
Los Alamos Canyon near Los Alamos	10/23	UF	CS	3010	<	1.1		28.2		124.00		0.76	<	2.4		2.4	144.0		0.22	43.7		470.0
Los Alamos Canyon near Los Alamos	10/27	F	CS	38		5.4		1.3		1.15		0.85				2.4	81.6	<	0.01	1.8		12.3
Pueblo Canyon near Los Alamos	10/23	F	CS	1360		3.3		3.4		4.05		3.62			<	2.0	145.0	<	0.01	6.7		164.0
Pueblo Canyon near Los Alamos	10/23	UF	CS	14900		2.6		76.8		216.00		0.60		4.0	<	2.0	643.0		0.76	132.0		692.0
Sandia Canyon at TA-3	7/17	UF	CS							46.80		1.44							0.40			
Sandia Canyon at TA-3	7/17	UF	CS	390	<	10.0		9.7		43.00		2.90	<	5.0	<	50.0	55.0	<	10.00	13.0		500.0
TA-55	7/17	UF	CS							12.70	<	0.11							0.35			
TA-55	7/17	UF	CS	120	<	10.0		4.6		8.30	<	20.00	<	5.0	<	50.0	28.0	<	10.00	6.6		240.0
TA-55	10/7	UF	CS	62		2.0		2.5		4.06		0.26	<	2.4			17.9		0.46	3.9		201.0
TA-55	10/7	UF	DUP	61	<	1.1		2.2		4.19	<	0.11	<	2.4			17.5		0.13	3.8		198.0
Cañada del Buey near TA-46	10/23	UF	CS	328	<	1.1		11.9		93.20		0.46	<	2.4	<	2.0	72.9		0.47	22.2		358.0
TA-54, MDA-J	8/9	UF	CS	1880		2.1		50.4		70.30	<	0.68		5.8		3.2	201.0		1.23	132.0		392.0
TA-54, MDA-J	8/9	UF	DUP	1880		1.5		49.6		74.30	<	0.11		3.0	<	2.0	198.0		0.91	135.0		386.0
TA-54, MDA-J	7/15	UF	CS							3.93		4.84							0.24			
TA-54, MDA-J	7/15	UF	CS	180	<	10.0		5.9		3.30		5.00	<	5.0	<	50.0	59.0	<	10.00	6.4		320.0
TA-54, MDA-J	7/17	F	CS							0.22		2.59							0.26			
TA-54, MDA-J	7/17	UF	CS							3.34		10.90							0.24			
TA-54, MDA-J	10/7	UF	CS	61	<	1.1		1.9		2.01		1.10	<	2.4			25.4		0.32	3.0		249.0
TA-54, MDA-G-6	7/29	F	CS	51	<	1.5	<	3.1		0.05		3.39	<	2.4	<	3.1	155.0	<	0.01	3.1	<	2.2
TA-54, MDA-G-6	7/29	UF	CS	1390		2.4		32.3		45.70		1.70	<	2.4	<	3.1	283.0		0.53	75.0		364.0
TA-54, MDA-G-6	8/18	F	CS	28	<	1.1	<	3.1	<	0.08		8.61			<	2.0	103.0		0.34	2.9		2.7
TA-54, MDA-G-6	8/18	UF	CS	676		3.8		18.1		20.10		6.41		4.0		3.7	158.0		0.48	41.5		204.0
TA-54, MDA-G-6	8/18	UF	DUP							20.50		6.04							0.20			
TA-54, MDA-G-6	10/11	F	CS	13	<	1.1		1.0		0.18		5.34	<	2.4	<	2.0	46.5	<	0.01	2.3		6.6
TA-54, MDA-G-6	10/11	UF	CS	907	<	1.1		14.9		24.60		4.02	<	2.4	<	2.0	126.0		0.27	34.2		188.0
TA-54, MDA-G-6	10/11	UF	DUP	879	<	1.1		14.5		24.60		3.71	<	2.4	<	2.0	124.0	<	0.01	32.2		185.0
Cañada del Buey at White Rock	7/29	UF	CS	9200		2.0		259.0		305.00	<	3.41	<	2.4		6.2	991.0		5.43	452.0		983.0
Cañada del Buey at White Rock	7/29	F	CS	228	<	1.5		1.6		0.26	<	0.68	<	2.4	<	3.1	79.2	<	0.01	7.7	<	2.2
Cañada del Buey at White Rock	8/18	F	CS	8	<	1.1	<	3.1		0.02	<	0.11			<	2.0	43.4	<	0.01	5.4	<	3.9
Cañada del Buey at White Rock	8/18	UF	CS	5660		2.2		106.0		206.00	<	0.11		7.8		5.2	450.0		2.69	201.0		348.0
Cañada del Buey at White Rock	10/11	UF	CS	5940	<	1.1		85.4		43.50		0.41	<	2.4	<	2.0	659.0		0.53	76.2		188.0
Cañada del Buey at White Rock	10/23	UF	CS	4410	<	1.1		86.1		62.70		0.30		3.2		2.4	380.0		0.44	133.0		213.0

Table B-5. (Cont.)

Location Name	Date		Codes[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Cañada del Buey at White Rock	10/28	F	CS	33	<1.1	2.0	1.65	0.59		2.4	32.3	<0.01	6.6	9.9
Cañada del Buey at White Rock	10/28	UF	CS	2190	<1.1	31.2	20.60	0.17	4.4	2.4	227.0	0.44	32.4	51.5
Pajarito Canyon above SR 501	6/28	F	CS	450	5.9	3.6	1.41	5.73	4.1	<16.0	420.0	3.56	3.9	6.1
Pajarito Canyon above SR 501	6/28	UF	TOTC	53278	39.7	255.1	851.87	25.08	41.7	290.8	6944.4	26.36	654.2	1883.5
Pajarito Canyon above SR 501	9/8	F	CS	307	<1.1	2.1	0.33	0.68		<2.0	150.0	0.03	2.7	5.7
Pajarito Canyon above SR 501	9/8	UF	CS	19000	2.2	92.4	227.00	1.37	<2.4	4.6	953.0	1.48	189.0	557.0
Pajarito Canyon above SR 501	9/8	UF	DUP	19000	2.9	93.3	248.00	<0.11	<2.4	<2.0	955.0	1.17	185.0	564.0
Pajarito Canyon above SR 501	10/23	F	CS	90	<1.1	<3.1	<0.08	<0.11		2.4	149.0	0.02	1.8	0.5
Pajarito Canyon above SR 501	10/23	UF	CS	2150	<1.1	8.7	21.40	0.20	<2.4	2.4	228.0	0.02	17.0	49.8
Pajarito Canyon above SR 501	10/23	UF	DUP	2140	<1.1	8.6	21.80	<0.11	<2.4	<2.0	226.0	0.03	16.5	54.1
Pajarito Canyon at TA-22	6/28	F	CS	320	8.2	3.9	1.46	4.86	<3.5	<16.0	360.0	3.57	4.2	9.0
Pajarito Canyon at TA-22	6/28	UF	TOTC	5985	82.8	76.4	157.55	47.70	50.3	562.0	1022.1	47.60	105.1	491.7
Starmer's Gulch at TA-22	6/28	F	CS	530	7.5	6.0	2.22	5.76	<3.5	<16.0	340.0	3.58	1.7	11.0
Starmer's Gulch at TA-22	6/28	UF	TOTC	14187	24.9	56.3	135.89	15.74	22.3	143.1	1524.7	17.23	101.7	588.1
TA 54 MDA G-1	10/11	F	CS	8	<1.1	1.4	0.25	0.39	<2.4	<2.0	15.1	<0.01	2.3	3.1
TA 54 MDA G-1	10/11	UF	CS	858	<1.1	19.1	35.80	0.32	<2.4	<2.0	88.9	0.14	51.3	122.0
TA-54, MDA-G-2	7/29	F	CS	84	<1.5	<3.1	0.02	<0.68	<2.9	<3.1	379.0	<0.01	3.1	<2.2
TA-54, MDA-G-2	7/29	UF	CS	867	1.5	16.4	24.80	<0.68	<2.4	<3.1	431.0	0.26	42.8	211.0
TA-54, MDA-G-2	8/9	F	CS	24	<1.1	<3.1	<0.08	<0.68		3.5	108.0	0.12	4.1	<3.9
TA-54, MDA-G-2	8/9	UF	CS	1790	3.4	29.6	52.30	0.69	<2.4	7.2	253.0	0.77	75.0	379.0
TA-54, MDA-G-2	10/11	F	CS	25	<1.1	1.5	<0.08	1.74	<2.4	<2.0	160.0	<0.01	2.4	3.5
TA-54, MDA-G-2	10/11	UF	CS	437	<1.1	12.0	12.10	0.98	<2.4	<2.0	195.0	<0.02	27.3	115.0
TA-54, MDA-G-3	7/29	UF	CS	3700	5.2	68.1	142.00	<0.68	<2.4	3.9	465.0	1.21	149.0	570.0
TA-54, MDA-G-3	8/18	F	CS	26	5.4	<3.1	<0.08	<0.11		<2.0	182.0	<0.01	5.4	<3.9
TA-54, MDA-G-3	8/18	UF	CS	207	2.5	4.8	9.33	1.00	<2.4	<2.0	214.0	<0.01	15.4	44.1
TA-54, MDA-G-3	10/11	F	CS	21	4.0	1.3	0.11	1.36	<2.4	<2.0	57.5	<0.01	5.5	7.3
TA-54, MDA-G-3	10/11	UF	CS	349	3.9	10.0	13.20	0.78	<2.4	<2.0	88.8	<0.02	23.5	149.0
TA-54, MDA-G-3	10/25	F	CS	28	<1.1	2.4	0.30	0.52		<2.0	44.4	<0.01	2.7	149.0
TA-54, MDA-G-3	10/25	UF	CS	3080	4.1	36.7	13.60	0.52	3.9	<2.0	200.0	0.07	77.0	322.0
TA-54, MDA-G-3	10/28	F	CS	16	3.8	<3.1	0.20	0.52		2.4	47.8	<0.01	2.9	9.1
TA-54, MDA-G-3	10/28	UF	CS											
TA-54, MDA-G-5	10/23	F	CS	16	<1.1	<3.1	0.10	<0.11		2.4	10.5	0.02	1.0	12.4
TA-54, MDA-G-5	10/23	UF	CS	160	<1.1	3.8	6.32	<0.11	3.2	2.4	19.4	0.02	7.2	36.9
TA-54, MDA-G-4	8/15	UF	CS	355	4.1	5.8	11.10	2.00	2.9	<2.0	71.1	0.39	15.2	125.0
TA-54, MDA-G-4	8/15	UF	DUP	336	1.5	5.9	10.80	1.99	2.4	<2.0	69.7	0.20	14.4	122.0
TA-54, MDA-G-4	10/12	F	CS	16	<1.1	2.3	0.32	1.90	<2.4	<2.0	89.7	<0.01	2.7	23.9
TA-54, MDA-G-4	10/12	UF	CS	71	<1.1	4.3	3.39	1.96	<2.4	<2.0	95.2	<0.02	6.7	61.6
Pajarito Canyon above SR 4	6/28	F	CS	1100	14.0	9.6	1.21	8.15	<3.5	<16.0	590.0	5.04	4.2	8.1
Pajarito Canyon above SR 4	6/28	UF	CS				3.34	3.06				0.26		
Pajarito Canyon above SR 4	6/28	UF	TOTC	28652	18.0	89.0	209.30	8.54	17.5	73.6	3823.6	14.07	125.7	540.9
Pajarito Canyon above SR 4	10/24	F	CS	112	<1.1	2.7	1.03	0.45		<2.0	152.0	<0.01	3.9	141.0
Pajarito Canyon above SR 4	10/24	UF	CS	2020	<1.1	22.6	55.00	0.48	4.2	<2.0	271.0	0.42	40.6	163.0
Pajarito Canyon above SR 4	10/27	F	CS	16	2.1	1.8	0.44	0.67		2.4	162.0	<0.01	2.2	4.5
Pajarito Canyon above SR 4	10/27	UF	CS	1540	2.9	20.0	65.10	0.62	<2.4	2.4	237.0	0.56	41.4	184.0
Water Canyon above SR 501	6/28	UF	TOTC	16992	6.4	20.2	53.90	5.60	8.3	29.0	2908.4	7.44	30.7	155.0
Water Canyon above SR 501	10/23	F	CS	168	<1.1	2.1	1.72	0.47		2.4	124.0	0.02	4.7	7.5
Water Canyon above SR 501	10/23	UF	CS	26600	2.0	73.8	21.40	<0.11	3.1	2.4	1510.0	0.49	114.0	696.0
Cañon del Valle above SR 501	6/28	UF	TOTC	31369	11.6	43.0	135.50	6.52	20.1	56.8	3311.7	12.91	84.4	374.2
Cañon del Valle above SR 501	10/23	F	CS	73	<1.1	1.7	<0.08	<0.11		2.4	123.0	0.02	1.2	4.6
Cañon del Valle above SR 501	10/23	UF	CS	17900	<1.1	50.0	86.40	0.52	<2.4	2.4	955.0	0.85	73.3	506.0
Water Canyon at SR 4	6/28	UF	TOTC	22469	17.3	70.6	238.89	8.19	19.9	66.0	3541.9	11.23	137.6	522.9
Water Canyon at SR 4	10/27	F	CS	448	3.2	2.1	3.18	0.81		2.4	166.0	0.06	5.4	12.0
Water Canyon at SR 4	10/27	UF	CS	21400	3.4	62.9	121.00	0.59	17.3	2.4	1860.0	1.46	135.0	600.0
Water Canyon at SR 4	10/27	UF	DUP	21400	2.9	65.0	126.00	0.52	17.4	<2.0	1850.0	1.18	136.0	599.0
Indio Canyon at SR 4	6/28	UF	CS				3.92	2.81				0.25		
Water Canyon below SR 4	6/28	F	CS	670	12.0	6.0	1.56	5.62	<3.5	<16.0	470.0	3.56	1.9	7.5
Water Canyon below SR 4	6/28	UF	TOTC	45170	25.3	175.7	599.89	17.71	45.0	197.9	5134.0	18.61	341.3	1316.8
Water Canyon below SR 4	7/29	UF	CS	24500	5.9	152.0	471.00	<3.41	23.3	9.3	1860.0	4.62	266.0	1520.0
Water Canyon below SR 4	7/29	UF	DUP	26900	6.8	179.0	612.00	<0.11	<2.4	11.2	1910.0	3.33	308.0	1710.0
Water Canyon below SR 4	8/12	UF	CS	29800	5.1	55.7	113.00	<0.11	7.8	3.7	1900.0	1.59	111.0	634.0
Water Canyon below SR 4	8/18	F	CS	27	2.1	<3.1	0.04	<0.11		<2.0	79.0	<0.01	3.9	<3.9
Water Canyon below SR 4	8/18	UF	CS	754	1.7	7.0	19.00	<0.11	<2.4	<2.0	132.0	0.08	17.9	49.8
Water Canyon below SR 4	8/18	UF	DUP	771	<1.1	7.5			<2.4	<2.0	134.0		18.1	51.2
Water Canyon below SR 4	10/23	F	CS	205	<1.1	1.7	0.45	2.44		<2.0	165.0	0.04	5.1	25.3

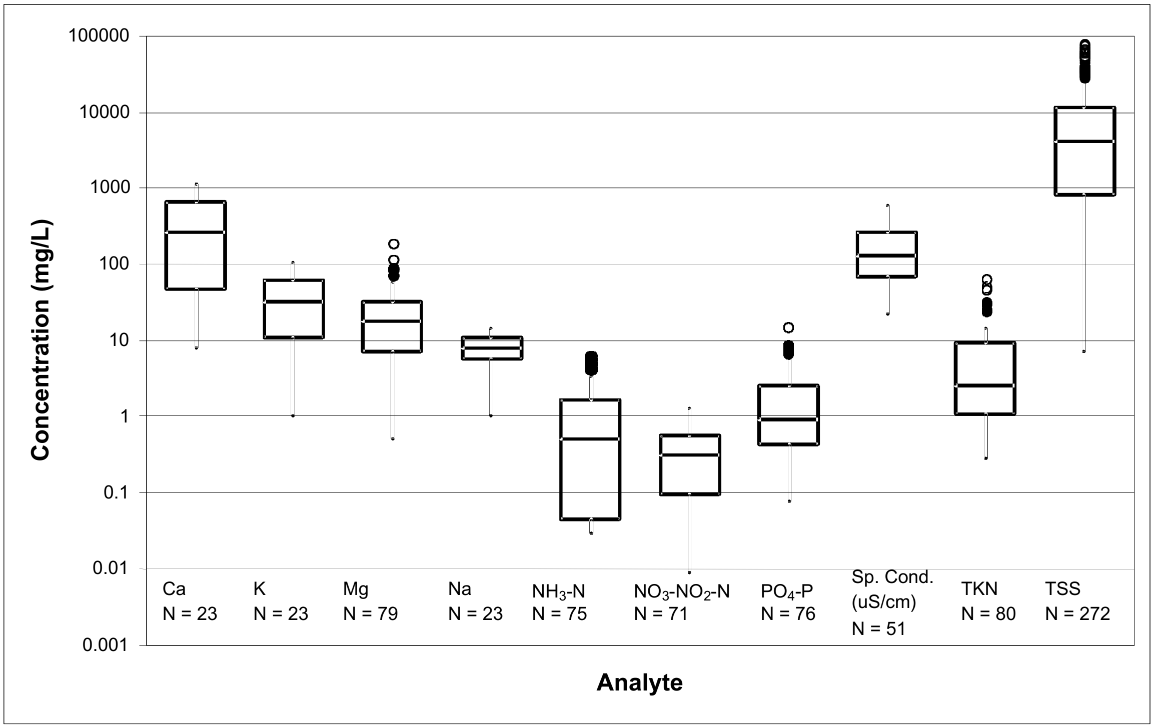
Table B-5. (Cont.)

Location Name	Date	Codes[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Water Canyon below SR 4	10/23	UF	CS	30600	<1.1	51.9	72.20	0.81	<2.4	<2.0	1650.0	1.15	79.4	589.0
Water Canyon below SR 4	10/23	UF	DUP	29900	<1.1	52.1	74.60	0.47	<2.4	<2.0	1660.0	0.64	79.9	591.0
Water Canyon below SR 4	10/27	F	CS	44	2.0	1.6	1.08	0.54		2.4	93.0	<0.01	2.7	6.0
Water Canyon below SR 4	10/27	UF	CS	12100	2.5	59.9	144.00	0.77	11.1	2.4	799.0	1.07	110.0	556.0
Potrillo Canyon near White Rock	8/9	UF	CS	4170	1.5	62.2	106.00	<0.68	2.3	<3.1	334.0	1.17	127.0	247.0
Potrillo Canyon near White Rock	10/23	F	CS	14	<1.1	1.3	0.85	0.69		<2.0	15.0	0.02	2.6	13.3
Potrillo Canyon near White Rock	10/23	UF	CS	2680	<1.1	33.4	44.50	0.86	3.5	<2.0	176.0	0.29	50.6	151.0
Ancho Canyon at TA-39	8/18	UF	CS	7360	2.6	233.0	356.00	<3.41	5.2	12.1	788.0	5.72	360.0	922.0
Ancho Canyon at TA-39	10/28	UF	CS	1440	1.5	49.9	75.10	0.40	4.2	2.4	155.0	0.92	96.9	262.0
Ancho Canyon near Bandelier NP	8/18	UF	CS	4810	2.6	156.0	240.00	<3.41	6.2	7.9	505.0	5.37	249.0	716.0
Ancho Canyon near Bandelier NP	8/18	UF	DUP	4830	1.7	151.0	261.00	<0.11	5.0	7.2	513.0	3.27	227.0	674.0
Ancho Canyon near Bandelier NP	10/23	UF	CS	1800	<1.1	37.9	62.40	0.46	<2.4	<2.0	187.0	0.61	63.7	181.0
Ancho Canyon near Bandelier NP	10/28	UF	CS	1110	<1.1	26.1	46.10	0.29	<2.4	2.4	125.0	0.47	48.4	106.0
Upper Los Alamos Reservoir	8/31	F	CS	2000	2.5	5.5	<0.08	<0.11		<2.0	385.0	<0.03	4.2	10.3
Upper Los Alamos Reservoir	8/31	UF	CS	701	3.3	2.6	0.09	<0.11	<2.4	<2.0	183.0	0.39	1.6	2.9
Los Alamos Reservoir	8/31	F	CS	676	2.4	1.8	0.50	<0.11		<2.0	179.0	0.05	1.6	2.2
Los Alamos Reservoir	8/31	UF	CS	2010	3.5	5.9	4.42	<0.11	<2.4	<2.0	378.0	0.27	4.5	19.2
Los Alamos Reservoir	8/31	UF	DUP	1980	2.5	5.7	4.20	<0.11	2.2	<2.0	377.0	<0.01	4.2	10.1
Los Alamos Canyon at SR 4 Weir	7/21	F	CS	1870	10.9	5.1	0.37	1.09	<2.4	<2.0	416.0	0.36	3.4	4.5
Los Alamos Canyon at SR 4 Weir	7/21	UF	CS	3900	9.2	30.4	58.30	0.78	<2.4	<2.0	598.0	0.87	33.2	171.0
Los Alamos Canyon at SR 4 Weir	7/21	UF	DUP	3940	7.9	29.9	58.10	0.74	<2.4	<2.0	602.0	0.84	33.7	165.0
Rendija Canyon 3rd Crossing	7/17	F	CS				0.72	10.70				0.34		
Rendija Canyon 3rd Crossing	7/17	F	CS	480	<10.0	5.0	<3.00	280.00	<5.0	<50.0	160.0	<10.00	3.7	6.8
Rendija Canyon 3rd Crossing	7/17	UF	CS	16000	<10.0	39.0	160.00	21.00	10.0	<50.0	1000.0	<7.30	35.0	560.0
Rendija Canyon 3rd Crossing	7/17	UF	DUP	19000	<4.2	45.8	191.00	25.50	10.3	<20.4	1000.0	<7.32	41.6	659.0
Guaje Canyon at SR 502	7/9	F	CS	530	13.0	6.9	2.34	5.61	<2.6	<20.0	210.0	3.71	3.8	5.3
Guaje Canyon at SR 502	7/9	UF	CS	17000	5.8	14.0	1209.00	6.21	8.8	<20.0	2400.0	11.24	13.0	93.0
Guaje Canyon at SR 502	9/8	F	CS	765	5.1	2.9	0.36	0.68		<2.0	212.0	0.03	2.1	3.2
Guaje Canyon at SR 502	9/8	UF	CS	102000	5.3	826.0	91.50	1.37	<2.4	12.7	4780.0	4.24	536.0	3610.0
Starmer's Gulch above SR 501	10/23	F	CS	576	<1.1	5.9	6.99	0.21		2.4	134.0	0.02	12.2	37.3
Starmer's Gulch above SR 501	10/23	UF	CS	22800	<1.1	44.6	64.90	0.26	<2.4	2.4	1030.0	0.29	66.4	454.0
Two-mile Canyon at SR 501	10/23	F	CS	269	<1.1	1.2	0.15	0.20		2.4	124.0	0.02	1.5	0.6
Two-mile Canyon at SR 501	10/23	UF	CS	18800	<1.1	50.2	124.00	0.39	<2.4	2.4	1140.0	0.81	83.3	538.0
Pajarito Canyon at TA-18 Culvert	6/28	F	CS	670	13.0	10.0	1.45	5.93	3.9	<16.0	490.0	3.55	2.9	4.7
Pajarito Canyon at TA-18 Culvert	6/28	F	DUP	659	12.0	8.9	<0.95	<3.48	<3.5	<15.7	491.0	<3.37	2.5	5.0
Pajarito Canyon at TA-18 Culvert	6/28	UF	TOTC	47249	27.4	240.8	689.88	25.16	56.7	223.9	4916.0	20.24	408.1	1574.9
Pajarito Canyon at SR 4 Culvert	6/28	F	CS	930	16.0	10.0	3.54	6.35	3.8	<16.0	590.0	3.41	3.6	9.1
Pajarito Canyon at SR 4 Culvert	6/28	UF	TOTC	43163	30.3	245.8	629.89	14.32	48.3	168.1	4501.1	20.23	385.0	1592.9
Water Quality Standards[c]														
EPA Primary Drinking Water Standard						100		6	50		2			
EPA Secondary Drinking Water Standard				50										5,000
EPA Action Limit							15							
EPA Health Advisory											25,000-90,000		80-110	
NMWQCC Livestock Watering Standard							100		50					25,000
NMWQCC Groundwater Limit				200	1,000	200	50		50					10,000
NMWQCC Wildlife Habitat Standard									5					

[a]Codes: UF- unfiltered; F- filtered; CS - customer sample; DUP - labor

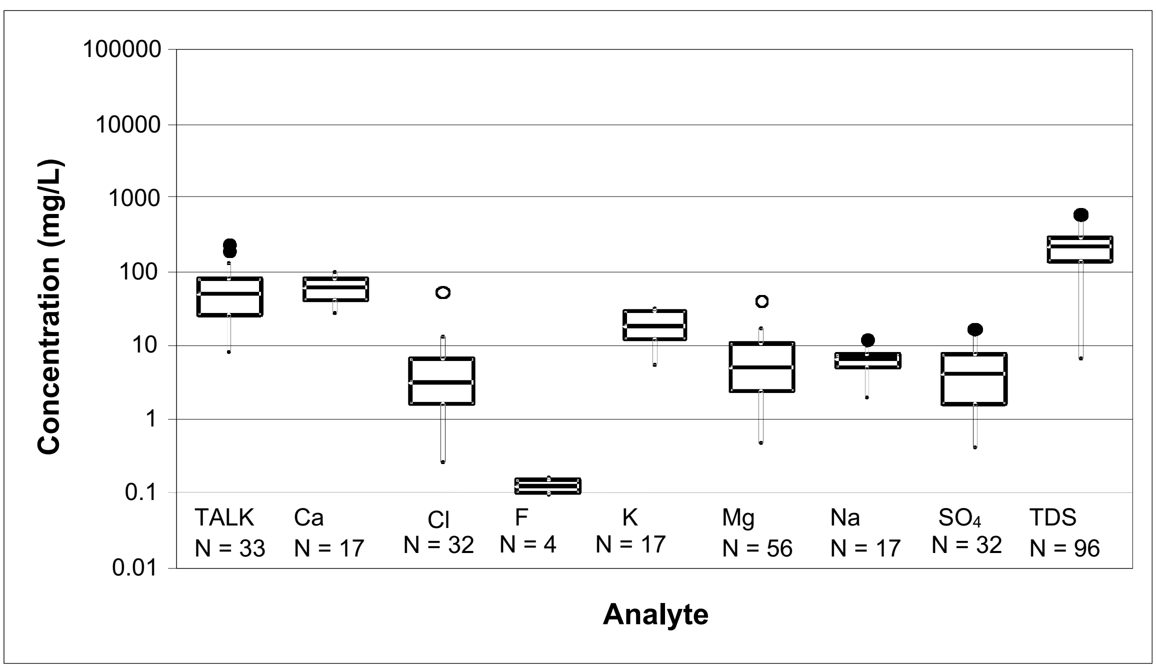
[b]Less than symbol (<) means measurement was below the specified l

[c]Standards given here for comparison only, see Appendix A. Note tha
Mexico Livestock Watering and Groundwater limits are based on diss
concentrations, whereas many of these analyses are of unfiltered sam
concentration may include suspended sediment quantities.



(n = number of analytical results.)

Figure B-1. Summary of general water quality parameters in unfiltered storm water runoff in 2000.



(n = number of analytical results.)

Figure B-2. Summary of general water quality parameters in filtered storm water runoff in 2000.

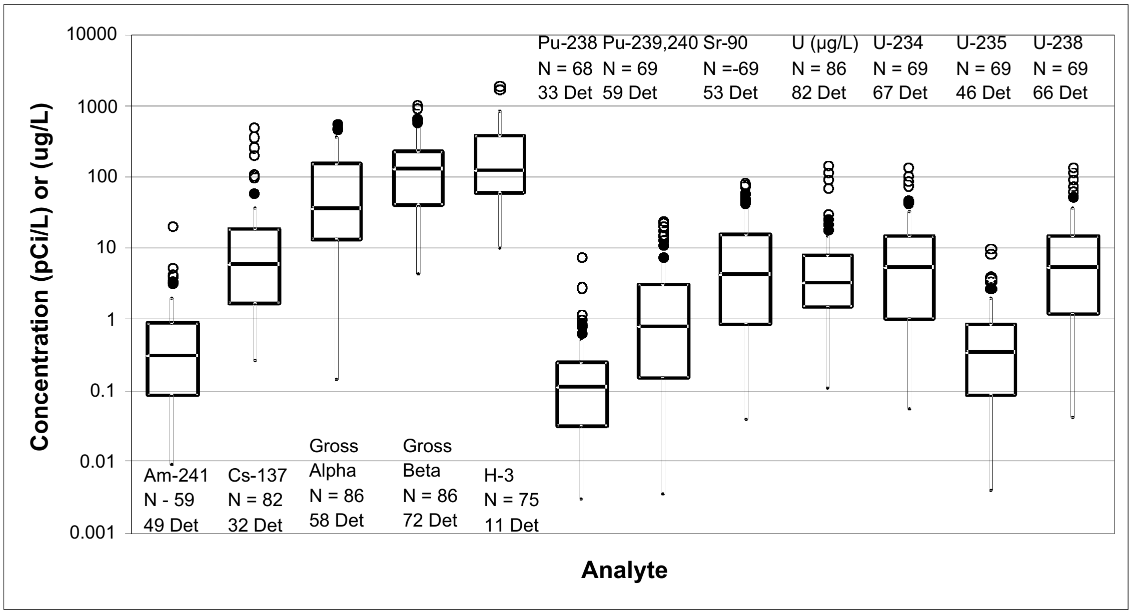


Figure B-3. Summary of radionuclides in unfiltered storm water runoff in 2000.

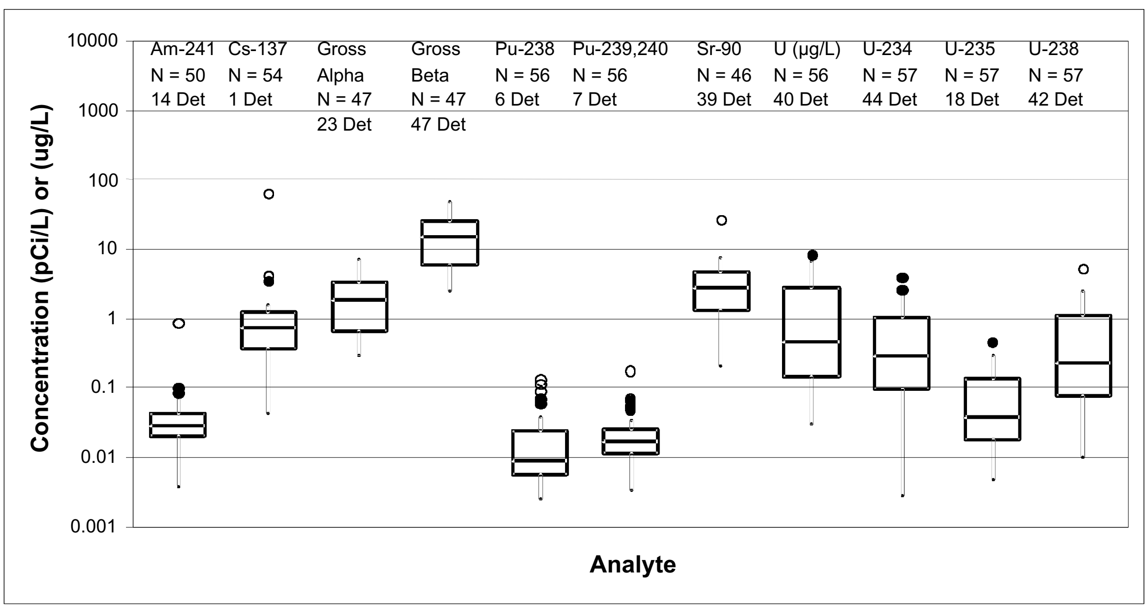


Figure B-4. Summary of radionuclides in filtered storm water runoff in 2000.

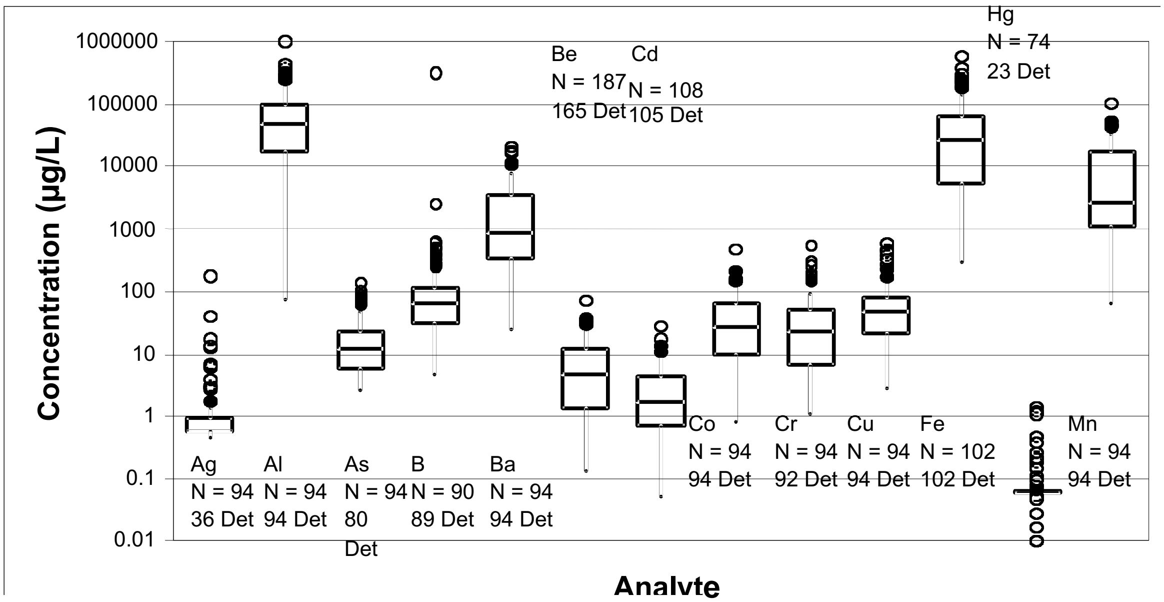


Figure B-5a. Summary of metals concentrations in unfiltered storm water in 2000.

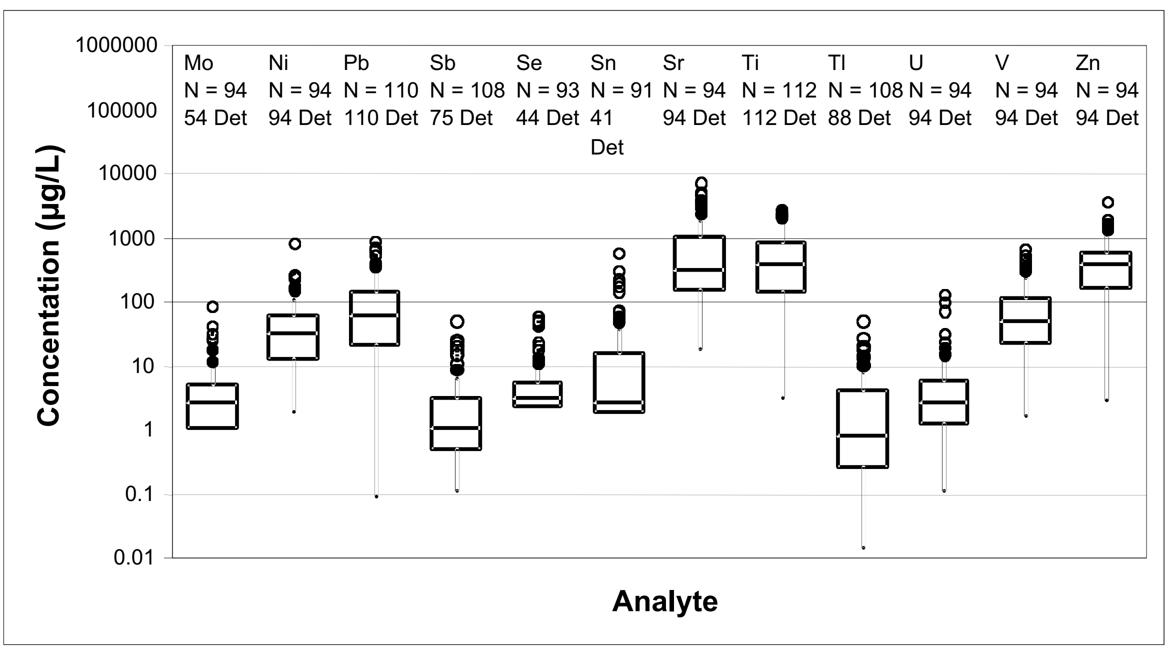


Figure B-5b. Summary of metals concentrations in unfiltered storm water in 2000 (continued).

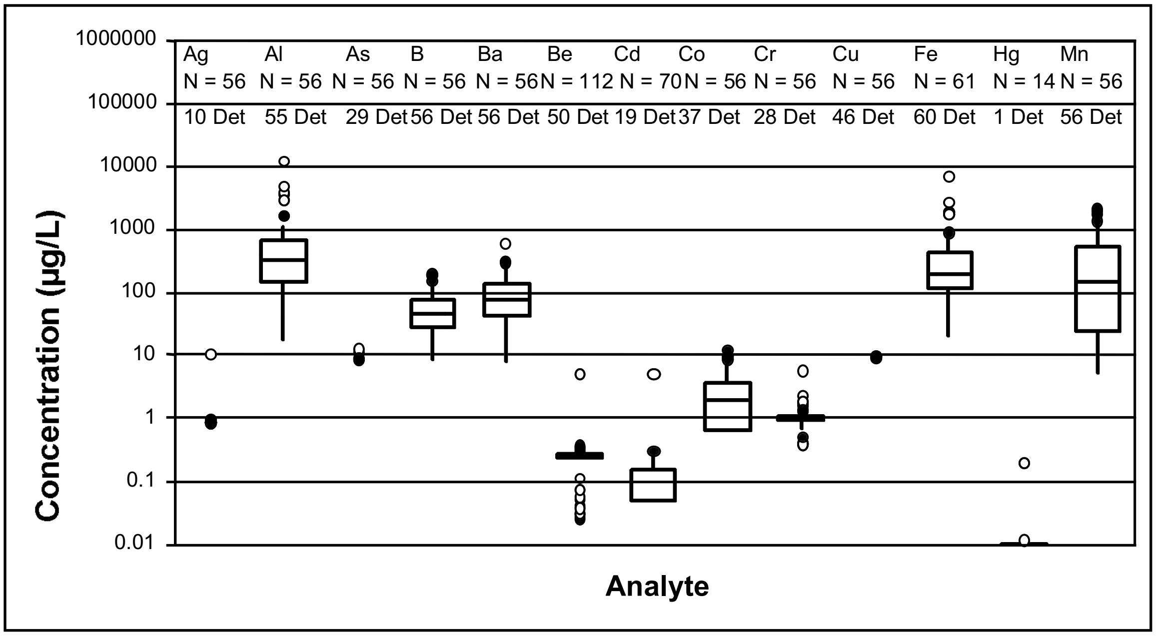


Figure B-6a. Summary of metals concentrations in filtered storm water in 2000.

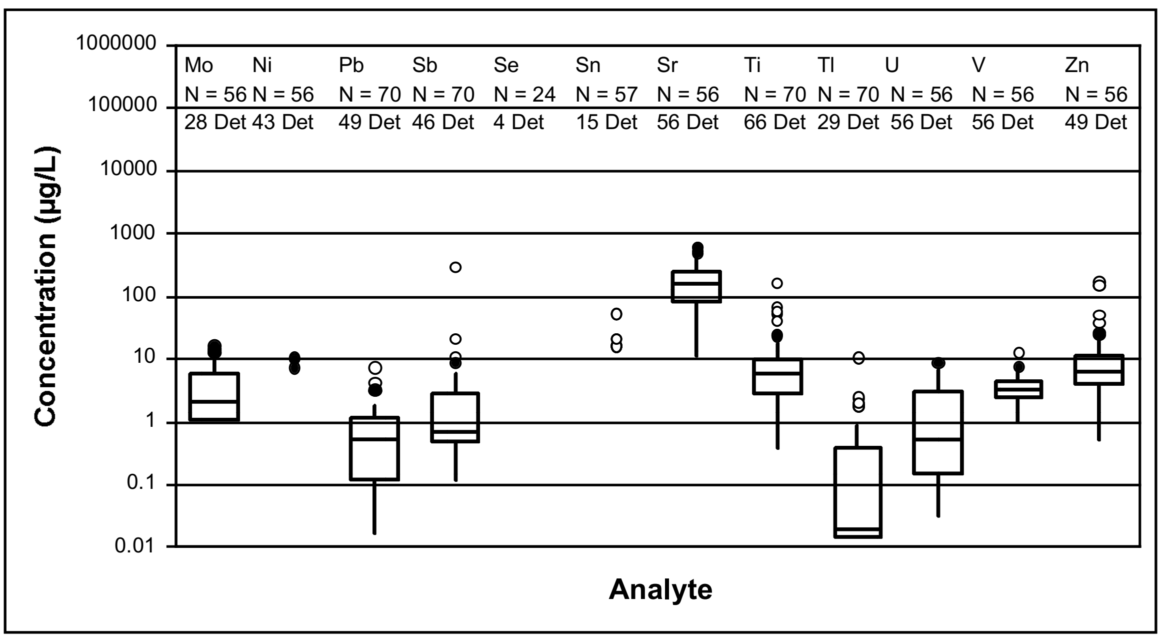


Figure B-6b. Summary of metals concentrations in filtered storm water in 2000 (continued).

Appendix C. Supplemental Review of Selected Chemical Constituents

C.1 Total Dissolved Solids

Figure C-1 shows the distribution of TDS concentrations at upstream, onsite, and downstream locations for prefire and postfire samples. The highest concentration from samples collected at LANL was 492 mg/L from Water Canyon. The highest concentrations of TDS at LANL are from upstream sites, where samples have a median concentration of 314 mg/L. Samples collected from onsite and downstream locations have generally lower TDS values, with median values of 157 and 252 mg/L, respectively. Many of the samples collected onsite were from TA-54, MDA-G, which were not impacted by the fire, and typically are from relatively low-flow, small-drainage-area runoff collections sites. Prefire samples collected at upstream sites have TDS values from 96 to 128 mg/L; postfire upstream samples have TDS concentrations ranging from 187 to 438 mg/L, indicating that samples collected at upstream sites after the fire were significantly impacted by increased TDS values in the runoff.

The TDS concentrations of samples collected onsite after the fire are not significantly different than for samples collected before the fire (see Figure C-1). However, the median concentration of samples collected at downstream locations after the fire was 252 mg/L, compared with the prefire median concentration of 141 mg/L, which indicates a fire-related impact to TDS in runoff at downstream locations.

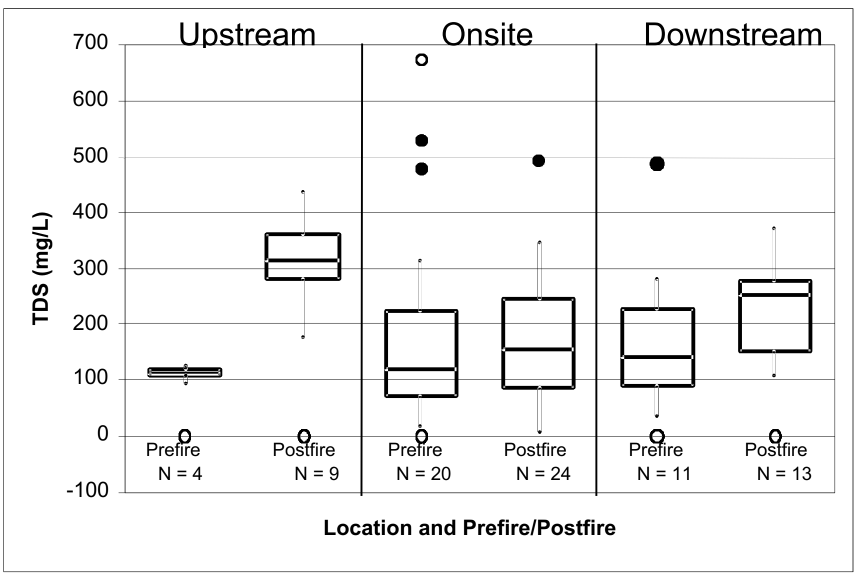
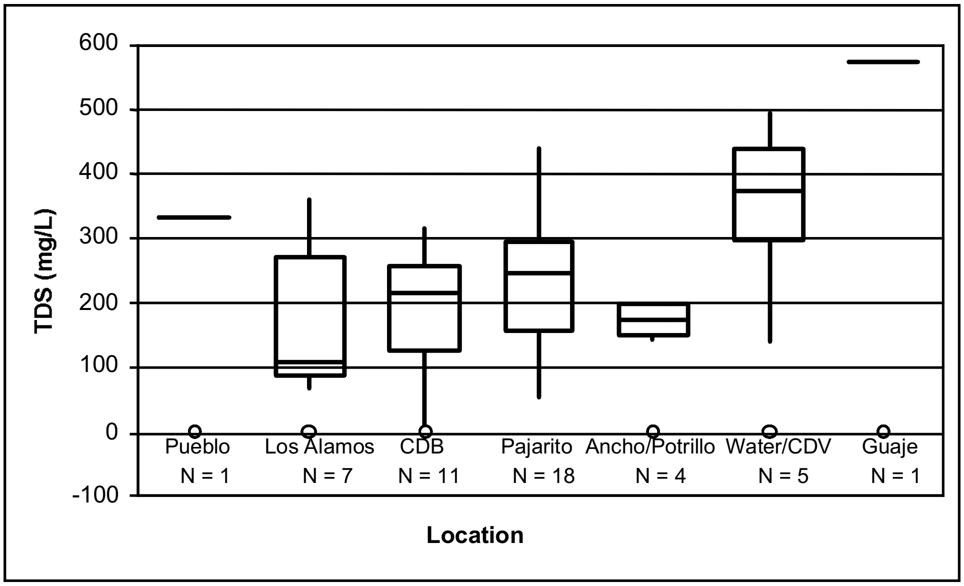


Figure C-1. TDS in runoff from upstream, onsite, and downstream locations, prefire and postfire.

Figure C-2 shows the TDS concentrations for samples collected from each canyon system. The highest concentration of TDS in storm water runoff samples was 570 mg/L from Guaje Canyon above SR 502 during a high-volume runoff event on September 8. For samples collected at LANL, the highest distribution of TDS concentrations was from Water Canyon and Cañon de Valle. The lowest distribution of TDS concentrations is from Ancho and Potrillo Canyons, which were not significantly impacted by the Cerro Grande Fire.



Note: CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-2. TDS concentrations in samples from each canyon system in 2000.

C.2 Calcium in Runoff

Figure C-3 shows the distributions of calcium concentrations in unfiltered runoff at upstream, onsite, and downstream locations for samples collected before the fire and after the fire. Figure C-4 shows the distributions of calcium concentrations in filtered runoff. The maximum concentration of calcium observed in runoff before the fire was 140 mg/L, which was collected at the downstream location (gage E230) in Cañada del Buey. The highest calcium concentration in an upstream runoff sample before the fire was 6.9 mg/L. After the fire, significantly higher concentrations of calcium are observed in the storm water runoff samples. The median concentration of calcium in upstream samples was 407 mg/L and the highest concentration was 1110 mg/L, which was from Pajarito Canyon above SR 501 (gage E240) on June 28. Runoff samples collected at downstream locations after the fire show similar increases, the median concentration at downstream sites after the fire was 558 mg/L and the maximum concentration was 971 mg/L in a sample from Water Canyon below SR 4 (gage E265) on June 28. The runoff samples collected onsite after the fire have a median concentration similar to prefire samples; samples in this concentration range are mostly from areas that were not impacted by the fire. Higher concentrations of calcium from onsite locations, up to 877 mg/L (collected from Pajarito Canyon at TA-18 on June 28), are obviously associated with runoff from fire-impacted areas.

The distributions of concentrations of dissolved calcium are shown in Figure C-4. The dissolved calcium concentrations are significantly lower in filtered samples than in unfiltered for samples collected before and after the fire, indicating that the higher concentrations of calcium seen in unfiltered samples are typically not dissolved in storm water runoff, but are carried in suspended materials such as ash. Runoff samples collected before the fire generally did not contain calcium in concentrations greater than about 32 mg/L, and the median concentrations at upstream, onsite, and downstream locations were 6.25, 13.5, and 11 mg/L, respectively. After the fire, dissolved calcium concentrations were significantly higher, and median values at upstream and onsite locations were 58 mg/L, and at downstream locations was 80 mg/L, about six to eight times higher than prefire concentrations.

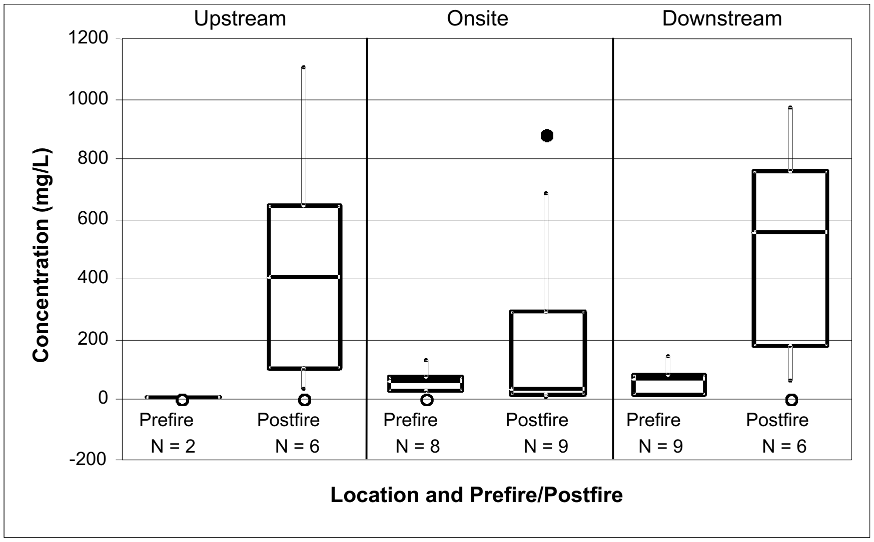


Figure C-3. Calcium concentrations in unfiltered runoff at upstream, onsite, and downstream locations, prefire and postfire.

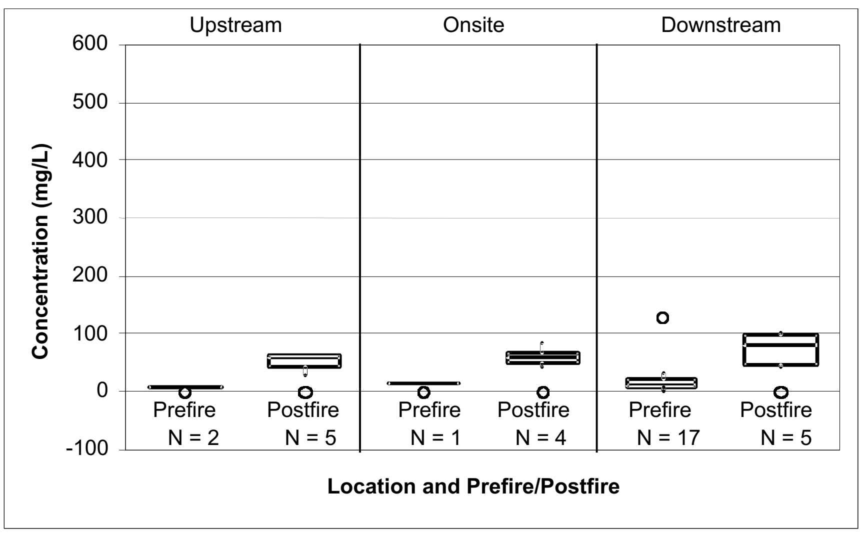


Figure C-4. Calcium concentrations in filtered runoff at upstream, onsite, and downstream locations, prefire and postfire.

Figure C-5 shows the time series of calcium concentrations in unfiltered runoff samples in 2000. The highest concentrations of calcium in runoff were from the June 28 runoff event that primarily affected Pajarito Canyon and Water Canyon. Calcium concentrations observed in samples from the first runoff event after the fire, which impacted Los Alamos Canyon on June 2 and 3, are higher than prefire concentrations (see Figure C-3) but not as high as samples from the June 28 and July runoff events. The calcium concentration in one sample collected on October 23 from Pajarito Canyon above SR 501 (gage E240) was 35.9 mg/L, significantly lower than samples collected on June 28; however, flows were commensurately lower on October 23 compared with the June 28 runoff event. As shown in Figure 4-6, the calcium concentrations in unfiltered runoff are proportional to the TSS concentration.

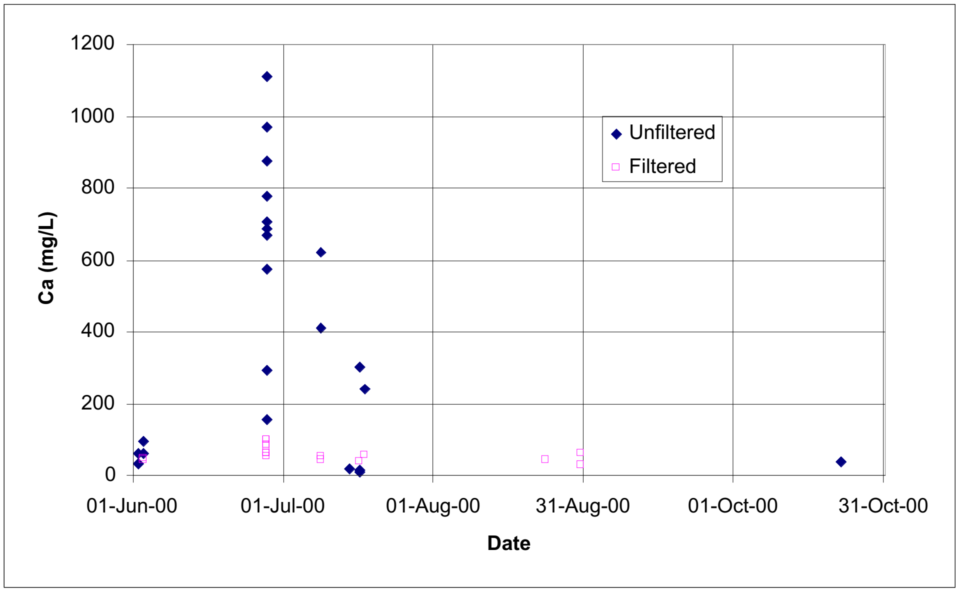


Figure C-5. Time series of calcium in unfiltered runoff in 2000.

Figure C-6 shows the distribution of calcium concentrations in unfiltered samples collected from each canyon system. The highest distributions of calcium are from Pajarito Canyon and Water Canyon and Cañon de Valle, which were mainly impacted by the June 28 high-runoff event. Runoff samples collected in Guaje and Rendija Canyons contained calcium concentrations of 620 and 300 mg/L, respectively; these samples were collected from relatively high runoff events. Runoff samples collected in Los Alamos Canyon in 2000 appear to have a significantly lower distribution of calcium values; the highest concentration of calcium in Los Alamos Canyon runoff was 410 mg/L, collected on July 9 during a relatively inconsequential runoff event (Koch et al. 2001).

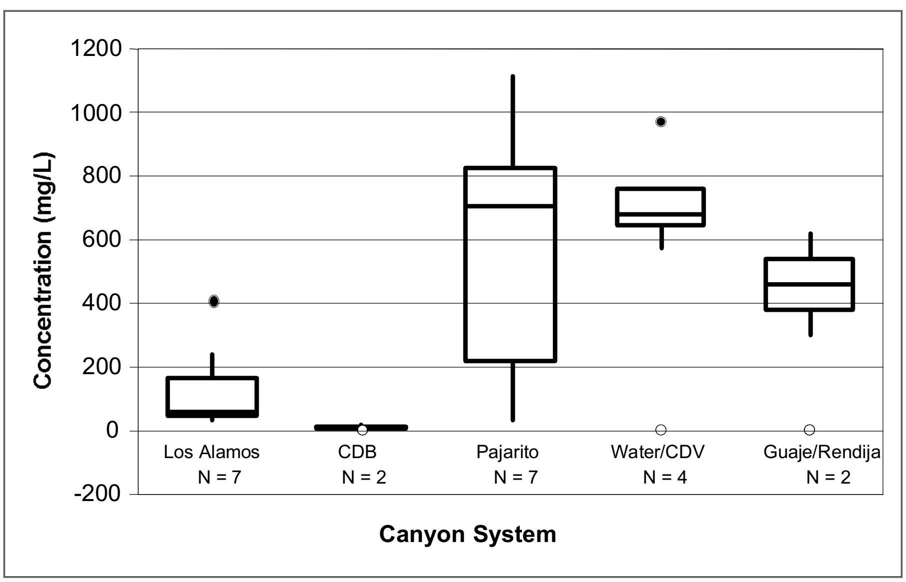


Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-6. Calcium in unfiltered runoff from each canyon system.

Increased concentrations of calcium in runoff after forest fires have been found to be from ash, soil, and sediments remaining after the fire (Bitner et al. 2001; DeBano et al. 1979; Raison et al. 1985). Concentrations of calcium in ash from a forest fire were found to be 10 to 50 times greater than the calcium concentrations in the unburned litter following a fire (Raison et al. 1985).

C.3 Cyanide in Runoff

The summary of cyanide detected in storm water runoff in 2000 is shown in Figure C-7. Total cyanide concentrations of 95 samples analyzed ranged from 0.003 to 0.176 mg/L; the highest concentration was from Guaje Canyon on July 9. The mean concentration of 52 detects of total cyanide was 0.0176 mg/L. There is no surface water standard for total cyanide and all values observed in runoff in 2000 are below the NMWQCC ground water standard of 0.2 mg/L and the EPA primary drinking water standard of 0.2 mg/L. The total cyanide concentrations observed at upstream and onsite locations were not significantly different, but the total cyanide concentrations observed at downstream locations were slightly lower (see Figure C-7).

Amenable cyanide is that portion of cyanide that is amenable to chlorination and is toxic to aqueous organisms. Of 93 samples analyzed, 10 samples contained detectable amenable cyanide. The detected concentrations ranged from 0.003 to 0.062 mg/L, with a mean concentration of 0.008 mg/L. The concentrations of amenable cyanide observed at upstream and downstream sites were similar, whereas concentrations of amenable cyanide onsite were significantly lower (see Figure C-7).

Amenable cyanide values were greater than the NMWQCC wildlife watering standards (0.0052 mg/L) in three samples from Water Canyon, and possibly in several other samples where the analytical detection limits were greater than the standard. Cyanide in its free (amenable), unbound form is toxic to aquatic biota and wildlife. However, most of the cyanide observed in storm water runoff in 2000 appears to be in a far less toxic form bound with other elements.

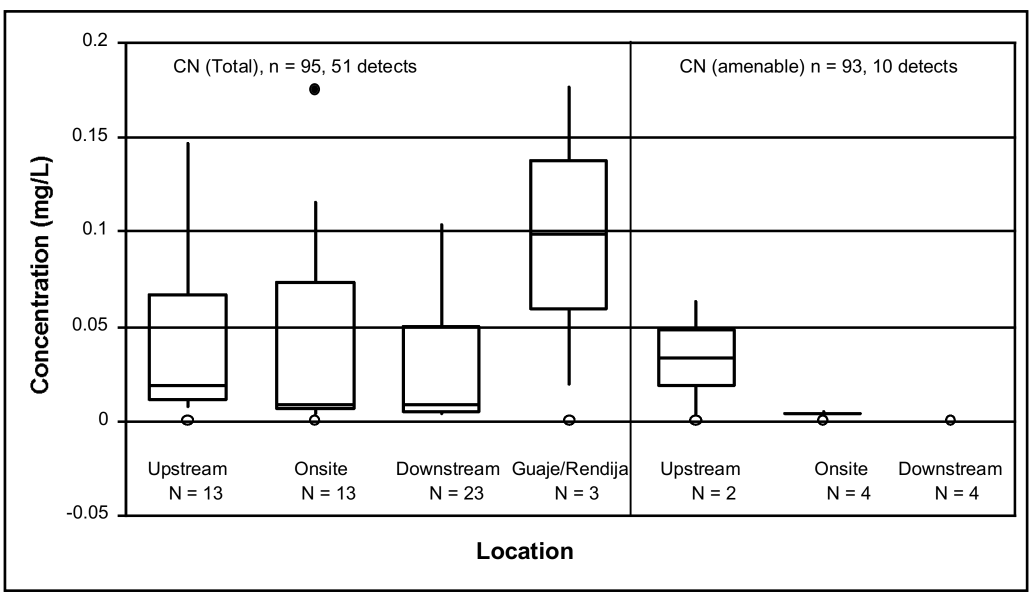
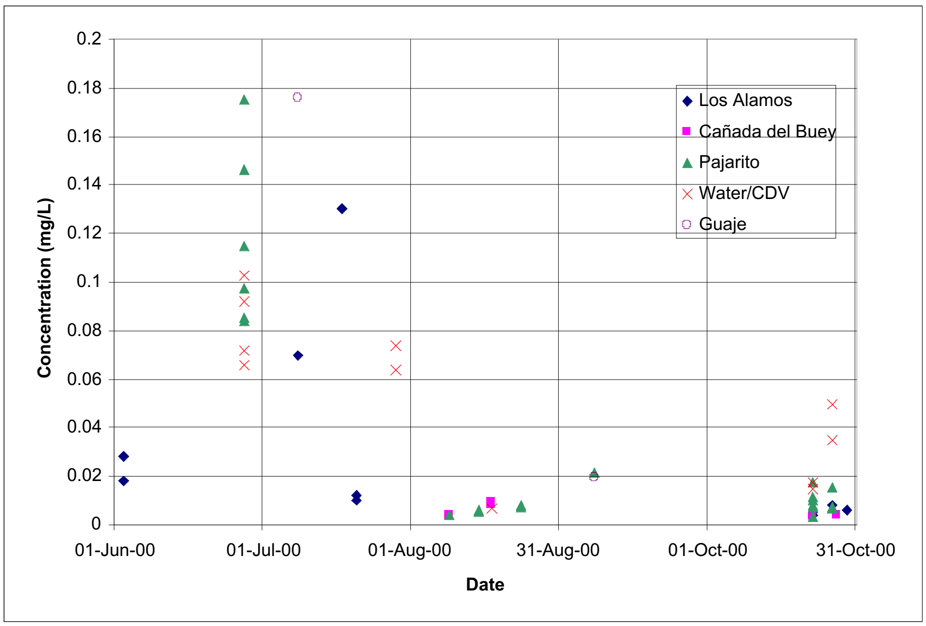


Figure C-7. Summary of detects of cyanide in runoff by location in 2000.

Possible sources of the cyanide may have been fire retardant used in the Cerro Grande Fire that contains a sodium hexaferrocyanide compound added as an anti-caking additive and as a corrosion inhibitor.

According to US Forest Service estimates, approximately 110,000 gallons of fire retardant were dropped during the fire suppression efforts (G. Kuyumjian, personal communication 10/04/2000). Another possibility is that some cyanide may have been naturally created through slow burning or smoldering of biomass (e.g., Yolkeson et al. 1997) and then transported in the runoff with the ash.

Figure C-8 shows the time series of cyanide (total) concentrations in each canyon. Cyanide concentrations in runoff were highest in June and July runoff events and declined as the runoff season progressed. The highest total cyanide concentrations were measured in Pajarito Canyon and Guaje Canyon in high-volume runoff from fire-impacted areas. Significantly lower concentrations were measured later in the runoff season.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDV = Cañon de Valle.

Figure C-8. Time series of cyanide (total) in runoff from each canyon system in 2000.

C.4 Nitrate in runoff

Figure C-9 shows the distribution of concentrations of nitrate-nitrite as nitrogen (NO_3+NO_2-N) (nitrate) in runoff at upstream, onsite, and downstream locations for samples collected before the fire (1997 through 1999) and in 2000 after the fire. The concentrations of nitrate in two samples from upstream locations collected before the fire were both less than 0.05 mg/L; samples collected at upstream locations after the fire contained nitrate concentration up to 0.85 mg/L with a median concentration of 0.26 mg/L. The highest distribution of nitrate concentrations in historic samples was from samples collected onsite, which had a maximum concentration of 2.5 mg/L and a median concentration of 0.55 mg/L. The maximum concentration of nitrate in samples collected from onsite locations in 2000 after the fire was 1.27 mg/L in a sample from TA-54, MDA-G (gage 249.5, formerly G-4), and the median concentration was 0.4 mg/L, slightly lower than observed in prefire samples. The distribution of concentrations of nitrate in runoff samples collected from downstream locations after the fire are not significantly different than for samples collected before the fire.

Figure C-10 shows the concentrations of nitrate in runoff for each canyon system throughout the runoff season in 2000. The maximum concentration of nitrate in runoff in 2000 was 1.27 mg/L from a mesa top collection site at TA-54, MDA-G, which was not impacted by fire. One sample from lower Pueblo Canyon (gage E060) downstream of the Los Alamos County Sewage Treatment Plant collected on October 23 contained 0.64 mg/L. The concentrations of nitrate in runoff do not appear to have been affected by the fire.

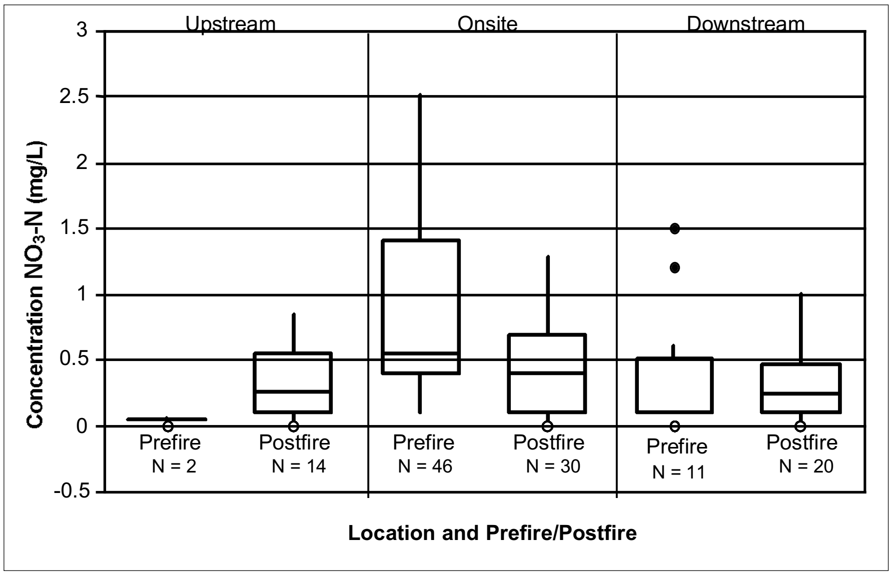
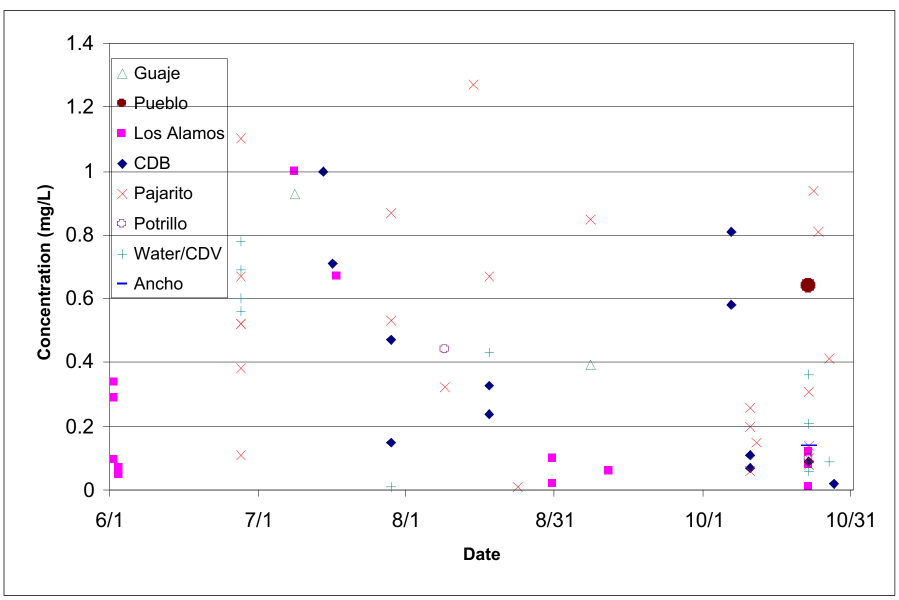


Figure C-9. Distribution of nitrate concentrations in runoff at upstream, onsite, and downstream locations, prefire and postfire.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-10. Time series of nitrate concentrations in runoff from each canyon system in 2000.

C.5 Ammonia in Runoff

Figure C-11 shows the distribution of concentrations of ammonia (NH_3) in runoff at upstream, onsite, and downstream locations for samples collected before the fire (data only available for 1999) and in 2000 after the fire. No historic ammonia data are available for upstream locations before the fire; samples collected at upstream locations after the fire contained ammonia concentrations up to 6.2 mg/L with a median concentration of 0.78 mg/L. The highest concentrations of ammonia in runoff in 2000 were from the large June 28 runoff event. The highest concentration of ammonia at upstream locations was from upper Cañon de Valle (gage E253), and the highest concentration from onsite locations was 5.1 mg/L in a sample collected in Pajarito Canyon at TA-18 (gage E18C). The highest concentration at downstream locations was 4.9 mg/L in a sample collected from lower Water Canyon (gage E265). The median concentrations of ammonia in samples collected onsite (0.1 mg/L) and downstream (0.5 mg/L) were not significantly different compared with samples collected before the fire, however, the maximum concentrations observed after the fire were higher than before the fire.

Figure C-12 shows the concentrations of ammonia for each canyon system throughout the runoff season in 2000. The highest concentrations of ammonia were observed in runoff events in late June and in July. Ammonia concentrations in October were generally less than 1 mg/L. Increased concentrations of ammonia in runoff in the two months following the fire may have been related to impacts of fire in the upper watershed areas.

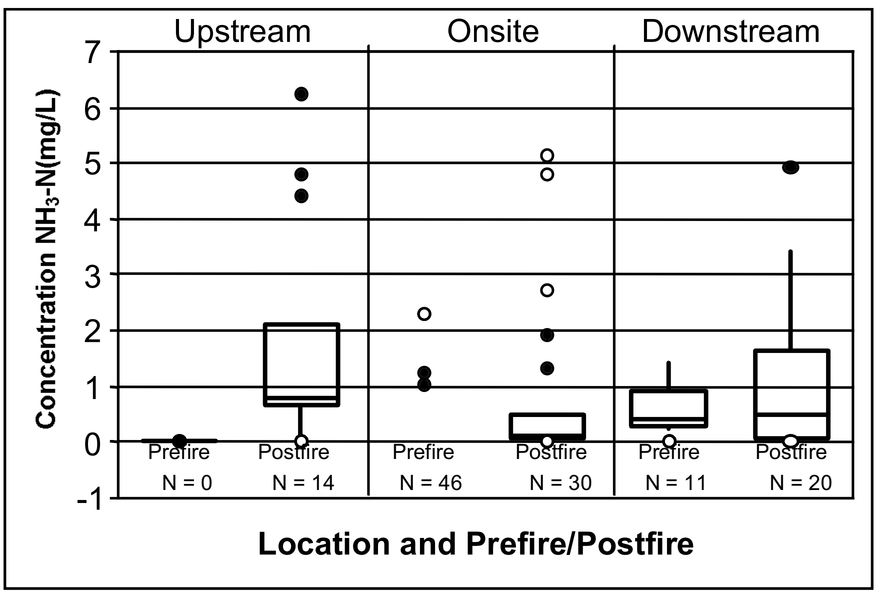
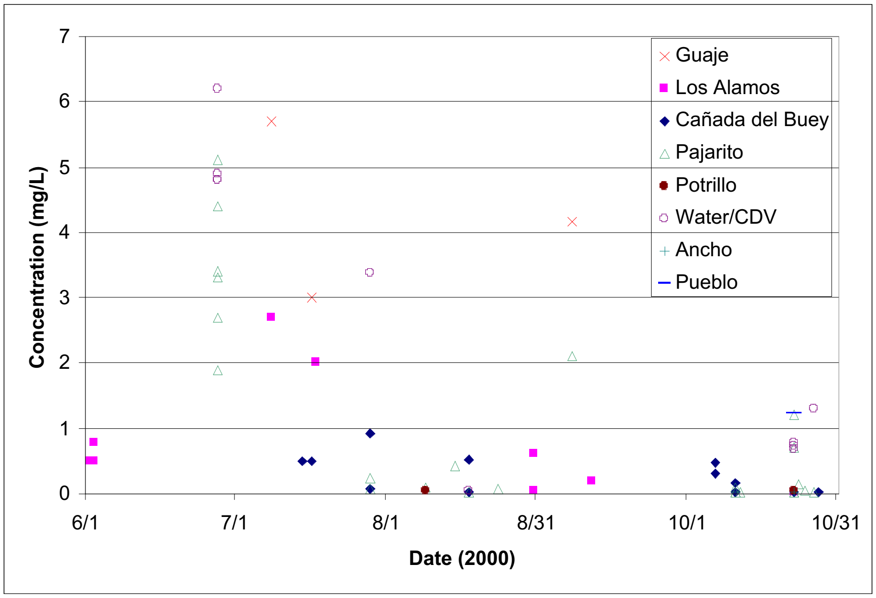


Figure C-11. Ammonia in runoff at upstream, onsite, and downstream locations, prefire and postfire.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-12. Time series of ammonia in runoff from each canyon system in 2000.

C.6 Americium-241 in Runoff

The concentrations of americium-241 detected in unfiltered runoff (all discussion is based on alpha spectrometry data) range from 0.035 to 20.7 pCi/L with a mean value of 0.374 pCi/L; in filtered runoff the detected concentrations of americium-241 ranged from 0.024 to 0.863 pCi/L with a mean value of 0.049. The highest concentration of americium-241 in an unfiltered sample was from a sample collected in lower DP Canyon on October 12. The highest concentration of americium-241 in a filtered sample was collected from TA-54, MDA-G-4, also on October 12. Neither of these samples was related to the effects of the Cerro Grande Fire.

Figure C-13 shows the summary of americium-241 concentrations in unfiltered runoff at upstream, onsite, and downstream sites relative to LANL, for both prefire and postfire periods. The data shown for the upstream prefire period in Figure C-13 and in the following figures for other radionuclides are supplemented with surface water data because only two upstream prefire runoff samples are available for comparison with postfire data; the results of the upstream prefire sample for americium-241 were both below detection limits. The surface water samples were collected from spring-fed stream reaches in Los Alamos Canyon and Pajarito Canyon; none of the prefire upstream samples detected americium-241 in concentrations above method detection limits. The upstream surface water and runoff data are shown in the following figures for comparison with the 2000 runoff samples collected upstream of the Laboratory.

The highest concentration of americium-241 from upstream locations in 2000 was 1.61 pCi/L in a sample collected from upper Pajarito Canyon (gage E240) on June 28, when a large runoff event occurred. The highest concentration from onsite locations in 2000 was 20.7 pCi/L in a sample collected from lower DP Canyon (gage E040) on October 12. The highest concentration of americium-241 from downstream sites was 4.2 pCi/L in a sample collected from lower Water Canyon (gage E265) on July 29. The range of concentrations of americium-241 in runoff onsite and downstream after the fire is not significantly different than concentrations observed before the fire, and the distributions of concentrations after the fire are slightly lower than before the fire (see Figure C-13).

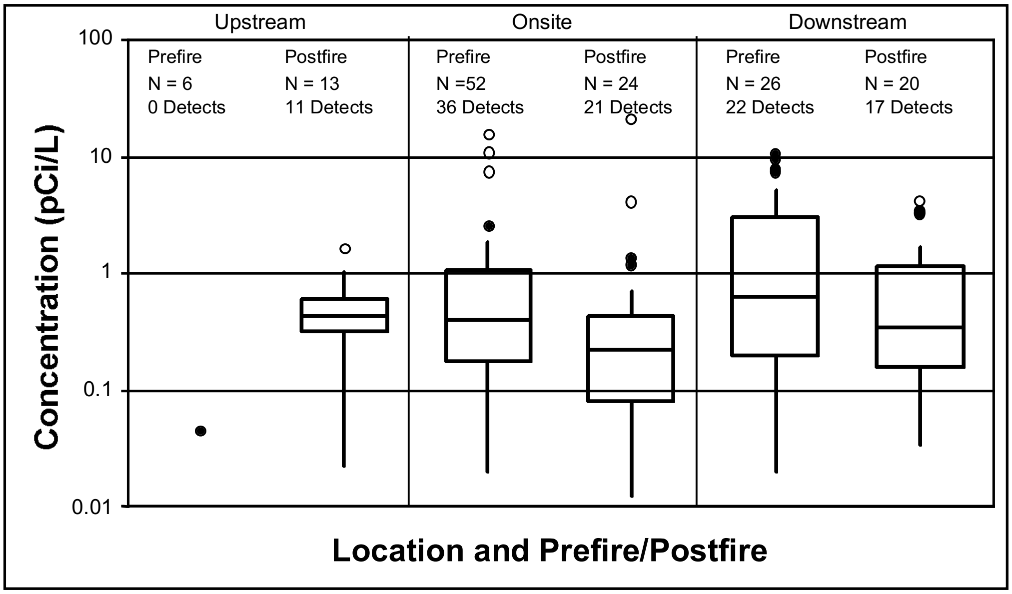


Figure C-13. Americium-241 in unfiltered runoff upstream, onsite, and downstream, prefire and postfire.

Figure C-14 shows the concentrations of dissolved americium-241 in runoff at upstream, onsite, and downstream locations for prefire and postfire periods. The dissolved concentrations of americium-241 are about an order of magnitude lower than the values for unfiltered samples for both onsite and downstream locations. The maximum dissolved concentration at upstream sites was 0.044 pCi/L in a sample collected from upper Pajarito Canyon (gage E240) on June 28. The maximum concentration from onsite locations was 0.863 pCi/L in a sample collected from TA-54, MDA-G (gage E249.5) on October 12. The highest concentration at downstream locations was 0.0836 pCi/L in a sample collected from the Los Alamos Canyon weir on July 21. The range of dissolved concentrations observed after the fire is not significantly different than the concentrations observed before the fire at onsite and downstream locations and the distribution of concentrations at upstream, onsite, and downstream locations are approximately similar. The maximum concentrations at onsite and downstream locations in 2000 are likely LANL contributions.

Along the upstream Laboratory boundary, median concentrations of americium-241 in unfiltered waters increased by 16 times from prefire levels. Otherwise, the americium-241 data for both filtered and unfiltered data indicate that the fire did not have an appreciable effect on americium-241 concentrations in runoff, when compared to prior years.

Figure C-15 shows the summary of concentrations of americium-241 in unfiltered runoff for each canyon system. The highest concentration of americium-241 in an unfiltered sample was 20.7 pCi/L, from a sample collected in lower DP Canyon, within the Los Alamos Canyon system. The concentrations observed in two samples from Guaje and Rendija Canyons (5.55 and 2.0 pCi/L, respectively) were higher than most samples collected in canyons at LANL.

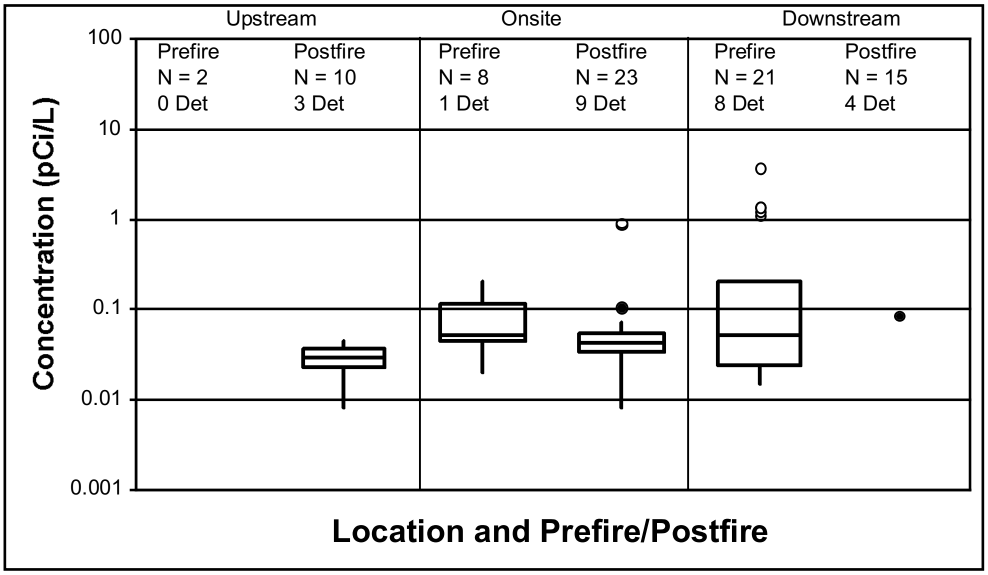
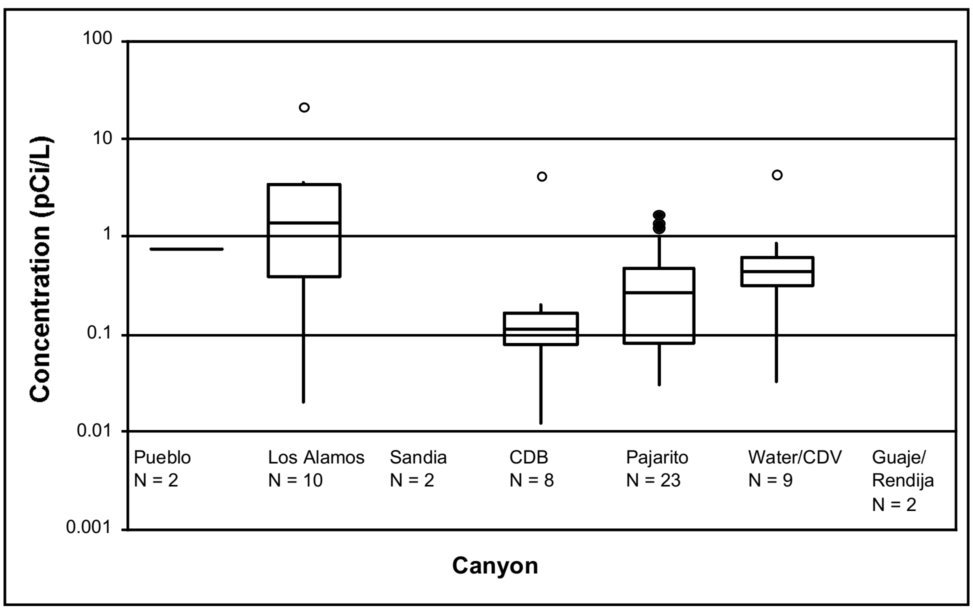


Figure C-14. Americium-241 in filtered runoff upstream, onsite, and downstream, prefire and postfire.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle

Figure C-15. Americium-241 in unfiltered runoff in each canyon.

C.7 Cesium-137 in runoff

The concentration of cesium-137 detected in unfiltered samples ranged from 3.6 to 511 pCi/L with a median concentration of 3.745 pCi/L; the highest value was from a sample collected in Two-mile Canyon (a tributary to Pajarito Canyon) above SR 501, which was a fire-impacted drainage. Cesium-137 was detected in only four filtered samples, where the concentration ranged from 3.3 to 62.4 pCi/L with a median concentration of 2.76 pCi/L. The highest concentration measured in filtered samples was from TA-54, MDA-G-2, which was not a fire-impacted sample. Three of the filtered runoff samples in which cesium-137 was detected were from TA-54 and were not fire related; the only possible filtered fire-related sample in which cesium-137 was detected was from lower Los Alamos Canyon at gage E042 on October 23, where the concentration was 3.33 pCi/L. The results of the analyses for cesium-137 indicate that fire-related cesium-137 was contained primarily in the unfiltered portion of runoff samples.

The average concentration of cesium-137 in ash and muck sediments after the fire was 4.4 pCi/g (LANL 2000b; Katzman et al. 2001), about five times the BV for cesium-137 (0.9 pCi/g) in prefire background sediments and soils (Ryti et al. 1998). Flood ash and muck deposits sampled kilometers from the fire-related source of ash show persistent elevated concentrations of the radionuclide and inorganic constituents, including in watersheds unaffected by Laboratory discharges (Katzman et al. 2001). The ash and muck carried by the storm water are likely the source of elevated cesium-137 concentrations in the storm water runoff. Cesium-137 has been shown to concentrate in ash and sediment up to two times prefire conditions as the result of forest fires (Bitner et al. 2001).

Figure C-16 shows the summary of cesium-137 concentrations in unfiltered runoff at upstream, onsite, and downstream sites relative to LANL, for both prefire and postfire periods. The data show that the distribution of cesium-137 concentrations in the runoff samples collected upstream of the Laboratory after the Cerro Grande Fire are higher than the distribution for upstream samples collected before the fire, with several postfire values greater than 100 pCi/L. The distributions of cesium-137 concentrations in samples collected onsite and downstream after the fire are not significantly different than for samples collected before the fire (see Figure C-16).

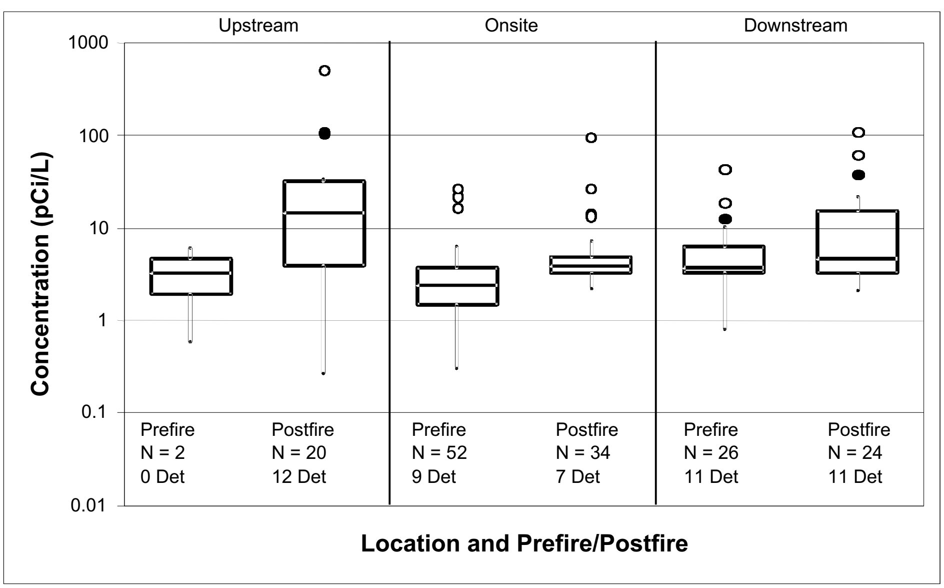


Figure C-16. Cesium-137 in unfiltered runoff at upstream, onsite, and downstream locations, prefire and postfire.

Figure C-17 shows the distributions of cesium-137 concentrations in filtered samples collected upstream, onsite, and at downstream sites before and after the fire. The results show that cesium-137 concentrations in filtered runoff were not significantly different after the fire compared with prefire samples. The highest concentration of dissolved cesium-137 was in a sample from TA-54, MDA-G, which was unrelated to fire effects.

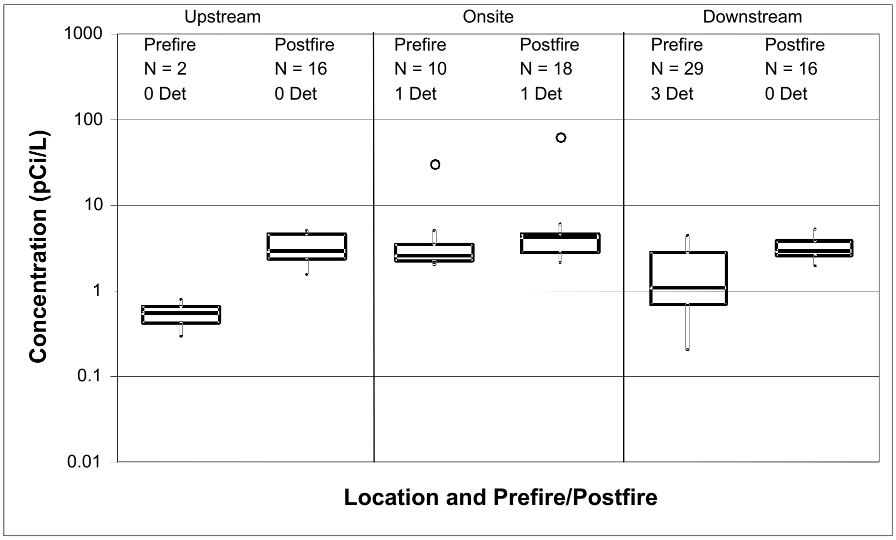
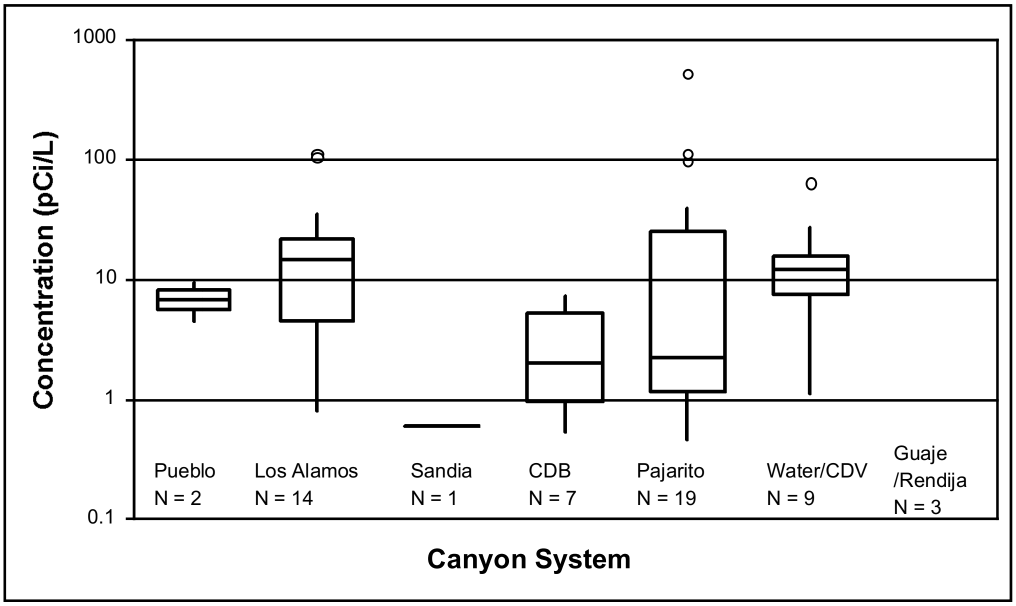


Figure C-17. Cesium-137 in filtered runoff at upstream, onsite, and downstream locations, prefire and postfire.

Figure C-18 shows the distribution of concentrations of cesium-137 in unfiltered runoff for each canyon where runoff samples were collected. Cesium-137 concentrations in runoff samples collected from Rendija and Guaje Canyons were 267 and 359 pCi/L, respectively, which were some of the highest concentrations observed in runoff samples collected after the fire. Prefire data for these canyons are not available. The median of values in Pueblo, Los Alamos, and Water Canyon/Cañon de Valle are about 10 pCi/L and values range from about 8 to 20 pCi/L. The median values observed in Cañada del Buey and Pajarito Canyon are lower, about 2 or 3 pCi/L.

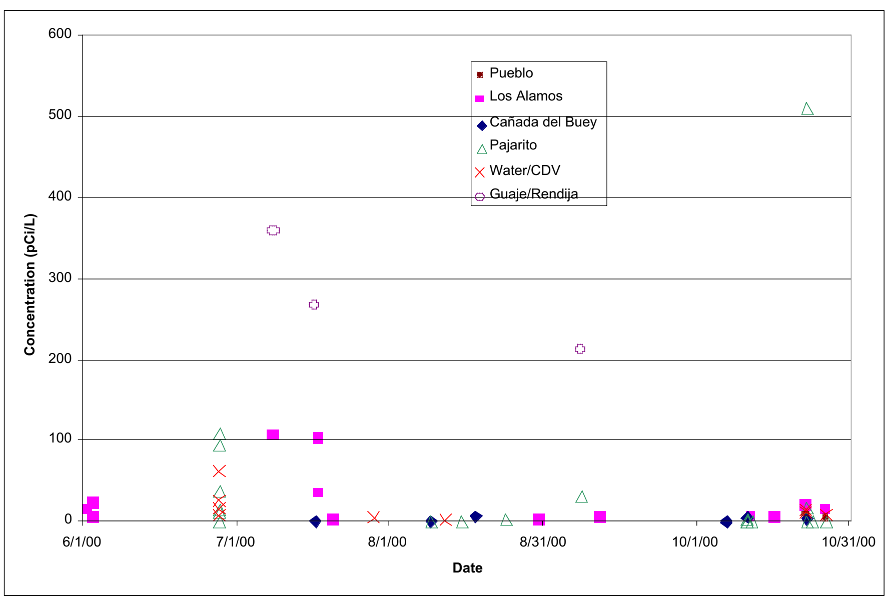
Figure C-19 shows the time series of cesium-137 concentrations in unfiltered runoff samples from each canyon system in 2000. In general, the higher concentrations in samples from each canyon were collected in June and July, and concentrations of cesium-137 tended to decrease throughout the runoff season. This relationship appears to be valid for Los Alamos Canyon, Water Canyon/Cañon de Valle, and Guaje/Rendija Canyons. However, the highest concentration of cesium-137 was in a sample collected from Two-mile Canyon, a tributary to Pajarito Canyon, on October 23. Other samples collected in Pajarito Canyon tended to contain lower concentrations of cesium-137 later in the runoff season.

The total mass of cesium-137 in runoff at upstream and downstream sites was calculated by multiplying the concentration of cesium-137 in each sample collected by the total volume of flow recorded at each gaging station or by the volume of flow estimated by the sampling personnel (see Shaull et al. 2001 and Koch et al. 2001, for estimated flow volumes and gaged flow volumes). Figure C-20 shows the calculated mass of cesium-137 that passed through upstream and downstream stations in Rendija/Guaje, Pueblo, Los Alamos, Cañada del Buey, Pajarito, and Cañada de Valle/Water Canyons. Upstream samples were not obtained in Rendija/Guaje, Pueblo, and Cañada de Buey, so data are shown for downstream stations only in these canyons in Figure C-18. Data are available for both upstream and downstream stations in Los Alamos, Pajarito, and Cañon de Valle and Water Canyons. The available data show that the total mass of cesium-137 that was carried onto LANL in 2000 was more than what was carried downstream in Pajarito (6.5 mCi) and Los Alamos (0.44 mCi) Canyons. In Water Canyon, slightly more cesium-137 (0.187 mCi) was carried in runoff at downstream sites than at upstream sites.



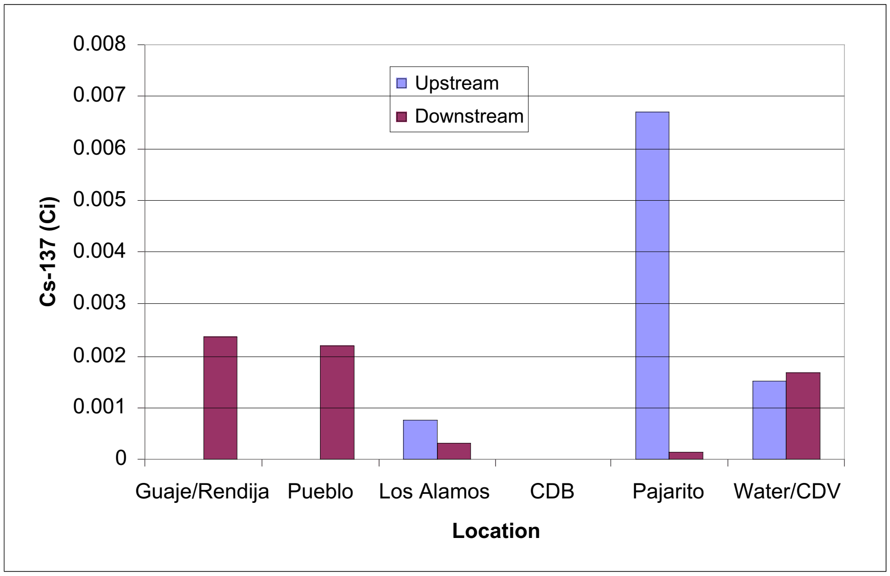
Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-18. Cesium-137 in unfiltered runoff from each canyon system.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDV = Cañon de Valle.

Figure C-19. Time series of cesium-137 in unfiltered runoff from different canyons in 2000.



Note: CDB = Cañada del Buey; CDV = Cañon de Valle

Figure C-20. Total activity of cesium-137 in runoff at Los Alamos in 2000.

C.8 Gross Alpha Activity in Runoff

Gross alpha is a general measure of the total (gross) alpha particle radiation present in a sample. Figure C-21 shows the distribution of gross alpha activity in unfiltered runoff at upstream, onsite, and downstream locations for both prefire and postfire periods. Figure C-22 shows the gross alpha activity in filtered samples. Gross alpha activity in unfiltered samples is one to two orders of magnitude higher than in filtered samples. Gross alpha activity in unfiltered samples from upstream locations was higher after the fire by about a factor of 10, but the range and distribution of activities at onsite and downstream locations after the fire were not significantly different than before the fire.

The highest gross alpha activity in unfiltered samples from upstream locations in 2000 was 337 pCi/L in a sample collected October 23 from upper Water Canyon (gage E252). The highest activity in samples from onsite locations was from two samples collected on June 2 from lower DP Canyon (328 pCi/L at gage E040) and middle Los Alamos Canyon (268 pCi/L from gage E030). The highest activity in samples from downstream locations was 570 pCi/L, which was also collected on June 2 in lower Los Alamos Canyon at gage E042. DP Canyon was not affected by the fire, and the highest gross alpha activities do not appear to be related to fire effects. However, most runoff samples containing greater than 200 pCi/L gross alpha activity were from runoff from fire-impacted areas.

The highest dissolved gross alpha activities in filtered samples were collected from the large runoff event in Pajarito Canyon on June 28. The maximum activity in filtered samples from upstream locations was 3.6 pCi/L in a sample collected on June 28 in upper Pajarito Canyon at gage E240. Maximum onsite activity was 5.7 pCi/L at the TA-18 culvert (gage E18C), and the maximum at downstream locations was 7 pCi/L at the SR 4 culvert (location ES4C). This was the largest runoff event at LANL in 2000, which carried the most ash, muck, and sediment load, but it is not clear why samples from this runoff event contained the highest dissolved gross alpha activity when the highest activities in unfiltered samples were from Los Alamos Canyon on June 2 and 3. The distributions of gross alpha activities dissolved in runoff at onsite and downstream locations after the fire are not substantially different from activities in runoff before the fire (see Figure C-22).

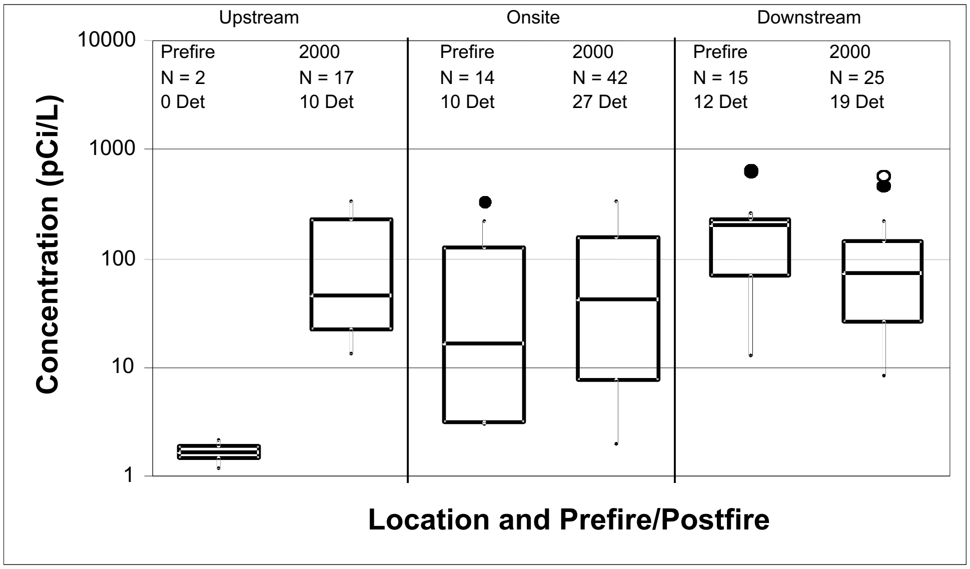


Figure C-21. Gross alpha activity in unfiltered runoff at upstream, onsite, and downstream locations, prefire and postfire.

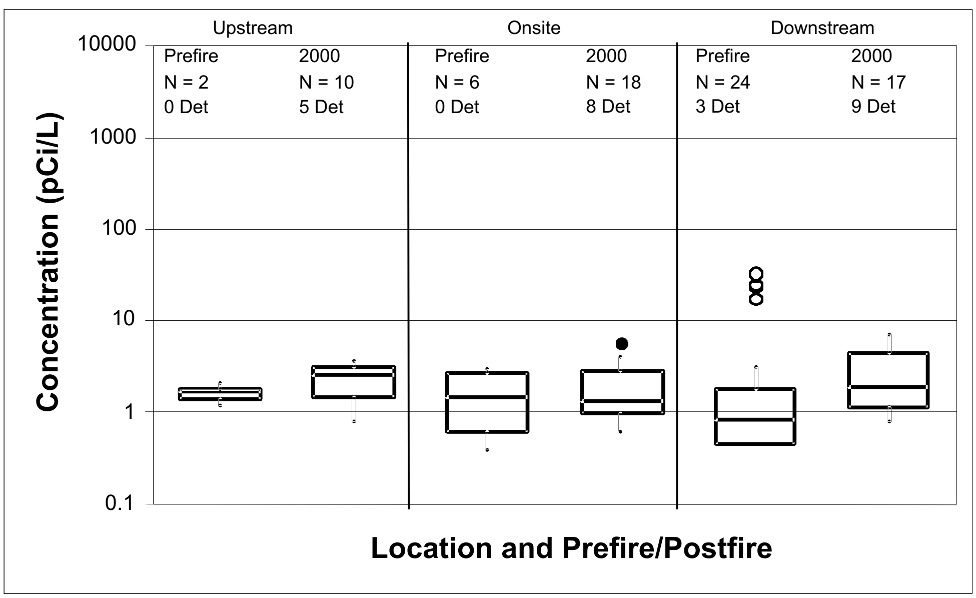


Figure C-22. Gross alpha activity in filtered runoff at upstream, onsite, and downstream locations, prefire and postfire.

Figure C-23 shows the gross alpha activity in unfiltered runoff samples related to the concentrations of TSS in the runoff. In general, the higher-TSS-concentration samples contained higher total radioactivity. Samples collected during an intense short-lived runoff event will generally contain higher total alpha activity levels than samples collected from the same location under slower flows with less sediment-carrying power. While some of the gross alpha activity in 2000 was associated with ash-laden runoff from fire-impacted areas, the relationship with TSS is also observed in prefire runoff samples.

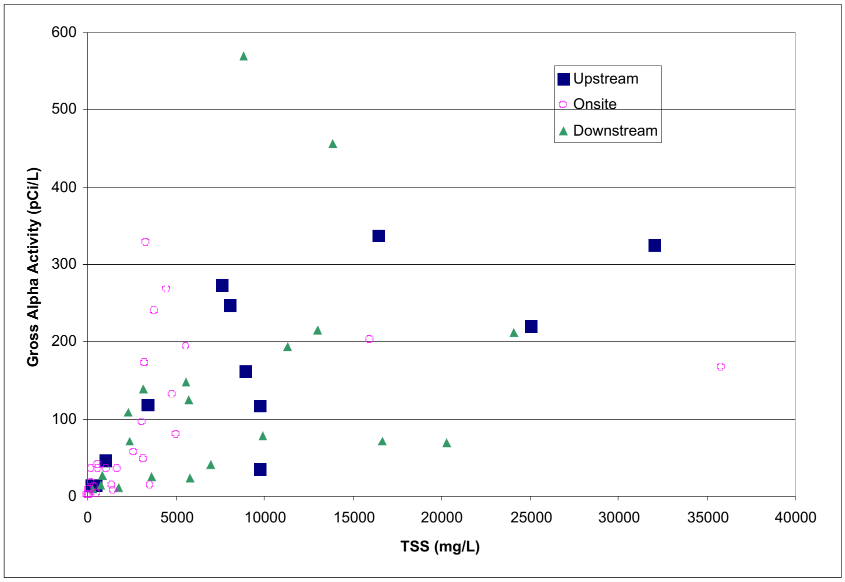
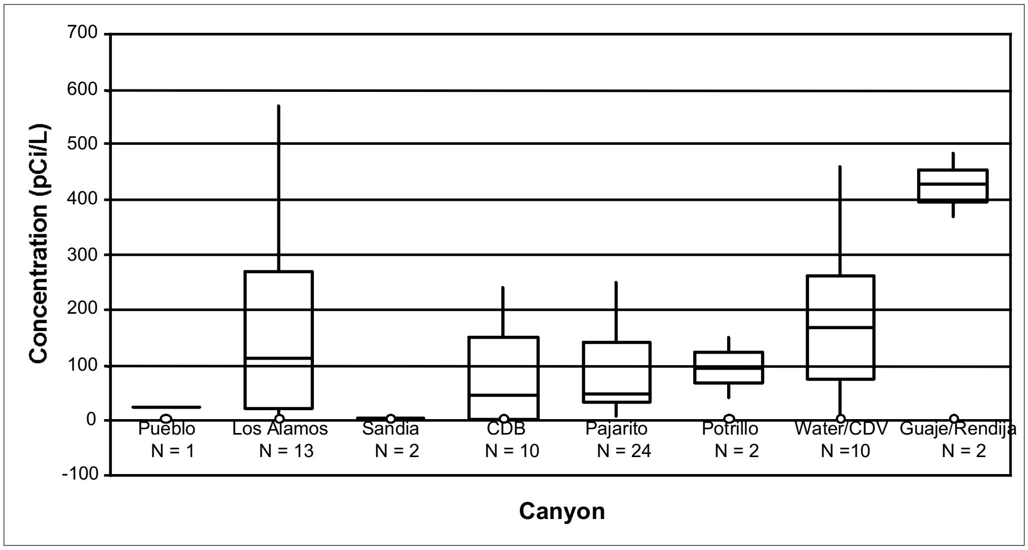


Figure C-23. Gross alpha activity vs TSS concentrations in unfiltered runoff.

Regression analysis of TSS concentration and gross alpha activity for all runoff data show an R-squared value of 0.27, which does not indicate a significant correlation. R-squared values for samples collected at upstream, onsite, and downstream locations are 0.52, 0.19, and 0.14, respectively. The R-squared value for samples with TSS concentrations less than 5000 mg/L is 0.52, while the R-squared value for TSS concentrations greater than 5000 mg/L is 0.03. It is obvious that the higher TSS concentrations in high-volume runoff do not contain similarly high gross alpha activities (see Figure C-23). This is likely because higher-runoff volumes with the higher TSS concentrations contain larger-sized particles such as sand and pebble-sized grains of quartz and other minerals that do not have as high gross alpha concentrations as smaller-sized materials.

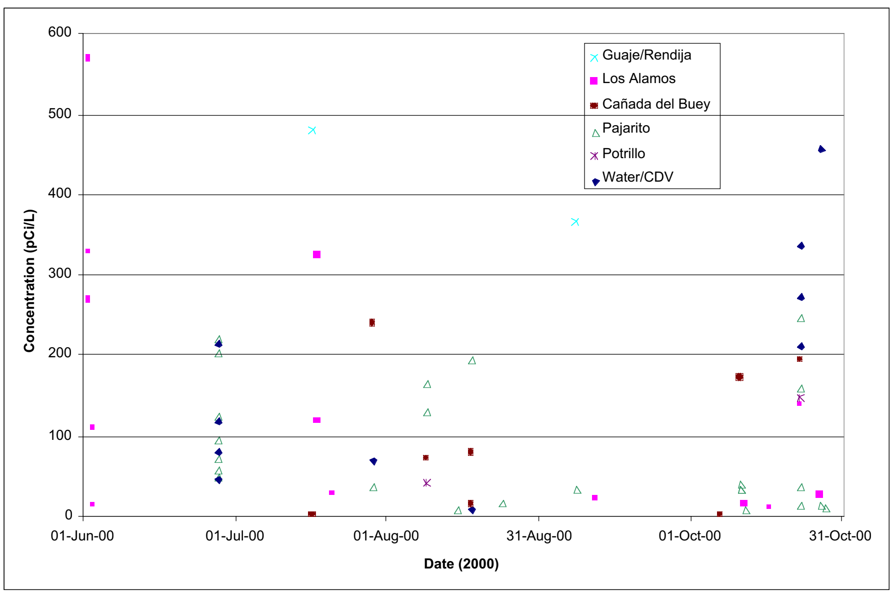
Figure C-24 shows the distributions of gross alpha activity in unfiltered runoff samples from each canyon system. As mentioned previously, the highest concentrations of gross alpha activity were from Los Alamos Canyon; however, the canyon system with the highest median activity (423.5 pCi/L) was Guaje/Rendija, followed by Water Canyon/Cañon de Valle with a median activity of 165 pCi/L. The higher gross alpha activities in each canyon are in runoff from fire-impacted areas. One sample from Pueblo Canyon collected on October 27 contained relatively low gross alpha activity.

Figure C-25 shows the time series of gross alpha activity in unfiltered runoff throughout the 2000 runoff season for samples from each canyon system. The time-series data show that activity in runoff decreased throughout the runoff season until October when some samples from Water Canyon and Pajarito Canyon contained up to 457 pCi/L. The higher water-borne gross alpha activities generally do not indicate that some new contaminant source contributed to increased radioactivity levels, but that more sediment was transported in these higher-runoff volume storm events after the fire.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-24. Gross alpha activity in unfiltered runoff from each canyon system.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-25. Time series of gross alpha activity in unfiltered runoff from each canyon system.

C.9 Gross Beta Activity in Runoff

Gross beta is a general measure of the total (gross) beta radiation present in a sample. Figure C-26 shows the distribution of gross beta activity in unfiltered runoff at upstream, onsite, and downstream locations for both prefire and postfire periods. Figure C-27 shows the gross beta activity in filtered samples. Gross beta activity in unfiltered samples is about one order of magnitude higher than in filtered samples. Gross beta activity in unfiltered samples from upstream locations was higher after the fire by about a factor of 100, but the range and distribution of activities at onsite and downstream locations after the fire were not significantly different than before the fire.

The highest gross beta activity in unfiltered samples from upstream locations in 2000 was 670 pCi/L in a sample collected June 28 from upper Pajarito Canyon (gage E240). The highest activity in samples from onsite locations was 593 pCi/L from a sample collected on June 28 from Pajarito Canyon at the TA-18 culvert (gage E18C). The highest activity in samples from downstream locations was 930 pCi/L in a sample from lower Los Alamos Canyon at gage E042 collected on June 2. The higher gross beta activities (over 300 pCi/L) in unfiltered runoff are from fire-impacted areas.

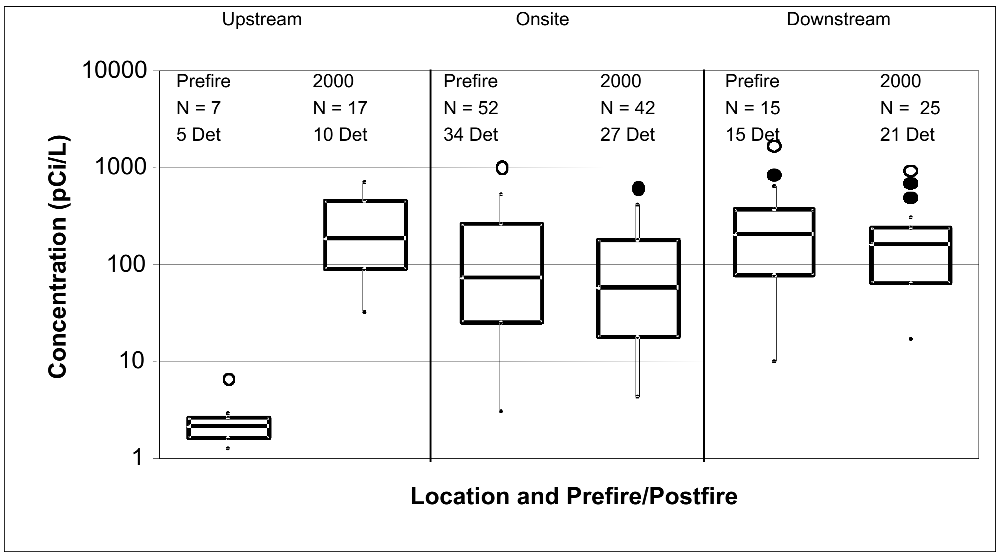


Figure C-26. Gross beta activity in unfiltered runoff from upstream, onsite, and downstream locations, prefire and postfire.

The highest dissolved gross beta activities in filtered runoff samples were collected from the large runoff event on June 28. The maximum activity in filtered samples from upstream locations was 28.8 pCi/L in a sample collected on June 28 in upper Pajarito Canyon at gage E240. Maximum onsite activity was 47.2 pCi/L from Pajarito Canyon near G-1 (manual sample EPG1), and the maximum activity from downstream locations was 47.3 pCi/L at the SR 4 culvert (location ES4C). The distributions of gross beta activities dissolved in runoff at onsite and downstream locations after the fire are not significantly different from activities in runoff before the fire (Figure C-27).

Figure C-28 shows the gross beta activity in unfiltered runoff samples compared with the concentrations of TSS in the runoff. In general, the higher-TSS-concentration samples contained higher total radioactivity. Samples collected during an intense short-lived runoff event will generally contain higher total beta activity levels than samples collected from the same location under slower flows with less sediment carrying power. While some of the gross beta activity in 2000 was associated with ash-laden runoff from fire-impacted areas, the relationship with TSS is also observed in prefire runoff samples.

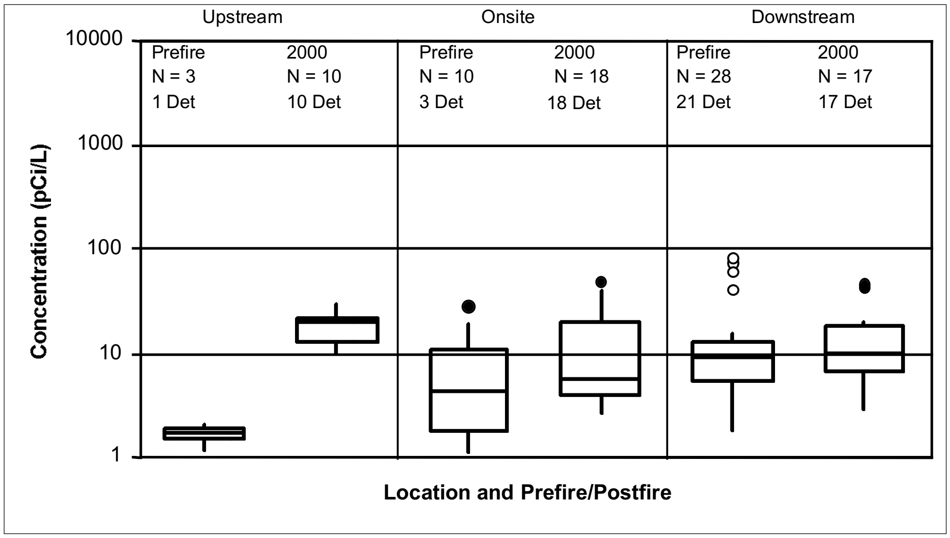


Figure C-27. Gross beta activity in filtered runoff from upstream, onsite, and downstream locations, prefire and postfire.

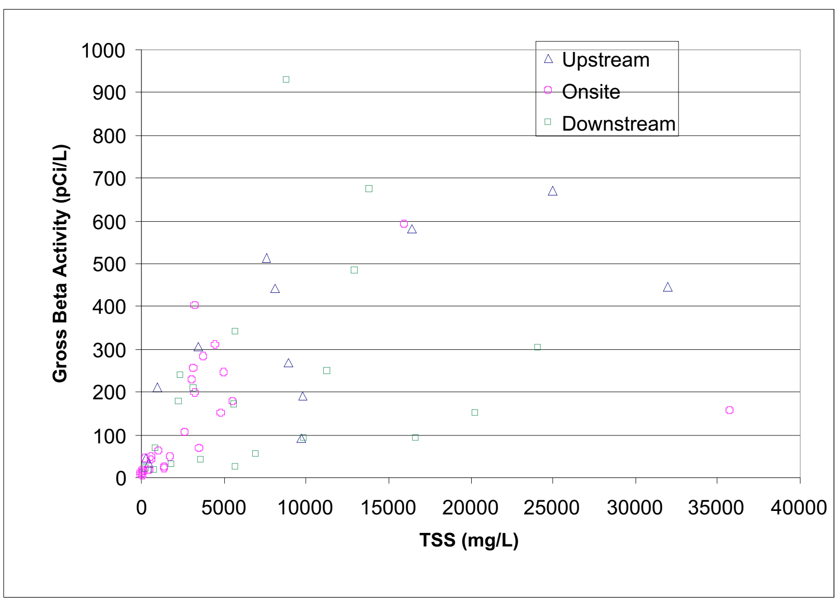
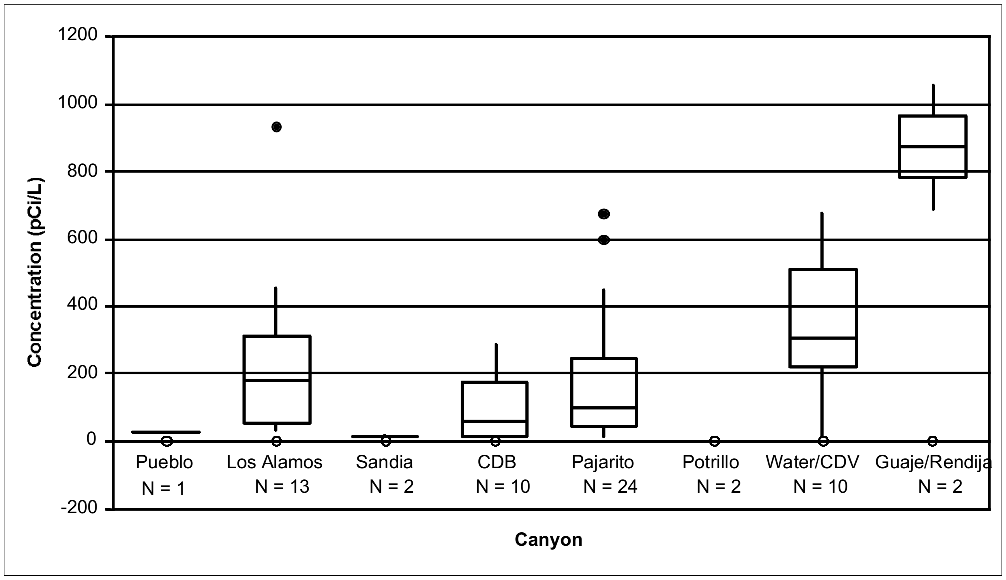


Figure C-28. Gross beta activity vs TSS concentrations in unfiltered runoff.

Regression analysis of TSS concentration and gross beta activity for all runoff data show an R-squared value of 0.27, which does not indicate a significant correlation. R-squared values for samples collected at upstream, onsite, and downstream locations are 0.46, 0.18, and 0.11, respectively. The R-squared value for samples with TSS concentrations less than 5000 mg/L is 0.57, while the R-squared value for TSS concentrations greater than 5000 mg/L is 0.02. It is obvious that the higher TSS concentrations in high-volume runoff do not contain similarly high gross beta activities (see Figure C-28). This is likely because higher runoff volumes with the higher TSS concentrations contain larger-sized particles such as sand and pebble-sized grains of quartz and other minerals that do not have as high gross beta activities as smaller-sized materials.

Figure C-29 shows the gross beta activity of unfiltered runoff samples from each canyon system in 2000. The canyons with the highest activity were Rendija Canyon (1054 pCi/L) and Guaje Canyon (685 pCi/L). At LANL, runoff from Water Canyon contained the highest median concentration of about 300 pCi/L, followed by Los Alamos Canyon with 177 pCi/L. All samples that contained greater than 300 pCi/L were from runoff from fire-impacted areas or from DP Canyon.

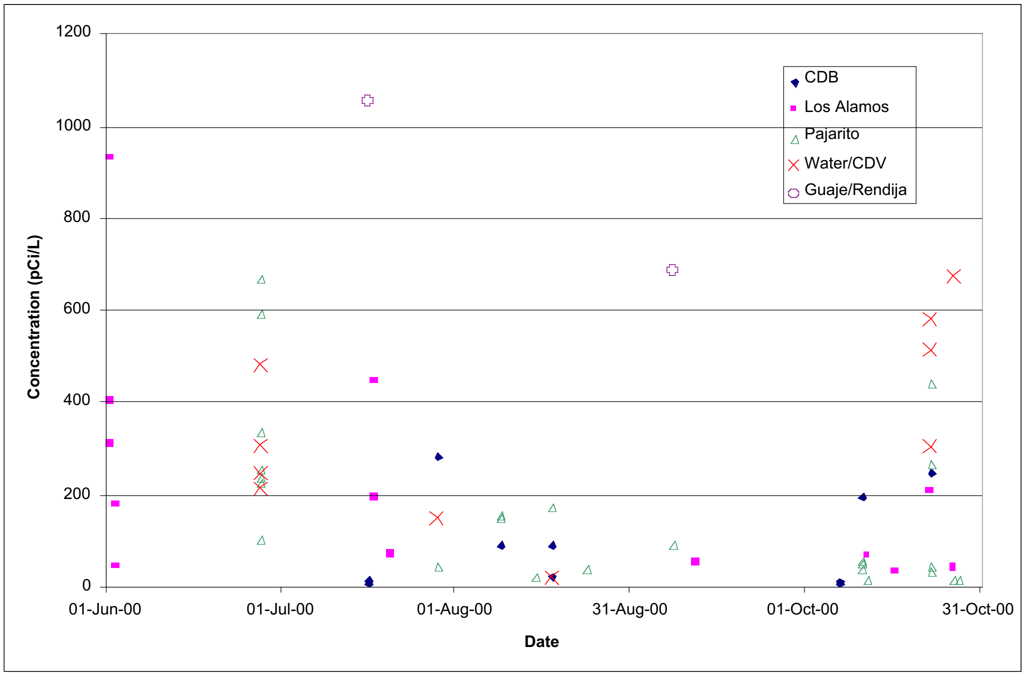


Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-29. Gross beta activity in unfiltered runoff from each canyon system.

Figure C-30 shows the time series of gross beta activity in unfiltered runoff throughout the 2000 runoff season for samples from each canyon system. The time-series data show that activity in runoff decreased throughout the runoff season until late in October when some samples from Water Canyon and Pajarito Canyon contained up to 700 pCi/L. The higher water-borne gross beta activities do not indicate that some new contaminant source contributed to increased radioactivity levels, but that more sediment was transported in the higher runoff volume storm events after the fire.

The analyses of radionuclides in storm runoff indicate that most alpha and beta activities in the runoff samples are accounted for by naturally occurring potassium, uranium, and thorium isotopes and their daughter decay products. These daughter products are not measured by the analyses (and often are short-lived), but can be calculated from the measured uranium and thorium concentrations. The decay products account for most of the gross alpha and gross beta radiation measured in the runoff. Within the accuracy of the analytical methods, the levels of gross alpha and gross beta radiation observed in these runoff samples can be attributed to high suspended sediment loads (from erosion) and naturally occurring levels of potassium, thorium, and uranium, along with their daughter products, carried in that sediment.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-30. Time series of gross beta activity in unfiltered runoff from each canyon system.

C.10 Tritium in Runoff

Tritium concentrations in 75 unfiltered storm water runoff samples collected in 2000 ranged from below detection limits to 1870 pCi/L. The highest concentrations were from TA-54, MDA-G gage E227 (formerly G-6) in a tributary to Cañada del Buey where the tritium concentration in runoff was 1730 pCi/L (duplicate sample 1710 pCi/L) on August 18 and 1870 pCi/L on October 11. A sample from TA-54, MDA-G, gage E248 (formerly G-2) collected on October 11 contained a tritium concentration of 864 pCi/L. All other concentrations of tritium in runoff were generally below 600 pCi/L and the median concentration of all samples was 122 pCi/L. The median concentration of 11 detected values was 500 pCi/L.

C.11 Lead-210 in Runoff

The analyses of lead-210 in runoff samples were performed using the gamma spectroscopy laboratory method for samples collected in June, July, and up until the middle of September. This laboratory method produced results with MDAs of several hundred (up to nearly 900) pCi/L, and only 3 of 28 unfiltered samples contained detectable lead-210. These detections were 840 pCi/L (uncertainty 332 pCi/L) in a sample collected in Guaje Canyon on September 8; 652 pCi/L in a sample collected August 12 from lower Water Canyon (gage E265), and 655 pCi/L in a sample collected August 18 from lower Cañada del Buey (gage E230).

After the middle of August most analyses for lead-210 were performed using the gas proportional counting laboratory method and results were generally less than 50 pCi/L with minimum detectable activities generally less than 3 pCi/L. The distribution of lead-210 concentrations in unfiltered runoff in 2000 is shown in Figure C-31 (historical data for lead-210 before the fire are not available). The normal distribution of concentrations at upstream locations ranged up to 60 pCi/L with an outlier concentration of 106 pCi/L in a sample collected from Water Canyon (gage E252) on October 23. The concentrations of lead-210 in samples collected onsite were significantly lower, where the highest concentration was 28.8 pCi/L in a non-fire related sample collected at TA-54, MDA-G, on August 18. The highest concentration of lead-210 was 120 pCi/L in a sample collected in lower Water Canyon (gage E265) on October 27.

The median upstream concentration was 36.2 pCi/L, the median onsite concentration was 5.48 pCi/L, and the median downstream concentration of lead-210 was 16.7 pCi/L. In the absence of historical lead-210 data, insufficient data are available to assess the fire-related runoff data characteristics in 2000.

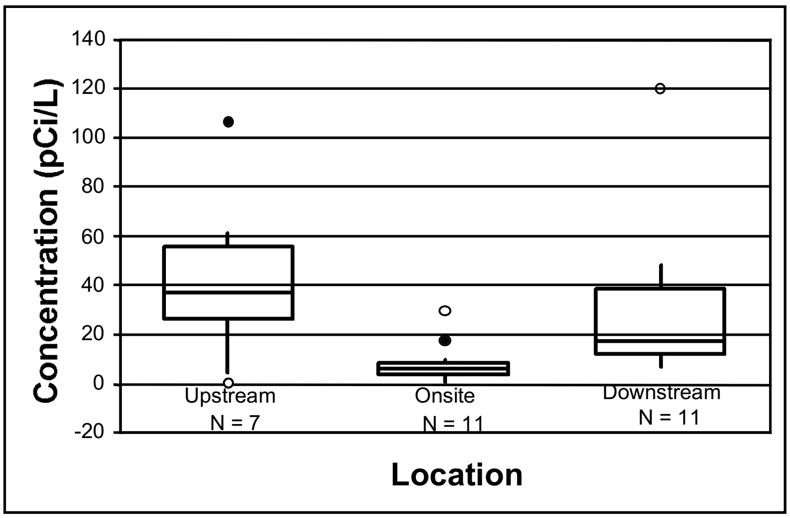


Figure C-31. Distribution of lead-210 in runoff at upstream, onsite, and downstream locations in 2000.

C.12 Plutonium-238 in Runoff

Figure C-32 shows the distribution of plutonium-238 in unfiltered runoff for samples collected prefire and postfire, and at upstream, onsite, and downstream locations relative to the Laboratory. Before the fire, only two upstream runoff samples had been analyzed for radionuclides, and the results of these samples for plutonium-238 were both below the detection limit. Therefore, available surface water data from upstream locations were included in Figure C-32 for comparison purposes; although results of all analyses were less than three times the uncertainty. All other data shown in Figure C-32 are from runoff samples.

Plutonium-238 concentrations in unfiltered runoff at upstream locations in 2000 ranged from below detection limits to 0.36 pCi/L; plutonium-238 was not detected in any upstream samples collected before the fire. Samples collected onsite ranged from 0.012 to 7.61 pCi/L. The highest concentration of plutonium-238 at onsite locations was from TA-54, MDA-G-3 (gage E248.5), which was not affected by fire. Samples collected from lower DP Canyon at gage E040 contained up to 0.878 pCi/L, which were also not affected by the fire. Runoff samples collected at downstream stations in 2000 contained plutonium-238 ranging from 0.03 to 2.86 pCi/L. The highest concentration was collected from lower Cañada del Buey at gage E230 on August 9. Samples collected at the downstream stations before the fire contained a similar range and median value for plutonium-238 in unfiltered runoff (Figure C-32).

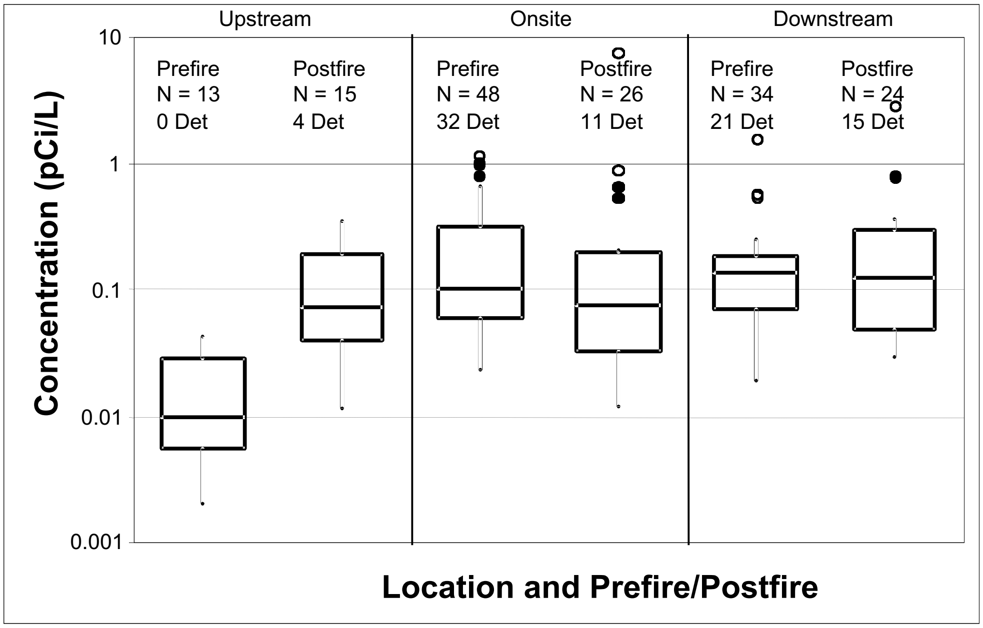


Figure C-32. Plutonium-238 in unfiltered runoff prefire and postfire at upstream, onsite, and downstream stations.

Figure C-33 shows the summary of plutonium-238 in filtered runoff for samples collected prefire and postfire, at upstream, onsite, and downstream stations. The concentrations in filtered samples are less than those observed in unfiltered samples and at upstream and downstream locations were mostly below detection limits. The one detection from onsite locations was 0.057 pCi/L in a sample collected from the Pajarito Canyon Retention Pond on August 24. The highest concentrations of plutonium-238 in filtered samples were from downstream stations in Pueblo Canyon (0.111 pCi/L) and Los Alamos Canyon (0.125 pCi/L from the weir above SR 4). No significant differences in the distribution of dissolved plutonium-238 are observed in samples collected before the fire and after the fire. Prefire and postfire filtered samples collected downstream of the Laboratory have slightly higher median concentrations of plutonium-238 than upstream and onsite samples, indicating a probable LANL contribution to plutonium-238 concentrations, mainly in Pueblo and Los Alamos Canyons. The distribution of dissolved concentrations and the mean concentration in samples from downstream locations in 2000 are lower than observed before the fire.

Figure C-34 shows the summary of plutonium-238 in unfiltered runoff for each canyon system. The largest range of concentrations is observed in Los Alamos Canyon (including DP Canyon), where concentrations of plutonium-238 in unfiltered runoff ranged from below the detection limit to 0.878 pCi/L. The highest distribution of plutonium-238 is observed in Guaje and Rendija Canyons where runoff samples contained up to 1.23 pCi/L. The median concentrations observed in Guaje/Rendija Canyons are significantly higher than the median concentrations observed for samples collected at the Laboratory (see Figure C-34). The runoff in Rendija and Guaje Canyons was substantially affected by the fire. Runoff samples collected in Cañada del Buey, Pajarito Canyon, Water Canyon, and Cañon de Valle appear to contain approximately similar distributions of plutonium-238 concentrations.

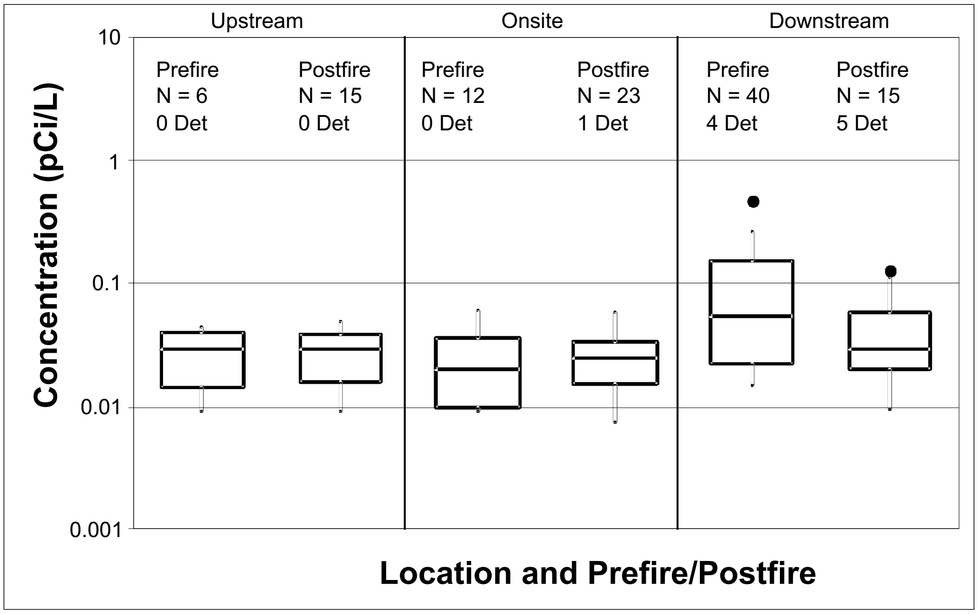
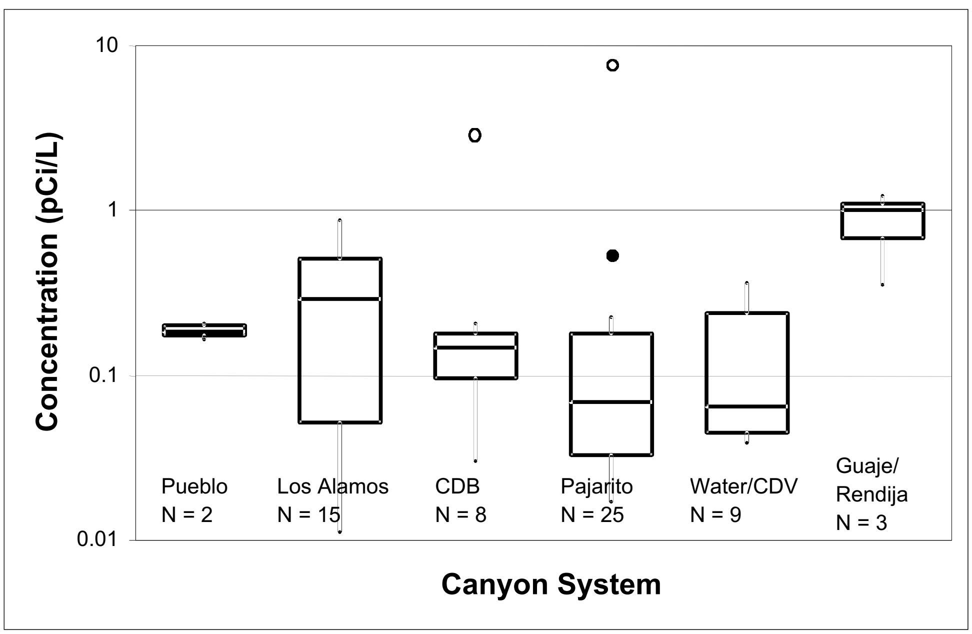


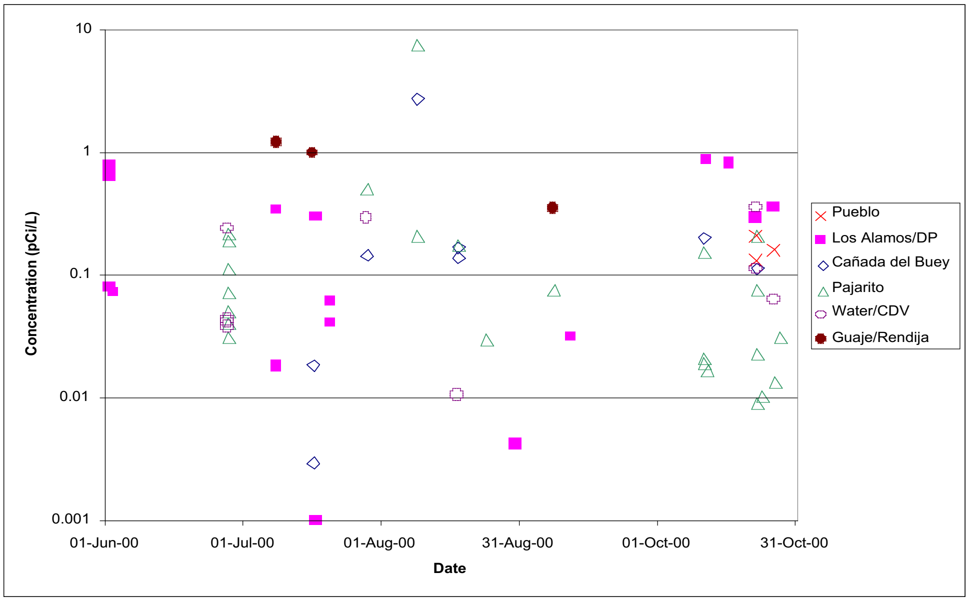
Figure C-33. Plutonium -238 in filtered runoff prefire and postfire at upstream, onsite, and downstream stations.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-34. Plutonium-238 in unfiltered runoff samples from each canyon system in 2000.

Figure C-35 shows the time series of plutonium-238 in unfiltered runoff from each canyon system in 2000. The higher concentrations are from samples collected in August, and for the major canyons including Los Alamos Canyon, Pajarito Canyon, and Water Canyon, similar concentrations are observed throughout the runoff season.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon. CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-35. Time series of plutonium-238 in unfiltered runoff from each canyon system in 2000.

C.13 Plutonium-239,240 in runoff

The distributions of plutonium-239,240 concentrations in unfiltered runoff samples at upstream, onsite, and downstream locations for prefire and postfire samples are summarized in Figure C-36. The highest concentration of plutonium-239,240 observed in upstream samples after the fire was 5 pCi/L at the upstream Los Alamos Canyon site (gage E025) on July 18, 2000. Concentrations >1 pCi/L were also observed at upstream sites in Pajarito Canyon (4.4 pCi/L on June 28), Cañon de Valle (2.45 pCi/L on October 23), Water Canyon (1.15 pCi/L on October 23), and Two-mile Canyon (1.09 pCi/L on October 23). The median concentration at upstream sites was 1.0 pCi/L, significantly higher than the prefire samples, in which no detections of plutonium-239,240 were observed from 1995 to 1999.

The highest concentration of plutonium-239,240 from onsite locations was 13.5 pCi/L in a sample from middle Los Alamos Canyon above DP Canyon (gage E030) collected on June 2, 2000. The median value of samples collected onsite after the fire was 0.284 pCi/L, lower than the prefire median concentration of 0.687 pCi/L. The highest concentrations of plutonium-239,240 from downstream locations were from lower Pueblo Canyon (at gage E060) and lower Los Alamos Canyon (gage E042). The highest concentration at downstream sites after the fire was 22.77 pCi/L in a sample from lower Los Alamos Canyon collected on July 9, 2000. The samples collected at downstream locations after the fire have a similar range and distribution as samples collected before the fire, but maximum concentrations in runoff after the fire were slightly higher than before the fire.

The unfiltered plutonium-239,240 runoff data show that higher concentrations are observed at upstream sites after the fire, but higher maximum concentrations at onsite and downstream locations indicate a probable LANL contribution of plutonium-239,240 to runoff across Laboratory property.

The distributions of plutonium-239,240 concentrations in filtered runoff samples at upstream, onsite, and downstream locations for prefire and postfire samples are summarized in Figure C-37. Dissolved plutonium-239,240 concentrations are generally about an order of magnitude lower than in unfiltered samples. Five samples from upstream locations collected before the fire did not contain detectable dissolved plutonium-239,240; similarly, after the fire, none of 15 samples detected plutonium-239,240.

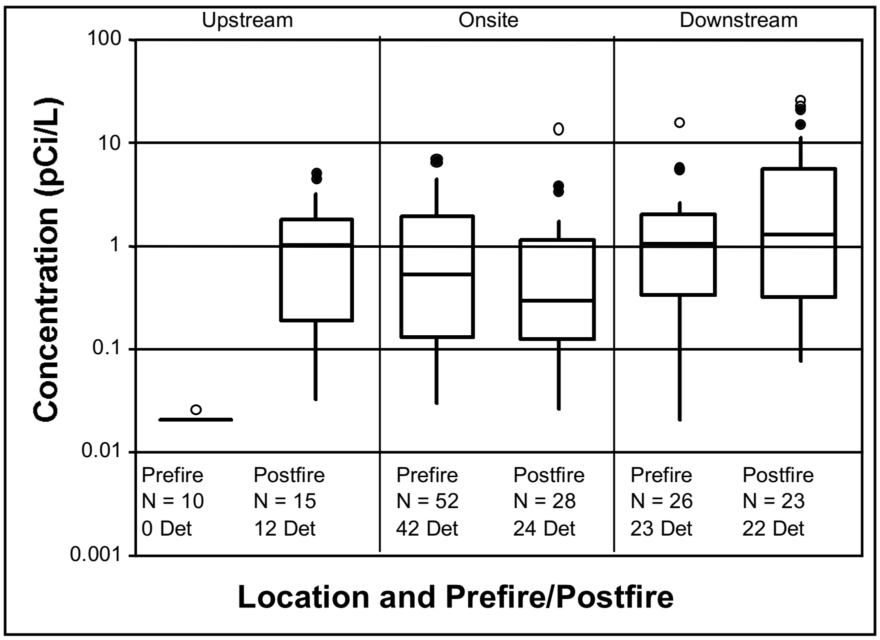


Figure C-36. Plutonium-239,240 in unfiltered runoff prefire and postfire at upstream, onsite, and downstream stations.

The median concentrations of dissolved plutonium-239,240 detected at onsite and downstream locations were 0.050 and 0.064 pCi/L, respectively, and the distributions of concentrations at these locations were similar to prefire distributions, but higher dissolved concentrations of plutonium-239,240 were observed in runoff at downstream locations before the fire (the four highest dissolved concentrations at downstream sites before 2000 were from lower Los Alamos Canyon). The highest concentration of dissolved plutonium-239,240 at onsite locations was 0.0517 pCi/L in a sample from TA-54, MDA-G (gage E249.5), and the highest concentration at downstream sites was 0.169 pCi/L in a sample collected from lower Pueblo Canyon (gage E060) on October 27.

Figure C-38 shows the distribution of plutonium-239,240 in unfiltered runoff for each canyon system for 2000. Runoff samples collected in Pueblo Canyon had the highest plutonium-239,240 concentrations that ranged from 15.1 to 22.8 pCi/L. Samples from Guaje and Rendija Canyons contained similar concentrations that in three samples ranged from 7.6 to 17.7 pCi/L. Of 17 samples collected in Los Alamos Canyon, three samples contained plutonium-239,240 in concentrations greater than 10 pCi/L. Samples collected in Cañada del Buey contained the lowest concentrations of plutonium-239,240, well below 1 pCi/L. Samples from Pajarito Canyon, Water Canyon, and Cañon de Valle contained less than 5 pCi/L.

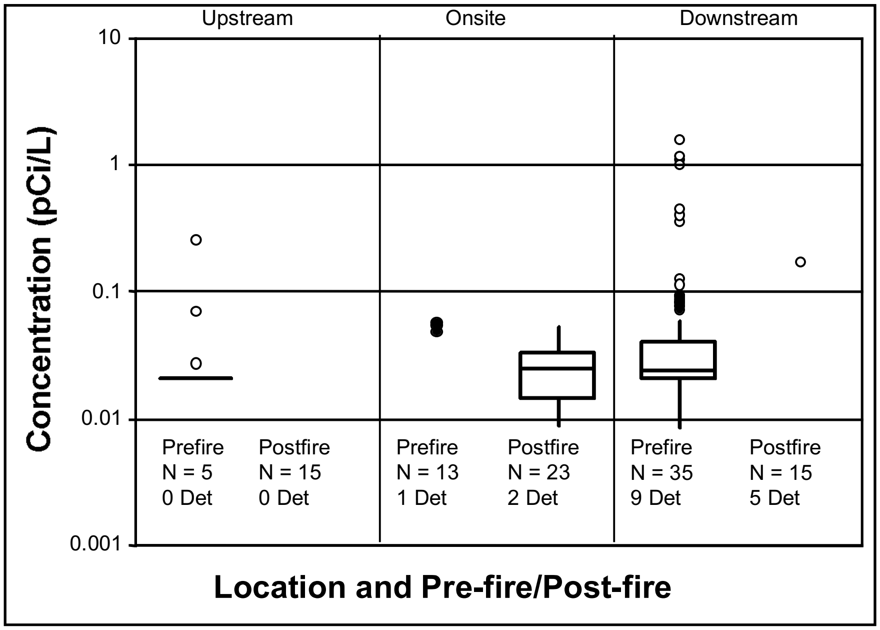
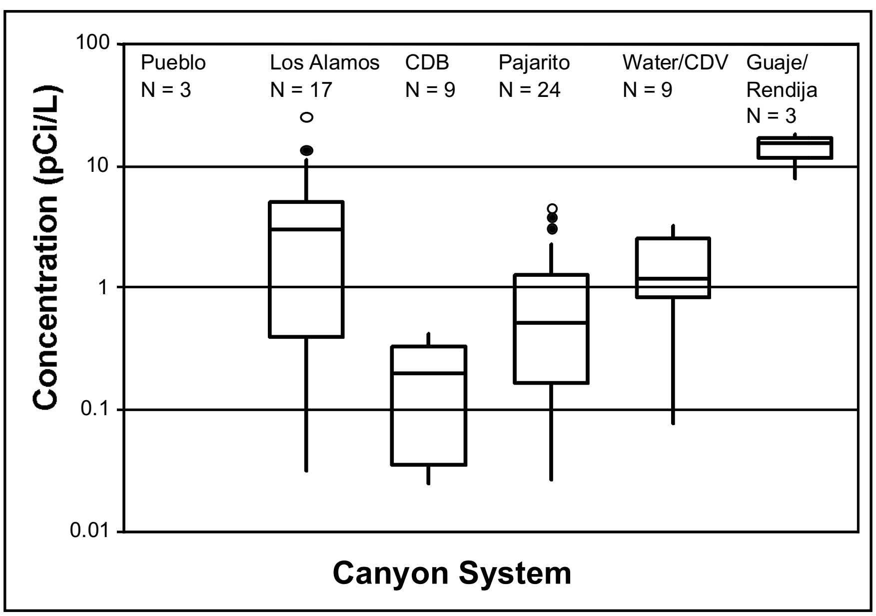


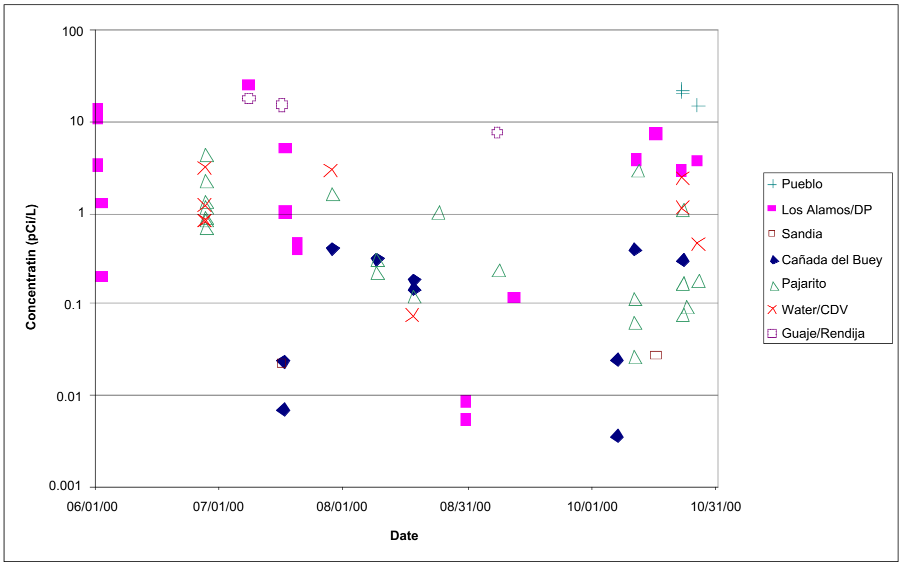
Figure C-37. Plutonium-239,240 in filtered runoff prefire and postfire at upstream, onsite, and downstream stations.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle

Figure C-38. Plutonium-239,240 in unfiltered runoff in each canyon system.

Figure C-39 shows the time series of plutonium-239,240 concentrations in unfiltered runoff from each canyon in 2000. In Los Alamos Canyon, the concentrations observed in June and July are similar to concentrations observed in October. In some canyons such as Pajarito Canyon, Water Canyon, and Guaje/Rendija Canyons, higher concentrations are present in June and July and concentrations appear to decrease slightly throughout the runoff season. The concentrations may be related to the volume of runoff from fire-related areas.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.

Figure C-39. Time series of plutonium-239,240 in unfiltered runoff from each canyon system in 2000.

Figure C-40 shows the distribution of plutonium-239,240 concentrations in unfiltered runoff in Los Alamos Canyon at upstream, onsite, and downstream locations throughout the runoff season. The median concentration at the upstream site (gage E025) was 0.60 pCi/L, at onsite stations (gage E030 in Los Alamos Canyon and gage E040 in DP Canyon) was 3.72 µg/L, at the downstream location (E042) was 5.49 pCi/L. The runoff data indicate a LANL contribution of plutonium-239,240 to runoff in Los Alamos Canyon.

C.14 Strontium-90 in Runoff

The distribution of strontium-90 concentrations in unfiltered runoff samples at upstream, onsite, and downstream locations for prefire and postfire samples are summarized in Figure C-41. The highest concentration of strontium-90 observed in upstream samples after the fire was 59.2 pCi/L from upper Pajarito Canyon (gage E240) on June 28. The median concentration observed at upstream locations after the fire was 12.1 pCi/L, slightly higher than the one detected value (8.9 pCi/L) obtained before the fire.

The highest concentration of strontium-90 in unfiltered runoff from onsite locations after the fire was 75.4 pCi/L in a sample from Pajarito Canyon at the TA-18 culvert (gage E18C) collected on June 28. The median concentration from onsite locations after the fire was 0.83 pCi/L. Runoff samples collected at onsite stations after the fire have a significantly lower concentration distribution compared with samples collected before the fire; however, the range of concentrations in onsite postfire samples is similar to those observed before the fire.

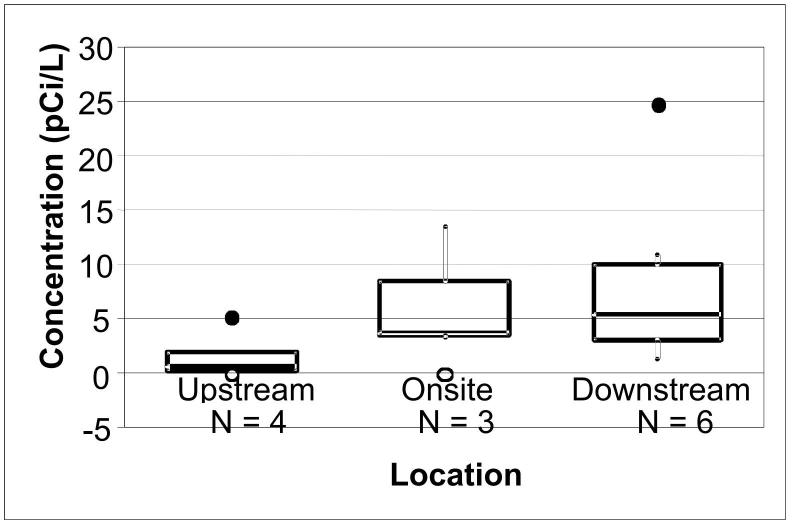


Figure C-40. Distribution of plutonium-239,240 in unfiltered runoff in 2000 at upstream, onsite, and downstream locations.

The highest concentration of strontium-90 in unfiltered runoff at downstream locations was 62.1 pCi/L in a sample from Water Canyon below SR 4 (gage E265) collected on June 28. The mean concentration of downstream samples in 2000 was 7.7 pCi/L. The range of strontium-90 concentrations in samples collected at downstream locations after the fire is similar to samples collected before the fire but the distribution of concentrations appears to be lower after the fire (see Figure C-41). The differences observed in the concentration distributions between prefire and postfire samples at onsite and downstream locations may be the result of using laboratory methods that have lower detection limits in 2000, which tends to skew the concentration distribution patterns to lower values.

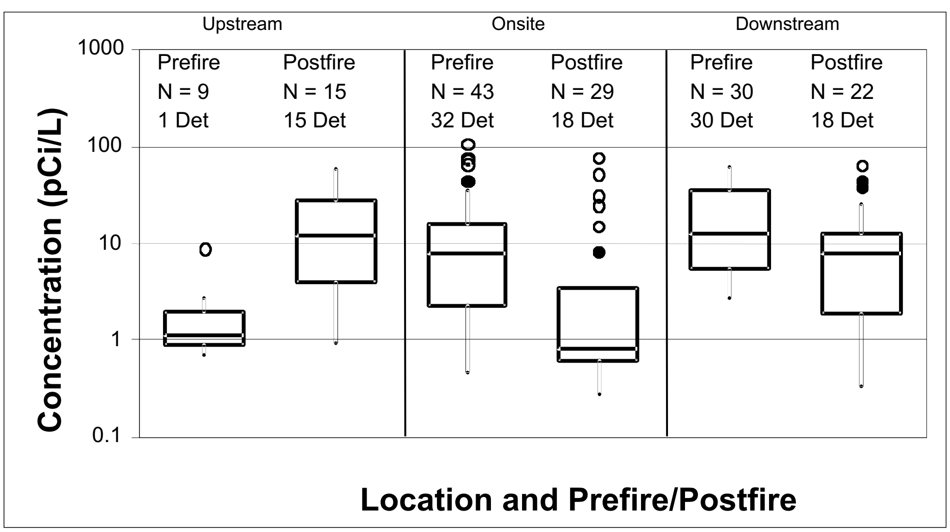


Figure C-41. Strontium-90 in unfiltered runoff at upstream, onsite, and downstream locations, prefire and postfire.

The distributions of dissolved strontium-90 concentrations in filtered runoff samples at upstream, onsite, and downstream locations for prefire and postfire samples are summarized in Figure C-42. The highest concentration of strontium-90 observed in upstream filtered samples after the fire was 5.07 pCi/L in a sample from upper Water Canyon (gage E252) on October 23. Strontium-90 was not detected in two upstream runoff samples collected before the fire. The maximum concentration of dissolved strontium-90 in 2000 was 26.6 pCi/L in a sample collected from discharge from the Los Alamos Canyon weir above SR 4 on July 21. The range and distribution of dissolved strontium-90 concentrations in runoff collected after the fire at downstream locations does not appear to be significantly different than for samples collected before the fire.

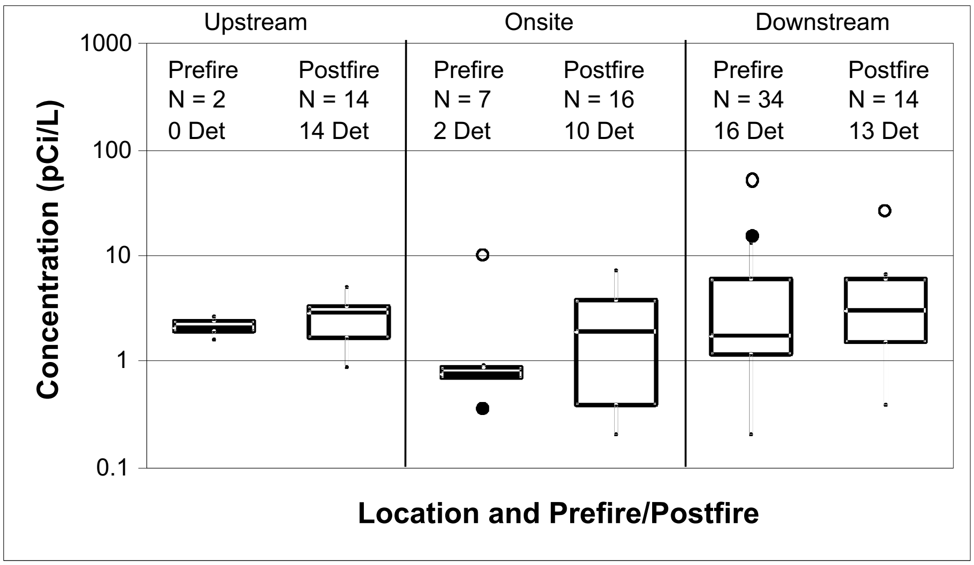
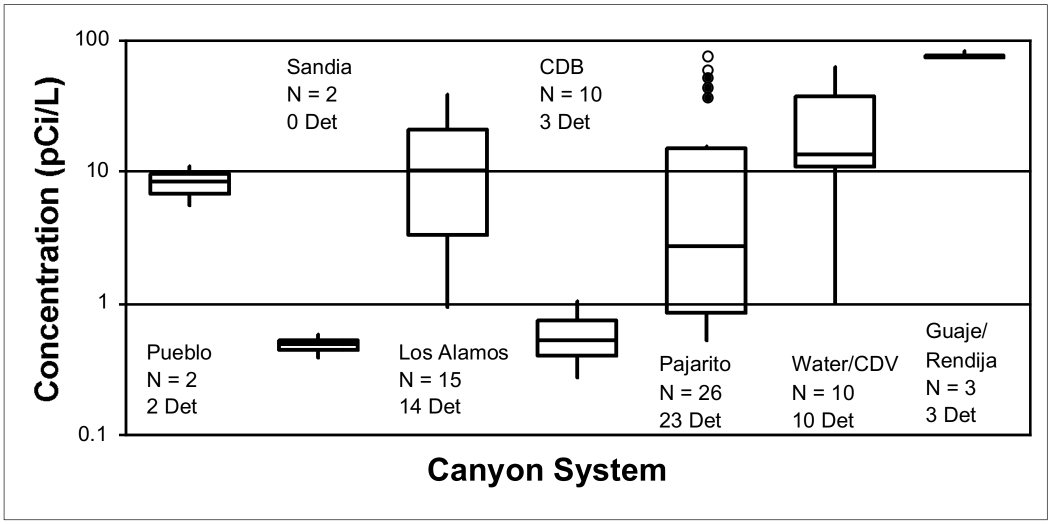


Figure C-42. Strontium-90 in filtered runoff at upstream, onsite, and downstream locations, prefire and postfire.

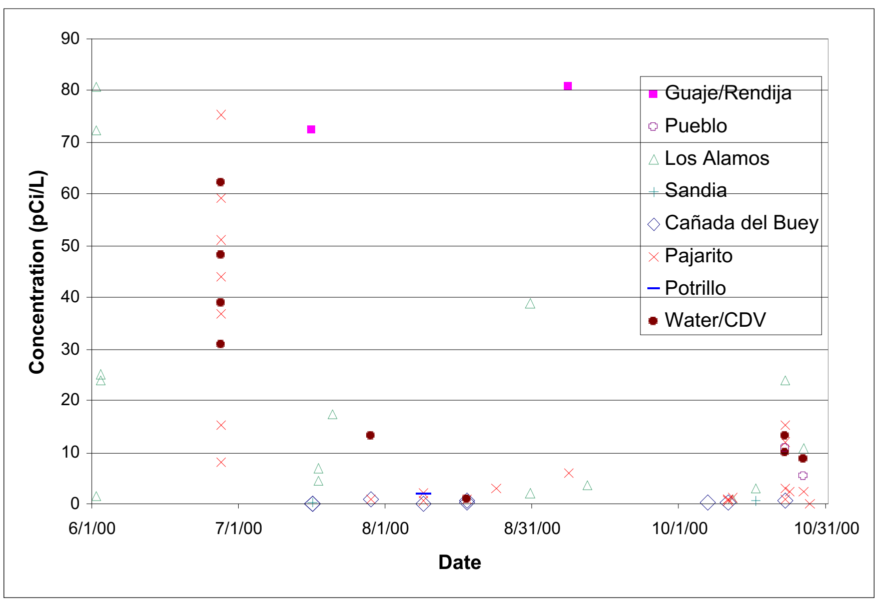
Figure C-43 shows the distribution of strontium-90 in unfiltered runoff collected from each canyon system. The highest concentrations of strontium-90 in runoff in 2000 were collected in Guaje and Rendija Canyons, samples from which contained 80.8 and 73 pCi/L, respectively. Canyon systems at LANL that contain strontium-90 in concentrations above 1 pCi/L include Pueblo, Los Alamos, Pajarito, and Water Canyon/Cañon de Valle. Samples from Sandia Canyon and Cañada del Buey contained generally less than 1 pCi/L strontium-90. The higher concentrations of strontium-90 in Pajarito Canyon and Water Canyon are from the large June 28 runoff event. The higher concentrations of strontium-90 in runoff in 2000 are associated with runoff from fire-impacted areas.

Figure C-44 shows the concentrations of strontium-90 in unfiltered runoff for each canyon system in a time series throughout the 2000 runoff season. The highest concentrations of strontium-90 in each canyon system were from the initial runoff events, and subsequent runoff events tended to have lower concentrations, suggesting that strontium-90 was primarily carried in ash suspended in runoff. The first runoff event on June 2 and 3 was primarily in Los Alamos Canyon, where concentrations of strontium-90 in unfiltered runoff were up to 80.8 pCi/L. Subsequent runoff events in Los Alamos Canyon did not contain greater than 40 pCi/L strontium-90. The next major runoff event on June 28 primarily involved Pajarito Canyon and Water Canyon/Cañon de Valle where strontium-90 concentrations ranged up to 75.4 pCi/L in Pajarito Canyon and 62.1 pCi/L in Water Canyon. Subsequent runoff events in these canyons did not contain greater than 15 pCi/L.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

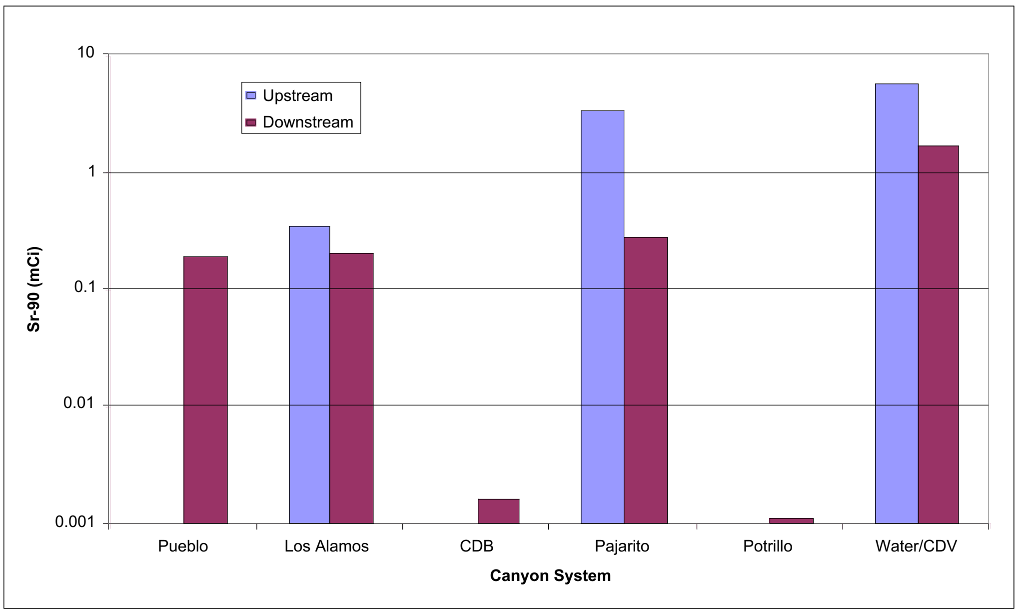
Figure C-43. Strontium-90 in unfiltered runoff in each canyon system.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-44. Time series of strontium-90 in unfiltered runoff from each canyon system.

Figure C-45 shows the total activity of strontium-90 that was carried in runoff at upstream and downstream locations in each canyon system at LANL. Each of the canyons that have upstream sampling stations show that more strontium-90 was carried in runoff entering LANL from upstream fire-impacted areas than flowed downstream from LANL. The highest activities of strontium-90 were measured in the Water Canyon/Cañon de Valle system, where 5.7 mCi passed through upstream stations and 1.7 mCi passed through the downstream station. Similarly, 3.5 mCi strontium-90 flowed through the upstream station in Pajarito Canyon and 0.3 mCi passed through the downstream station. The bulk of this activity was associated with the large runoff event on June 28. In Los Alamos Canyon approximately 0.34 mCi entered the Laboratory at gage E025 and approximately 0.21 mCi passed through the downstream station at gage E042.



Note: CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-45. Total activity of strontium-90 in runoff at upstream and downstream locations.

Cañada del Buey and Potrillo Canyons have similar watersheds that are smaller in area than Pajarito and Water Canyons and correspondingly smaller activities of strontium-90 flowed downstream. Potrillo Canyon was not affected by fire and has the least amount of activity (0.0011 mCi) in runoff at the downstream station; the upper part of Cañada del Buey was affected by the fire and has slightly more activity (0.0016 mCi) of strontium-90 in runoff at the downstream station.

The runoff data indicate that a total of approximately 9.6 mCi of strontium-90 entered the Laboratory from areas affected by the Cerro Grande Fire and a total of approximately 2.4 mCi left LANL in runoff at downstream locations. The data indicate that approximately 7.2 mCi of strontium-90 were deposited in canyon floor sediments at LANL, and most amounts were deposited in Water Canyon and Pajarito Canyon. The Los Alamos Reservoir in upper Los Alamos Canyon provided a catchment for runoff from burned areas in the upper watershed and may have trapped sediment and strontium-90 in the upper canyon, reducing the amount available to flow onto LANL.

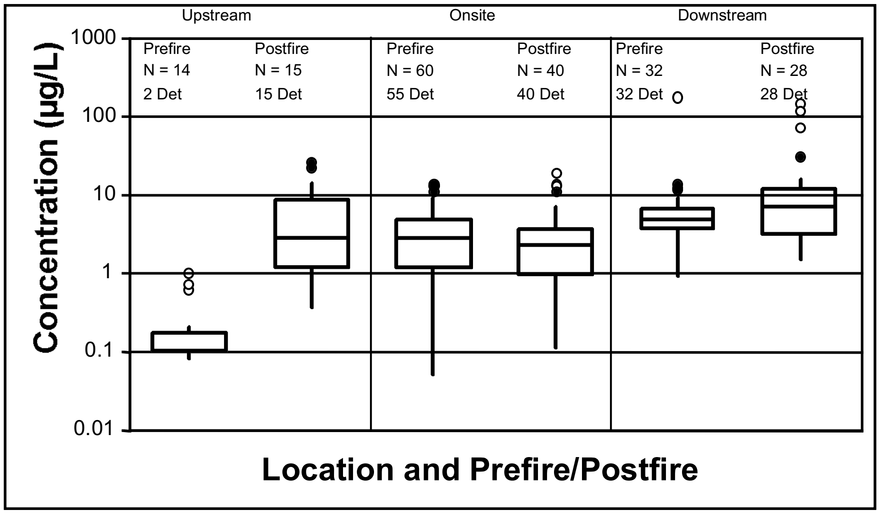
C.15 Uranium in Runoff

The distribution of uranium in unfiltered runoff samples at upstream, onsite, and downstream locations for prefire and postfire samples is summarized in Figure C-46. The highest concentration of uranium in upstream samples after the fire was 21.5 μg/L at gage E025 in Los Alamos Canyon on July 18. In upstream samples collected before the fire, uranium was not detected in two runoff samples and was detected in only two surface water samples, where the highest concentration was 0.2 μg/L in a sample collected from the Los Alamos Canyon Reservoir. The runoff samples collected before the fire were relatively low volume, low TSS samples compared with the higher volume, and higher TSS runoff samples collected after the fire. The lack of comparable prefire upstream runoff data for uranium precludes an accurate comparison of upstream uranium concentration distributions, however, after the fire, the median concentration of 15 samples was 2.82 μg/L, which suggests a possible impact associated with the fire.

The distributions of uranium concentrations in unfiltered samples after the fire at upstream and onsite locations are not significantly different, and these distributions are similar to the distribution of uranium concentrations from samples collected before the fire at onsite locations (Figure C-46). The highest uranium concentration observed in unfiltered runoff from downstream sites before the fire was 170 μg/L in a sample from lower Ancho Canyon (gage E275) collected on June 18, 1999. After the fire, the highest concentration of uranium in unfiltered runoff samples was 146 μg/L, in a sample from lower Water Canyon (gage E265) collected on July 29 (duplicate analysis was 115 μg/L) (both of these locations are downstream of explosive testing sites at LANL). The next highest uranium concentration was 68.4 μg/L, in a sample collected from lower Los Alamos Canyon (gage E042), on July 9. The precipitation event on July 29, 2000, was mainly over the central and eastern part of the Pajarito Plateau and did not significantly affect upstream fire-impacted areas (Koch et al. 2001).

The distributions of uranium in runoff at onsite and downstream locations after the fire are similar to the distributions observed before the fire. The median uranium concentrations in unfiltered runoff at onsite and downstream locations were 2.27 and 7.09 μg/L, respectively, also similar to prefire median concentrations. The maximum onsite concentrations after the fire are similar to the maximum concentrations measured in upstream samples after the fire, indicating a similar provenance of the runoff from fire-impacted areas. However, the data show an increase in median and maximum concentrations of uranium in samples collected from downstream sites compared with upstream and onsite locations (Figure C-46), which likely reflects a contribution from LANL impacts. However, this increase at downstream locations may result from Laboratory impacts or may be partially due to the higher natural background concentration of uranium in Unit 1v of the Tshirege Member of the Bandelier Tuff, which contains about three times higher concentrations of uranium than other units of the Bandelier Tuff (Ryti et al. 1998). Unit 1v outcrops in the central and eastern portions of the Pajarito Plateau and likely contributes a higher percentage of material to suspended sediment at downstream locations.

The distribution of uranium concentrations in filtered runoff is summarized in Figure C-47. The dissolved uranium concentrations are about an order of magnitude lower than total concentrations in unfiltered samples (see Figures C-46 and C-47). Dissolved uranium was not detected in four runoff samples collected at upstream locations before the fire. After the fire, the highest dissolved uranium concentration from an upstream site was 4.74 μg/L at gage E025 in Los Alamos Canyon on July 18, 2000, and the median concentration of 12 samples was 0.76 μg/L. The increased concentration of dissolved uranium in upstream samples appears to be fire-related and may be attributable to geochemical changes in the runoff caused by increased concentrations of metals and inorganics in the ash (e.g., Longmire et al. 2001).



Note: Upstream prefire data set includes both runoff (2 samples) and surface water (12 samples).

Figure C-46. Uranium in unfiltered runoff at upstream, onsite, and downstream locations, prefire and postfire.

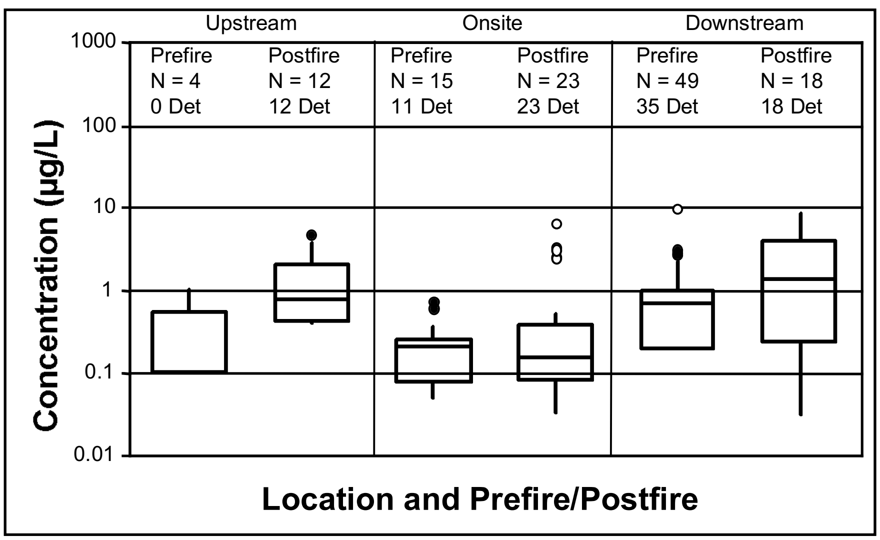
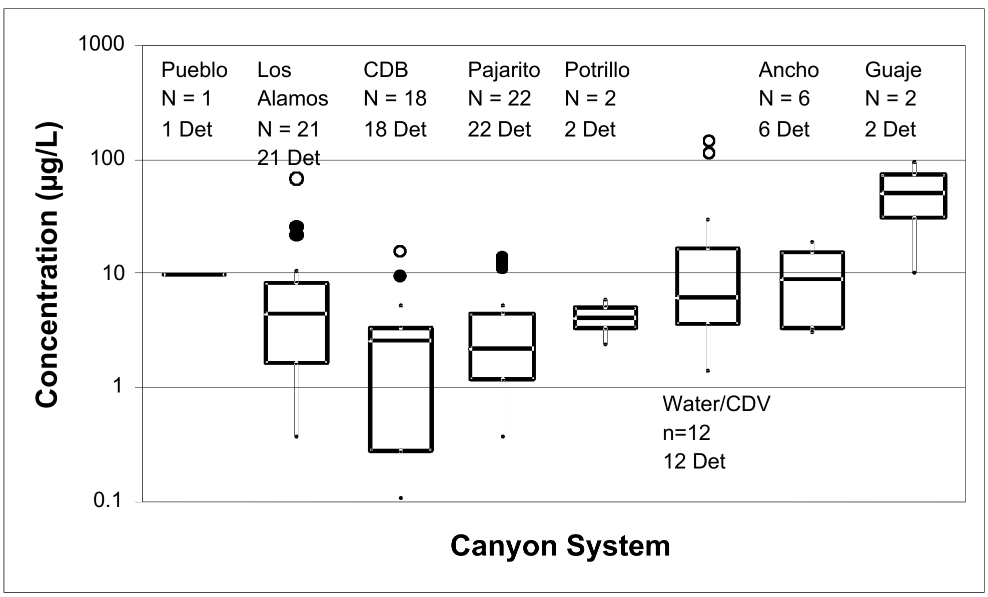


Figure C-47. Uranium in filtered runoff at upstream, onsite, and downstream locations, prefire and postfire.

The distributions of dissolved uranium concentrations at onsite stations before and after the fire are similar, but the maximum concentrations at onsite locations are about an order of magnitude higher than prefire maximum concentrations, and similar to maximum concentrations measured at upstream locations after the fire, suggesting a similar provenance for these samples in upstream fire-impacted areas. The highest concentration of dissolved uranium at onsite locations was 6.34 µg/L in a sample collected from Pajarito Canyon at the TA-18 culvert (gage E18C). Of four other samples from onsite locations that contained >1 µg/L dissolved uranium, three samples were from Pajarito Canyon and one sample was from Water Canyon.

The highest concentration of dissolved uranium at downstream sites in 2000 after the fire was 8.37 µg/L in a sample collected from Pajarito Canyon at the SR 4 culvert on June 28. Before the fire, the highest downstream concentration was 9.5 µg/L in a sample from Ancho Canyon collected in 1995. The distribution of dissolved uranium concentrations at downstream sites after the fire is higher than before the fire, with a postfire median concentration of 1.35 µg/L, about twice the prefire median concentration of 0.70 µg/L (see Figure C-47). The higher concentrations of dissolved uranium in runoff collected from downstream locations after the fire are similar to the higher concentrations measured at upstream and onsite locations and are associated with runoff from upstream fire-impacted areas. However, some contribution at downstream locations may be associated with LANL impacts and/or with Unit 1v of the Tshirege Member of the Bandelier Tuff, which contains higher concentrations of uranium, as mentioned above.

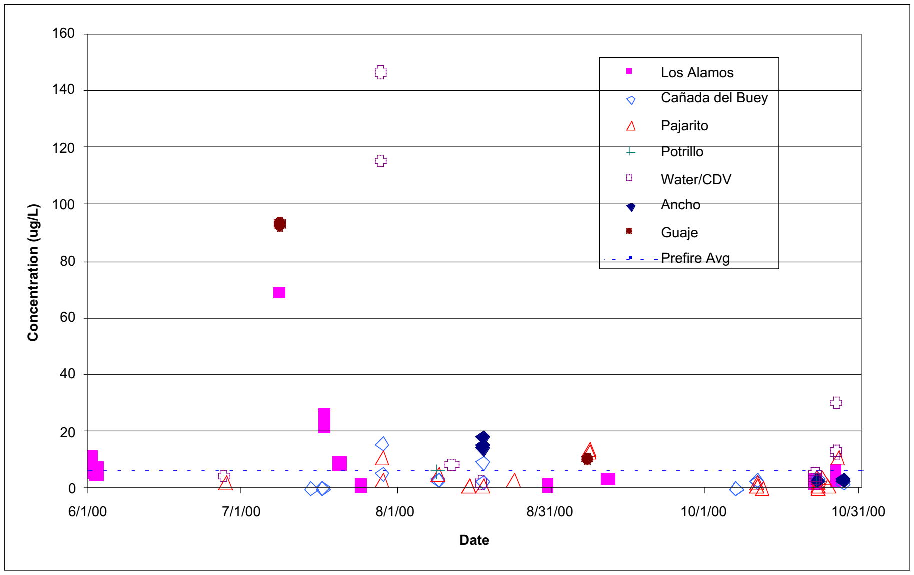
Figure C-48 shows the distribution of uranium in unfiltered runoff collected from each canyon system. The highest concentrations of uranium in runoff in 2000 were collected at the downstream location in Water Canyon (gage E265). Other canyons where runoff samples contained uranium concentrations over 50 µg/L were Guaje and Los Alamos Canyons. The canyon at LANL with the highest median dissolved uranium concentration was Ancho Canyon with 8.99 µg/L.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-48. Uranium in unfiltered runoff from each canyon system.

Figure C-49 shows the time series of concentrations of uranium in unfiltered runoff from each canyon system in 2000. Maximum concentrations are from samples collected in July and August from Water Canyon and Guaje Canyon. Most unfiltered uranium concentrations throughout the runoff season were less than 20 µg/L and a systematic pattern in uranium concentrations in runoff potentially relating to fire-impacts is not obvious. After August 1, the average concentration of uranium in unfiltered runoff was 5 µg/L, similar to the prefire average of 5.8 µg/L.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

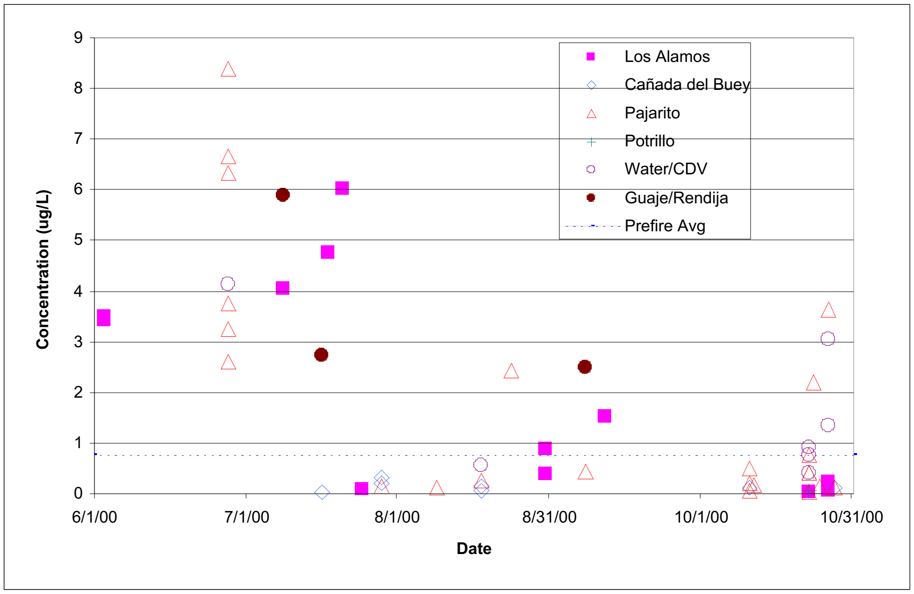
Figure C-49. Time series of uranium in unfiltered runoff from different canyon systems in 2000.

Figure C-50 shows the time series of concentrations of dissolved uranium in filtered runoff from each canyon system in 2000. The highest concentrations are observed during the June 28 runoff event in Pajarito Canyon. Concentrations tend to decrease throughout the runoff season and by the end of October, most concentrations were below or near the prefire average concentration of 0.76 µg/L.

Figure C-51 shows the relationship between uranium in unfiltered runoff with TSS concentrations. In general, the higher TSS concentration samples contain higher concentrations of uranium. Samples collected during an intense short-lived runoff event will generally contain higher uranium concentrations than samples collected from the same location under slower flows with less sediment carrying power. Regression analysis of all uranium and TSS values show an R-squared value of 0.14, which does not indicate a significant amount of correlation. However, runoff samples that contain less than 10,000 mg/L TSS have a slightly higher R-squared value of 0.31. The R-squared value of samples collected at upstream, onsite, and downstream locations are 0.01, 0.54, and 0.04, respectively. The uranium and TSS data suggest that samples that were associated with fire-related runoff have a lower correlation than samples that were collected from non fire-related areas.

The concentrations of uranium in runoff may be related to (1) increased uranium concentrations in the ash, (2) geochemical changes in the runoff caused by increased concentrations of metals and inorganics in the ash (e.g., Longmire et al. 2001), and/or (3) LANL impacts from historical releases at some onsite and downstream locations.

Comprehensive analyses of the runoff samples for uranium isotopes were performed in 2000; however, concentrations of uranium isotopes in runoff from previous years are not available. The summary of the results of analyzing runoff samples for uranium isotopes in 2000 is in Table 4-3. The concentrations of the uranium isotopes suggest that naturally occurring uranium was present in the majority of the runoff samples collected along the Laboratory's downstream boundary. Sixteen of 18 samples contained uranium of natural composition (within 2σ uncertainty of natural). Enriched uranium was detected in two runoff samples collected in Los Alamos Canyon during the relatively small-magnitude runoff events of June 2 and 3.



Note: CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-50. Time series of dissolved uranium in runoff from different canyon systems in 2000.

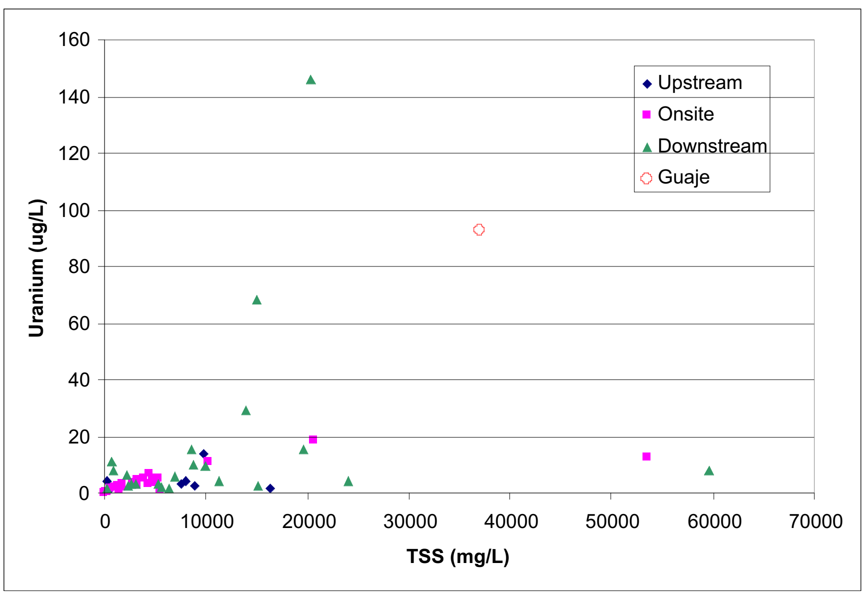


Figure C-51. Uranium concentration in unfiltered runoff compared with TSS.

Laboratory-derived uranium (enriched or depleted uranium) was not predominant in the samples mainly because naturally occurring uranium from bedrock sources comprises the majority of the uranium in storm water runoff and tends to mask smaller concentrations of potentially Laboratory-derived uranium. Historically, LANL-derived uranium composed a small fraction of the total uranium found in Pajarito Plateau stream sediments and was not discernible in Rio Grande stream sediments (Gallaher et al.1999). The results of this investigation were based on mass spectrometry analyses of stream sediments and of Cochiti Reservoir bottom sediments collected before the fire.

C.16 Aluminum in Runoff

The highest concentration of aluminum in unfiltered runoff in 2000 was 995,000 µg/L in a sample collected from Guaje Canyon on September 8. The highest concentration observed in runoff from LANL was 417,000 µg/L in a sample from lower Cañada del Buey (gage E230) on July 29. The upper portion of the Cañada del Buey watershed was affected by fire, however, the highest directly fire-related runoff concentration of aluminum was 376,000 µg/L in a sample collected from upper Pajarito Canyon (gage E240) on June 28. High aluminum concentrations in unfiltered runoff are directly related to the concentration of TSS in the sample.

The highest concentration of aluminum in filtered runoff in 2000 was 11,500 µg/L in a sample from Starmer's Gulch above SR 501, a tributary to upper Pajarito Canyon, collected on October 23. The next highest concentration of aluminum was much lower, 4830 µg/L, from lower Cañada del Buey (gage E230) on October 28.

C.17 Barium in Runoff

The distributions of barium concentrations in storm water runoff at upstream, onsite, and downstream locations for prefire and postfire periods are shown in Figure C-52; the distributions of dissolved barium concentrations are shown in Figure C-53. The concentrations of barium in unfiltered samples are about an order of magnitude higher than in filtered samples. The majority of the barium appears to be in the suspended sediment fraction of the unfiltered samples.

The median concentrations of barium in unfiltered runoff after the fire at upstream and downstream sites are significantly higher than before the fire. Two samples collected at upstream locations (Pajarito Canyon and Los Alamos Canyon) before the fire both contained less than 50 µg/L barium, but after the fire, the median concentration of 17 samples from upstream sites was 2019 µg/L. Similarly, before the fire the median concentration of barium at downstream sites was 503 µg/L and after the fire the median was 2265 µg/L, about four times higher. The distribution of barium concentrations in unfiltered samples at onsite locations before and after the fire does not appear to have changed significantly, but the highest concentrations are within the range of upstream and downstream maximum concentrations (see Figure C-52); most of these samples are runoff from fire-impacted areas.

The highest concentration of barium in unfiltered storm water runoff at LANL in 2000 was 17,367 µg/L from lower Water Canyon (gage E265) on June 28. A close second-highest concentration was from the upstream Pajarito Canyon site (gage E240), also collected on June 28. The highest concentration of barium from onsite locations was from Pajarito Canyon (TA-18 culvert) on June 28. The higher concentrations of barium appear to be associated with runoff from fire-impacted areas upstream from LANL.

Dissolved barium concentrations in runoff (Figure C-53) at onsite and downstream locations do not appear to have substantial differences in samples collected after the fire compared with prefire samples. Two upstream samples collected before the fire contained less than 50 µg/L barium, however, after the fire, upstream samples contained a median concentration of 100 µg/L and the highest dissolved barium concentration at upstream locations was 227 µg/L from Los Alamos Canyon above the reservoir on August 31. The second highest dissolved concentration was 210 µg/L from upper Pajarito Canyon (gage E240) on June 28. The highest dissolved concentrations of barium at downstream sites were 550 µg/L from lower Water Canyon (gage E265) and 310 µg/L from lower Pajarito Canyon (gage E250), both of which were collected on June 28. Similarly, the highest concentrations of dissolved barium from onsite locations were from Pajarito Canyon (at TA-18 culvert) on June 28.

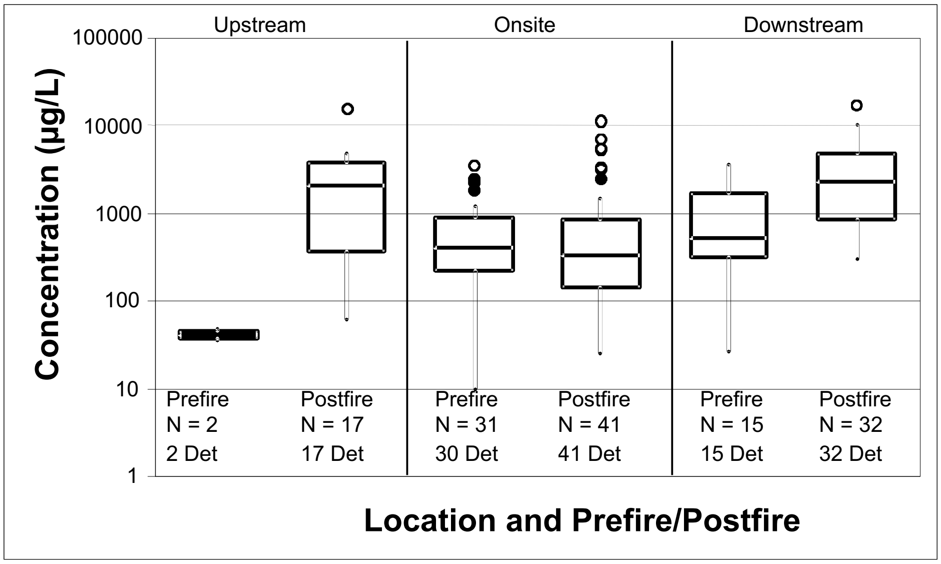


Figure C-52. Barium in unfiltered runoff at upstream, onsite, and downstream locations, prefire and postfire.

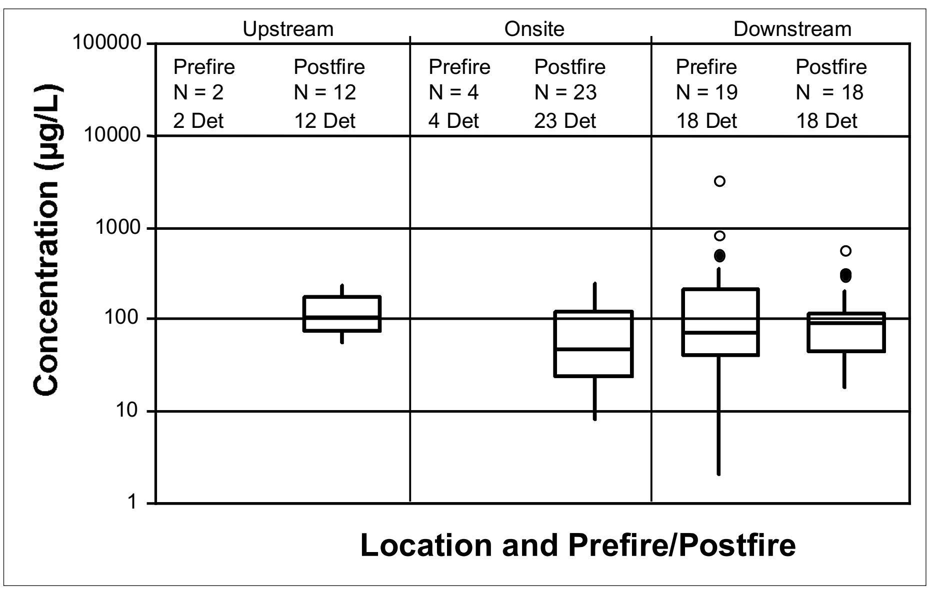
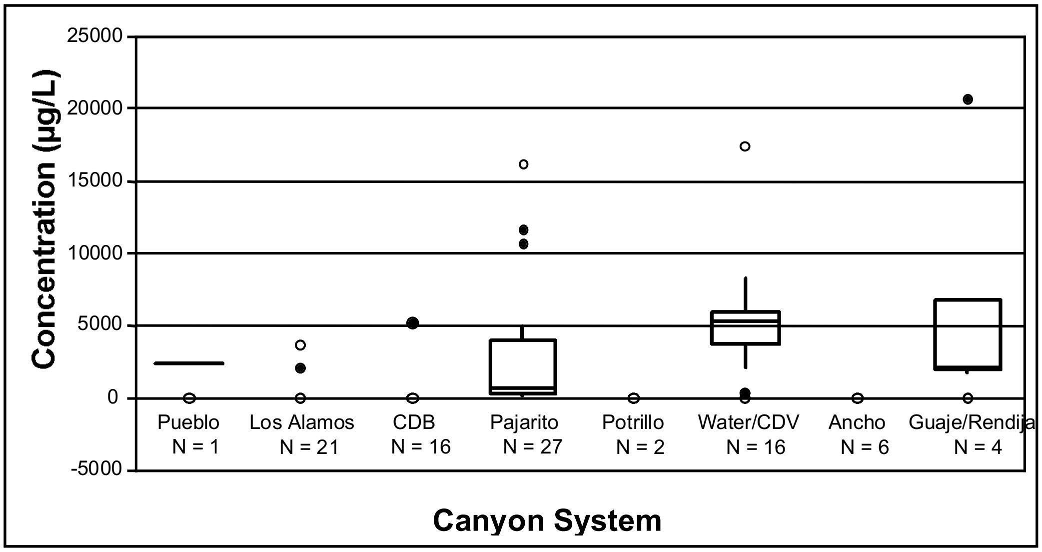


Figure C-53. Barium in filtered runoff at upstream, onsite, and downstream locations, prefire and postfire.

Figure C-54 shows the barium concentrations in unfiltered runoff for each canyon system. The highest barium concentration in unfiltered runoff was 20,700 µg/L from Guaje Canyon on September 8. Other samples from Guaje and Rendija Canyons contained barium concentrations around 2000 µg/L. The canyon system at LANL with the highest distribution of barium concentrations was Water Canyon and Cañon de Valle where the median concentration was 5210 µg/L. Concentrations over 10,000 µg/L were measured in each of the canyons at LANL from the large June 28 runoff event.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-54. Barium in unfiltered runoff from each canyon system.

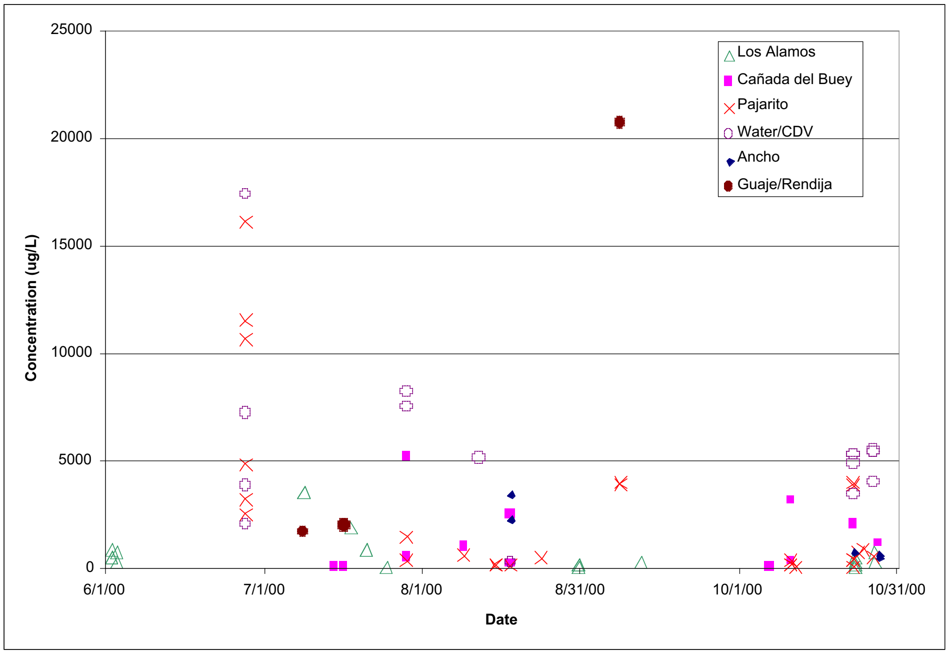
Figure C-55 shows the time series of barium concentrations in unfiltered runoff from each canyon system in 2000. The highest concentrations of barium in runoff at LANL were in Pajarito Canyon and Water Canyon/Cañon de Valle on June 28, and concentrations in runoff later in the year were generally lower. The higher concentrations of barium in runoff in the two months after the fire may be associated with increased ash content in the runoff from fire-related areas.

Figure C-56 shows the time series of dissolved barium in runoff in 2000. The highest concentrations are in samples from Water Canyon and Pajarito Canyon collected on June 28, similar to the barium concentrations in unfiltered samples. Most concentrations of dissolved barium in runoff were <200 µg/L with no obvious trend throughout the runoff season.

C.18 Iron in Runoff

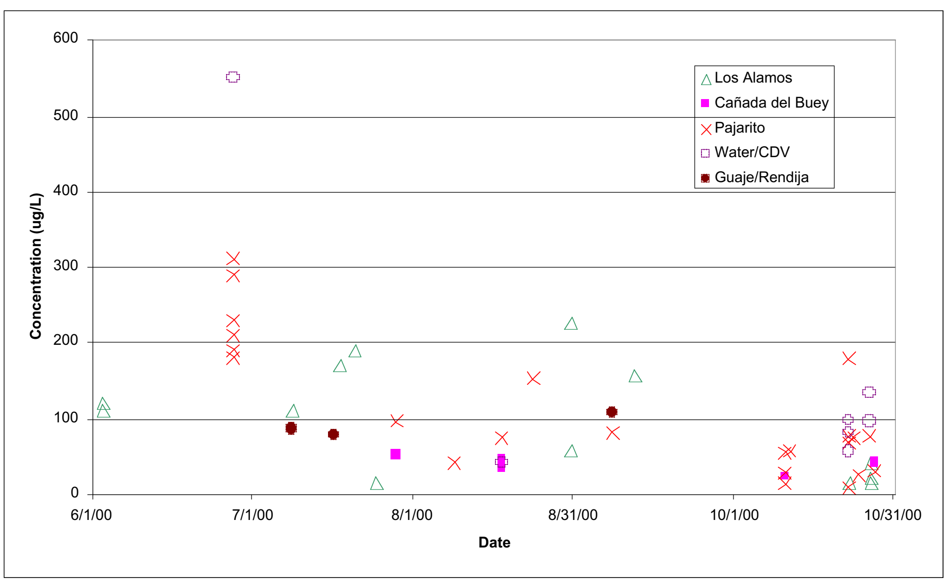
The distributions of iron concentrations in storm water runoff at upstream, onsite, and downstream locations for prefire and postfire periods are shown in Figure C-57; the distributions of dissolved iron concentrations are shown in Figure C-58. The concentrations of iron in unfiltered samples are about two orders of magnitude higher than in filtered samples, suggesting that the majority of the iron is contained in the suspended sediment fraction of the unfiltered samples.

The median concentrations of iron in unfiltered samples after the fire are higher than prefire concentrations. Two upstream locations sampled before the fire contained iron concentrations less than 2000 µg/L, but after the fire, the median concentration at upstream locations was 32,700 µg/L. However, the range of concentrations observed in upstream samples after the fire included the range observed in the two samples collected before the fire. The median concentrations of iron in unfiltered samples from onsite and downstream locations were higher after the fire than before the fire but the ranges of concentrations observed at these locations after the fire were not appreciably different from prefire samples (Figure C-58).



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-55. Time series of barium in unfiltered runoff in each canyon system in 2000.



Note: Figure shows filtered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-56. Time series of dissolved barium in runoff from each canyon system in 2000.

The maximum concentration of iron in upstream-unfiltered samples collected at LANL after the fire was 375,572 µg/L, from a sample collected in upper Pajarito Canyon (gage E240) on June 28; the second highest concentration was from Los Alamos Canyon (gage E025) on July 18. The maximum concentration of iron in unfiltered samples onsite was 256,000 µg/L from Pajarito Canyon (TA-18 culvert) on June 28, and the maximum concentration at downstream locations was 285,000 µg/L from Cañada del Buey (gage E230) on July 29. The higher iron concentrations in runoff appear to be associated with suspended materials derived from fire-related areas upstream of LANL and within LANL. Upper Cañada del Buey within the Laboratory near TA-46 suffered extensive fire damage but lower Cañada del Buey was not affected by the fire.

The distributions of concentrations of iron dissolved in runoff are shown in Figure C-58. The middle quartile distributions and median concentrations of iron dissolved in runoff after the fire are lower than those observed before the fire, although the range of iron concentrations dissolved in samples before and after the fire are similar. Maximum dissolved concentrations of iron at upstream and onsite locations after the fire are higher than before the fire. The highest concentration of iron dissolved in runoff at upstream locations after the fire was 6910 µg/L in a sample from Pajarito Canyon Tributary, Starmer's Gulch (location M2417) on October 23. The highest concentration of iron dissolved in runoff collected at downstream locations before the fire was 19,329 µg/L from lower Los Alamos Canyon (gage E042) in 1998, but the highest concentration of iron dissolved at downstream locations after the fire was 2510 µg/L in a sample from Cañada del Buey (gage E230) on October 28.

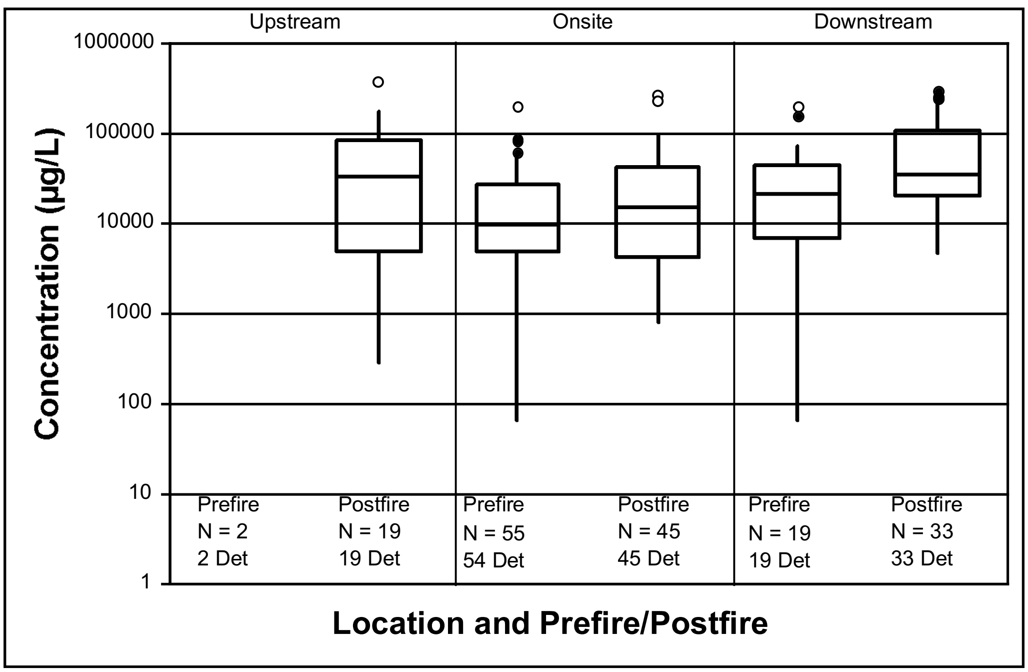


Figure C-57. Iron in unfiltered runoff at upstream, onsite, and downstream locations, prefire and postfire.

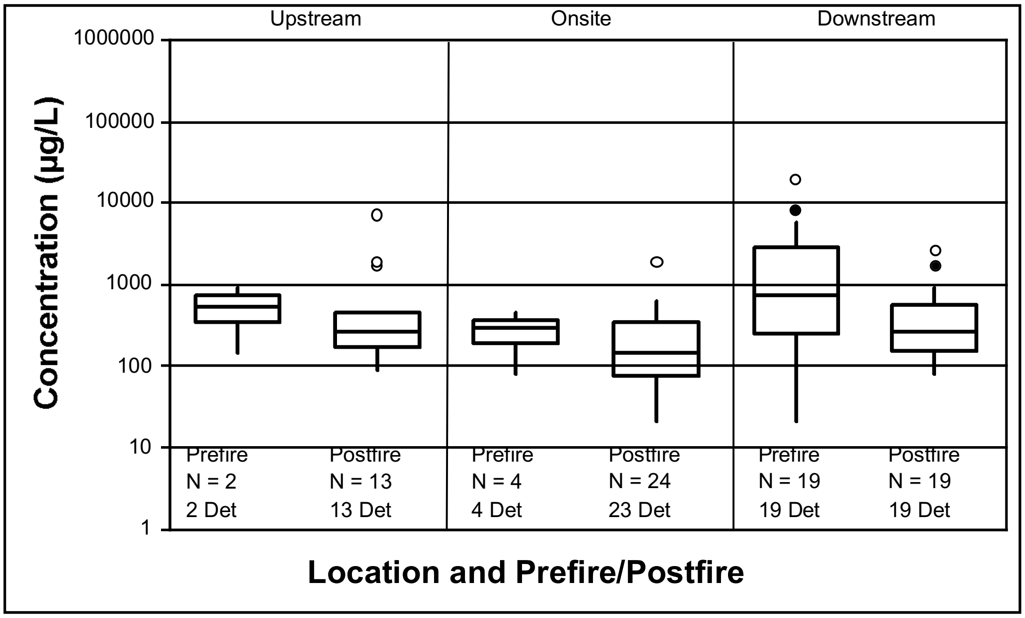
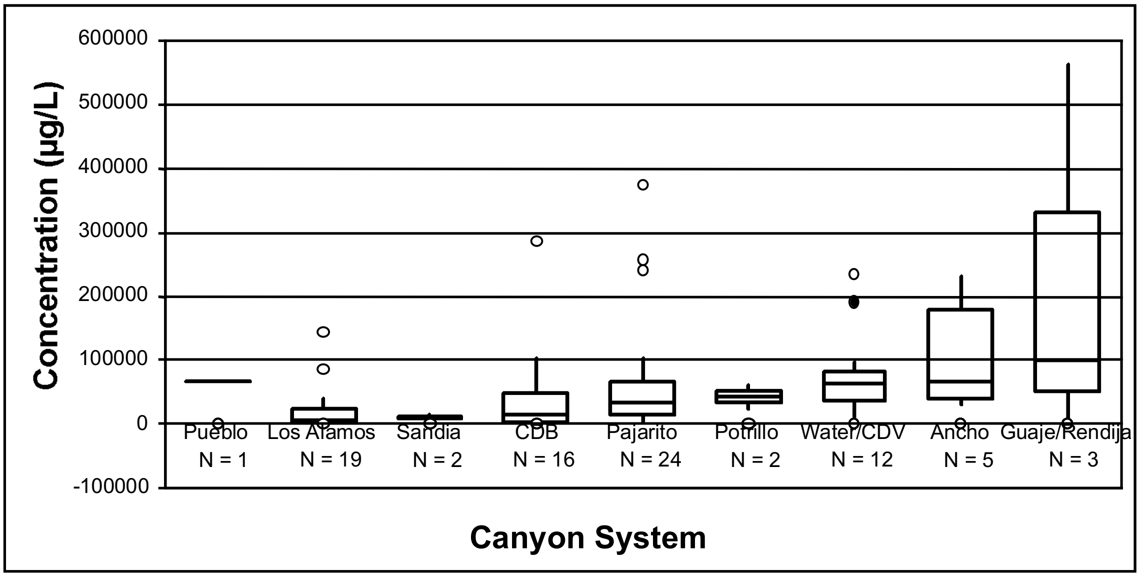


Figure C-58. Iron in filtered runoff at upstream, onsite, and downstream locations, prefire and postfire.

Figure C-59 shows the iron concentrations in unfiltered runoff samples collected from each canyon system. The maximum iron concentration observed in unfiltered runoff was 560,000 µg/L in a sample from Guaje Canyon collected on September 8. Other samples collected from Guaje and Rendija Canyons contained less than 100,000 µg/L. The canyon systems at LANL with the highest concentrations of iron in unfiltered runoff were Pajarito, Water/Cañon de Valle, Cañada del Buey, and Ancho. The canyon with the highest median concentration of iron was Ancho Canyon where the median concentration was 63,500 µg/L, with Water Canyon a close second with a median concentration of 62,350 µg/L.

Most iron concentrations above 230,000 µg/L in each of the canyons at LANL were from the large June 28 runoff event, except for a sample from Cañada del Buey that had a concentration of 285,000 µg/L on July 29. These high iron concentrations in unfiltered runoff are the result of runoff from fire-impacted areas. Runoff samples collected from canyons that were not significantly impacted by the fire, such as Sandia Canyon and Potrillo Canyon do not have iron concentrations that exceed 100,000 µg/L.

Figure C-60 shows the time series of iron concentrations in unfiltered runoff in 2000 for each canyon system and the prefire average concentration in runoff. In general, the highest iron concentrations were in June and July and lower concentrations are observed near the end of the runoff season in October. The first runoff event in Los Alamos Canyon on June 2 and 3 did not have high iron concentrations like the June 28 runoff event in Pajarito and Water Canyons, possibly because of the presence of the Los Alamos Canyon Reservoir in upper Los Alamos Canyon, which trapped significant volumes of ash and muck. Runoff samples collected in October contained iron concentrations near the prefire average.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-59. Iron in unfiltered runoff from each canyon system.

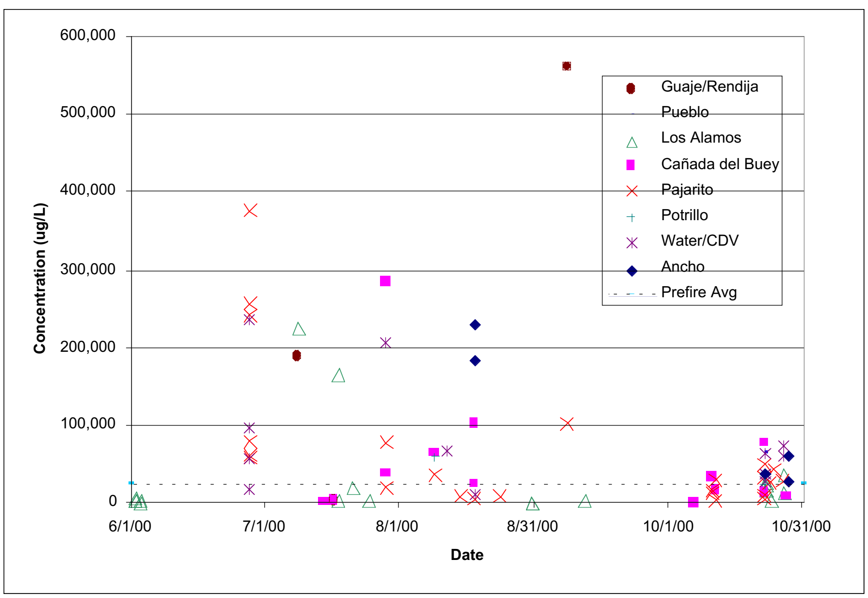


Figure C-60. Time series of iron in unfiltered runoff from each canyon system in 2000.

Figure C-61 shows the time series of dissolved iron concentrations in filtered runoff in 2000 for each canyon system and the prefire average concentration in runoff. In general, the lowest dissolved iron concentrations were in June and July following the fire, and higher concentrations are observed near the end of the runoff season in October, opposite of the unfiltered iron concentrations. Runoff samples collected in October contained dissolved iron concentrations closer to the prefire average concentration.

The lower concentrations of dissolved iron in runoff after the fire are likely attributed to geochemical changes in the runoff caused by the presence of the ash and muck (e.g., Longmire et al. 2001).

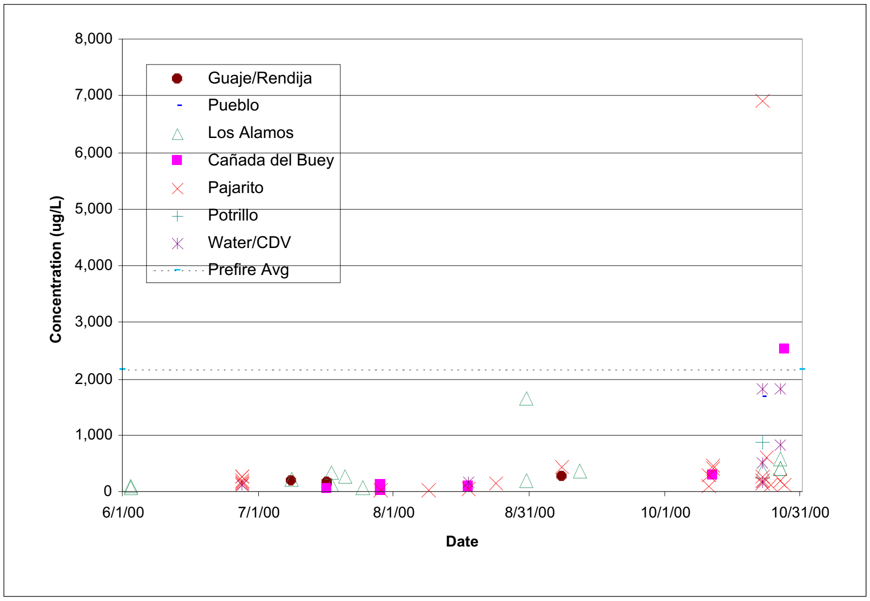


Figure C-61. Time series of iron in filtered runoff from each canyon system in 2000.

C.19 Lead in Runoff

The maximum concentration of lead in unfiltered runoff in 2000 was 1180 µg/L in a sample collected from lower Guaje Canyon on July 9. The highest concentration from samples at LANL was 1080 µg/L in a sample from lower Los Alamos Canyon (gage E042) on July 9.

The maximum concentration of dissolved lead in runoff in 2000 was 6.99 µg/L in a sample from Starmer's Gulch above SR 501, a tributary to upper Pajarito Canyon, collected on October 23. The next highest concentration was 4.05 µg/L in a sample collected from lower Pueblo Canyon (gage E060) on October 23.

Increased lead concentrations in runoff in 2000 appear to be primarily related to higher TSS concentrations associated with higher runoff volumes and may partially be attributable to urban runoff (e.g., Purtymun and Adams 1980; LANL 1999).

C.20 Manganese in Runoff

The distributions of manganese concentrations in storm water runoff at upstream, onsite, and downstream locations for prefire and postfire periods are shown in Figure C-62; the distributions of dissolved manganese concentrations are shown in Figure C-63. The concentrations of manganese in unfiltered samples are about one to two orders of magnitude higher than in filtered samples, suggesting that the majority of manganese is contained in the suspended sediment fraction of the unfiltered samples.

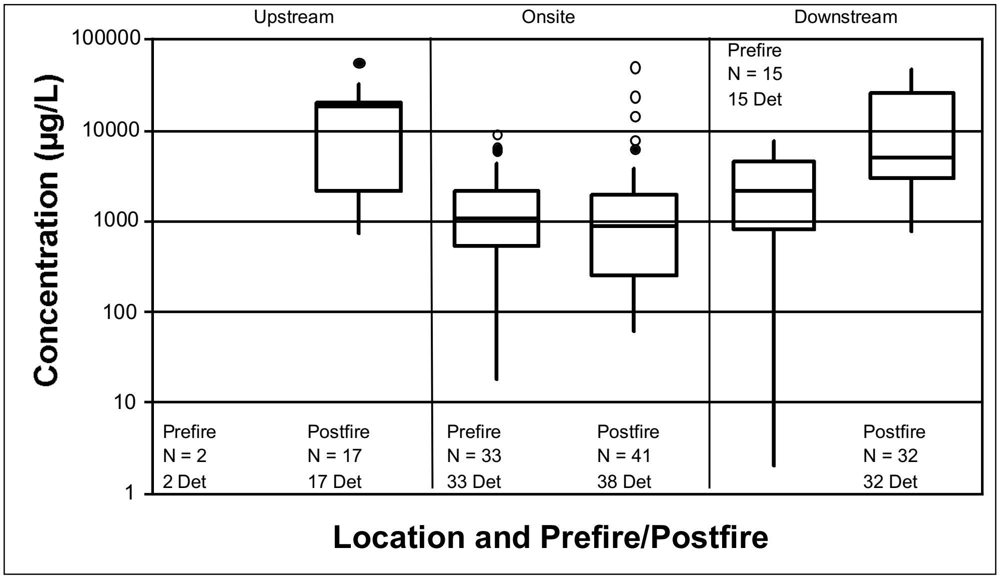


Figure C-62. Manganese in unfiltered runoff at upstream, onsite, and downstream locations, prefire and postfire.

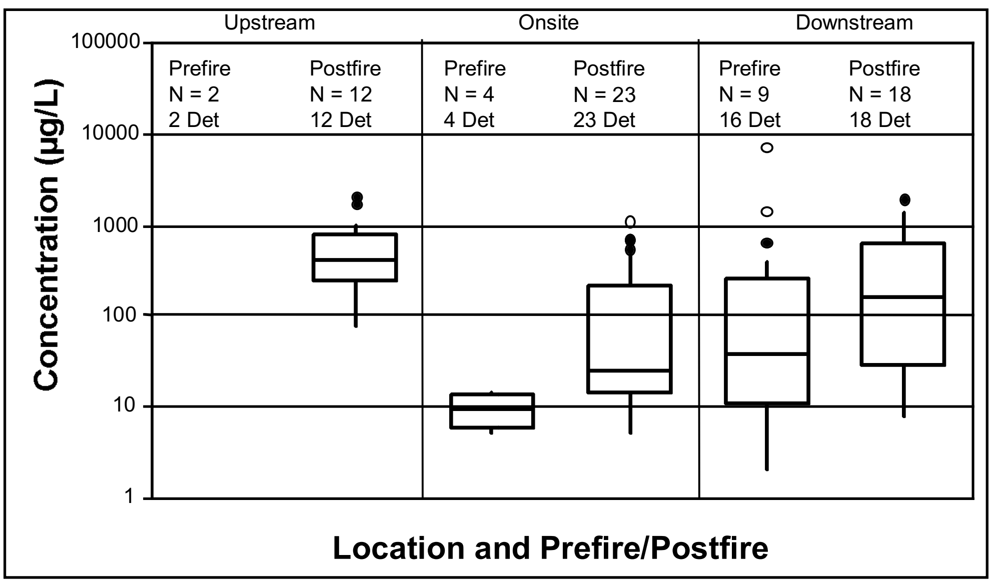


Figure C-63. Manganese in filtered runoff at upstream, onsite, and downstream locations, prefire and postfire.

The concentrations of manganese in upstream samples collected after the fire were significantly higher than before the fire. Two upstream locations sampled before the fire contained manganese concentrations in unfiltered samples less than 50 µg/L; after the fire, the median concentration of samples collected at upstream locations was 17,900 µg/L. The distributions of manganese concentrations in samples collected onsite before and after the fire are similar, however, the maximum of concentrations in samples collected onsite after the fire are significantly higher than samples collected before the fire. The distribution of manganese concentrations in samples collected at downstream locations after the fire is higher than samples collected before the fire and similar to concentrations observed in the upstream postfire samples. The median concentration of manganese in unfiltered samples from downstream locations after the fire was 4820 μg/L, compared with the prefire median concentration of 2060 μg/L (Figure C-58).

The maximum concentration of manganese in upstream-unfiltered samples at LANL after the fire was 53,278 μg/L, from a sample collected in upper Pajarito Canyon (gage E240) on June 28. The maximum concentrations of manganese at onsite (47,249 μg/L from Pajarito Canyon at the TA-18 culvert) and downstream (Water Canyon at gage E265) locations were also from samples collected on June 28. The minimum concentrations of manganese in unfiltered runoff samples after the fire were significantly higher after the fire compared with minimum concentrations observed in prefire samples (Figure C-62). Manganese concentrations in unfiltered runoff samples were significantly increased after the fire as a result of runoff from fire-impacted areas.

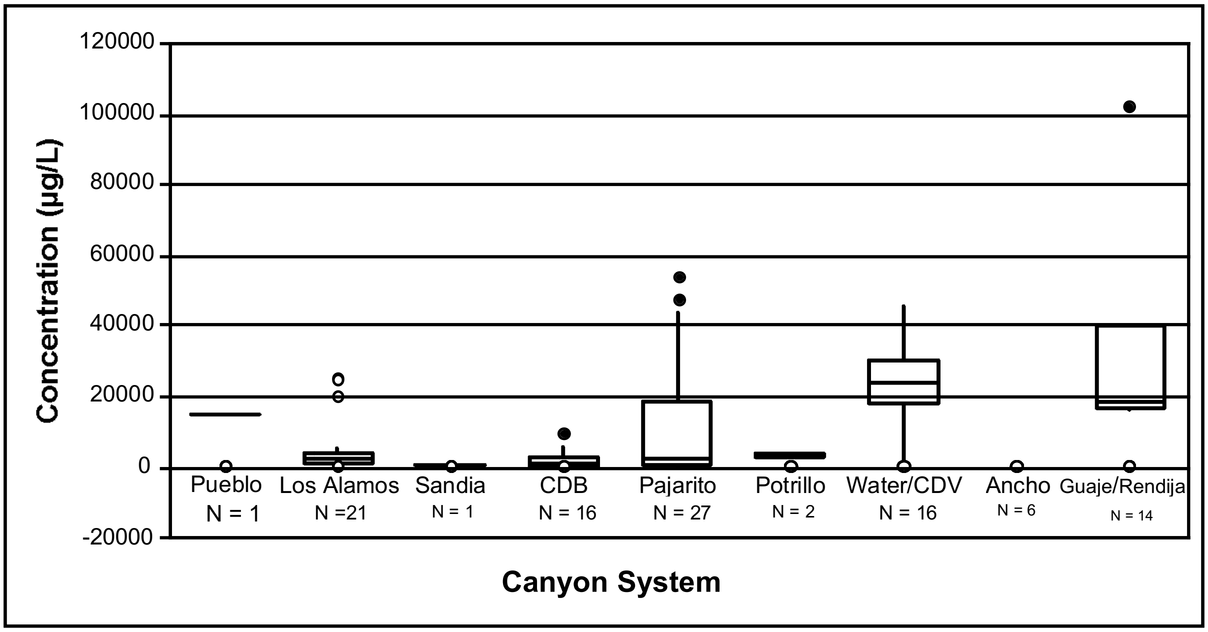
The maximum concentration of dissolved manganese in runoff samples after the fire was 2000 μg/L in a sample collected from upper Los Alamos Canyon above the reservoir on August 31. The next three highest dissolved concentrations of manganese at upstream locations were also collected in upper Los Alamos Canyon at the Los Alamos Canyon Reservoir and at gage E025. The maximum concentration of dissolved manganese at onsite locations was 1080 μg/L in a sample from the Pajarito Canyon retention structure (construction site) collected on August 24, 2000. The highest concentration of dissolved manganese collected from downstream locations was 1870 μg/L in a sample collected from ponded water discharged from the construction site for the lower Los Alamos Canyon weir on July 21.

The samples that contained the highest concentrations of dissolved manganese were all collected from residual runoff or ponded water several days after runoff events (see Koch et al. 2001 for a discussion of samples collected and runoff events). The dissolved manganese data indicated that higher dissolved concentrations resulted from a longer residence time of the runoff or ponded water with fire-related ash, muck, and sediments and that manganese contained in ash, muck, and sediments progressively dissolved into residual runoff and ponded water. The maximum concentration of dissolved manganese obtained during a runoff event was 1360 μg/L in a sample collected from lower Pueblo Canyon (gage E060) on October 23. The highest concentration of dissolved manganese that resulted from the large runoff event on June 28 was 1100 μg/L in a sample collected in lower Pajarito Canyon (gage E250) several hours after the precipitation event and initial runoff event.

The median concentrations of dissolved manganese in samples collected at onsite locations after the fire was 24.8 μg/L, about two times the prefire median concentration. The median concentration of samples collected at downstream locations after the fire was 112 μg/L, over three times the prefire median concentration.

Manganese concentrations in soil have been observed to increase significantly after forest fires (e.g., Bitner et al. 2001). The source of increased manganese in soil is likely from ash that contains manganese that has been concentrated by combustion of vegetation, especially resinous plants (e.g., Parra et al. 1996). Additionally, the concentration of water-soluble manganese increases in soil that has been heated to 400^{o}C, such as by a forest fire (Chambers and Attiwill 1994). The available data from storm water runoff after the Cerro Grande Fire indicate that manganese concentrations in unfiltered runoff increased up to two orders of magnitude, which is largely attributable to suspended materials that included ash and muck from the fire-impacted areas. The maximum dissolved concentrations of manganese were not observed in samples from the initial storm water runoff event, but in samples of ponded water and residual runoff that were collected two to three days after runoff events.

Figure C-64 shows the manganese concentrations in unfiltered runoff samples collected from each canyon system. The maximum concentration of manganese in unfiltered runoff was 102,000 µg/L in a sample from Guaje Canyon on September 8. Other canyons at LANL that showed higher concentrations of manganese were Pajarito and Water Canyon/Cañon de Valle, which had samples containing over 40,000 µg/L, which resulted from the high runoff event on June 28. Canyons with the lowest concentrations of manganese in unfiltered runoff were Sandia Canyon, Potrillo Canyon, and Ancho Canyon, which were not significantly impacted by the fire. Los Alamos Canyon shows relatively smaller concentrations of manganese, which may be due to not being affected by a large runoff event like Pajarito Canyon and Water Canyon. The Los Alamos Canyon Reservoir may have helped trap ash, muck, and sediment from burned areas and prevented large flow events from entering the canyon.

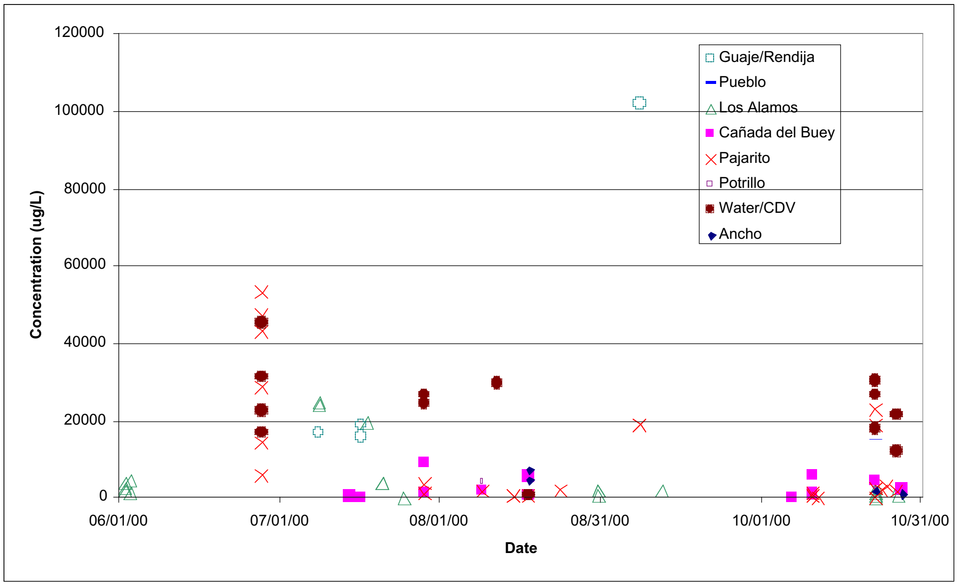


Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-64. Manganese in unfiltered runoff from each canyon system.

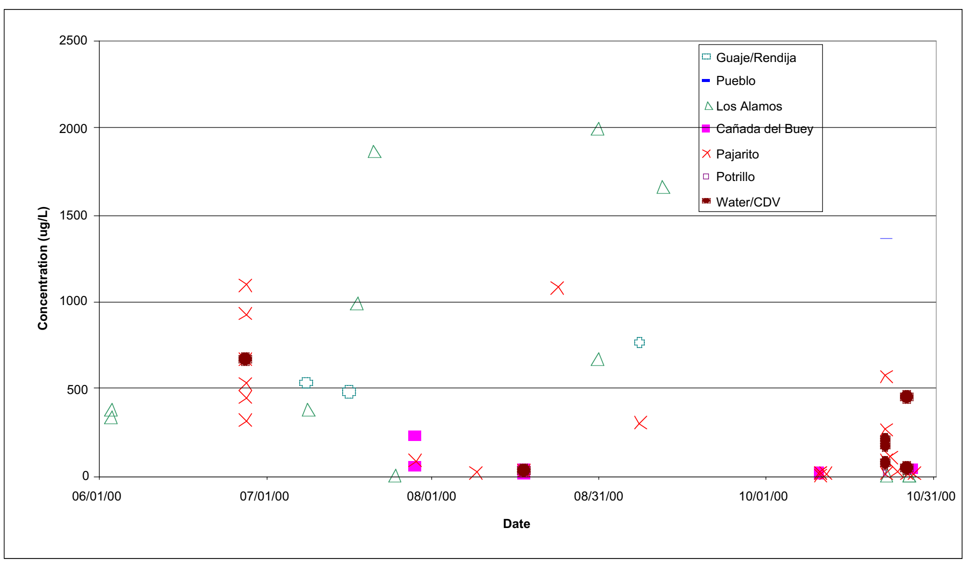
Figure C-65 shows the time series of manganese in unfiltered runoff from each canyon system. Higher concentrations are observed in Pajarito Canyon and Water Canyon during the June 28 runoff event and in Guaje Canyon on September 8; however, manganese concentrations appear to have been similar throughout the runoff season.

Figure C-66 shows the time series of dissolved manganese concentrations in runoff from each canyon system in 2000. No obvious trend appears to be present in the time series data with respect to progression of the runoff season after the Cerro Grande Fire.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-65. Time series of manganese in unfiltered runoff from each canyon system.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon.
CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-66. Time series of dissolved manganese in runoff from each canyon system.

Figure C-67 shows the dissolved manganese concentrations with respect to the elapsed time of sample collection after the precipitation event. Most samples collected within one hour of the precipitation event contained less than about 500 µg/L dissolved manganese. However, samples collected several hours after the precipitation event (usually downstream samples) often contained higher concentrations of dissolved manganese, from 500 to 1000 µg/L. Samples collected several days after the precipitation event usually contained over 1000 µg/L manganese. Samples that were collected more than one hour after the precipitation event that do not show increased concentrations of manganese are usually samples from non fire-impacted locations, such as samples collected from DP Canyon and Potrillo Canyon, or were samples collected after precipitation events that did not significantly impact fire-related areas. Two factors appear to have contributed to the occurrence of higher dissolved manganese concentrations: (1) the presence of ash and muck from fire-impacted areas and (2) increased residence time of runoff in contact with ash and muck materials.

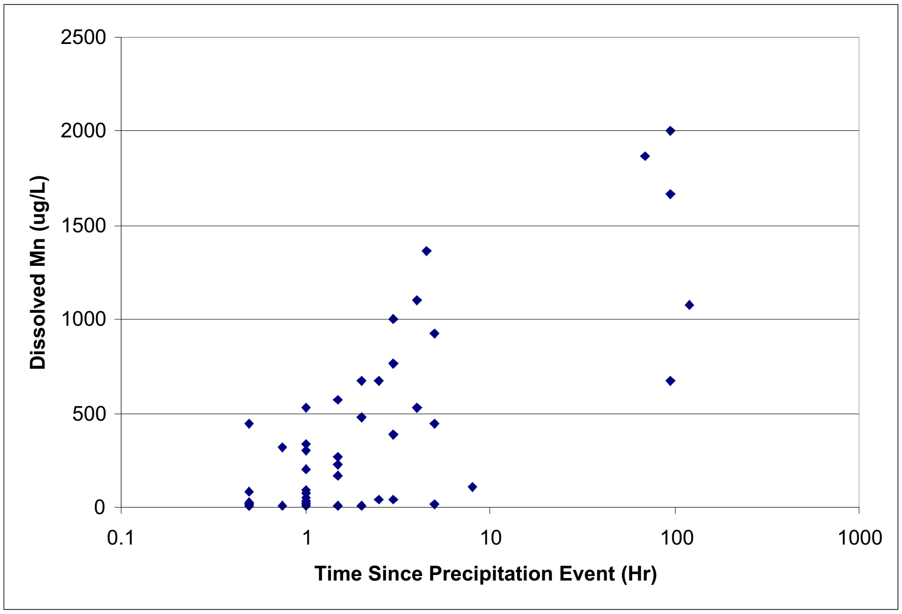


Figure C-67. Dissolved manganese in runoff vs time since precipitation event.

C.21 Silver in Runoff

Figure C-68 shows the distribution of silver in runoff in 2000 at upstream, onsite, downstream, and in Guaje and Rendija Canyons. The laboratory method detection limit used for the analysis of silver in 2000 was about 0.62 µg/L or less, whereas the detection limit used during prior years was 6 µg/L or greater and most results were below detection limits. Therefore, comparison of the distributions of silver concentrations obtained in 2000 with previous years is not useful. The historical maximum silver concentration in runoff was 20 µg/L in a sample collected in Sandia Canyon in 1999.

The highest concentration of silver in unfiltered runoff from upstream locations was 6.084 µg/L in a sample collected from upper Pajarito Canyon (gage E240) on June 28; the next highest concentration was 2.644 µg/L in a sample collected from upper Cañon de Valle (gage E253), also on June 28. The four highest concentrations of silver in samples from onsite locations (6.759 to 39.368 µg/L) were from the June 28 runoff event in Pajarito Canyon and Water Canyon. The two highest concentrations of silver in runoff at downstream locations were also on June 28 when the maximum concentration was 171 µg/L in a sample collected from lower Water Canyon (gage E265). Silver was detected in one sample from Rendija Canyon in a concentration of 0.95 µg/L.

The one detection of dissolved silver in runoff in 2000 was 0.95 µg/L in a sample from lower Cañada del Buey (gage E230) collected on August 18.

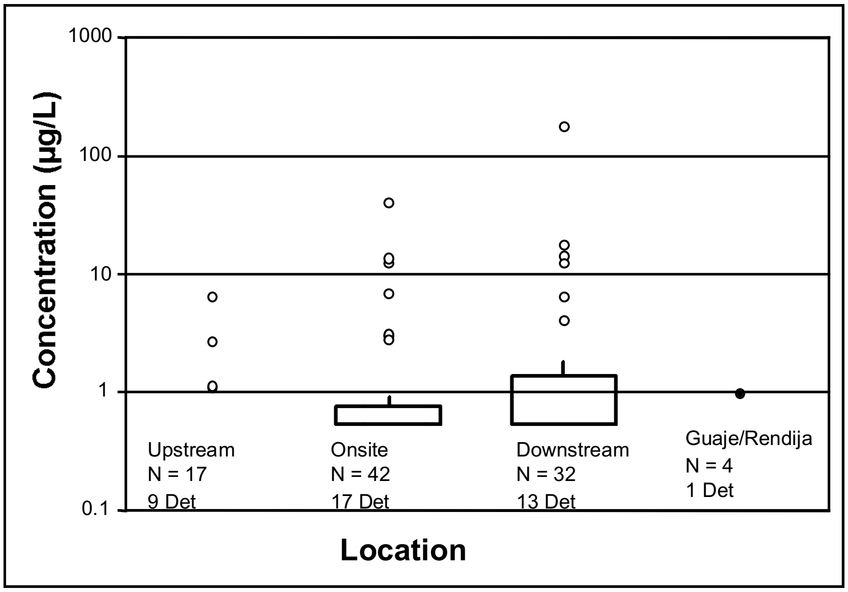
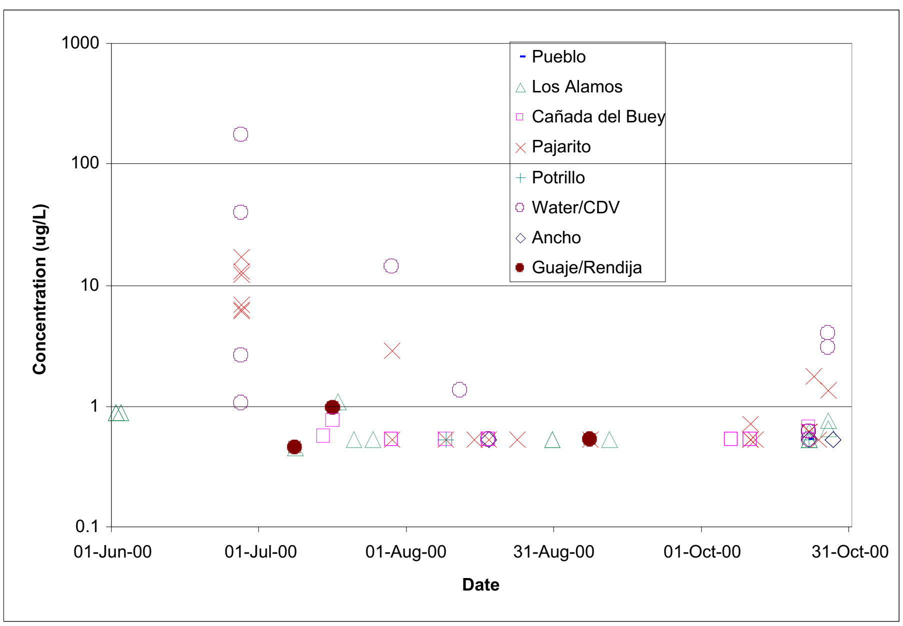


Figure C-68. Silver in unfiltered runoff at upstream, onsite, and downstream locations.

Figure C-69 shows the time series of silver concentrations in unfiltered runoff from each canyon system in 2000. Samples of runoff from Pueblo Canyon, Ancho Canyon, Cañada del Buey, Potrillo Canyon, and Guaje and Rendija Canyons did not contain silver >1.0 µg/L. Of 20 samples that contained greater than 1.0 µg/L silver, 10 of the samples were from Water Canyon/Cañon de Valle, 9 were from Pajarito Canyon, and 1 was from Los Alamos Canyon. The time series data show that the highest concentrations of silver were associated with the June 28 runoff event. Most samples collected from other runoff events contained significantly lower silver concentrations.



Note: Figure shows unfiltered results from upstream, onsite, and downstream locations in each canyon. CDB = Cañada del Buey; CDV = Cañon de Valle.

Figure C-69. Time series of silver in unfiltered runoff from each canyon system in 2000.

The higher concentrations of silver in unfiltered runoff in 2000 are from relatively high runoff events generated from the fire-impacted areas. However, the higher silver concentrations tend to be from onsite and downstream locations and may be related to high-volume runoff transporting silver from previous LANL discharges in some canyons rather than to direct impacts from the Cerro Grande Fire. Strengthening the possibility that silver is Laboratory-derived is the observation that silver was largely not detected in samples from Guaje and Rendija Canyons, which showed high concentrations for most other metals and radionuclides. If the major source of the silver was fire or sediment related, higher silver concentrations likely would have been observed in Guaje and Rendija Canyons.

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