6. WATERSHED MONITORING

contributing authors:
Bruce M. Gallaher, Richard J. Koch, Cathy H. Smith, and David B. Rogers

To Read About **Turn to Page**

A. INTRODUCTION

The Laboratory monitors the quality of surface water and stream sediments throughout northern New Mexico to evaluate the potential environmental effects of Laboratory operations. The Laboratory analyzes samples for several parameters, including radionuclides, high explosives, metals, a wide range of organic compounds, and general chemistry of surface water. In this chapter, we assess effects of Laboratory operations and evaluate any trends over time. We also compare the monitoring results with criteria established to protect human health and the aquatic environment.

For decades, this monitoring was conducted primarily to assess the radiological impacts from the Laboratory. During this time, monitoring of the non-radiological impacts has increased. Much of the current non-radiological monitoring of surface water is determined by recent agreements with federal and state regulatory agencies. The result of these agreements is more widespread monitoring of both perennial and ephemeral stream flows for an extensive list of constituents. Increased sampling of base flow has resulted from the New Mexico Environment Department (NMED) Compliance Order on Consent, discussed in Chapter 2. Increased sampling of storm runoff and snowmelt has resulted from the Federal Facility Compliance Agreement (FFCA) and Administrative Order (AO) (EPA 2005 a, b). Sampling is conducted at dozens of new locations. The total surface water monitoring effort has yielded a substantial amount of water quality data. While data collected for the FFCA and AO are published elsewhere (LANL 2006), we summarize the results in this chapter for 2005.

B. HYDROLOGIC SETTING

Watersheds that drain Laboratory property are dry for most of the year. No perennial surface water extends completely across Laboratory land in any canyon. The canyons consist of over 85 miles of watercourses located within the Laboratory and immediately upstream of the Laboratory within Los Alamos Canyon. Of the 85 miles of watercourse, approximately two miles are naturally perennial, and approximately three miles are perennial waters created by effluent.

The remaining 80 or more miles of watercourse are dry for varying lengths of time. The driest segments may flow in response only to local precipitation or snowmelt, and the streambed is always above the water table. The flow in these streams is ephemeral. Other streams may sometimes have the water table higher than the streambed and/or extensive snowmelt in the watershed and are said to be intermittent. Intermittent streams may flow for several weeks to a year or longer. To aid in water quality interpretation, we divide stream flow into three types or matrices. Each of the three flow types might be collected at a single location within a time span of as little as a week, depending on weather conditions. At times, the flow might represent a combination of several of these flow types.

The three types are

- Base flow—persistent stream flow, but not necessarily perennial water. (This stream flow is present for periods of weeks or longer. The water source may be effluent discharge or shallow groundwater that discharges in canyons.)
- Snowmelt—flowing water present because of melting snow. (This type of water often may be present for a week or more and in some years may not be present at all.)
- Storm runoff—flowing water present in response to rainfall. (These flow events are generally very short lived, with flows lasting from less than an hour to—rarely—several days.)

Because base flow is present for extended periods of time, it is available for potentially longer-term exposures, such as wildlife watering. While storm runoff or snowmelt may provide a short-term water source for wildlife, that water is a principal agent for moving Laboratory-derived constituents off-site and possibly into the Rio Grande.

None of the streams within Laboratory boundaries average more than one cubic ft per second (cfs) of flow annually. It is unusual for the combined mean daily flow from all LANL canyons to be greater than 10 cfs. By comparison, flow in the Rio Grande commonly averages approximately 800 to 1,000 cfs. Although most of the watercourses at LANL are dry throughout the year, occasional floods can redistribute sediment in a streambed to locations downstream from where a release or spill occurs.

Runoff was slightly above normal in 2005, primarily because of a heavy snowpack that created a large snowmelt runoff from February through May. Summer precipitation in 2005, following six consecutive years of below average amounts, was similar to the average of pre-Cerro Grande fire years, 1995 through 1999. Snowmelt runoff extended across the Laboratory in all major canyons and totaled about 1175 ac-ft at the downstream stations. Total storm runoff volume in 2005, at downstream gages in the watersheds crossing LANL lands, was higher than the two previous years, primarily due to three large runoff events in August and September. Flow volumes in lower Pueblo Canyon were approximately equal to that of the other LANL canyons combined, similar to the pre-fire conditions (Gallaher and Koch 2005). The largest peak runoff event for the year was recorded in Pueblo Canyon on August 14, 2005, at 116 cfs (Shaull et al. 2006), significantly smaller than previous peak flows recorded since the Cerro Grande fire. Hydrologic conditions in all LANL canyons and in Pueblo Canyon have recovered to near pre-fire levels. However, recovery after the fire has been somewhat counteracted in upper Pueblo Canyon by urbanization. The increased pavement and roofs shed more local precipitation into the canyon.

The large snowmelt caused continuous stream flow in Los Alamos Canyon extending from the Jemez Mountains, across the Laboratory, and into the Rio Grande. Continuous flow fed by snowmelt was present for approximately four months, from February through May. The total quantity of snowmelt measured in Los Alamos Canyon at the Laboratory's eastern boundary was approximately 710 ac-ft and 680 ac-ft at the confluence with the Rio Grande.

C. SURFACE WATER AND SEDIMENT STANDARDS

Table 6-1 summarizes the standards used to evaluate the monitoring data. The suite of standards varies, depending on the stream flow conditions and established or potential uses. To evaluate Laboratory impacts, we compare analytical results for surface water and sediment samples with regulatory water quality criteria or with risk-based screening levels.

1. Applicable New Mexico Surface Water Standards

The New Mexico Water Quality Control Commission (NMWQCC) establishes surface water standards for waters of the state in Standards for Interstate and Intrastate Surface Waters (NMWQCC 2005). Certain watercourses may be 'classified' and have segment-specific designated uses. A designated use may be an attainable or an existing use (e.g., livestock watering, aquatic life) for the surface water. Nonclassified surface waters are described as ephemeral, intermittent, or perennial, each of which also has corresponding designated uses. The designated uses for surface water are associated with use-specific water quality criteria, including numeric criteria.

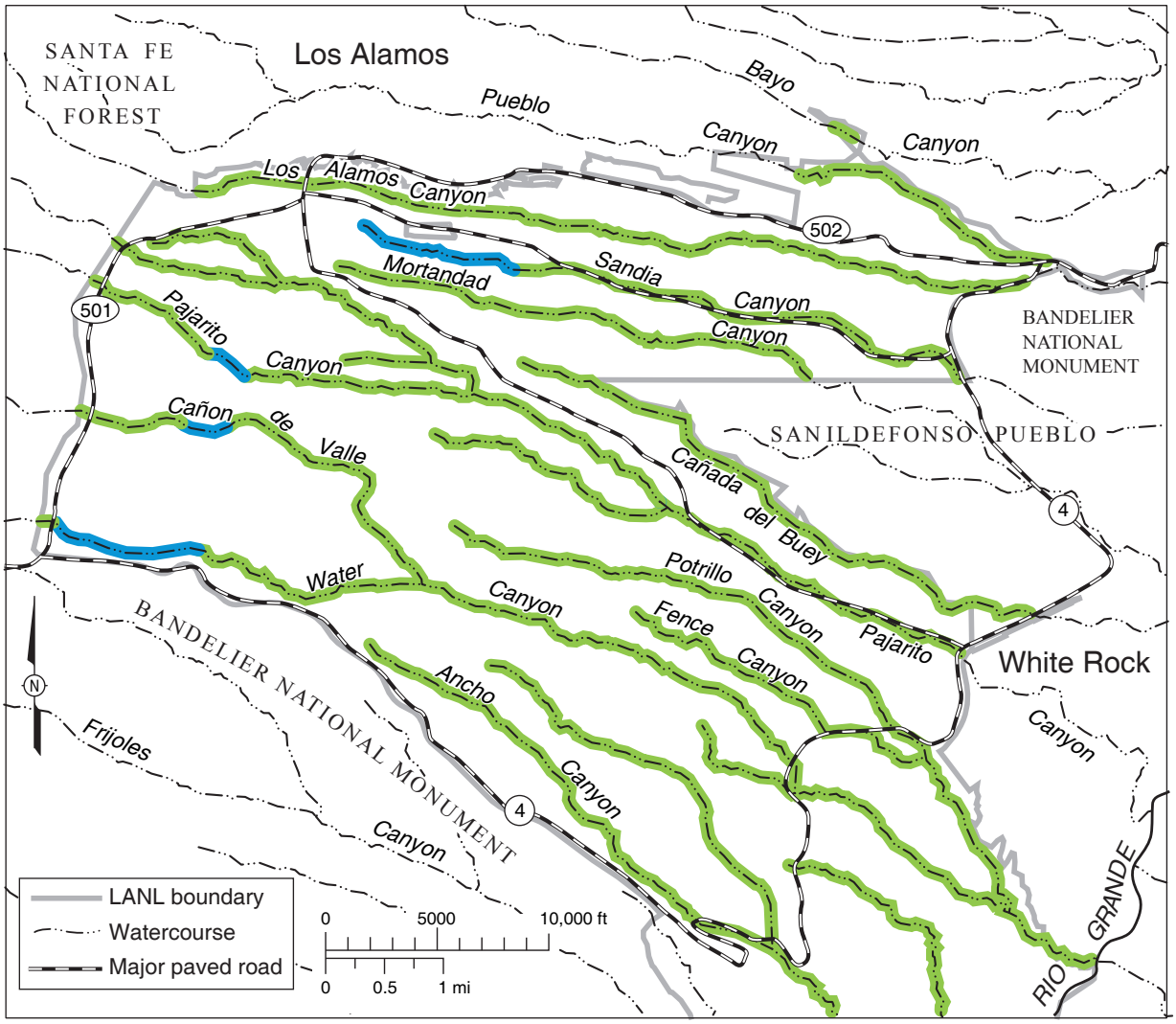
Table 6-1
Application of Surface Water Standards and Sediment Screening Values to Monitoring Data

Medium	Standard	Risk- or Dose-Based Screening Level	Reference	Location	Notes
Surface water					
Radionuclides		Biota Concentration Guides	DOE Technical Standard	On-site and off-site	Surface waters are present sporadically or are not available for long-term access and do not provide persistent drinking water. The actual exposure pathway is to plants/animals, and not to humans. BCGs based on 1 rad/day exposure limit for aquatic animals and terrestrial plants, and 0.1 rad/day for terrestrial animals. Comparison with radionuclide criteria based on time-weighted average over the year per DOE Order 5400.5 and 20.3.4 NMAC.
		New Mexico Radiation Protection Regulations	20.3.4 NMAC		
	State water quality standards for surface water		20.6.4 NMAC	On-site and off-site	Based on the protection of livestock watering for Ra-226 + Ra-228, tritium, and gross alpha radiation. NMWQCC standards are not specific about exposure frequency or duration; for screening purposes, compare single sample results with numeric criteria.
Non-radionuclides	State water quality standards for surface water		20.6.4 NMAC	On-site ephemeral, intermittent streams	Single sample results are compared with numeric water quality criteria corresponding to livestock watering, wildlife habitat, and limited aquatic life standards (including acute aquatic life and human health criteria for persistent pollutants).
				On-site perennial streams	Single sample results are compared with numeric water quality criteria corresponding to livestock watering, Wildlife Habitat, and coldwater aquatic life standards (including chronic aquatic life and human health criteria). For screening purposes, single sample results are compared with 1.5 times the chronic aquatic life criteria (NMED 2006a).
				Off-site	Single sample results are compared with numeric water quality criteria corresponding to designated uses contained in NMWQCC water quality standards.
	State water quality standards for ground water		20.6.2 NMAC	On-site and off-site	Single sample result comparisons with groundwater quality criteria are used to determine potential for stream flows to impact underlying bodies.

Table 6-1 (continued)

Medium	Standard	Risk- or Dose-Based Screening Level	Reference	Location	Notes
Sediments					
	None	Human health screening levels	LANL	On-site and off-site	Screening levels derived to determine if more detailed assessment is needed to evaluate impacts to the public; comparisons are made for recreational or industrial exposure parameters; based on a dose rate limit 15 mrem/year (LANL 2005). Recreational levels are appropriate for Laboratory lands because of public access. There are no residential uses of LANL lands and residential use is impractical at most locations (e.g., many canyon bottoms)
Radionuclides		Biota concentration guides	DOE technical standard	On-site and off-site	Dose limit to biota same as for surface water. Individual results compared to BCGs.
		Background	LANL or McLin (2004)		We compare results from Pajarito Plateau stations to plateau-specific background levels (LANL 1998). Results from regional stations are compared to background levels specific to the major rivers within the Rio Grande drainage system (McLin 2004).
	None	Screening levels	NMED, EPA Region VI, or LANL	On-site and off-site	Recreational or industrial screening levels derived to determine if more detailed assessment is needed to evaluate impacts to the public.
Non-radionuclides		Background	LANL or McLin (2004)		We compare results from Pajarito Plateau stations to plateau-specific background levels (LANL 1998). Results from regional stations are compared to background levels specific to the major rivers within the Rio Grande drainage system (McLin 2004).

Significant changes were made in the NMWQCC stream standards that became effective July 17, 2005. The most significant change, with respect to surface water monitoring at the Laboratory, is the classification of all surface waters with segment-specific designated uses within the Laboratory boundary. Four segments, with designated uses of coldwater aquatic life, livestock watering, wildlife habitat, and secondary contact, are classified as perennial (Figure 6-1). The remaining segments, with designated uses of limited aquatic life, livestock watering, wildlife habitat, and secondary contact, are classified as ephemeral or intermittent.



Stream Type Designated Uses
Perennial (NM 20.6.4.126): Coldwater Aquatic Life, Livestock Watering, Wildlife Habitat, Secondary Contact
Ephemeral and Intermittent (20.6.4.128): Limited Aquatic Life, Livestock Watering, Wildlife Habitat, Secondary Contact

Perennial Ephemeral and Intermittent

Figure 6-1. Designated stream segments and uses at Los Alamos National Laboratory.

The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water. While direct use of the surface water is minimal within the Laboratory, stream flow may extend beyond the LANL boundaries where the potential is greater for more direct use of the water. Stream flows may extend onto Pueblo de San Ildefonso tribal land. Spring water may be used traditionally and ceremonially by San Ildefonso tribal members, and uses may include ingestion or direct contact.

2. Radionuclides in Surface Water

There are no drinking water systems on the Pajarito Plateau that rely on surface water supplies because of the limited extent of stream flow. The emphasis of our radiological assessment of surface water is, therefore, on potential exposures to aquatic organisms and terrestrial plants and animals, rather than to humans. For protection of biota population, we compare concentrations of radionuclides in surface water with the DOE Biota Concentration Guides (BCGs; DOE 2002). Comparison of water quality results to BCGs is done based on annual flow-weighted radionuclide content of the water rather than on individual samples. We also compare surface water results with the NMWQCC water quality standard for protection of livestock watering use, which is a designated use for surface water within the Laboratory boundary (NMWQCC 2005). NMWQCC standards are not specific about exposure frequency or duration; for screening purposes, we compare single sample results with numeric criteria for Ra-226 + Ra-228 and tritium, as discussed in Section 3 below.

3. Gross Alpha in Surface Water

The NMWQCC livestock watering standard includes a numeric criterion for adjusted gross alpha. Adjusted gross alpha means the total alpha radioactivity, excluding that arising from radon-222, uranium, and (as defined by the Atomic Energy Act) source, special nuclear, and by-product material (NMWQCC 2005). Monitoring results of storm runoff after the Cerro Grande fire have shown widespread gross alpha activities greater than the 15 pCi/L livestock watering criterion. In response to these findings, the NMED designated several Los Alamos area drainages as water-quality impaired and added them to the federal Clean Water Act §303(d) list (NMWQCC 2004). The affected drainages with heightened gross alpha activities are Guaje Canyon, Pueblo Canyon, Los Alamos Canyon, Mortandad Canyon, Pajarito Canyon, and Water Canyon. In the 2002 and 2003 surveillance reports, we showed that the gross alpha activities generally correspond to the suspended sediment concentrations, and upstream gross alpha activities were comparable to on-site gross alpha activities and largely were due to the natural radioactivity in the surface sediments. This natural alpha radioactivity arises from the presence in the sediment material of naturally occurring uranium, thorium, and members of their decay chains. The 2005 gross alpha activities also correspond to sediment concentrations. The upstream gross alpha activities have declined substantially as stream flows are reduced with recovery in the burned areas, which has resulted in reduced concentrations of suspended solids. Although gross alpha activities have progressively declined since the Cerro Grande fire, about 60 percent of the surface water samples collected in 2005 contained adjusted gross alpha activities greater than the 15 pCi/L livestock watering criterion. Gross alpha radioactivity is a general screening measurement of limited value in assessing radiological hazards because specific alpha emitters in the water cannot be identified or quantified. Therefore, we do not discuss gross alpha results in detail in this report. Instead, we emphasize the concentrations measured for specific individual radionuclides identified in LANL waste streams (Watkins and Del Signore 2005) or known to be associated with the nuclear industry (Langmuir 1997). A listing of gross alpha concentrations measured in surface water is provided in Supplemental Table S6-1.

4. Nonradioactive Constituents in Surface Water

We compare surface water concentrations of nonradioactive constituents with the NMWQCC (2005) numeric water quality criteria that correspond to the designated uses for the stream. All surface waters within the Laboratory boundary have the designated uses of livestock watering and wildlife habitat. For classified ephemeral and intermittent watercourses, the limited aquatic life use applies, along with the acute (short-term) aquatic life criteria and the human health criteria for persistent pollutants. The NMWQCC human health criteria are based on the US Environmental Protection Agency (EPA) criteria for "consumption of organisms only." Within the classified perennial waters, the coldwater-designated use applies, together with both the acute and chronic (long-term) aquatic life criteria and the human health criteria for toxic pollutants, including persistent and carcinogenic pollutants. Hardness-dependent aquatic life numeric criteria are calculated using a water hardness value of 100 mg $CaCO_3$/L.

For evaluating the potential impact of chronic exposure to surface water constituents on aquatic life, we adopt the protocol employed by the NMED for assessing standards attainment in waters of the state (NMED 2006a). For designated perennial stream segments, single sample results are compared with the chronic screening level that is 1.5 times the chronic aquatic life criterion. Surface water quality results are lastly compared with the NMWQCC groundwater standards to evaluate the potential for stream flows to impact underlying groundwater bodies (NMWQCC 2002).

5. Sediments

We screen sediment results to screening levels to identify concentrations of a constituent that may require further assessment. The Laboratory's Environmental Remediation and Surveillance Program uses residential, industrial worker, or recreational screening action levels (SALs) to identify radionuclide activity levels of interest (LANL 2005). Comparisons with SALs are used to readily distinguish the areas with the most potential concern: concentrations below the SALs are not of concern to public health, whereas concentrations greater than the SALs would trigger more detailed investigations. Only industrial worker or recreational screening levels for radionuclides are applicable on Laboratory land. At present, industrial and recreational are the only uses of Laboratory land. Concentrations of nonradioactive compounds in sediments are compared with recreational or industrial soil-screening levels developed by NMED (2006), EPA Region 6 (EPA 2005), or LANL (2005). All of these screening levels are conservative (protective) because they are calculated based on the assumption that humans will be exposed to the chemicals or radionuclides for extended periods of time, which is not the case on LANL property. For sediment stations located on the Pajarito Plateau we also compare sediment data with established plateau-specific background levels of metals or background activities of radionuclides that are naturally occurring or result from atmospheric fallout (LANL 1998) and other sources than LANL. Data from regional sediment stations are compared to background levels established for the major drainages of the area, the Rio Grande, Rio Chama, and Jemez River (McLin 2004).

D. SAMPLING LOCATIONS AND DATA ANALYSIS METHODS

1. Regional Monitoring Locations

Regional base flow and sediment sampling stations (Figure 6-2) are located in northern New Mexico. Samples from regional stations reflect background concentrations and provide a basis for evaluating Laboratory impacts to the Rio Grande drainage system. We obtained regional sediment samples from stations on the Rio Grande and the Jemez River, from Abiquiu Reservoir on the Rio Chama, and from Cochiti Reservoir on the Rio Grande. Sampling stations in the Rio Grande drainage system are located up to approximately 60 km upstream of the Laboratory.

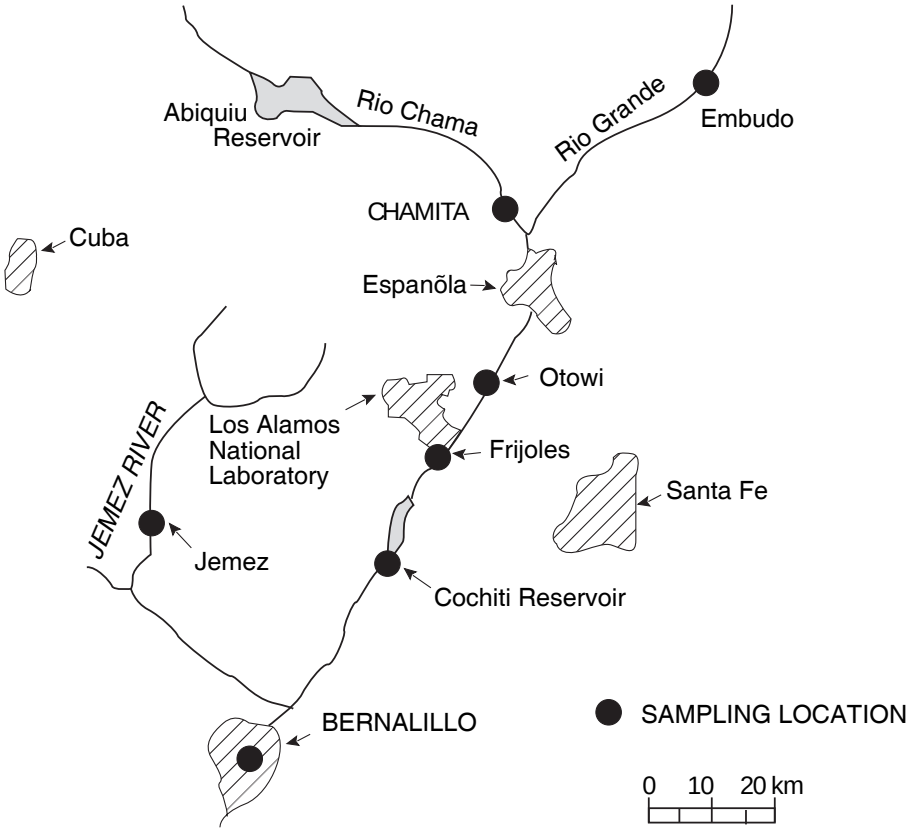


Figure 6-2. Regional base flow and sediment sampling locations.

2. On-Site and Perimeter Monitoring Locations

We sample surface water and sediments in all major canyons that cross current or former Laboratory lands. Stream sediments are sampled to evaluate any accumulation of undissolved contaminants in the aquatic environment (DOE 1991). Surface water samples are collected across the Pajarito Plateau within and near the Laboratory, with particular emphasis placed on monitoring at the Laboratory boundaries. We collect base-flow grab samples from locations where effluent discharges or natural springs maintain stream flow (Figure 6-3).

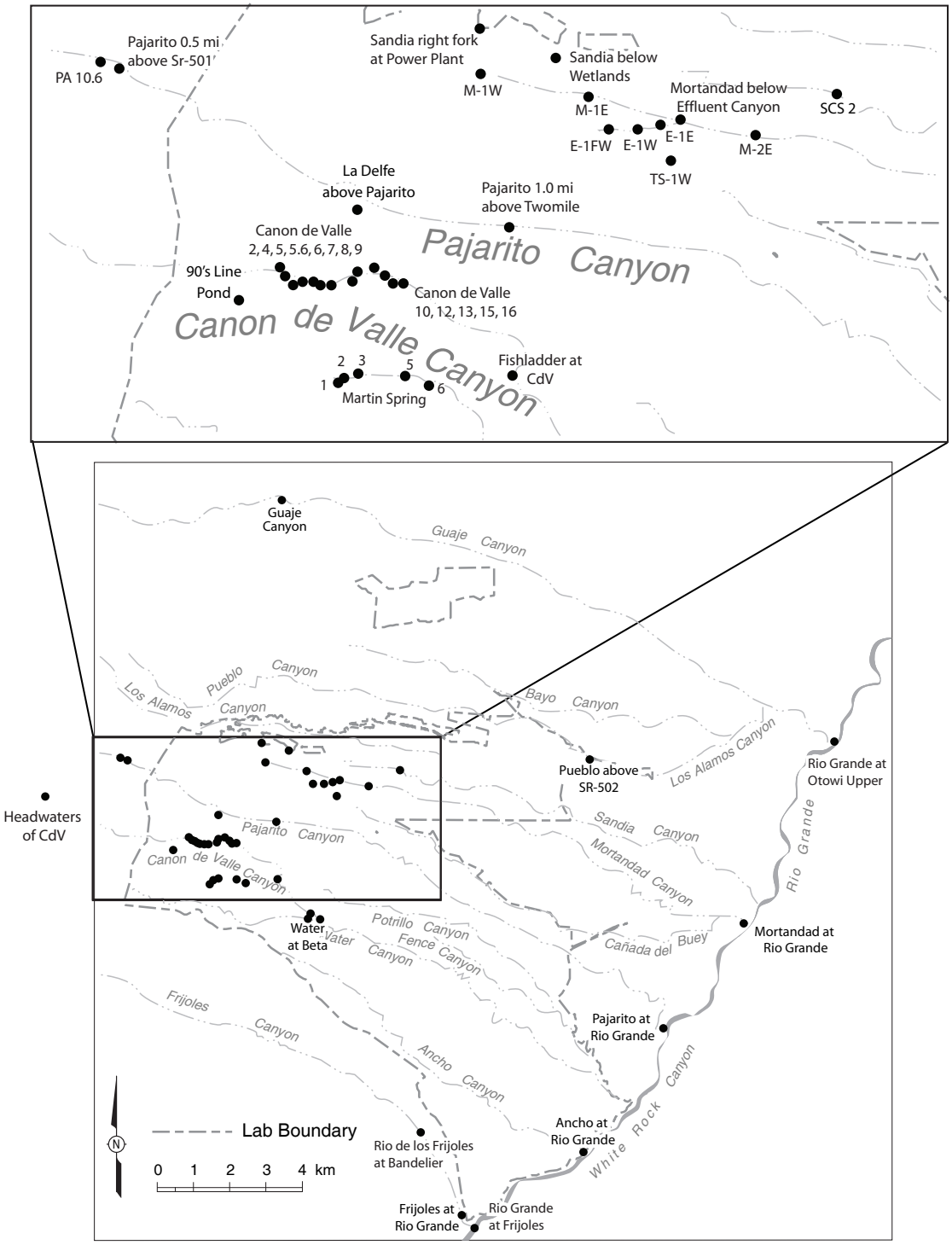


Figure 6-3. Base flow sampling locations in the vicinity of Los Alamos National Laboratory.

Storm runoff samples in watercourses are collected using stream-gaging stations with automated samplers (Figure 6-4). Many gaging stations are located where drainages cross the Laboratory's boundaries. We also sample storm runoff at many mesa-top sites that allow us to target specific Laboratory activities (Figure 6-5). These sites usually have negligible runoff from other sources.

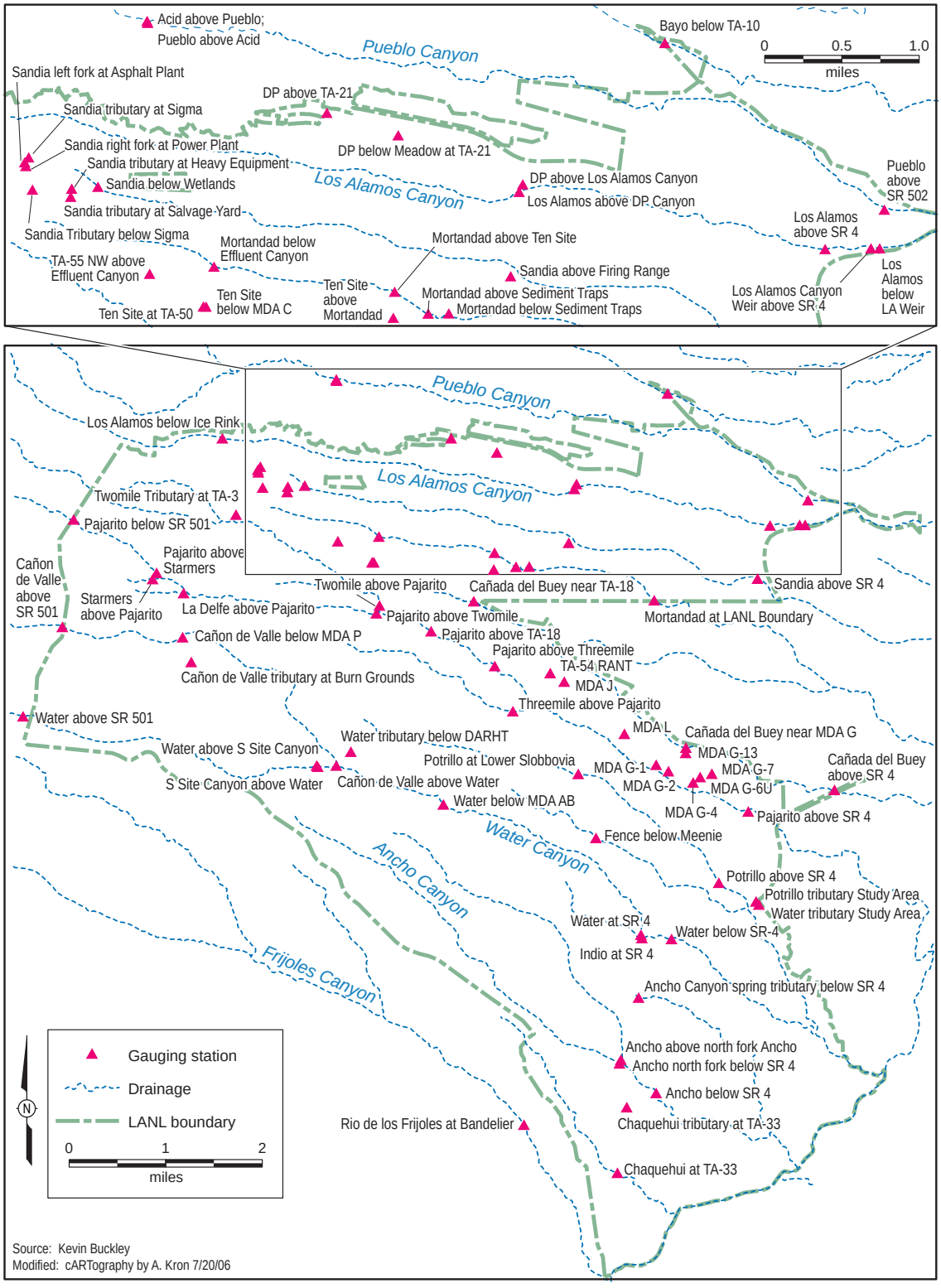


Figure 6-4. Storm runoff sampling (gage) stations in the vicinity of Los Alamos National Laboratory.

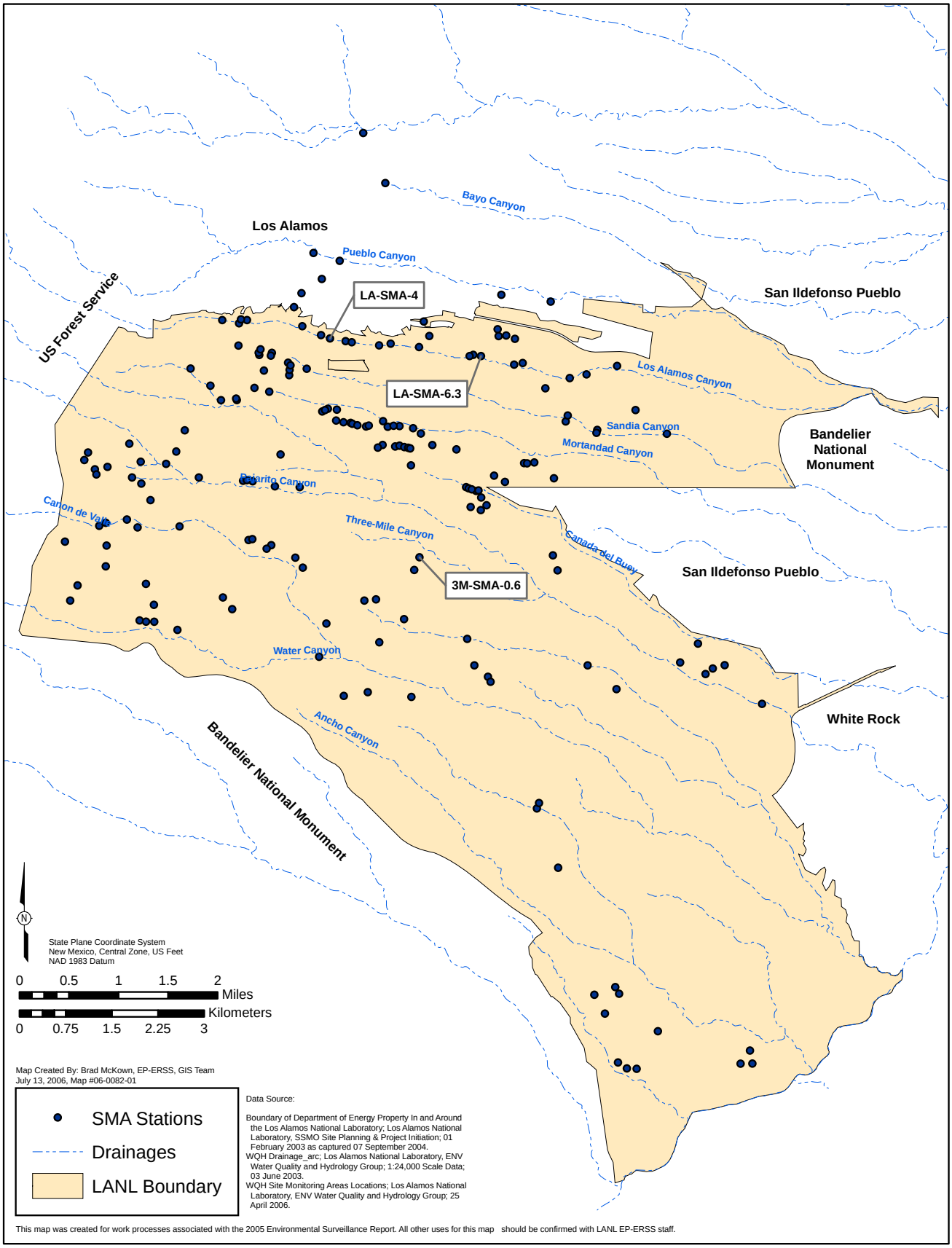


Figure 6-5. Site-specific storm runoff sampling stations in the vicinity of Los Alamos National Laboratory.

Sediment stations on the Pajarito Plateau (Figure 6-6) are located within approximately 4 km of Laboratory boundaries, with the majority located within Laboratory boundaries. Many of the sediment-sampling stations on the Pajarito Plateau are located within canyons to monitor sediment contamination in the active channel related to past and/or present effluent release sites. We sampled three major canyons in 2005 (Pueblo, Los Alamos, and Mortandad) that have experienced past or present liquid radioactive releases; samples are collected from upstream of the Laboratory to their confluence with the Rio Grande.

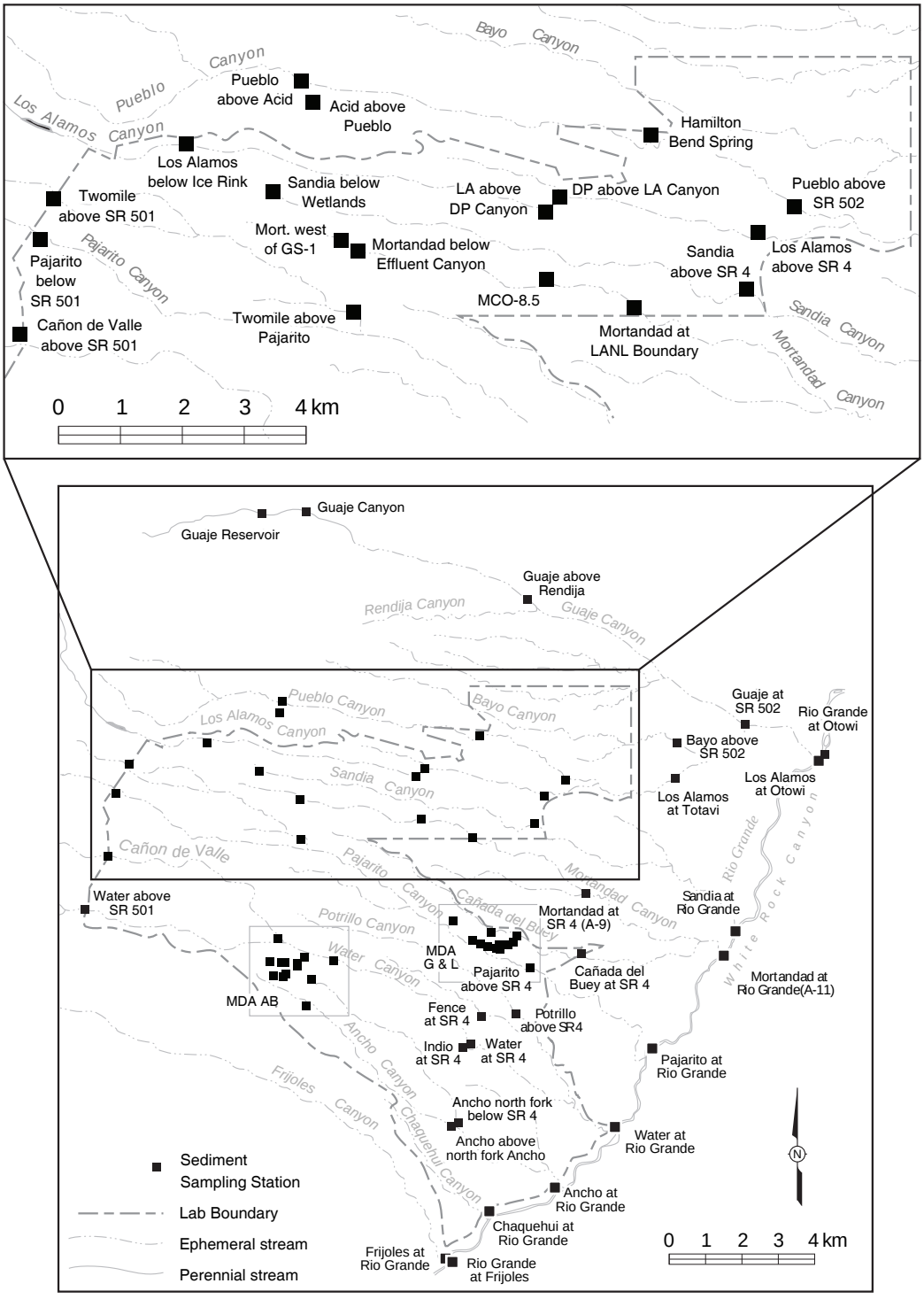


Figure 6-6. Sediment sampling locations in the vicinity of Los Alamos National Laboratory. Material disposal areas with multiple sampling locations are shown in Figures 6-7 and 6-8.

We collected sediments from drainages downstream of two material disposal areas (MDAs), MDA G and MDA AB. Material Disposal Area G at Technical Area (TA)-54 is an active waste storage and disposal area. Nine sampling stations were established outside its perimeter fence in 1982 (Figure 6-7) to monitor possible transport of radionuclides from the area. Material Disposal Area AB at TA-49 was the site of underground nuclear weapons testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). The tests involved high explosives (HEs) and fissionable material insufficient to produce a nuclear reaction. We established 11 stations in 1972 to monitor surface sediments in drainages adjacent to MDA AB (Figure 6-8).

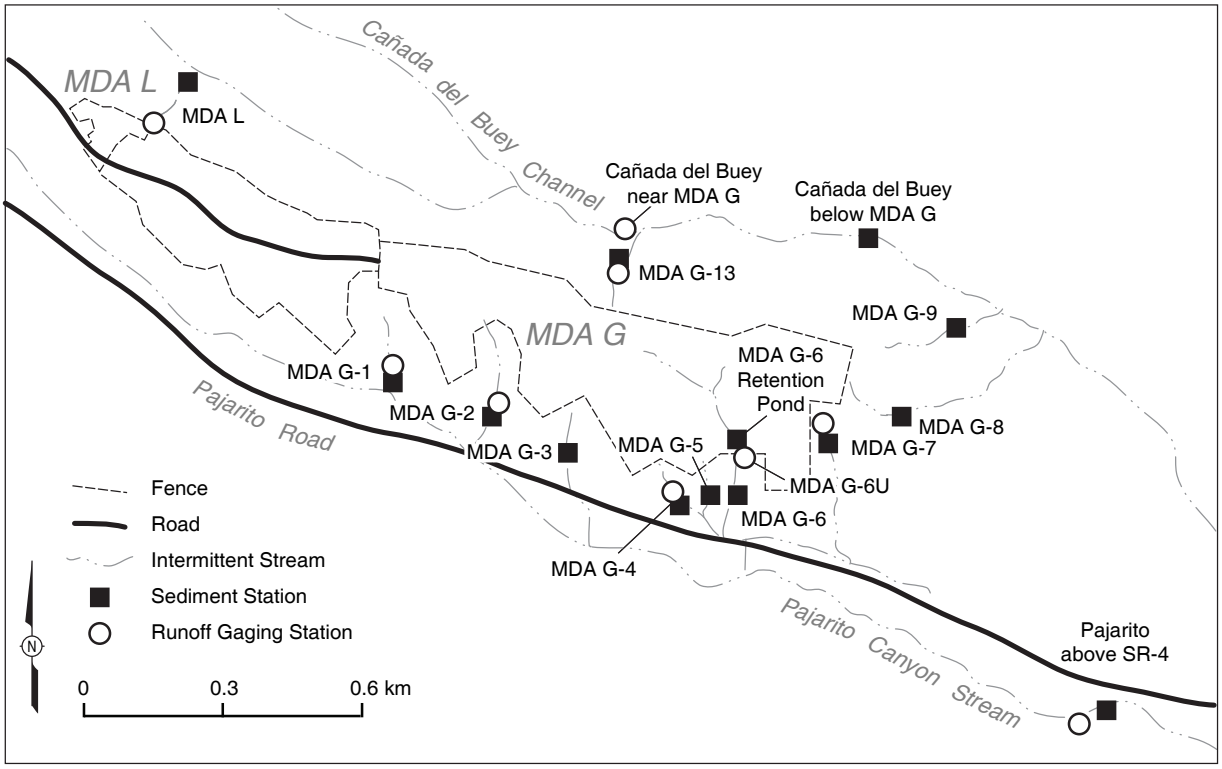


Figure 6-7. Sediment and storm runoff sampling stations at TA-54, MDA L, and MDA G.

We also sample surface water and sediments at several locations on San Ildefonso Pueblo lands. DOE entered into a Memorandum of Understanding with the Pueblo and the Bureau of Indian Affairs in 1987 to conduct environmental sampling on pueblo land. The watershed drainages that pass through LANL onto Pueblo lands are Los Alamos/Pueblo, Sandia, Mortandad, and Canada del Buey Canyons.

3. Sampling and Analysis Procedures

Our procedures for sampling and analysis depend on the type of stream flow and location. We collect grab samples of base flow and snowmelt runoff from free-flowing streams near the bank. We filter and preserve grab samples in the field. The storm runoff (gage) stations, located mostly in canyon bottoms, are equipped with automated samplers that are activated at the start of significant flow events. Typically, the automated samplers collect water from the first 30 minutes of the runoff event to sample the first flush of storm water. This is the second year that we have sampled the first flush and it is a significant change from previous years. Previously, we sampled over a two-hour period. We expect higher concentrations in the first flush compared to the average concentration during a flow event, so the 2004 and 2005 data are not directly comparable to data from previous years.

Storm runoff samples from mesa tops are collected with buried single-stage runoff samplers. Individual storm runoff sample bottles are shipped to the commercial analytical laboratory as is, without compositing or splitting. The analytical laboratory filters and preserves runoff samples because filtering highly sediment-laden waters in the field is difficult.

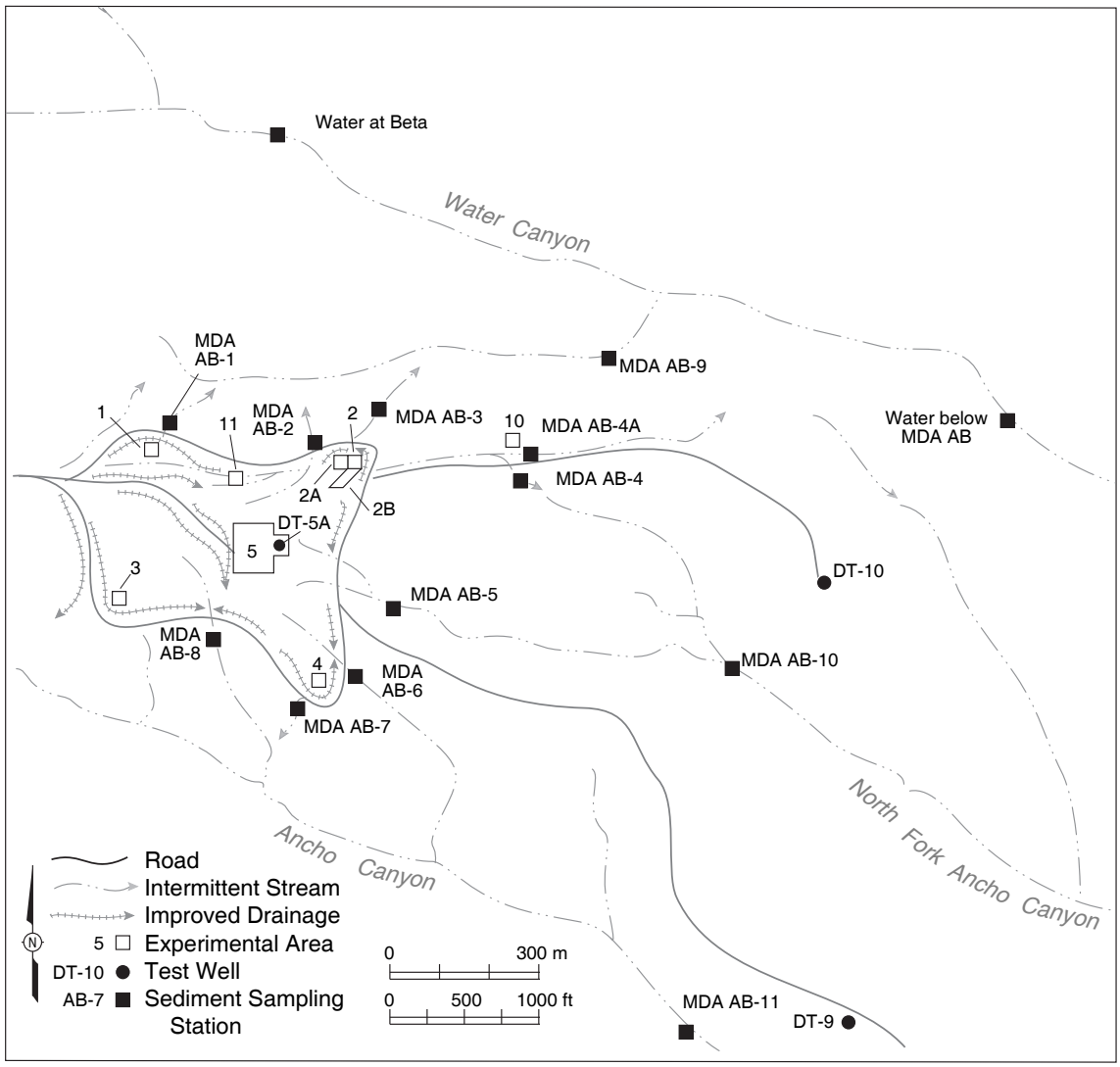


Figure 6-8. Sediment sampling stations at Area AB, TA-49.

We collect sediment samples from edge of the main channels of flowing streams. To collect samples from the beds of intermittently flowing streams, we use a disposable scoop to collect fine-textured sediment across the main channel to a depth of 20 mm.

4. Contaminant Maps

We reviewed recent watershed monitoring results to develop a broad picture of key analytes that reflect possible effects from Laboratory operations. Most of the above-background results for surface water were found in storm runoff samples. We prepared a series of maps to show general patterns of where potential contamination from Laboratory operations was measured in surface water or sediment during 2005. To add confidence to the 2005 results, we also considered previous sampling results in the development of the maps. When the same pattern showed up in several samples within part of a canyon, we highlighted that area on the maps.

We prepared separate maps for sediments and for storm runoff, although they often show similar distribution for a constituent. Because of the lack of flow, storm runoff data are sparse in some parts of the Laboratory. The maps show analytes that are widely distributed, possibly affecting an entire watershed, and may not show localized contamination. The maps are presented later in this chapter.

The maps show contaminant distributions extrapolated beyond the area covered by monitoring locations. This extrapolation takes into account the location of contaminant sources and direction of sediment and surface

water movement. Question marks on the maps indicate where contaminant extent is inferred, but not confirmed by monitoring coverage, or they indicate locations where analytical measurements indicate detections that are contradicted by other measurements. Along canyons, the extent of contamination lateral to the canyon is diagrammatic: contamination is quite narrow at the map scale.

E. 2005 WATERSHED MONITORING DATA TABLES

The supplemental data tables contain all the 2005 watershed-related surface water and sediment analytical results, with one general exception. Storm runoff results from the FFCA monitoring program were separately published (LANL 2006) and thus are not included in the supplemental data tables; this mainly includes trace metals and organic compounds in runoff. In the supplemental data tables, radiological results are presented in sequence for each of these media, followed by the results for major chemical quality analytes, trace metals and minor constituents, and organic compounds.

Surface water and sediment samples are analyzed for gross alpha, gross beta, and selected radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, uranium isotopes, and tritium, cobalt-60, potassium-40, neptunium-237, radium-226, radium-228, and sodium-22). Table S6-1 in the Data Supplement lists the results of radiochemical analyses of surface water for 2005. The tables also list the total propagated one-sigma analytical uncertainty and the analysis-specific minimum detectable activity, where available. Uranium was analyzed by isotopic methods. For most radionuclide measurements, a detection is an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier codes of X or U (indicating nondetect). Trace-level tritium measurement results for base flow samples are presented in Table S6-2. The results of radiochemical analyses of sediments appear in Table S6-3. Table S6-4 lists radiological detections for results that are higher than river or reservoir sediment background levels and identifies values that are near or above SALs.

Concentrations of major chemical constituents in base flow are listed in Table S6-5. Table S6-6 and S6-7 present results of metals analyses for base flow and sediments, respectively.

The scope and results of organic analyses are presented in Table S6-9 through S6-12. Table S6-9 presents the number and type of organic analyses performed on base flow samples, and Table S6-10 presents results for any organic compound detected in base flow. Similarly, Tables S6-11 and S6-12 present summaries of organic analyses of stream sediments.

Qualifier codes are shown in some tables to provide additional information on analytical results that are not detections: in some cases, for example, the analyte was found in the laboratory blank, or there were other analytical issues. The tables show two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7).

F. 2005 WATERSHED MONITORING FINDINGS

The overall quality of most surface water in the Los Alamos area is good, containing low levels of dissolved solutes. Of the more than 200 analytes measured in sediment and surface water within the Laboratory, most are at concentrations far below regulatory standards or risk-based levels. However, nearly every major watershed indicates some effect from Laboratory operations, often for just a few analytes. This section first presents a Laboratory-wide overview on how surface water quality compares to DOE and New Mexico regulatory standards or guidelines, and then discusses in more detail the key findings on a watershed-by-watershed basis.

1. Comparison to DOE Radiological Guides

Table 6-2 compares the annual average concentrations of radioactivity in surface waters at Los Alamos against the DOE's BCGs. In order to compare surface water sample results with the DOE BCGs, we calculated the time-weighted average annual radioactivity in waters, focusing on the wetter stream segments. Time-weighted average concentrations were calculated for the individual radionuclides of primary concern on the landscape at Los Alamos: americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, tritium, and several uranium isotopes. Concentrations measured during base flow periods and during storm runoff periods were weighted proportionally after reviewing stream flow records (Shaull et al. 2006) to distinguish the flow regimes; periods with no flow were assigned concentrations of zero.

Table 6-2
Comparison of Estimated Annual Average Unfiltered Surface Water Concentrations of Radionuclides in Selected Canyons with the Biota Concentration Guides (pCi/L)

Radionuclide	BCGs[a]	Pueblo above Acid	Lower Pueblo Canyon	DP Canyon below TA-21	LA Canyon at Skate Rink	LA Canyon between DP and SR-4	LA Canyon at Rio Grande	Mortandad Canyon below Effluent Canyon	Pajarito Canyon above SR-4	Max percent of BCG[a]
Am-241	400		0.4	0.02		3.3	0.1	5.1		1%
Cs-137[b]	20,000	3		2	11	24		20		0.1%
H-3	300,000,000	161			131			237		0.0%
Pu-238	200	0.08		0.06		0.17		2.1		1%
Pu-239,240	200	0.1	11	0.4	0.1	2.5	0.4	2.9		1%
Sr-90	300	0.5	0.4	3.5	0.3	1.7	2.0	3.4	0.4	1%
U-234	200	5.6	1.7	1.9	1.3	7.9	3.4	2.0	0.1	4%
U-235,236	200	0.6	0.1	0.1	0.1	7.1	0.3	1.1		4%
U-238	200	2.4	1.6	1.8	1.4	0.5	3.3	1.9	0.1	2%
Sum of ratios to BCGs		0.05	0.07	0.03	0.02	0.11	0.04	0.07	0.00	

[a] BCG = DOE Biota Concentration Guides (DOE 1992).
[b] The BCG for Cs is a site-specific modified BCG from McNaughton 2005.
Blank cells indicate no analytical laboratory detection in 2005.

This approach is consistent with DOE guidance (DOE 2003). For waters containing more than one radionuclide, a ratio for each radionuclide is calculated by dividing the concentration of each radionuclide by its particular BCG. To be consistent with DOE Order 5400.5, the sum of the ratios should not exceed 1.0. Because the calculations are often based on limited sample sets and hydrologic interpretation, these results should be viewed as approximations.

The time weighted annualized concentrations and sum of ratios, for unfiltered surface water in the major canyons were well below the BCGs. Table 6-2 shows that concentrations of all of the individual isotopes were less than 5 percent of their respective BCGs. When the mixtures of isotopes are considered, the largest sum of the ratios was found in the Los Alamos Canyon stream segment between DP Canyon and SR-4, at 11 percent of the standard.

2. Comparison to New Mexico Surface Water Quality Standards

The New Mexico Surface Water Quality Standards (NMWQCC 2005) vary across the Laboratory depending on the designated uses for a particular stream segment, as discussed in Section C.1. To evaluate how 2005 monitoring results compare to the state standards, we matched the applicable standards to results for each specific location. During the year, 580 sampling events were conducted at 169 locations. The monitoring included 86 site-specific (mesa top or hillside) sites and 79 watercourse (canyon floor) sites on the Pajarito Plateau. The FFCA testing program varied by watershed but surface water samples typically were tested for more than 100 analytes. FFCA runoff results (mainly metals and organic compounds) are reported elsewhere (LANL 2006). All other sample results are given in the supplemental tables.

We identified 16 analytes that were present at concentrations greater than water quality standards. Storm runoff accounted for the largest proportion of high concentrations, consistent with previous years. Generally, these concentrations reflect the large sediment load carried by the storm runoff events. In contrast, high concentrations in base flow or snowmelt samples were infrequent for most analytes. Figure 6-9 compares the frequency at which storm runoff and base flow/snowmelt results were greater than standards for these 16 analytes. Data for base flow and snowmelt were combined for this analysis because of their similarity in water quality (low sediment load) and flow duration (several weeks or longer).

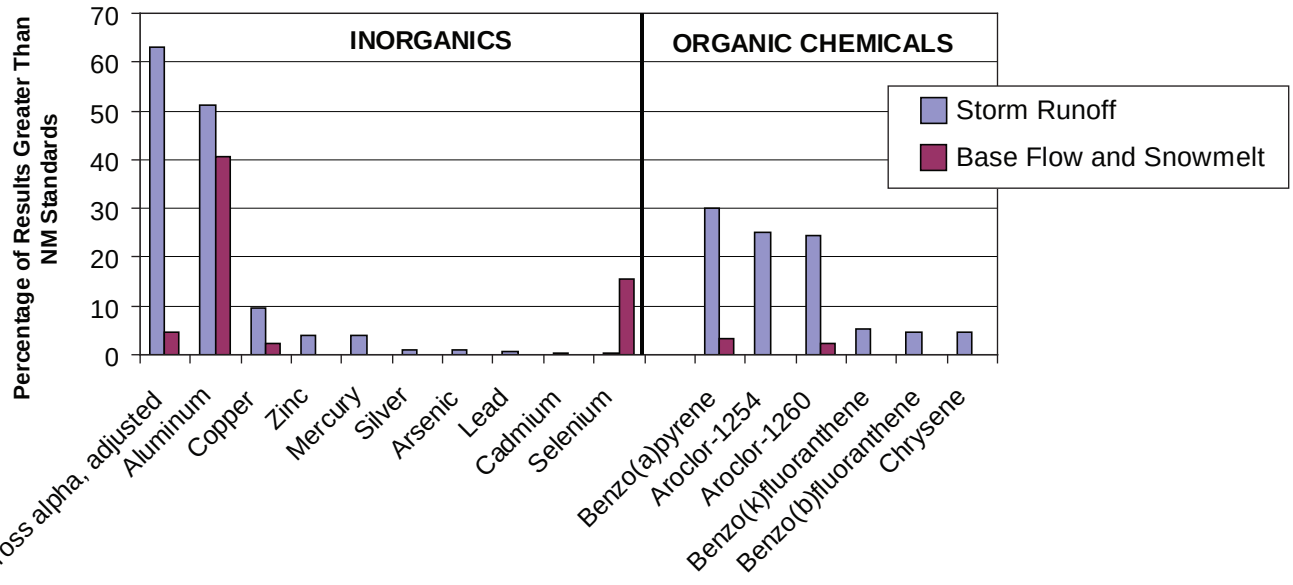


Figure 6-9. Frequency that storm runoff and base flow/snowmelt results were greater than New Mexico Water Quality Standards.

More than half of the storm runoff samples contained concentrations of adjusted gross alpha and aluminum that were higher than New Mexico standards for livestock watering (gross alpha) or aquatic life (dissolved aluminum). About 40 percent of base flow/snowmelt samples also contained concentrations of aluminum higher than aquatic life standards. Aluminum is a natural component of soil and not derived from Laboratory operations. The majority of the adjusted gross alpha activity is likely caused by suspended sediment made up of native soils and sediments, as activities from major Laboratory-associated radionuclides are not reflected in the adjusted gross alpha results (see discussion in Section C.3).

Approximately one-fourth of the storm runoff samples contained concentrations of PCBs (Aroclors 1254 and 1260) above human health and wildlife habitat standards. The PCBs are likely Laboratory-derived. These PCB concentrations reflect the large sediment load in a storm water runoff event and are due to their chemical affinity for the suspended sediment in the runoff. Frequent PCB concentrations above the standards were observed in Los Alamos and Sandia Canyons and at least one PCB detection was observed in nearly all sampled watersheds. Storm runoff concentrations of PCBs were higher than the effective human health standard by a maximum of approximately 4 times. Sampling by NMED (NMED 2006c) confirmed the presence of PCBs on LANL property.

It should be recognized that the New Mexico stream standards for PCBs are extremely low. The standards for aquatic life is 0.014 μg/L and for human health is 0.00064 μg/L (0.64 nanograms/L) (see discussion on PCBs in the Rio Grande in Section F.3 below).

The human health standards are levels where ingesting contamination through aquatic life consumption would harm peoples' health. Although there are no fish on Laboratory lands, a concern is the transport of PCBs into the Rio Grande by storm runoff events. In 2005, snowmelt sustained streamflow for four consecutive months in Los Alamos Canyon from the Laboratory to the confluence with the Rio Grande (see discussion in Section B, Hydrologic Setting).

Despite the detection of PCBs in runoff within the Laboratory, available data show no discernible impacts on PCB concentrations in the Rio Grande. Biological monitoring of reservoirs along the Rio Grande drainage does not indicate measurable increases in PCB concentrations due to Laboratory operations. Mean total PCB concentrations in fish from Abiquiu reservoir were statistically similar to mean total PCB concentrations in fish from Cochiti reservoir (see Chapter 8 for details). The statistical similarity in PCBs upstream and downstream of LANL has also been shown for dissolved water concentrations using samples taken with semi-permeable membranes. Additionally, sampling by NMED and LANL of the Rio Grande surface water shows whole water concentrations of PCBs are similar upstream and downstream of LANL (Mullen and Koch 2004). These results indicate there are other sources for PCBs in the Rio Grande.

Several polycyclic aromatic hydrocarbons (PAH), particularly benzo(a)pyrene, were detected in storm runoff samples at concentrations above the human health standards. PAHs are commonly associated with urban runoff and may also have been created through the Cerro Grande fire (Gallaher and Koch 2004).

Base flow and snowmelt contained concentrations of selenium slightly (1.1 to 2 times) above the wildlife habitat standard of 5 μg/L in approximately 10 percent of samples. However, most of the higher selenium concentrations appear to reflect analytical anomalies. All but one of the 11 exceedances were analyzed using SW-846:6010B, which has a nominal detection limit of 6 μg/L. Nearly all of the detections using this method were estimated by the analytical laboratory. We plan to revise methods used for analysis of selenium in surface and groundwater to obtain more sensitive results. Regardless, selenium is likely naturally occurring at these levels. Of the remaining constituents, only copper showed concentrations larger than standards in more than 5 percent of the samples.

Figure 6-10 shows a preliminary comparison of concentrations measured at site-specific monitoring stations and at watercourse stations. On this Laboratory-wide perspective, there appears to be minimal differences in the distribution of results for the two classes of monitoring stations. This is a somewhat surprising finding, as the site-specific FFCA monitoring is conducted close to potential contaminant sources under the assumption that site-specific stations would be more likely to detect a contaminant release than the watercourse stations. This preliminary analysis indicates that the watercourse stations appear to be just as effective in detecting elevated constituent concentrations as are the site-specific stations. More analysis is required to see if this initial finding holds on a watershed-by-watershed basis.

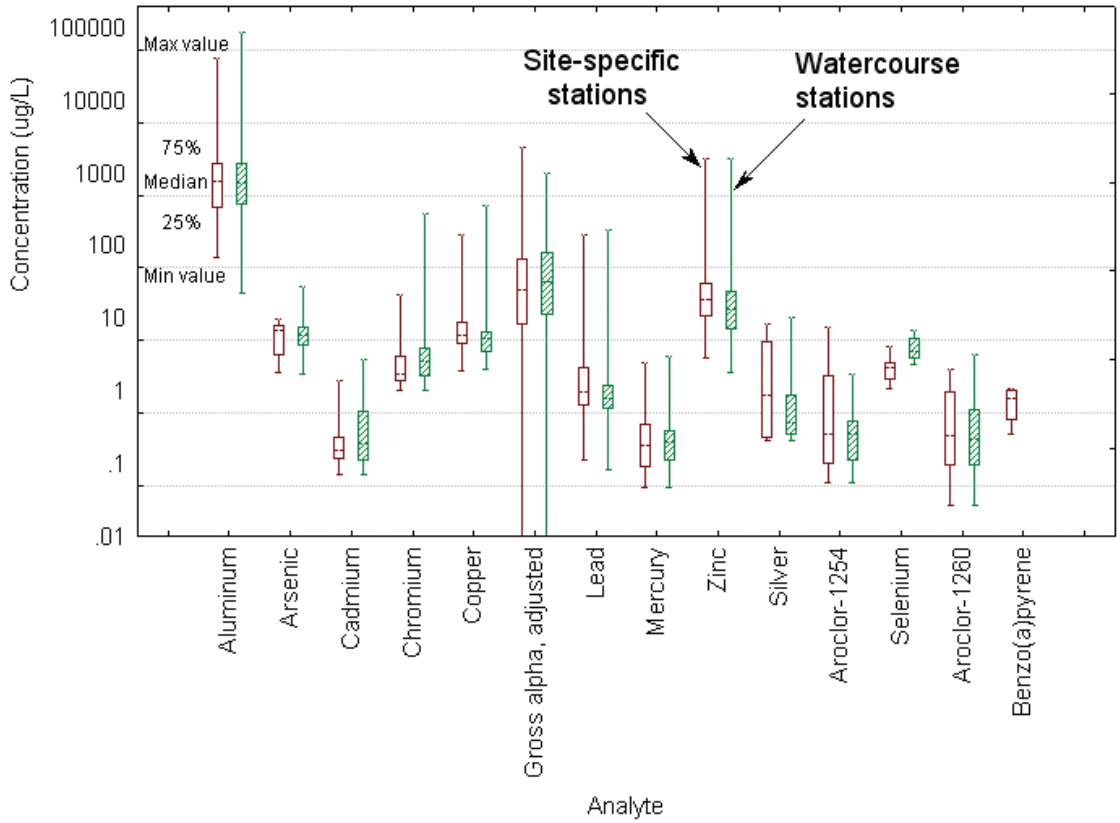


Figure 6-10. Comparison of concentrations measured in storm runoff at site-specific and watercourse stations. The vertical bars show the range of results and the middle 50 percent of the results occur within the boxes.

3. Impacts to the Rio Grande

Waters and sediments along the Rio Grande historically have shown relatively small impacts from Laboratory operations. Results for 2005 were consistent with those findings.

All base flow samples from the Rio Grande had concentrations below drinking water standards and standards for the protection of aquatic life, wildlife habitat, and irrigation. Radioactivity in these samples was low. None of the radionuclides commonly associated with LANL operations were detected, except for uranium. Uranium concentrations (0.5 to 2 μg/L) were well below the federal drinking water standard of 30 μg/L.

Radionuclide concentrations in bottom sediments from Cochiti Reservoir were lower than in other post-fire years. Plutonium-239,240 and cesium-137 concentrations showed increases for one to two years following the Cerro Grande fire (Gallaher and Koch 2005), but concentrations in 2005 have recovered to pre-fire levels. Plutonium-239,240 concentrations in 2005 were near or below analytical detection limits. Metals concentrations in the bottom sediments were unremarkable. The residual high-explosives organic compound 2-4-dinitrotoluene was detected in Cochiti Reservoir bottom sediments at an estimated concentration of 2.8 mg/kg, considerably below the EPA Region VI soil screening level of 120 mg/kg. This compound was not detected in earlier analyses (2003).

To further assess recent Laboratory impacts to the Rio Grande, we compared concentrations for key LANL analytes at locations along the Rio Grande upstream and downstream of LANL. Stations considered to be upstream of LANL surface water drainage are those located above the Rio Grande at Otowi bridge. Downstream stations along the segment from the Otowi bridge to the Cochiti Reservoir reflect any LANL influences. To focus on post-Cerro Grande fire conditions, with heightened drainage from the Los Alamos area to the Rio Grande, we limited the data to those for the years 2000 through 2005. We compared concentrations for metals (chromium, copper, lead, mercury) and radioactivity (cesium-137, plutonium-239,240, americium-241, total uranium) in sediments accumulated in the bottoms of reservoirs within the Rio Grande drainage system. Results are shown in Figures 6-11 and 6-12.

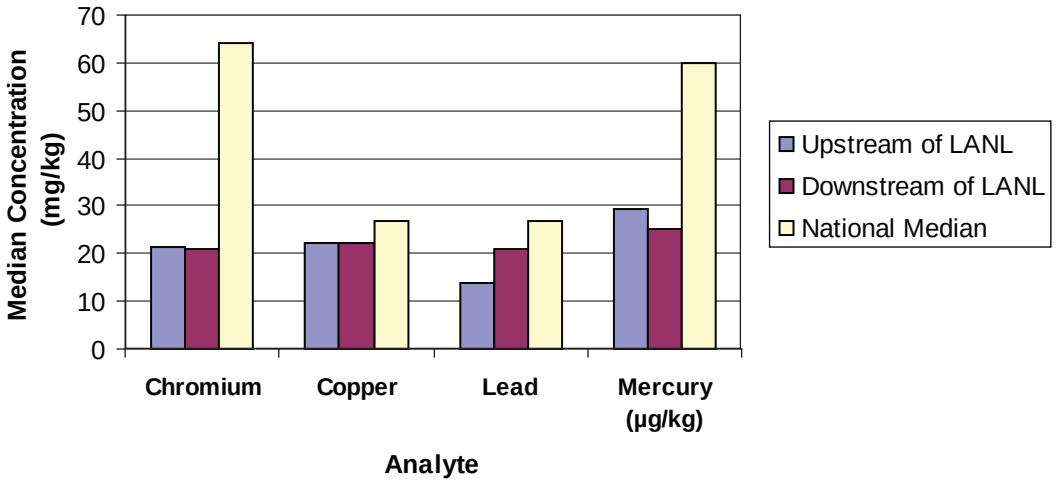


Figure 6-11. **Metals concentrations in bottom sediments from reservoirs within the Rio Grande drainage system. Reservoirs located upstream of LANL include Abiquiu, El Vado, Heron, and Rio Grande. The downstream reservoir is Cochiti. National median data are from the US Geological Survey (Gilliom et al. 1997).**

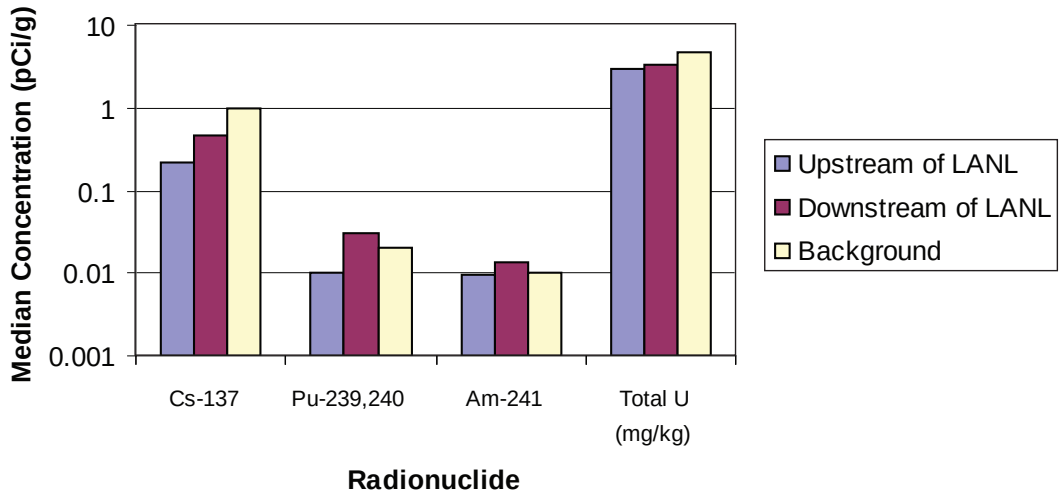


Figure 6-12. **Radionuclide concentrations in bottom sediments from reservoirs within the Rio Grande drainage system. Reservoirs located upstream of LANL include Abiquiu, El Vado, Heron, and Rio Grande. The downstream reservoir is Cochiti. Background upper limit radioactivity reference values are from McLin (2004).**

Of the four metals assessed, only lead shows a significant increase in downstream (Cochiti Reservoir) bottom sediment concentrations. The possible sources of lead are numerous, including urban and roadway runoff. Median concentrations for the four assessed metals are below US Geological Survey national median concentrations measured in reservoir studies across the country (Gilliom et al. 1997).

Concentrations of cesium-137 and plutonium-239,240 in reservoir bottom sediments show slight increases below LANL. However, the median concentration of cesium-137 remains within global fallout ranges for the region. Previous analysis concluded that the cesium-137 was primarily fallout-associated ash washed from the burned hillsides above Los Alamos (Gallaher and Koch 2005). The plutonium-239,240 was primarily attributed to Laboratory-contaminated sediments in Los Alamos Canyon watershed (see discussion in Section 4.B below).

Three independent types of measures show that PCB concentrations below LANL to Cochiti Reservoir are indistinguishable from above. We have measured PCB concentrations in fish tissue, in submerged synthetic membranes, and in the water column. All of the three measurement programs showed no significant difference in PCB concentrations between upstream and downstream locations. Fish tissue and membrane results are discussed in Chapter 8 of this report. Water column data are presented in Figure 6-13.

A preliminary analysis indicates that PCB concentrations greater than 0.1 ng/L can theoretically be ascribed to background fallout levels of PCBs. This is within the magnitude of some values measured in the Rio Grande water column (Figure 6-13). Around the world, PCB compounds are ubiquitous on the landscape. PCBs have been detected in soils from remote locations in the northern Rio Grande drainage system (Gonzales and Fresquez 2003).

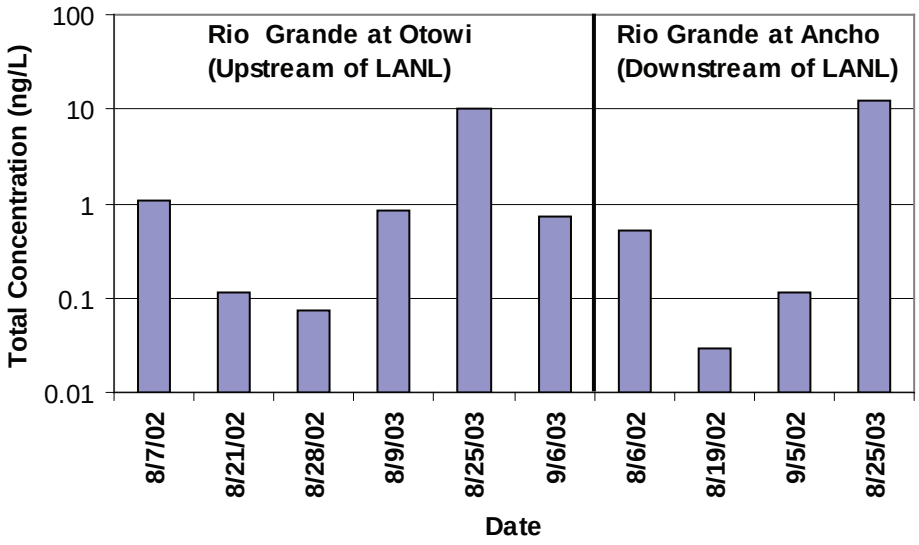


Figure 6-13. Total PCB concentrations in Rio Grande surface water in 2002 and 2003 (Mullen and Koch 2004).

4. Canyon-specific Results

a. Guaje Canyon (includes Rendija and Barrancas Canyons)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that heads in the Sierra de los Valles and lies north of Laboratory land. The canyon has not received any effluents from LANL activities. Concentrations of metals, organics, and radionuclides in Guaje Canyon base flow and sediments were below regulatory limits or screening levels. Active channel sediments contained background ranges of metals and radionuclides (LANL 1998).

b. Los Alamos Canyon (includes Bayo, Acid, Pueblo, and DP Canyon)

Los Alamos Canyon has a large drainage that heads in the Sierra de los Valles. The Laboratory has used the land in the Los Alamos Canyon watershed continuously since the mid-1940s, with operations conducted at some time in all of the sub-drainages. Each of the canyons draining the watershed also receives urban runoff from the Los Alamos town site, and lower Pueblo Canyon receives treated sanitary municipal wastewater.

Past release of radioactive liquid effluents into Pueblo (via tributary Acid Canyon), DP, and Los Alamos Canyons has introduced americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, and tritium, among other radionuclides, into the canyon. Many of these radionuclides bind to stream sediments and persist at levels several orders of magnitude above worldwide fallout levels. Elevated levels of radioactivity can be found in those canyons in both surface waters and stream bottom sediments. Plutonium has moved down Pueblo Canyon, through Los Alamos Canyon, offsite across Pueblo de San Ildefonso lands, and reaches the Rio Grande near the Otowi Bridge (Graf 1997; Reneau et al., 1998). Plutonium-239,240 contamination from past Acid Canyon discharges has been traced in stream sediments more than 55 km to lower Cochiti Reservoir (Gallaher and Efurd 2002). Several contaminated sediment removal efforts have been conducted in Acid Canyon. In 2005, additional stabilization of sediment was performed in Pueblo Canyon to retard transport downstream. The installation of 3,000 linear feet of jute matting along channel banks that contained elevated radionuclide concentrations, and the planting of 3,000 willow plants to provide additional stream bank support, was completed in 2005 (PPWP 2005).

High concentrations of radionuclides were measured in several storm runoff samples collected near specific facilities within the watershed. These results indicate that additional erosion controls and water management structures likely are needed within the watershed. In Acid Canyon, large plutonium-239,240 concentrations were measured in three samples collected from a station located at South Fork of Acid Canyon and in one sample collected at Acid Canyon above Pueblo. The maximum plutonium-239,240 concentration in Acid Canyon was 235 pCi/L. Although stream sediment concentrations of plutonium-239,240 have progressively declined in past decades, these data indicate that downstream transport of the contaminant from the canyon is ongoing.

Hillside stations in middle Los Alamos Canyon contained elevated concentrations of plutonium-239,240 and americium-241. The highest concentrations were measured in storm runoff from channels below the Manhattan Project-era plutonium research building at TA-1 (station LA-SMA-4) and DP site at TA-21 (station LA-SMA-6.3). Two samples at LA-SMA-4 showed concentrations of plutonium-239,240 an average of 50 pCi/L. The maximum plutonium-239,240 concentration measured at LA-SMA-6.3 was 775 pCi/L, amongst the largest recorded at the Laboratory. Despite the high plutonium-239,240 concentrations measured in hillside runoff, concentrations measured in the canyon floor stream were considerably lower. The maximum plutonium-239,240 concentration in all of the Los Alamos Canyon watercourse stations was 7 pCi/L.

A stream gage in lower Los Alamos Canyon above the Rio Grande was installed in 2002 to monitor downstream runoff from Los Alamos and Pueblo Canyons. In 2005, snowmelt runoff samples were collected from this site, but no storm runoff samples were collected.

In 2005, we estimate that storm runoff carried approximately 5 mCi of Pu-239,240 across the Laboratory boundary, primarily from Los Alamos Canyon. This is significantly less than approximately 60 mCi estimated for the years 2001 through 2003 after the Cerro Grande fire, but larger than estimated pre-fire levels in the late 1990s of 1 mCi per year or less. This constitutes approximately five percent of the total inventory of residual plutonium-239,240 stored in stream sediments within the Los Alamos Canyon watershed in the late 1990s (LANL 2004).

The Los Alamos Canyon weir was constructed in the summer of 2000 after the Cerro Grande fire to slow runoff and catch sediment and associated contaminants before runoff flows downstream of LANL (Figure 6-14). During 2005, six snowmelt or storm runoff samples were collected immediately upstream and downstream of the weir. We estimate that approximately two-thirds of the suspended sediment load measured at the upstream station in 2005 was trapped in the weir.

This trapping efficiency is comparable to those calculated by Gallaher and Koch (2004) for the years 2000 through 2003, where efficiencies ranged from 23 to 80 percent and averaged 45 percent. Thus, the structure plays a significant role in limiting offsite movement of contaminated sediments from LANL. Time-weighted average concentrations of americium-241 in 2005 are estimated to drop at this location from about 3.3 pCi/L immediately upstream of the weir to 0.9 pCi/L downstream of the weir. Average plutonium-239,240 concentrations similarly declined in 2005 from 2.5 to 1.1 pCi/L. With proper maintenance, such structures may prove to be valuable in reducing off-site transport.

Figure 6-14. Low-head weir in Los Alamos Canyon retaining storm runoff and sediment. Notice deposition of stream sediments in basin of weir. Photographs courtesy of UDSA Forest Service.

At all locations evaluated with elevated radionuclide concentrations, substantial reductions in radioactivity would result if the suspended sediment concentrations were reduced. To illustrate, annualized radionuclide concentrations, as well as suspended sediment concentrations, were reduced by approximately two thirds after passing through the low-head weir.

Throughout the Los Alamos Canyon watershed, radionuclide concentrations in sediments remained below recreational and even residential SALs. Plutonium-239,240 concentrations in lower Los Alamos Canyon sediments were below analytical detection limits. Analysis of sediments from Pueblo and Los Alamos Canyons found no significant changes in radionuclide concentrations from the previous year. Plutonium-239,240 and cesium-137 concentrations temporarily increased after the Cerro Grande fire and have since fallen to near pre-fire levels (Figures 6-15 through 6-18).

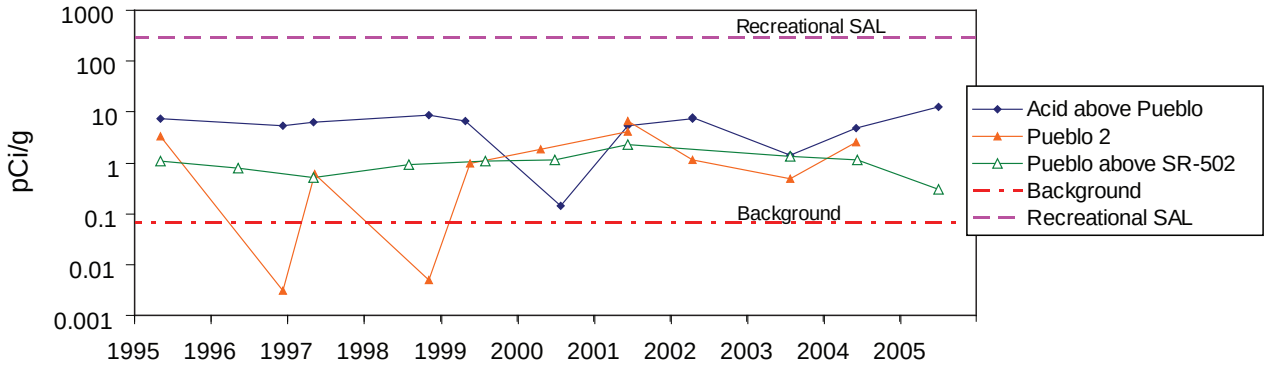


Figure 6-15. Long-term plutonium-239,240 trends in Pueblo Canyon sediments.

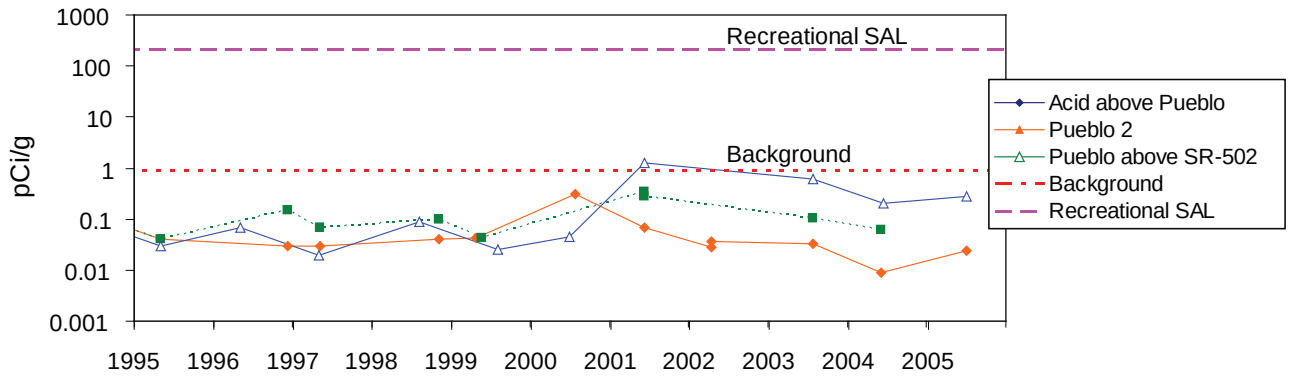


Figure 6-16. Long-term cesium-137 trends in Pueblo Canyon sediments.

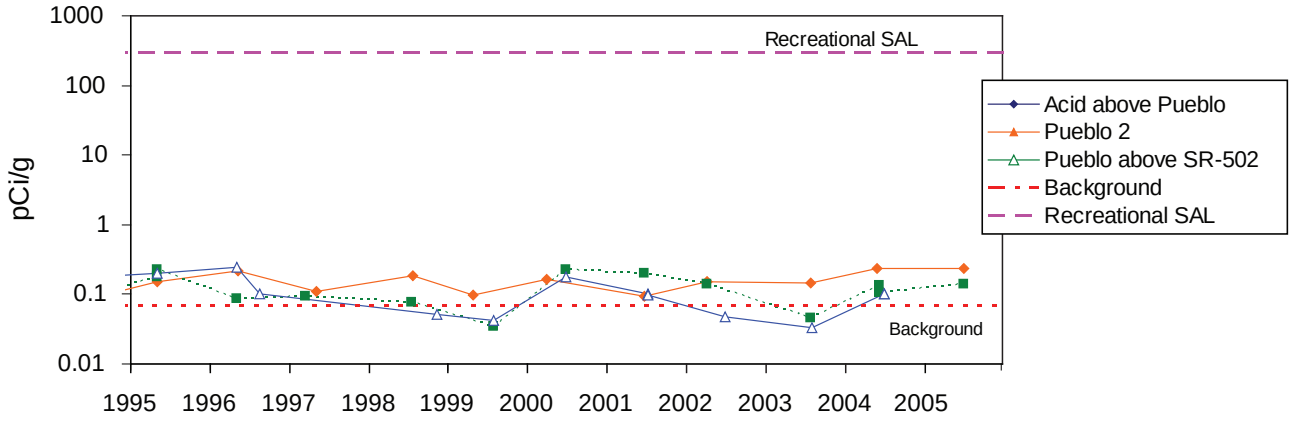


Figure 6-17. Long-term plutonium-239,240 trends in Los Alamos Canyon sediments.

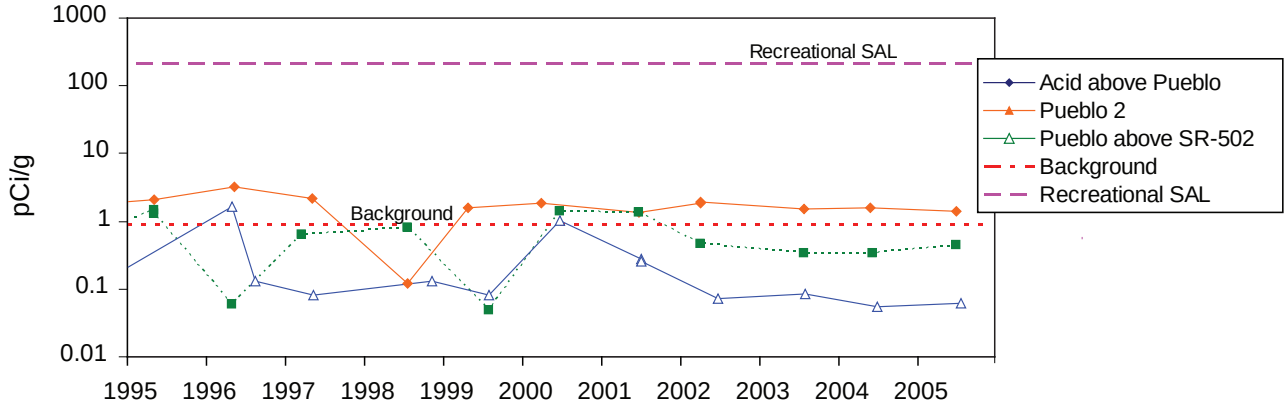


Figure 6-18 . Long-term cesium-137 trends in Los Alamos Canyon sediments.

Nonradiological constituents detected at significant concentrations in storm runoff and stream sediments in the Los Alamos Canyon watershed include PCBs, benzo(a)pyrene, mercury, copper, lead, and zinc. In Los Alamos Canyon (Figure 6-19), PCBs were detected in runoff above New Mexico water quality standards in multiple samples. The largest PCB concentrations in runoff were measured in middle Los Alamos Canyon from hillside channels that drain former TA-1 and TA-21. At one site immediately below LANL facilities at TA-21, concentrations were greater than standards in three of four PCB samples collected. Analysis in 2005 detected benzo(a)pyrene in sediment samples from station Acid Canyon above Pueblo at 94 percent of the draft recreational soil screening level (LANL 2005) and 1.2 times the industrial soil screening level (NMED 2006) (Figure 6-20). We previously concluded that the major source of benzo(a)pyrene in the Los Alamos Canyon drainage was urban runoff, rather than a Laboratory-related source (LANL 2004).

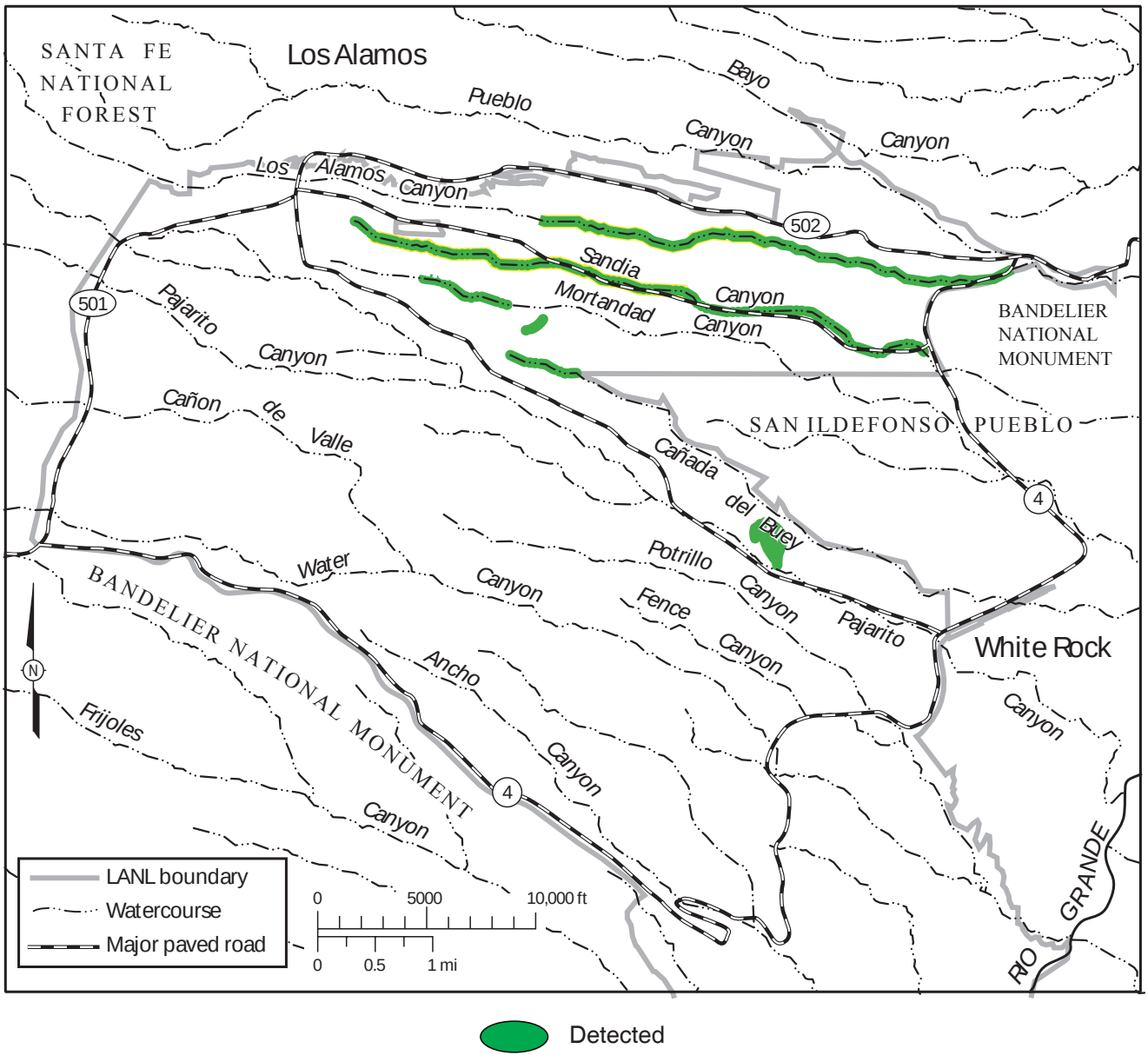


Figure 6-19. Location of surface water with detected PCBs.

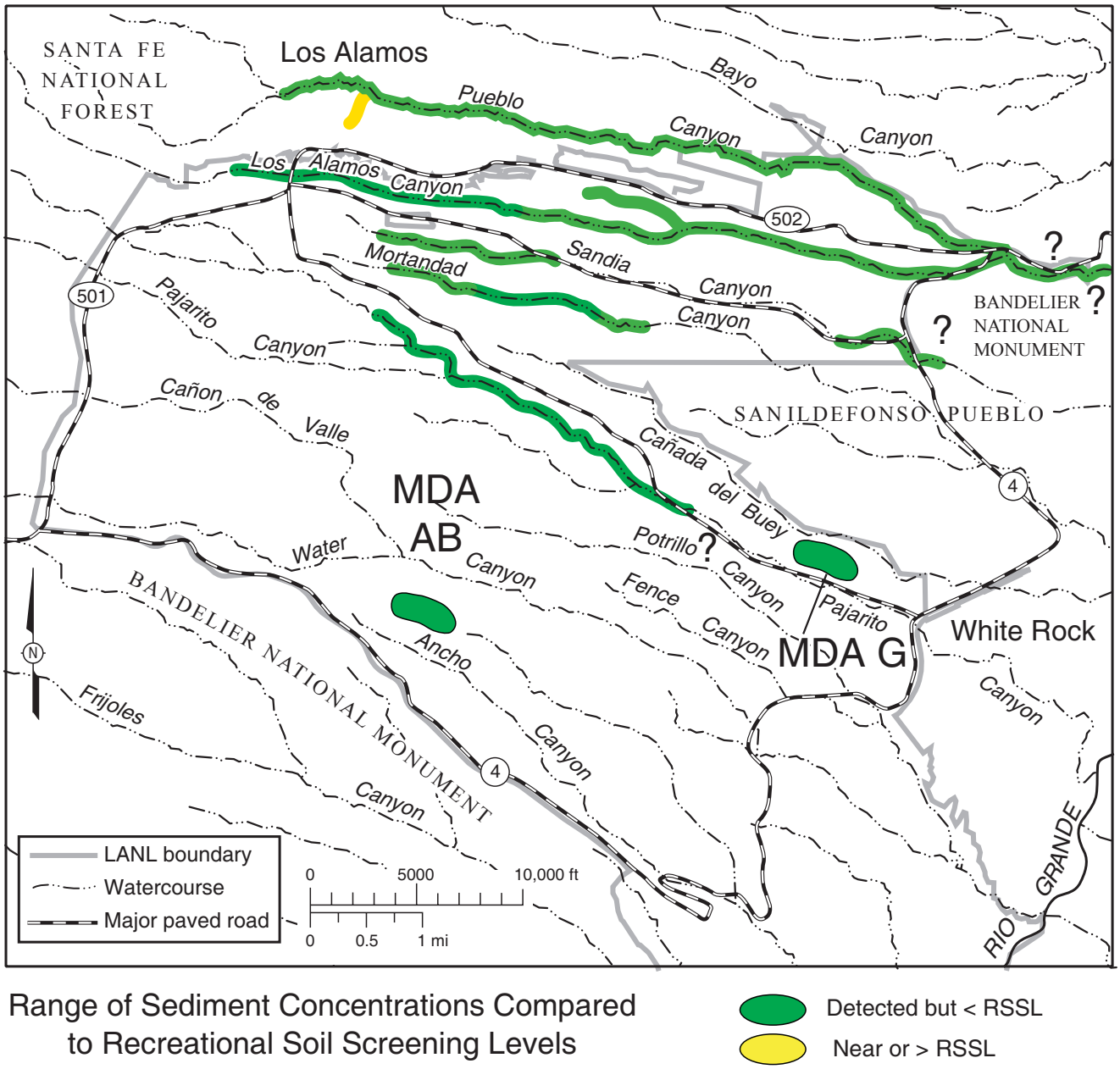


Figure 6-20. **Location of sediment with benzo(a)pyrene, a polycyclic aromatic hydrocarbon, detected or above screening levels. Different colors indicate where polycyclic aromatic hydrocarbons are detected or are above the LANL draft recreational soil screening level. The highest concentration in 2005 was in Acid Canyon, at 95 percent of the recreational soil screening level and 1.2 times the industrial soil screening level.**

Mercury was detected in runoff samples at several hillside locations in Pueblo and Los Alamos Canyons at concentrations two to three times above the wildlife habitat standard. In the canyon floors of these drainages, however, mercury concentrations were below the standard in Pueblo Canyon and only slightly (1.1 times) above the standard in Los Alamos Canyon. LANL mercury sources are known to exist in the drainage system, and erosion control features have been installed near the sources to minimize downstream movement. Concentrations of copper (Figure 6-21), lead, and zinc were detected above the NM acute aquatic life standards. Elevated concentrations of these elements were found in DP Canyon above LANL facilities at TA-21 and are likely derived from urban runoff sources rather than Laboratory operations.

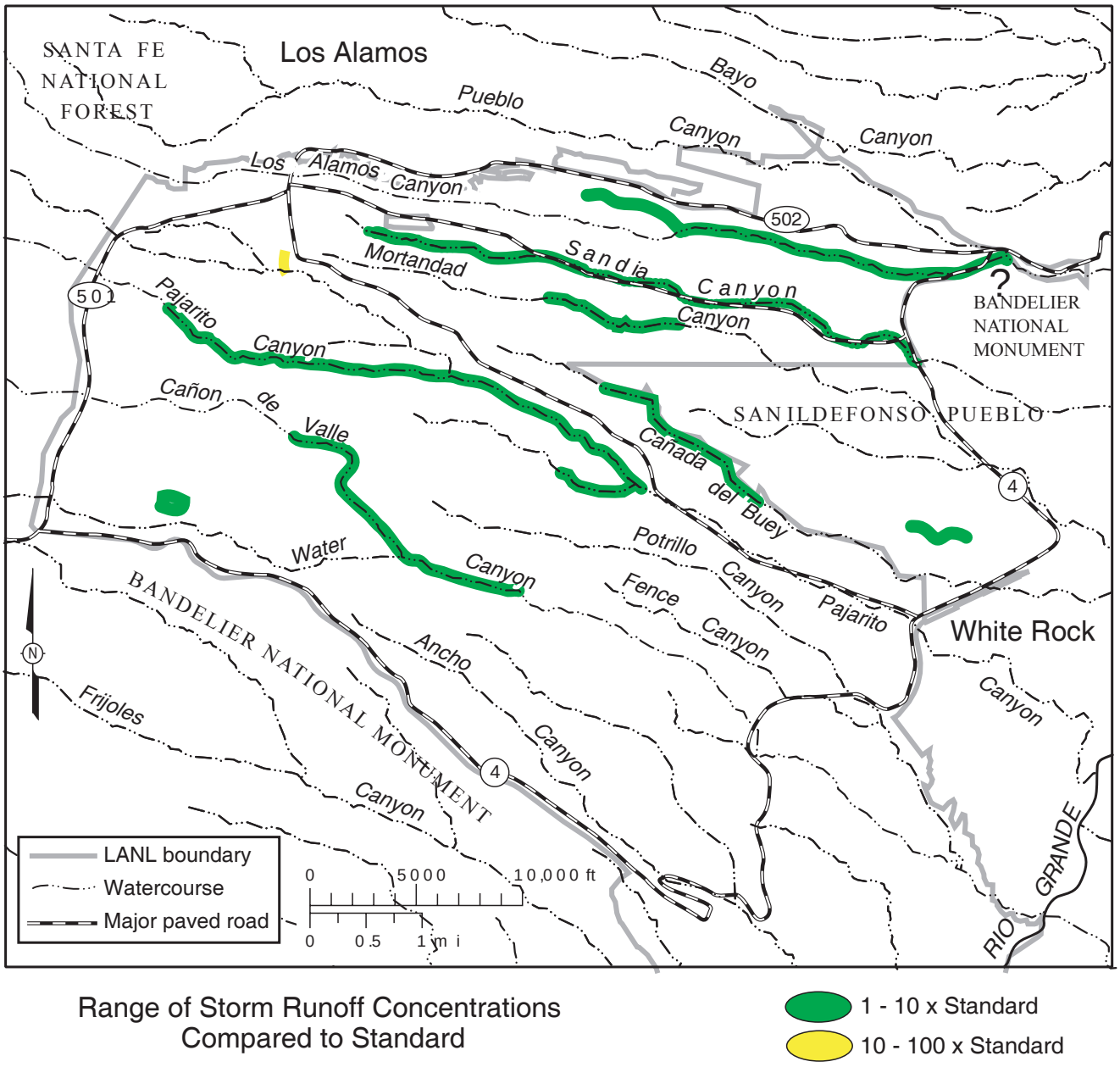


Figure 6-21. Location of surface water with levels of dissolved copper greater than stream standards.

c. Sandia Canyon

Sandia Canyon heads on the Pajarito Plateau within the Laboratory's TA-3 area and has a total drainage area of about 5.5 mi^2. This relatively small drainage extends eastward across the central part of the Laboratory and crosses Pueblo de San Ildefonso land before joining the Rio Grande. Effluent discharges primarily from power plant blowdown create perennial flow conditions along a 2-mi reach below TA-3. Only one day of runoff was recorded at the Laboratory boundary in 2005 (Shaull et al. 2006). Monitoring results have consistently shown minimal off-site contamination from the Laboratory in Sandia Canyon.

PCB concentrations above water quality standards were detected throughout the watershed from near the Laboratory's main technical area at TA-3 to the LANL downstream boundary at SR-4. Unlike the Los Alamos Canyon watershed, however, there is minimal off-site stream flow in Sandia Canyon. Four of four storm runoff

samples collected above the Sandia Canyon firing range contained PCB Aroclors 1254 and 1260 at concentrations greater than the New Mexico stream standards. The Aroclor 1260 was also detected in a runoff sample collected at the Laboratory's eastern boundary. The human health standards protect people from ingesting contamination through fish consumption, but there are no fish in Sandia Canyon. Further, flows from the canyon have little probability of reaching the Rio Grande. In addition, PCB concentrations above standards were detected at four site-specific monitoring stations in upper Sandia Canyon. Sediment samples collected in Sandia Canyon contained PCB concentrations well below (16 percent of) the LANL draft recreational soil screening level. Downstream sediment concentrations of PCBs decline quickly and are near background (fallout) ranges at the LANL downstream boundary. PCB concentrations in sediments at station Sandia below the Wetlands in 2005 are variable with no clear trend evident (Figure 6-22). PCB concentrations at the other canyon stream sediment stations were consistent with previous years.

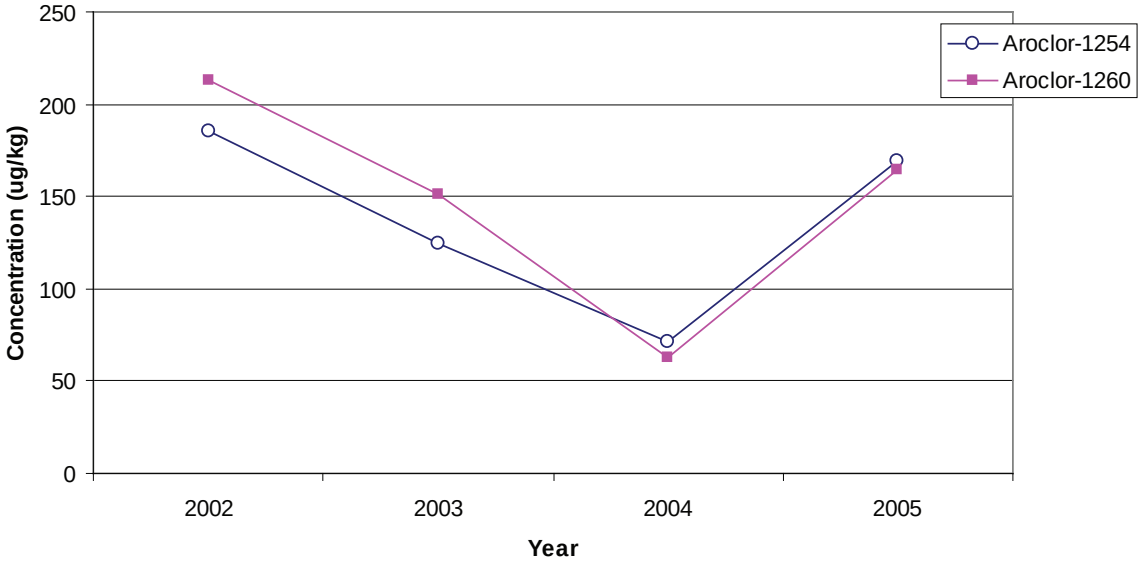


Figure 6-22. Recent trends of PCB concentrations in stream sediments at the Sandia below Wetlands station.

Above-background concentrations of chromium, copper, lead, mercury, silver, and zinc in surface water and sediments are found along an approximately two-mile segment of Sandia Canyon below TA-3. Storm runoff occasionally contains concentrations above regulatory standards. Measurements in 2005 found dissolved concentrations of copper (Figure 6-21) and lead above the acute and chronic aquatic life standards by two to six times, and total mercury concentrations were above the wildlife habitat standard by four times.

Perchlorate was detected in a base-flow sample collected in January 2003 from below the power plant at a concentration of 18.5 µg/L. We collected subsequent samples in March 2003 of outfalls 001 (power plant) and 03A027 (cooling tower) discharging to Sandia Canyon that did not detect perchlorate using EPA Method 314 at a detection limit of 4 µg/L. Analyses of Sandia Canyon base flow in 2005 did not detect perchlorate.

d. Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Mortandad Canyon heads on the Pajarito Plateau near the main Laboratory complex at TA-3. The canyon crosses Pueblo de San Ildefonso land before joining the Rio Grande.

The annual time-weighted average concentrations of americium-241, plutonium-238, and plutonim-239,240 are well below the BCG in unfiltered surface water collected below Effluent Canyon (Table 6-2). When the mixture of radionuclides is considered (see discussion in Section F.1), the surface waters in Mortandad Canyon below Effluent Canyon were seven percent of the BCG.

Figures 6-23 through 6-26 show activities of plutonium-238, plutonium-239,240, americium-241, and cesium-137 at four sediment stations in Mortandad Canyon. All of the stations are located below the RLWTF discharge. The stations MCO-8.5, MCO-9.5, and the LANL boundary are located below sediment traps, installed in the 1970s.

Stream sediments in Mortandad Canyon downstream of Effluent Canyon as far as the sediment traps, and downstream to near MCO-9.5, contain above background concentrations of americium-241, plutonium-238, plutonium-239,240, and cesium-137 (Figures 6-23 through 6-26). Radionuclide concentrations in active channel sediment upstream of the sediment traps were 5 percent or less of the recreational SAL (LANL 2005) (Figure 6-24). The sediment traps are located approximately two miles upstream of the Laboratory's eastern boundary. Despite the history of releases into the Mortandad Canyon watershed, radioactivity in sediments at the Laboratory's eastern boundary is within background levels or is only slightly elevated above background levels. Americium-241, cesium-137, and plutonium-239,240 concentrations in sediments at the boundary are orders of magnitude lower than at upstream stations closer to the Radioactive Liquid Waste Treatment Facility (RLWTF) discharge. The rarity of stream flow within Mortandad for two miles upstream of the Laboratory boundary is the main reason for the lower sediment radioactivity downstream.

Radioactivity concentrations in sediments just below the RLWTF have not changed appreciably in the past decade. Concentrations in Mortandad Canyon at the LANL boundary are near or below the sediment background levels. However, recent monitoring results show that concentrations near the Laboratory boundary are higher than previously recognized before 2001. The increase in plutonium and cesium activities at MCO-8.5 and –9.5 was due to relocating the sampling stations to the active channel.

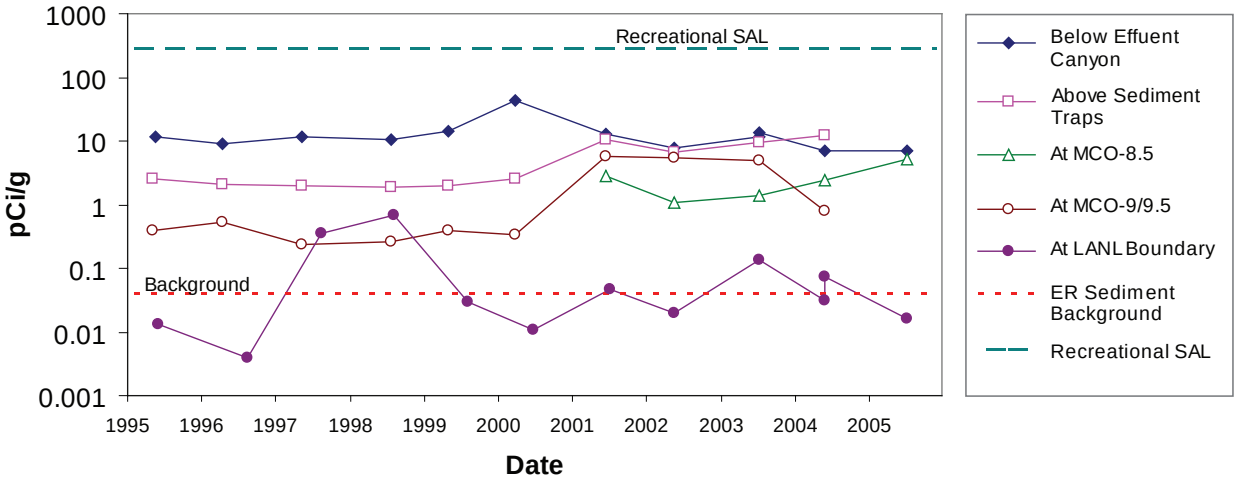


Figure 6-23. Long-term americium-241 trends in Mortandad Canyon sediments.

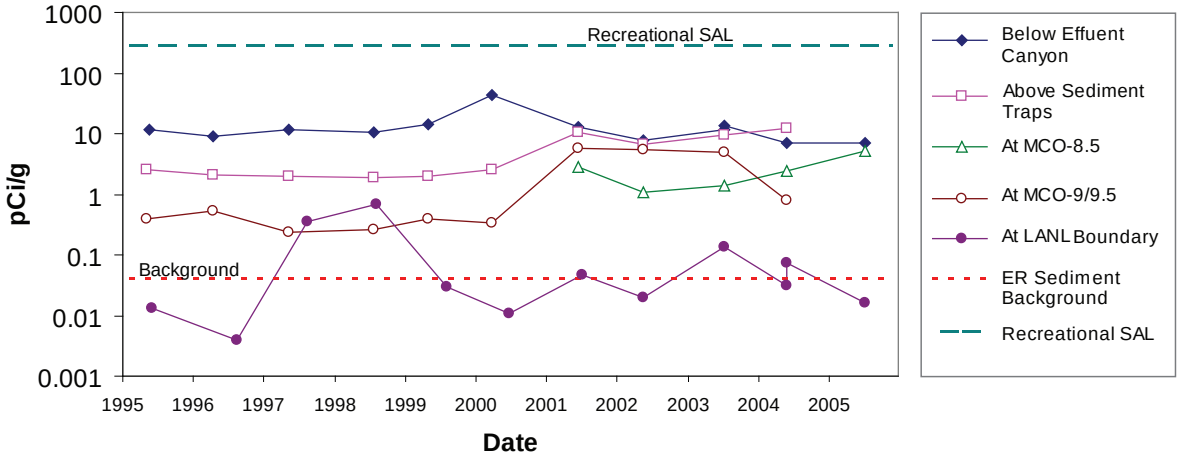


Figure 6-24. Long-term cesium-137 trends in Mortandad Canyon sediments.

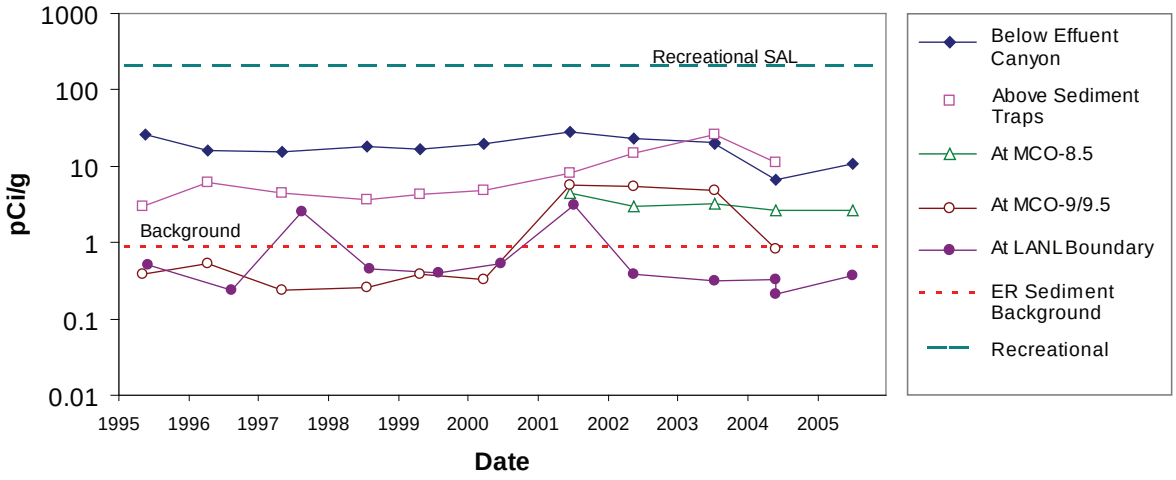


Figure 6-25. Long-term plutonium-238 trends in Mortandad Canyon sediments.

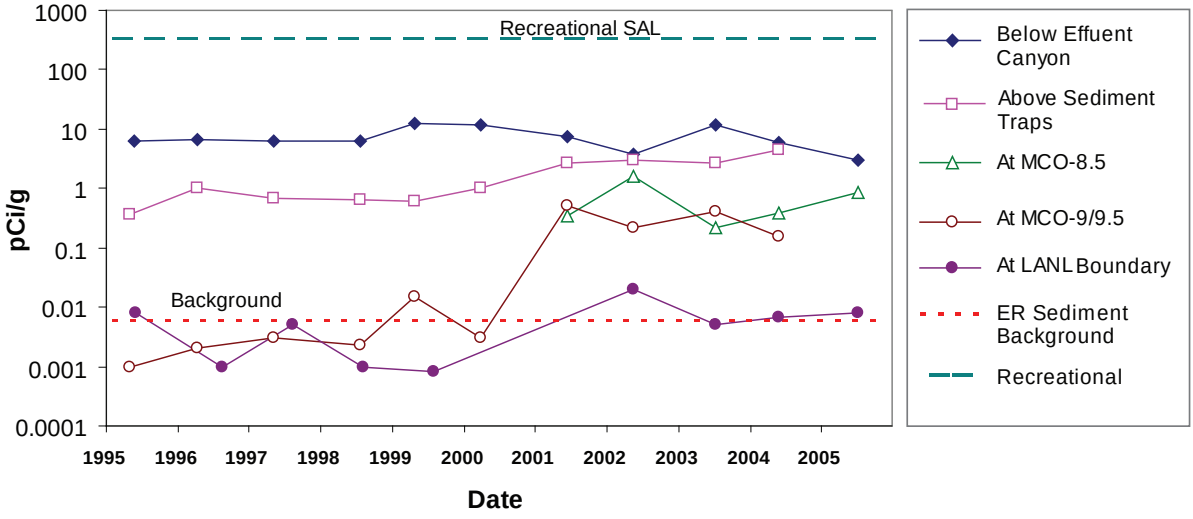


Figure 6-26. Long-term plutonium-239,240 trends in Mortandad Canyon sediments.

PCBs above water quality standards were detected in storm runoff samples from Mortandad and Ten Site Canyons, and from Cañada del Buey. In Mortandad Canyon and in Cañada del Buey the detections were for Aroclor-1254, while in Ten Site Canyon two detections for Aroclor-1260 were recorded—these results suggest different sources of PCBs in the canyons. Dissolved copper concentrations were detected above the New Mexico Acute Aquatic Life stream standard by three times in base flow and runoff samples collected at the station Mortandad below Effluent Canyon station.

Radioactivity in sediment around MDA G and in Cañada del Buey was generally consistent in 2005 with previous years, with the following exceptions. Starting in 2002, plutonium-239,240 concentrations have gradually increased at sediment sampling stations MDA G-7 and G-8, which are both located on the eastern portion of Area G (Figure 6-27). MDA G-7 station samples a tributary of Cañada del Buey and MDA G-8 is in a tributary that drains to Pajarito Canyon. While the 2005 results were approximately 10 times above background fallout levels, they were far below (0.1 percent) the recreational SAL (LANL 2005).

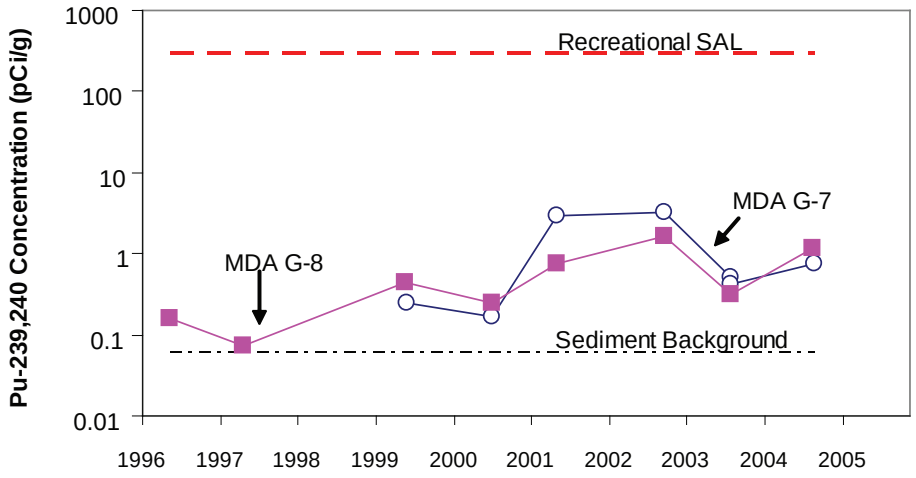


Figure 6-27. Recent trends of plutonium-239,240 activities at Material Disposal Area G sediment stations G-7 and G-8.

Plutonium-239,240 was not detected in Cañada del Buey sediments beyond the immediate vicinity of MDA G in 2005. One storm runoff sample collected from the hillside north of Area G (Station G-13) contained detectable PCB Aroclor-1254. The Laboratory's PCB disposal area is located within Area G but surface drainage is to the south, and in the opposite direction. The detection of PCBs in that sample likely reflects the large suspended sediment concentration in the sample (22,000 mg/L).

e. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon heads on the flanks of the Sierra de los Valles on US Forest Service lands. The canyon crosses the central part of the Laboratory before entering Los Alamos County lands in White Rock.

Consistent with past years, we found americium-241, plutonium-238, and plutonium-239,240 at concentrations greater than background in sediment samples from channels draining MDA G. Concentrations of these radionuclides were commonly 5 to 10 times background. Since 1997, station MDA G-8 shows a statistically significant ($p<0.05$, Kendall Tau nonparametric test) upward trend in Pu-239,240 concentrations. All of the radionuclides were at concentrations below recreational and even residential SALs.

In runoff samples collected in 2004, we detected dissolved copper concentrations greater than the New Mexico Acute Aquatic Life standard in channels throughout the Pajarito Canyon watershed, including Twomile, Threemile, and Starmers Canyons (Figure 6-21). Results for 2005 do not support that finding, as dissolved copper concentrations along Pajarito stream were below standards. Dissolved copper concentrations greater than standards were limited to three sites on hillsides. Concentrations of copper and zinc larger than standards have consistently occurred at the Twomile tributary at TA-3 station. That site monitors drainage from a large paved area and the Laboratory's main machine shop.

In Threemile Canyon, high concentrations of uranium-238 were detected in three runoff samples collected below a high-explosive firing site (station 3M-SMA-0.6) (Figure 6-5). The samples indicate the presence of depleted uranium, as activity ratios of uranium-238 to uranium-234 were in excess of seven.

A sediment sample from Pajarito Canyon above SR 4 contained 15 metals and several radionuclides elevated two to five times above sediment background (LANL 1998). Cesium-137 concentrations were 6.5 times above background. The 2005 results are similar to the 2004 results and indicate a source(s) other than MDA G because cesium-137 is not substantially elevated in sediments around Area G. The sample station was relocated in 2002. Previously, the station was downstream of SR-4, where flow is rapid and little sediment accumulates; the relocated station is in a depositional area upstream of the berm formed by SR-4. The elevated analyte levels may be related to the finer texture of sediment that accumulates above the highway. Some of the elevated constituents, for example, cesium-137, barium, and manganese, were also found at high concentrations in post–Cerro Grande fire runoff samples (Gallaher and Koch 2005). Because the station is now located where sediment accumulates, both Cerro Grande fire-related and Laboratory-derived constituents are probably present. A sediment sample collected from Pajarito Canyon below SR-501 (upstream of LANL operations) contained barium in a concentration 1.4 times the sediment background level and selenium in a concentration 5.3 times the background level (LANL 1998).

PCBs were detected in one of four runoff samples collected at the MDA G-6U station located on the southeastern corner of Area G. This station monitors drainage from the central portion of MDA G, including the Laboratory's PCB disposal facility. This is the first detection of PCBs in waters in years of monitoring several drainage channels along the southern perimeter of MDA G.

f. Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Water Canyon heads on the flanks of the Sierra de los Valles on US Forest Service land and extends across the Laboratory to the Rio Grande. Water Canyon and its tributary Cañon de Valle pass through the southern portion of the Laboratory where explosives development and testing take place. Elevated concentrations of barium, HMX, and RDX have previously been measured in sediment and surface water and are consistent with previous results. Average concentrations for dissolved barium and RDX for 2005 exceed these risk levels by about three and seven times, respectively. This area is being investigated under a RCRA Corrective Measures Study.

Base flow and storm runoff within Cañon de Valle and Water Canyons contain concentrations of dissolved copper, dissolved zinc, and dissolved silver larger (by two to three times) than the New Mexico Acute Aquatic Life standards. Past discharges from photography laboratories are probably the source of the silver.

G. SPECIAL STUDY OF RADIOLOGICAL CONCENTRATIONS IN THE JEMEZ RIVER DRAINAGE

The Pueblo of Jemez and the Laboratory collaborated in a joint reconnaissance evaluation of plutonium origins and radionuclide concentrations in the Jemez River drainage. Stream sediments were collected at three locations and analyzed for isotopic composition and radionuclide concentrations. Two of the sites were located on the East Fork of the Jemez River within the Valles Caldera National Preserve, and a third was located near the village of Canon, which is located approximately seven miles south of the town of Jemez Springs (Figure 6-28).

The origin of the plutonium was determined through Thermal Ionization Mass Spectrometry (TIMS) analyses. The TIMS procedure establishes the isotopic signature of the plutonium in the sample by precisely measuring the number of atoms of the isotopes plutonium-240 and plutonium-239. Plutonium derived from worldwide fallout has an isotopic signature (plutonium-240/plutonium-239 atom ratio) much different than plutonium used by LANL in its research activities. This technique has been successfully used in many studies around the world to identify the origin of plutonium. LANL and NMED have used this technique to assess stream sediments in the Rio Grande (for example, Gallaher and Efurd 2002). Split samples of the stream sediments were also submitted to the General Engineering Laboratories for conventional radionuclide concentration determinations.

Figure 6-28. Cooperative sampling of stream sediments in Jemez River drainage conducted with Pueblo of Jemez scientists. Sampling was conducted of the Jemez River near Jemez Springs (left picture) and two ponds along the East Fork of the Jemez River within the Valles Caldera National Preserve (right). Some samples were sieved (right) to determine how the size of the sediment affects the concentrations of radionuclides.

The TIMS results indicated that the plutonium was dominantly derived from fallout. All three isotopic signatures were consistent with those of regional background soils and sediments. The radionuclide concentrations were also within background ranges. Plutonium-238 and -239,240 concentrations were below analytical detection levels for conventional alpha spectrometry methods.

H. QUALITY ASSURANCE

To process watershed samples, we used the same quality assurance (QA) protocols and analytical laboratories described in Chapter 5. QA performance for the year is also described in Chapter 5.

I. REFERENCES

DOE 1990: "Radiation protection of the public and the environment," US Department of Energy Order 5400.5, Washington D.C.

DOE 1991: "Environmental regulatory guide for radiological effluent monitoring and environmental surveillance," DOE/EH-0173 (January 1991).

DOE 2002: "A graded approach for evaluating radiation dose to aquatic and terrestrial biota," DOE-STD-1153-2002.

DOE 2003: "Strategy for evaluation of surface water quality relative to DOE Order 5400.5," Department of Energy memorandum from Rex J. Borders, Albuquerque Operations Office, to G. Turner, Los Alamos Site Office, January 9, 2003.

EPA 2005a: United States Environmental Protection Agency Region 6, In the Matter of United States Department of Energy and the Los Alamos National Laboratory, NPDES Nos. NMR05A735, NMR05A734, and NM0028355, Federal Facility Compliance Agreement, Docket No.CWA-06-2005-1701 (February 2005) http://www.epa.gov/region6/6xa/lanl.pdf.

EPA 2005b: United States Environmental Protection Agency Region 6, In the Matter of University of California, Permittee, NPDES No. NMR05A734, Administrative Order, Docket No. CWA-06-2005-1734 (March 2005).

EPA 2005c: US Environmental Protection Agency Region 6, "EPA Region 6 Human Health Medium-Specific Screening Levels" (November 2005), http://www.epa.gov/arkansas/6pd/rcra_c/pd-n/screen.htm.

ESP 1988: Environmental Surveillance Program, "Environmental surveillance at Los Alamos during 1987," Los Alamos National Laboratory report LA-11306-MS (May 1988).

Gallaher and Efurd 2002: B. M. Gallaher and D. W. Efurd, "Plutonium and uranium from Los Alamos National Laboratory in sediments of the Northern Rio Grande Valley," Los Alamos National Laboratory report LA-13974 (August 2002).

Gallaher and Koch 2004: B. M. Gallaher and R. J. Koch, "Cerro Grande fire impacts to water quality and stream flow near Los Alamos National Laboratory: results of four years of monitoring," Los Alamos National Laboratory report LA-14177 (September 2004).

Gallaher and Koch 2005: B. M. Gallaher and R.J. Koch, "Water quality and stream flow after the Cerro Grande Fire, a summary," Los Alamos National Laboratory report LALP-05-009 (January 2005).

Gilliom et al. 1997: R.J. Gilliom, D.K. Mueller, and L.H. Nowell, "Methods for Comparing Water-Quality Conditions Among Water-Quality Study Units, 1992-1995," US Geological Survey Open-File Report 97-589.

Gonzales and Fresquez 2003: G. J. Gonzales and P. R. Fresquez, "Polychlorinated Biphenyls (PCBs) in Catfish and Carp Collected from the Rio Grande Upstream and Downstream of Los Alamos National Laboratory," Los Alamos National Laboratory report LA-14001 (February 2003).

Graf 1997: W. L. Graf, Plutonium and the Rio Grande: Environmental Change and Contamination in the Nuclear Age (Oxford University Press, New York, 1997).

Langmuir 1997: D. Langmuir, "Aqueous Environmental Geochemistry," Prentice Hall, Inc., ISBN 0-02-367412-1.

LANL 1998: "Inorganic and radionuclide background data for soils, canyon sediments, and Bandelier Tuff at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-98-4847 (September 1998).

LANL 2004: "Los Alamos and Pueblo Canyon investigation report," Los Alamos National Laboratory document LA-UR-04-2714 (April 2004).

LANL 2005: "Derivation and Use of Radionuclide Screening Action Levels, Revision 1," Los Alamos National Laboratory report LA-UR-05-1849 (May 2005).

LANL 2006: "Los Alamos National Laboratory Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan," Los Alamos National Laboratory report LA-UR-06-1840 (March 2006).

McLin, S.G. 2004: "Background Radioactivity in Sediments near Los Alamos, New Mexico," Science of the Total Environment 328:143-159 (January 2004).

McNaughton 2005: M.W. McNaughton, "Biota dose assessment at LANL," Los Alamos National Laboratory document LA-UR-05-4699 (April 2006).

Mullen and Koch 2004: "PCB congener preliminary results, 2000–2003 surface water and sediment sampling," Los Alamos National Laboratory document LA-UR-04-0758 (March 2004).

NMED 2003a: "Approved 2002–2004 State of New Mexico §303(d) list for assessed river/stream reaches requiring total maximum daily loads (TMDLs)," New Mexico Environment Department Surface Water Quality Bureau (June 2003).

NMED 2006a: State of New Mexico, "State of New Mexico Procedures for Assessing Standards Attainment for Section §303(d)/§305(b) Water Quality Monitoring and Assessment Report: Assessment Protocol." (January 2006) http://www.nmenv.state.nm.us/swqb/protocols/AssessmentProtocol.pdf, accessed July 19, 2006.

NMED 2006b: "Technical Background Document for Development of Soil Screening Levels, Revision 6.0," June 2006. ftp://ftp.nmenv.state.nm.us/hwbdocs/HWB/guidance_docs/NMED_June_2006_SSG.pdf

NMED 2006c: "Submittal of 2005 Polychlorinated Biphenyl (PCB) Storm Water Monitoring Data," Letter report from Stephen Yanicak (NMED DOE Oversight Bureau) to Gene Turner, (DOE Office of Los Alamos Site Operations), March 31, 2006.

NMWQCC 2002: New Mexico Water Quality Control Commission, "Ground and surface water protection," 20.6.2 NMAC (September 15, 2002).

NMWQCC 2004: New Mexico Water Quality Control Commission, "2004-2006 State of New Mexico Integrated Clean Water Act 303(d)/305(b) Report" (2004). http://www.nmenv.state.nm.us/wqcc/303d-305b/2004/index.html.

NMWQCC 2005: New Mexico Water Quality Control Commission, "State of New Mexico standards for interstate and intrastate surface waters," 20.6.4 NMAC (as amended through July 17, 2005). http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0004.pdf.

PPWP 2005: Pajarito Plateau Watershed Partnership/Los Alamos County 319 Grant Quarterly Report, April to June, 2005.

Purtymun and Stoker 1987: W. D. Purtymun and A. K. Stoker, "Environmental status of Technical Area 49, Los Alamos, New Mexico," Los Alamos National Laboratory report LA-11135-MS (November 1987).

Shaull et al. 2006: D. A. Shaull, D. Ortiz, M. R. Alexander, and R. P. Romero, "Surface Water Data at Los Alamos National Laboratory 2005 Water Year," Los Alamos National Laboratory report LA-14239-PR (May 2006).

Watkins and Del Signore 2005: "RLWTF annual report for 2004," Los Alamos National Laboratory document LA-UR-05-4395.

7. SOIL MONITORING

contributing author:
Philip Fresquez

To Read About **Turn to Page**

A. INTRODUCTION

A soil sampling and analysis program provides the most direct means of determining the concentration, distribution, and long-term trends of radionuclides and other chemicals around nuclear facilities (DOE 1991). The soil characterization program provides information about potential pathways (such as soil ingestion, food ingestion, resuspension into the air, and groundwater contamination) that may deliver radioactive materials or chemicals to humans.

The overall soil surveillance program at Los Alamos National Laboratory (LANL or the Laboratory) consists of

- An institutional component that monitors soils within and around the perimeter of LANL in accordance with Department of Energy (DOE) Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993); and
- A facility component that monitors soils within and around the perimeter of the Laboratory's
  - principal radioactive waste disposal area (Area G) in accordance with DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b), and
  - principal explosive test facility (Dual Axis Radiographic Hydrodynamic Test [DARHT]) in accordance with the Mitigation Action Plan (DOE 1996).

The objectives of LANL's soil surveillance program are to determine the following:

- Radionuclide and nonradionuclide (heavy metal and organic chemical) concentrations and distributions in soils collected from potentially impacted areas (Lab-wide and facility-specific);
- Trends over time (i.e., whether radionuclides and nonradionuclides are increasing or decreasing over time); and
- The committed effective dose equivalent potentially received by surrounding area residents (see Chapter 3 for the potential radiation doses that individuals may receive from exposure to soils).

B. SOIL STANDARDS

To evaluate Laboratory impacts from radionuclides and nonradionuclides, the soil-sampling team first compares the analytical results of soil samples collected from the Laboratory's on-site and perimeter areas to regional or baseline statistical reference levels (RSRLs or BSRLs). Where the results exceed these levels, we then compare the concentrations to the soil screening levels (SLs); and, finally, if needed, to the standard. Table 7-1 summarizes the levels and/or the standard used to evaluate the soil sample results.

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations = 99 percent confidence level) for radionuclides and nonradionuclides calculated from soil data collected from regional locations away from the influence of the Laboratory over at least the last five sampling periods. (Note: For a list of regional locations, see Fresquez 2004a.) RSRLs, which represent natural and fallout sources, are calculated annually and can be found in the annual issues of the Laboratory's Environmental Surveillance Report.
- On-site baseline levels: The Mitigation Action Plan for LANL's DARHT facility, the Laboratory's principal explosive test facility, mandated the establishment of baseline (pre-operational) concentrations for potential environmental contaminants that might result from DARHT operations (DOE 1996). BSRLs are the concentrations of radionuclides and nonradionuclides in soils and sediments around the DARHT facility during the years 1996 through 1999, before the operational phase (as of the year 2000). The BSRL concentrations of radionuclides and trace elements are calculated from the mean DARHT facility sample concentration plus two standard deviations, 95 percent confidence level (Fresquez et al. 2001a). (Note: Prior evaluations of BSRLs with RSRLs [at two sigma] show no statistical differences between the two. The soil-sampling team uses BSRLs at DARHT to meet Mitigation Action Plan requirements.)
- Soil Screening levels: SLs for radionuclides are set below the federal dose level of 100 mrem so that potential concerns may be identified in advance of major problems, i.e, a "yellow flag." If a constituent exceeds an SL, then we investigate the reason for that increase more thoroughly. LANL's Environmental Remediation and Surveillance Program developed screening action levels to identify potential contaminants of concern on the basis of a 15-mrem protective dose limit (this is 15 percent of the standard) (LANL 2005) using the RESRAD computer model version 6.21 (Yu et al. 1995). We compared nonradionuclides to the New Mexico Environmental Department (NMED) soil screening levels that are set at a 10^{-5} risk for carcinogens or a hazard quotient (HQ) of 1 for non-carcinogens (NMED 2005).
- Standard: If screening levels for radionuclides are exceeded, then a dose to a person would be calculated using RESRAD. The calculated dose would be based on a residential scenario with soil ingestion, inhalation of suspended dust, and ingestion of homegrown fruits and vegetables as the primary exposure pathways for one or more radionuclides taken from supplemental Table S7-1. Unit conversions, input parameters, model and parameter assumptions, and the uncertainty analysis that we used can be found in Fresquez et al. 1996. This calculated dose would be compared to the 100-mrem/yr DOE standard.

Table 7-1
Application of Soil Standards and Other Reference Levels to LANL Monitoring Data

Constituent	Sample Location	Standard	Screening Level	Background Level
Radionuclides	Perimeter, On-site, and Area G	100 mrem	15 mrem	RSRL
	DARHT	100 mrem	15 mrem	BSRL
Nonradionuclides	Perimeter		10^{-5} risk (resident) or HQ = 1	RSRL
	On-site		10^{-5} risk (industrial) or HQ = 1	RSRL
	Area G		10^{-5} risk (industrial) or HQ = 1	RSRL
	DARHT		10^{-5} risk (industrial) or HQ = 1	BSRL

C. INSTITUTIONAL MONITORING

1. Monitoring Network

For a complete description of the soil-sampling monitoring network, see Fresquez 2004a. In the past, the soil-sampling team collected samples from 12 on-site, 10 perimeter, and four regional locations on an annual basis (Figure 7-1). Because a review of past analytical data has shown that levels of radionuclides (Fresquez et al. 1998) and nonradionuclides (Fresquez et al. 2000, Fresquez et al. 2001b) in soils collected within and around the LANL perimeter have been very low and, for the most part, have not increased over time, soils are now sampled once every three years. Our last survey was in 2003 (Fresquez 2004a) and the next planned full-scale soil assessment will occur in 2006.

Although the soil-sampling program was changed to a three-year sampling cycle, the Pueblo de San Ildefonso requested that we annually collect two perimeter soil samples on their lands that are downwind of Area G, the Laboratory's principal radioactive waste disposal site. Area G, approximately 63 ac in size, is located in the Laboratory's Waste Disposal Site (Technical Area [TA] 54) at the Laboratory's eastern boundary. Soil samples at these locations were collected at the 0- to 2-in. depth from relatively level, open (unsheltered by trees or buildings), rock-free, and undisturbed areas on Pueblo de San Ildefonso lands.

One sample, identified as "San Ildefonso," was collected across Mortandad Canyon from Area G, and the other sample, identified as "Tsankawi/PM-1," was collected about 2.5 miles from Area G. These samples were analyzed for tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; and uranium-238. Also, the soils were analyzed for 23 trace and abundant elements, including barium, beryllium, chromium, mercury, cadmium, lead, and other metal elements. Results for tritium are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g dry weight basis; and, the results for the elements are reported on a mg/kg (parts per million) and µg/kg (parts per billion) dry weight basis. The results from these two samples are in supplemental Table S7-1.

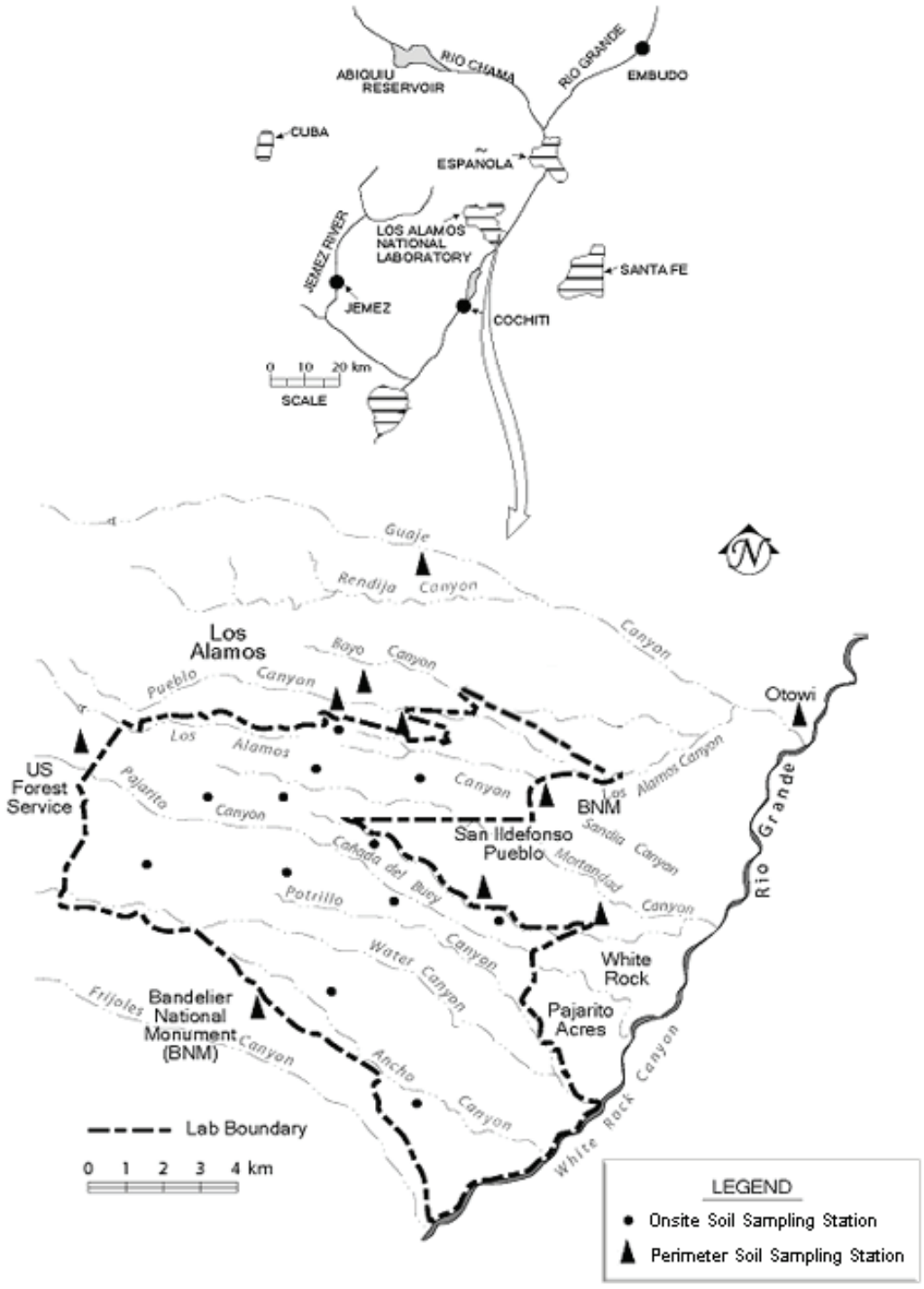


Figure 7-1. On-site Laboratory, perimeter, and off-site regional soil sampling locations.

2. Radionuclide Analytical Results

When we compared the radionuclide concentrations with regional background concentrations on both Pueblo de San Ildefonso sites, we found that all radionuclides (with the exception of uranium-234 and uranium-238 isotopes in the Tsankawi/PM-1 sample) were either nondetectable or below RSRLs (Table S7-1). A nondetectable value is one in which the result is lower than three times the total propagated analytical uncertainty and is not significantly different from zero (Keith 1991; Corely et al. 1981).

In 2004, the concentration of plutonium-239,240 in San Ildefonso soil (0.038 pCi/g dry) was just above the RSRL value of 0.032 pCi/g (Fresquez 2005a). This year, the concentrations of plutonium-239,240 are below the RSRL, and a comparison of concentrations detected since 1996 from this same general location show that, for the most part, levels are below the upper-level regional background concentration (Figure 7-2). Those concentrations that were above the RSRL (two out of 10 measurements) were still far below the residential screening level of 33 pCi/g dry and do not pose any significant human health hazards.

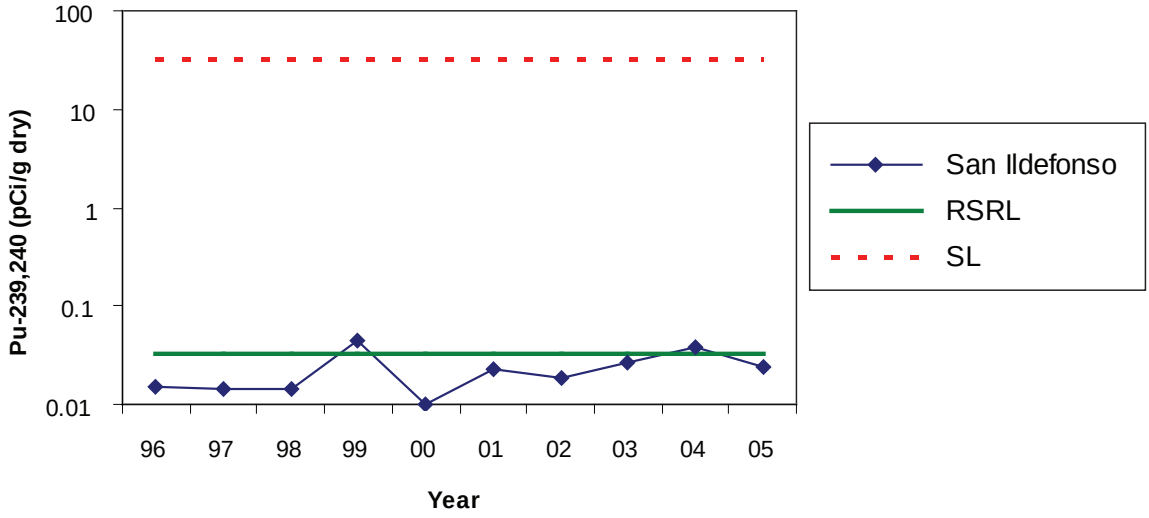


Figure 7-2. Plutonium-239,240 concentrations in soil samples collected from Pueblo de San Ildefonso lands over time, approximately one-half mile northeast of Area G, as compared with the regional statistical reference level (RSRL) and the screening level (SL).

Like 2004, the levels of uranium-234 and uranium-238 isotopes in the soil sample collected from the Tsankawi/PM-1 site show only slightly higher levels than RSRLs. A comparison of the isotopic distribution of uranium-234 and uranium-238 in the Tsankawi/PM-1 sample implies that the uranium is of natural origin and probably not a Laboratory contribution.

3. Nonradionuclide (Trace and Abundant Elements) Analytical Results

Table S7-2 shows the results of the elemental analysis, including many heavy metals, in surface soils collected from Pueblo de San Ildefonso lands. All elemental concentrations, including barium, beryllium, chromium, cadmium, lead, nickel, and mercury, in soils from Pueblo de San Ildefonso lands were below RSRLs.

D. FACILITY MONITORING

1. Monitoring Network

The Laboratory conducts facility-specific soil monitoring on an annual basis at Area G (Lopez 2002) and at DARHT (Nyhan et al. 2001). Area G is a 63-ac (25.5-hectare) radioactive waste processing area located on the east end of Mesa del Buey at TA-54 (Figure 7-3). Area G was established in 1957 and is the Laboratory's primary radioactive solid waste burial and storage site (Hansen et al. 1980, Soholt 1990). Tritium, plutonium, americium, uranium, and a variety of fission and activation products are the main radionuclides in waste materials deposited at Area G (DOE 1979). Monitoring at Area G includes the collection and analysis of air, sediments, surface water runoff, soil, vegetation, and small mammals for possible contaminants. Section D.2, below, reports on soil surface samples (15) collected at designated places within and around the perimeter of Area G for tritium; plutonium-238; plutonium-239,240; americium-241; uranium-234; uranium-235; and uranium-238. We report on the analysis of vegetation collected at Area G in Chapter 8, Section 4.b. Paragon Analytics, Inc., analyzed the samples.

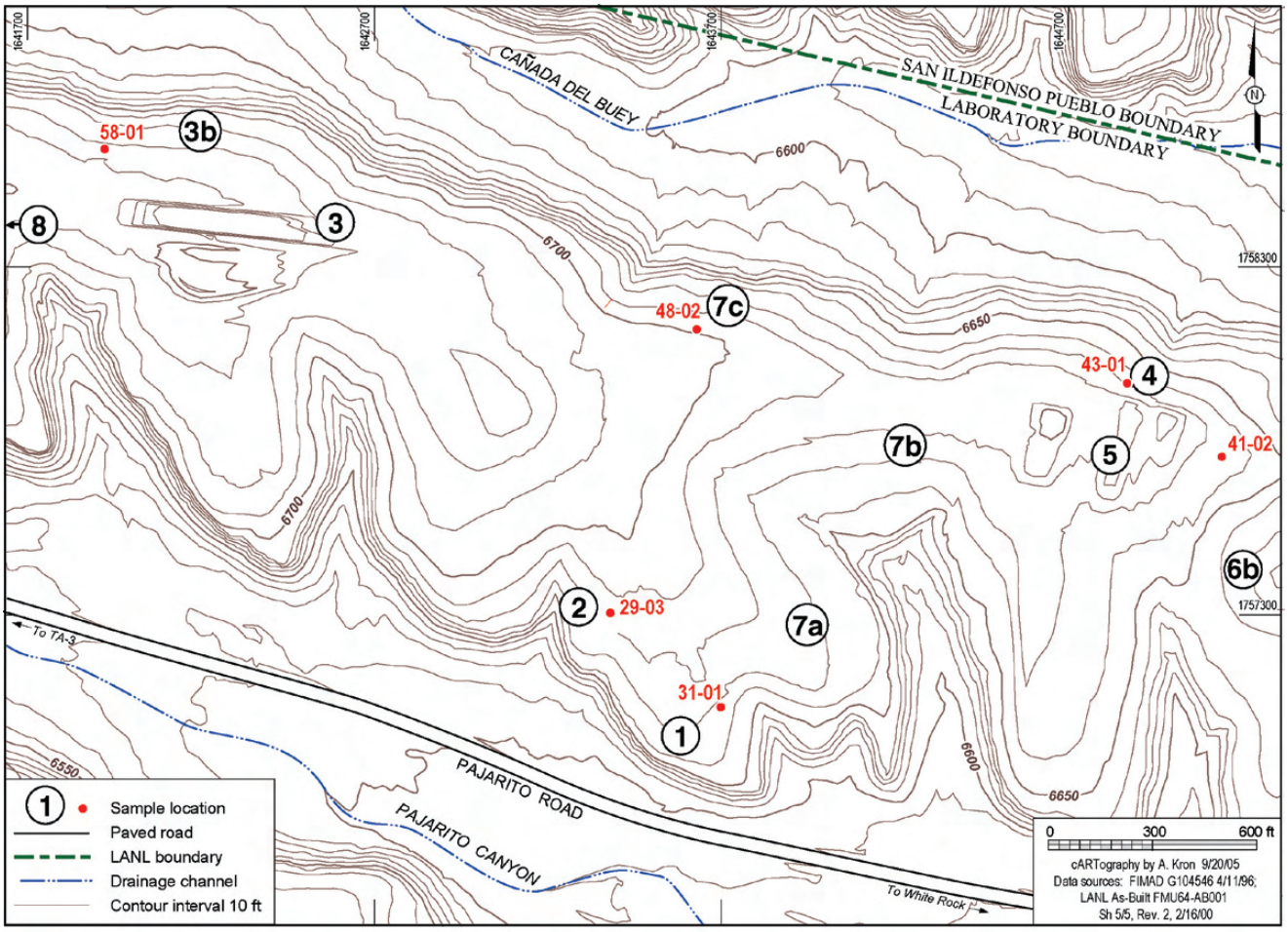


Figure 7-3. Sample locations of soils and vegetation at Area G.

DARHT, approximately 20 ac (eight hectares) in size, is located at R-Site (TA-15) at the Laboratory's southwestern end. Activities at DARHT include the utilization of very intense X-ray sources to radiograph a full-scale non-nuclear mock-up of a nuclear weapon's primary during the late stages of the explosively driven implosion of the device (DOE 1995). Possible contaminants include various radionuclides and heavy metals. Similar to Area G, the monitoring includes an assessment of various media to determine impacts, if any.

Section D.3, below, reports on four surface soil and four sediment samples collected at designated locations less than 200 feet away on all four sides of the facility within the DARHT grounds. Paragon Analytics, Inc., analyzed all samples for concentrations of tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; uranium-238; and for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium. We report on the analysis of vegetation collected at DARHT in Chapter 8, Section 4.c.

We compared Area G's results for radionuclides in soils with the RSRLs, whereas we compared DARHT results for radionuclides and nonradionuclides in soils and sediments with the BSRLs.

2. Radionuclide Analytical Results for Area G at TA-54

Many surface soil samples collected at Area G contained concentrations of tritium, plutonium-238, plutonium-239,240, and americium-241 above RSRLs (Table S7-3) (Fresquez et al. 2005). Concentrations of tritium in soils were detected above the RSRL in four of the 15 soil samples collected. Of these four samples, the highest levels were measured at 297 and 274 pCi/mL from soil samples (location #2 and 29-03) collected near the southern portion of Area G where the tritium waste disposal shafts are located (see Figure 7-3 for locations). Our

results are similar to concentrations detected in past years at these locations (Fresquez et al. 2004a, Fresquez and Lopez 2004) and match up well with the vegetation data collected at Area G on the southern side (see Chapter 8, Section 4.b). Although tritium is consistently detected above the RSRL in soil samples in the southern portion of Area G year after year, the concentrations are far below the SL of 5,400 pCi/mL (converted from the SL of 750 pCi/g and assuming 12 percent moisture content), and the migration of tritium from the Area G boundary, at least at surface and subsurface depths, is not extensive. In a recent study at Area G, tree samples were collected along a transect starting from the southern portion at various distances (approximately 10, 50, 100, 150, and 200 m) from the perimeter fence line (Fresquez et al. 2003). Results showed that the concentrations of tritium in trees collected nearest the perimeter boundary (10 to 16 m) were higher than the RSRL for vegetation. From there, the concentrations of tritium in trees significantly decreased with distance, and at about 90 m (295 ft) away, the concentrations were similar to the RSRL.

Some soil samples collected at Area G, particularly around the perimeter of the north and northeastern sections, contained americium-241 (eight out of 15), plutonium-238 (seven out of 15), and plutonium-239,240 (nine out of 15) above RSRLs. The highest concentrations of americium-241 (0.41 pCi/g dry), plutonium-238 (3.1 pCi/g dry), and plutonium-239,240 (1.1 pCi/g dry) were detected in a soil grab sample (site 41-02) located at the perimeter of the northeastern corner of Area G. All concentrations were below SLs, however. Out of 45 values, only one uranium isotope, uranium-234, was higher than the RSRL (1.4 vs. 1.3 pCi/g dry) and the distribution of uranium-234 to uranium-238 in all of the soil samples collected indicated natural sources. These data are very similar to last year's results (Fresquez and Lopez 2004). Overall, concentrations of radionuclides in surface soils at Area G are still very low (pCi/g range) and far below SLs and regulatory standards.

With reference to trends over time (1996–2005), Figures 7-4 and 7-5 show the concentrations of tritium and plutonium-239,240 in soils collected from areas that consistently have had the highest amounts detected year after year. The results for tritium at the "worst case" locations (sites #1, 2, 29-03, and 31-01) show that, with the exception of an increase in tritium concentrations that peak in 2002, all levels appear to decrease to those commonly observed in past years (Figure 7-4). We do not know completely why the concentrations of tritium in soils at these locations at Area G increased so dramatically during the period of time around 2002, but many factors associated with tritium movement at Area G—such as the different waste forms and containment systems, variabilities in the physical properties of the tuff (ash flows, open joints, and porosity), precipitation, temperature, and barometric pressure—all play roles in the fluctuating soil vapor levels observed from year to year (Purtymun 1973, Abeele and Nyhan 1987). As for the plutonium-239,240 concentrations in the "worst case" areas at Area G, which are located on the northern side (sites #4, 41-02, and 7c), they do not appear to be increasing over time (Figure 7-5).

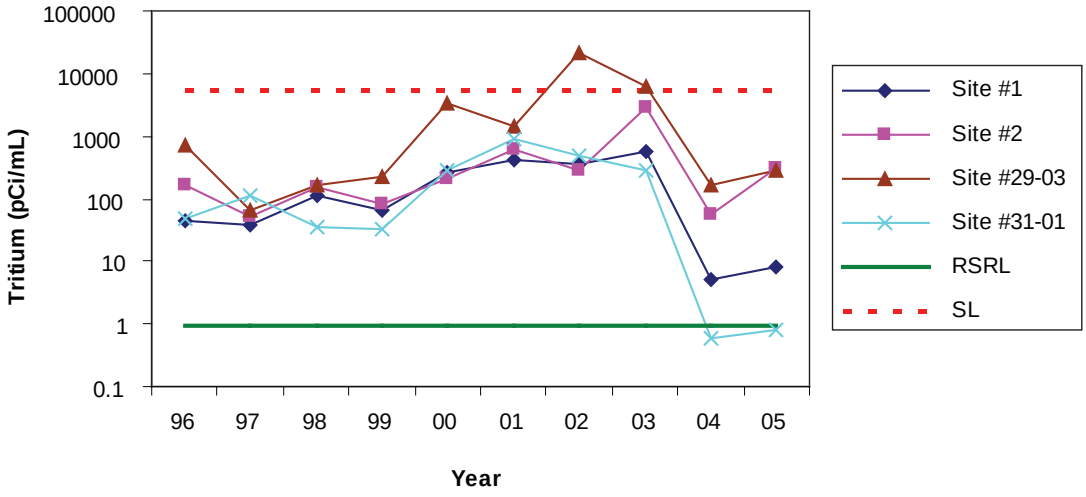


Figure 7-4. Tritium in surface soils collected from the worst case locations (southern portions) at Area G at TA-54 from 1996 to 2005 as compared with the regional statistical reference level (RSRL) and screening level (SL).

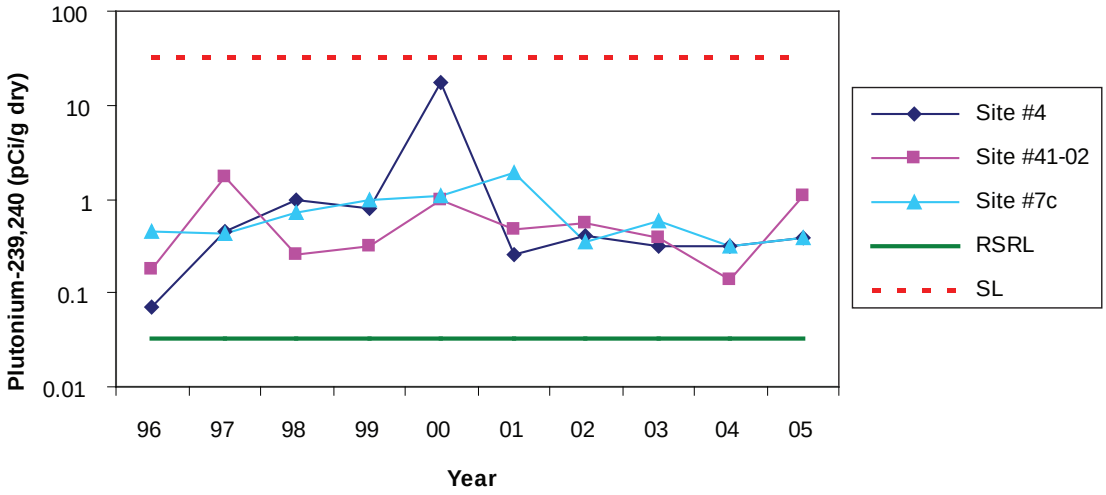


Figure 7-5. Plutonium-239,240 in surface soils collected from the worst case locations (northern portions) at Area G at TA-54 from 1996 to 2005 as compared with the regional statistical reference level (RSRL) and screening level (SL).

More chemical data associated with sediment transport within canyon reaches in Pajarito Canyon and Canada del Buey located downgradient of the tributary drainages from Area G, and deep boreholes drilled alongside Area G pits and shafts can be found in Chapter 9, Section E.2.

3. Radionuclide and Nonradionuclide Analytical Results for TA-15, DARHT

In general, all of the radionuclides in soils and sediments collected from around the DARHT facility are low, and most samples, especially the sediment samples, contained radionuclide concentrations that were either nondetectable or below BSRL values (Table S7-4) (Fresquez 2006).

Radionuclides that were above the BSRLs included concentrations of cesium-137 in three out of the four soil samples and one out of the four sediment samples, plutonium-239,240 in one out of the four soil samples and one out of the four sediment samples, and most of the uranium isotopes in the soil samples. All of the radionuclides in the soil and sediment samples were far below SLs and the distributions of uranium-234 to uranium-238 were consistent with natural uranium. These data, in terms of the concentration levels, exhibited similar results in past years (Nyhan et al., 2003, Fresquez et al., 2004b and Fresquez 2004b). We have, however, measured uranium consistent with depleted uranium in some soil samples in past years. Nevertheless, the concentrations and distributions of all observed radionuclides in soils and sediments from all locations collected in 2005 at DARHT are of no significant health concern. Similarly, all trace metal elements in soil and sediment samples collected at the DARHT facility were similar to BSRLs (Supplemental Table S7-5).

E. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND NONFOODSTUFFS BIOTA PROGRAM

1. Quality Assurance Program Development

The sampling team conducts soil, foodstuffs, and nonfoodstuffs biota (SFB) sampling according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the Quality Assurance Project Plan for the Soils, Foodstuffs, and Biota Monitoring Project and in the following procedures:

- "Produce Sampling,"
- "Fish Sampling,"
- "Game Animal Sampling,"
- "Processing and Submitting Samples,"

- "Soil Sampling,"
- "Chain-of-Custody Data for Soil, Foodstuffs, and Biota Samples,"
- "Sampling Soil and Vegetation at Facility Sites," and
- "Analytical Chemistry Data Management and Review for Soil, Foodstuffs and Biota."

These procedures, which are available at http://www.lanl.gov/community/environment/air/, ensure that the collection, processing, and chemical analysis of samples, the validation and verification of data, and the tabulation of analytical results are conducted in a consistent manner from year to year. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analyzing and reporting.

2. Field Sampling Quality Assurance

Overall quality of field sampling is maintained through the rigorous use of carefully documented procedures, described above, that govern all aspects of the sample-collection program.

The team collects all samples under strict chain-of-custody procedures, which minimize the chances of data transcription errors. We hand-deliver soil samples to the sample management office where they are directly shipped to an external analytical laboratory under full chain-of-custody. Foodstuffs and nonfoodstuffs biota samples are brought back in locked ice chests to the TA-21 laboratory and processed in a secure and radiologically clean laboratory. After processing, the sample management office ships the samples to an external analytical laboratory under full chain-of-custody. The project leader tracks all samples, and upon return of data from the supplier via electronic and hard copy means, the validation and verification staff chemist assesses the completeness of the field sample process along with other variables. A quality assessment document is created and attached to the data packet and provided to the project leader.

3. Analytical Laboratory Quality Assessment

Specific statements of work are written to govern the acquisition and delivery of analytical-chemistry services after the Data Quality Objective process has identified and quantified the program objectives. These statements of work are sent to potentially qualified suppliers who then undergo a pre-award, on-site assessment by experienced and trained quality systems and chemistry laboratory assessors. Statement of work specifications, professional judgment, and quality-system performance at each lab (including recent past performance on nationally conducted performance-evaluation programs) are primarily used to award contracts for specific types of radiochemical and inorganic analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. Each laboratory returns data by e-mail in an electronic data deliverable with a specified format and content. The analytical laboratory also submits a full set of paper records that serves as the legal copy of the data. Each set of samples contains all the internal quality control data the analytical laboratory generates during each phase of chemical analysis (including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the databases and immediately subjected to a variety of quality and consistency checks. Analytical completeness is calculated, tracking and trending of all blank and control-sample data is performed, and all the data are included in the quality-assessment memo mentioned in the field-sampling section. We track all parts of the data-management process electronically in each database and prepare periodic reports to management.

4. Field Data Quality Assessment Results

Field data completeness for SFB in 2005 was 100 percent.

5. Analytical Data Quality Assessment Results

Analytical data completeness for all SFB sampling programs was >95 percent. We track, trend, and report all quality control data in specific quality evaluation memos that we submit to project staff along with each set of analytical data received from our chemistry laboratories. The overall results of the 2005 program of quality monitoring indicate that all analytical laboratories maintained the same high level of control that has been observed in the past several years.

6. Analytical Laboratory Assessments

During 2005, two external laboratories performed all chemical analyses reported for SFB samples:

- Paragon Analytics, Inc., Fort Collins, Colorado, provided radiological and trace element analysis in soils, vegetation, fish, and small mammals.
- Alta Laboratory, El Dorado Hills, California, provided PCB analyses in fish tissue.

We performed an assessment of Paragon Analytics during 2004. The laboratory participated in national performance-evaluation studies during 2004 and 2005. The detailed results of these performance evaluations are included in the assessment report. Overall, the study sponsors judged the analytical lab to have acceptable performance for almost all analytes attempted in all matrices.

7. Program Audits

In 2005, we hosted a data quality assessment and evaluation to evaluate whether the procedures in various programs are being implemented as written. The auditors (Time Solutions 2) were external QA professional experts (ISO 9000 and 14001:2004 certified) and examined all aspects of the SFB program as it relates to procedures. While it was noted that improvements have been made to the SFB program since the last audit by auditors external to the group but internal to LANL, several observations were made to improve processes. These observations include keeping procedures up to date and meeting internal commitments made in our group quality assurance plans. Since that quality assessment, we have implemented all observations.

F. REFERENCES

Abeele and Nyhan 1987: W. V. Abeele and J. W. Nyhan, "Emanation and Dispersal of Tritiated Water from Disposal Shafts," Nuclear and Chemical Waste Management, 7:217-226 (1987).

Corely et al. 1981: J. P. Corely, D. H. Denham, R. E. Jaquish, D. E. Michels, A. R. Olsen, and D. A. Waite, "A Guide for Environmental Radiological Surveillance at US Department of Energy Installations," Department of Energy report DOE/EP-0023 (1981).

DOE 1979: US Department of Energy, "Final Environmental Impact Statement: Los Alamos Scientific Laboratory Site, Los Alamos, New Mexico," US Department of Energy report DOE/EIS-0018 (1979).

DOE 1991: US Department of Energy, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," US Department of Energy report DOE/EH-0173T (January 1991).

DOE 1993: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (1993).

DOE 1995: US Department of Energy, "Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement," US Department of Energy report USDOE/EIS-0228 (1995).

DOE 1996: US Department of Energy, "Dual-Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement Mitigation Action Plan," USDOE/EIS-0228 (1996).

DOE 1999a: US Department of Energy, "Radioactive Waste Management," US Department of Energy Order 435.1 (July 9, 1999).

DOE 1999b: US Department of Energy, "Radioactive Waste Management Manual," US Department of Energy report DOE M 435.1-1 (July 9, 1999).

DOE 2000: US Department of Energy, "Special Environmental Analysis for the Department of Energy, National Nuclear Security Administration, Actions Taken in Response to the Cerro Grande Fire at Los Alamos National Laboratory," Los Alamos Area Office report, DOE/SEA-03, Los Alamos, NM. (2000).

DOE 2003: US Department of Energy, "General Environmental Protection Program," US Department of Energy Order 450.1 (2003).

LANL 2004: "Los Alamos and Pueblo Canyons Investigation Report," Los Alamos National Laboratory report LA-UR-04-2714 (2004).

LANL 2005: "Derivation and Use of Radionuclide Screening Action Levels, Revision 1," Los Alamos National Laboratory report LA-UR-05-1849 (2005).

Fresquez 2004a: P. R. Fresquez, "Soil Monitoring," pp. 185-200. In: "Environmental Surveillance at Los Alamos during 2003," Los Alamos National Laboratory report LA-14162-ENV (2004).

Fresquez 2004b: P. R. Fresquez, "Concentrations of Radionuclides and Trace Elements in Soils and Vegetation around the DARHT Facility during 2004," Los Alamos National Laboratory report LA-14176-PR (2004).

Fresquez 2005a: P.R. Fresquez, "Soil Monitoring," pp. 187-195. In: "Environmental Surveillance at Los Alamos during 2004," Los Alamos National Laboratory report LA-14239-ENV (2005).

Fresquez 2005b: P. R. Fresquez, "The Characterization of Biotic and Abiotic Media Upgradient and Downgradient of the Los Alamos Canyon Weir," Los Alamos National Laboratory report LA-MS (2005).

Fresquez 2006: P. R. Fresquez, "Soils and Sediments," pp 7-15. In: Gonzales et al., "Concentrations of Radionuclides and Trace Elements in Environmental Media around the Dual-Axis Radiographic hydrodynamic Test Facility at Los Alamos National Laboratory during 2005," Los Alamos National Laboratory report LA-14284-PR (2006).

Fresquez and Lopez: P. R. Fresquez and E. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 2004 Growing Season," Los Alamos National Laboratory report LA-14181-PR (2004).

Fresquez et al.1996: P. R. Fresquez, D. R. Armstrong, and M. A. Mullen, "Radionuclides and Radioactivity in Soils within and around Los Alamos National Laboratory, 1974 through 1994: Concentrations, Trends, and Dose Comparisons," Los Alamos National Laboratory report LA-13149-MS (1996).

Fresquez et al.1998: P. R. Fresquez, D. R. Armstrong, and M. A. Mullen, "Radionuclides and Radioactivity in Soils Collected from within and around Los Alamos National Laboratory: 1974–1996," J. Environ. Sci. Heal. A 33 (2), pp. 263–278 (1998).

Fresquez et al. 2000: P. R. Fresquez, W. R. Velasquez, and L. Naranjo, Jr., "Effects of the Cerro Grande Fire (Smoke and Fallout Ash) on Soil Chemical Properties within and around Los Alamos National Laboratory," Los Alamos National Laboratory report LA-13769-MS (2000).

Fresquez et al. 2001a: P. R. Fresquez, J. W. Nyhan, and H. T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, and Vegetation Around the DARHT Facility," in Nyhan et al., "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees Around the DARHT Facility: Construction Phase (1996 through 1999)," Los Alamos National Laboratory report LA-13808-MS (2001), pp. 48–76.

Fresquez et al. 2001b: P. R. Fresquez, W. R. Velasquez, and L. Naranjo, Jr., "The Effects of the Cerro Grande Fire (Smoke and Fallout Ash) on Possible Contaminants in Soils and Crops Downwind of Los Alamos National Laboratory," Los Alamos National Laboratory report LA-13842-MS (2001).

Fresquez et al. 2003: P. R. Fresquez, L. Vasquez-Tator, and E. A. Lopez, "Tritium Concentrations in Vegetation as a Function of Distance from a Low-Level Waste Site at Los Alamos National Laboratory," Los Alamos National Laboratory report LA-14091-MS (2003).

Fresquez et al. 2004a: P. R. Fresquez, J. W. Nyhan, and E. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 2003 Growing Season," Los Alamos National Laboratory report LA-14108-PR (2004).

Fresquez et al. 2004b: P. R. Fresquez, J. W. Nyhan, and E. L. Taylor, "Concentrations of Radionuclides and Trace Elements in Soils and Vegetation Around the DARHT Facility during 2003," Los Alamos National Laboratory report LA-14099-PR (2004).

Fresquez et al. 2005: P. R. Fresquez, M. W. McNaughton, and M. J. Winch, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during 2005," Los Alamos National Laboratory report LA-14251-PR (2005).

Gallaher et al. 2005: B. M. Gallaher, D. R. Rodgers, and W. R. J. Turney, "Watershed Monitoring," pp. 157-184. In: Environmental Surveillance at Los Alamos during 2004, Los Alamos National Laboratory report LA-14239-ENV (2005).

Hansen et al. 1980: W. R. Hansen, D. L. Mayfield, and L. J. Walker, "Interim Environmental Surveillance Plan for LASL Radioactive Waste Areas," Los Alamos Scientific Laboratory report LA-UR-80-3110 (1980).

Keith 1991: L. H. Keith, Environmental Sampling and Analysis: A Practical Guide (CRC Press, Inc., Baca Raton, Fl., 1991).

Lopez 2002: E. Lopez, "MDA G and L Environmental Monitoring Plan for FY 2002," Los Alamos National Laboratory report LA-UR-02-6128 (2002).

NMED 2005: "Technical Background Document for Development of Soil Screening Levels, Rev. 3.0," (2005).

Nyhan et al. 2001: J. W. Nyhan, P. R. Fresquez, K. D. Bennett, J. R. Biggs, T. K. Haarmann, D. C. Keller, and H. T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)," Los Alamos National Laboratory report LA-13808-MS (2001).

Nyhan et al. 2003: J. W. Nyhan, P. R. Fresquez, and W. R. Velasquez, "Concentrations of Radionuclide and Trace Elements in Soils and Vegetation around the DARHT Facility during 2002," Los Alamos National Laboratory report LA-14056-PR (2003).

Purtymun 1973: W. D. Purtymun, "Underground Movement of Tritium from Solid-Waste Storage Shafts," Los Alamos Scientific Laboratory report LA-5286-MS (1973).

Soholt 1990: L. F. Soholt, "Environmental Surveillance of Low-Level Radioactive-Waste-Management Areas at Los Alamos during 1987," Los Alamos National Laboratory report LA-UR-90-3283 (1990).

Yu et al. 1995: C. Yu, A. J. Zielen, J. J. Cheng, T. C. Yuan, L. G. Jones, D. J. Lepoire, Y. Y. Wang, C. O. Loueiro, E. Gnanapragasam, J. E. Faillace, A. Wallo III, W. A. Williams, and H. Peterson, "A Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.60," Argonne National Laboratory report ANL/EAD/LD-2 (1995).

8. FOODSTUFFS AND BIOTA MONITORING

contributing authors:
Philip Fresquez, Gil Gonzales, Mike McNaughton, Chuck Hathcock, Guillermo Vigil

To Read About **Turn to Page**

A. FOODSTUFFS MONITORING

1. Introduction

A wide variety of wild and domestic edible vegetables, fruit, grain, and animal products are harvested in the area surrounding the Laboratory. Ingestion of foodstuffs constitutes an important exposure pathway by which radionuclides (Whicker and Schultz 1982) and nonradionuclides (heavy metals and organics) (Gough et al. 1979) can be transferred to humans. Over the years, we have collected a variety of foodstuff samples (e.g., fruits, vegetables, grains, fish, milk, eggs, honey, herbal teas, mushrooms, piñon nuts, domestic animals, and large and small game animals) from the surrounding area and communities to determine the impacts of Laboratory operations on human health via the human food chain. Department of Energy (DOE) Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993) mandate this monitoring program, and the guidance for assessing these impacts to foodstuffs are presented in DOE (1991).

The objectives of the program are as follows:

- Measure radioactive and nonradioactive concentrations in foodstuffs from on-site (the Los Alamos National Laboratory [LANL]) and perimeter areas, and compare these results to regional (background) areas;
- Determine trends over time; and
- Provide data used to estimate dose from the consumption of the foodstuffs (see Chapter 3 for dose estimates to individuals from the ingestion of foodstuffs).

This year, we focused on the collection and analysis of radionuclides, metals, and polychlorinated biphenyls (PCBs) in predator and bottom-feeding fish from Cochiti Reservoir—an impoundment downstream of LANL. For the second year, we also collected, analyzed, and assessed common purslane, a wild edible plant, collected from within Mortandad Canyon on Pueblo de San Ildefonso lands.

2. Foodstuffs Standards

To evaluate Laboratory impacts to foodstuffs from radionuclides and nonradionuclides, we first compared analytical results of foodstuffs samples to regional statistical reference levels (RSRLs). Where the levels exceed RSRLs, we then compared the concentrations to screening levels (SLs) and standards, if available. Table 8-1 summarizes the levels and/or the standards used to evaluate the foodstuffs monitoring program.

Table 8-1
Standards and Other Reference Levels Applied to Foodstuffs

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	All foodstuffs	100 mrem	1.0 mrem	RSRLs
Nonradionuclides					
Trace elements	On-site and perimeter	All foodstuffs			RSRLs
Mercury	Perimeter	Fish	1 µg/g (wet) in edible portion	0.3 µg/g (wet) in edible portion	RSRLs
Polychlorinated Biphenyls	Perimeter	Fish	2 µg/g (wet)	1.5 ng/g (wet) (limited consumption restrictions)	RSRLs

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations = 99 percent confidence level) calculated from foodstuffs data collected from regional locations away from the influence of the Laboratory (>9 miles away) (DOE 1991) over at least the last five sampling dates. (For a list of regional locations see Section A.3.a, "Monitoring Network.") RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of this report.
- Screening Levels: SLs are set below federal regulations so that potential concerns may be identified in advance of major problems—i.e., a "yellow flag." If a constituent exceeds an SL, then the reason for that increase is thoroughly investigated. For radionuclides, the dose assessment team developed screening levels to identify the potential contaminants of concern on the basis of a conservative 1 mrem protective annual dose limit (this is 1 percent of the 100 mrem/yr DOE standard presented in Order 450.1) (see the QA plan for dose assessment at http://www.lanl.gov/community/environment/air/). Nonradionuclides, like mercury and PCBs in fish, are compared with the Environmental Protection Agency (EPA) water quality criterion (EPA 2001).
- Standard: Based on the concentrations of radionuclides in foodstuffs, we calculated a dose to a person (see Chapter 3). We compared this dose with the 100-mrem/yr DOE all pathway dose standard. Nonradionuclides, like mercury and PCBs in fish, are compared to Food and Drug Administration (FDA) (FDA 2000) or EPA (EPA 2000) levels.

3. Fish

a. Monitoring Network

There are 19 canyons that, depending on the season and amount of precipitation, may carry water through LANL lands to the Rio Grande. We sampled Cochiti Reservoir, a recreational fishery on the Rio Grande located approximately five miles downstream of LANL, to determine if fish are affected by Laboratory operations (Figure 8-1). We compared fish collected from Cochiti Reservoir to background fish collected upstream of the Laboratory—principally from Abiquiu Reservoir or Heron Reservoir, depending on the availability of water.

Figure 8-1. Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations.

Abiquiu and Heron Reservoirs are located on the Chama River and are upstream from the confluences of the Rio Grande and the intermittent streams that cross Laboratory lands (Fresquez et al. 1994). Radionuclides, metals, and PCBs in fish from background areas are from worldwide fallout, natural sources, or other sources not associated with the Laboratory.

Samples that were collected from Cochiti and Abiquiu Reservoirs in 2005 included the predator fish northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides salmoides*), smallmouth bass (*Micropterus dolomieui*), white crappie (*Pomoxis annularis*), brown trout (*Salmo trutta*), white bass (*Morone chrysops*), and walleye (*Stizostedion vitreum*). Bottom-feeding fish collected included the white sucker (*Catostomus commersoni*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpiodes carpio*). We analyzed these fish for tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235 and uranium-238. Results for radionuclides in fish are reported on a per gram dry weight basis, with the exception of tritium, which is reported on a per mL basis (Table S8-1 and S8-2). In addition to radionuclides, 23 trace inorganic elements were analyzed (Table S8-3 and S8-4). Results for these elements are reported on a wet weight basis. Finally, PCB analysis included the full 209 congener list (Gonzales and Fresquez 2006) and are reported on a ng/g (ppb) wet weight basis (Table S8-5).

b. Radionuclide Analytical Results

The complete set of results for fish is found in the data supplement, Tables S8-1 and S8-2. All radionuclides in predator fish from Cochiti Reservoir were either not detected (the result is less than three times the analytical uncertainty) (Keith 1991, Corely et al. 1981) or detected at concentrations similar to radionuclide concentrations in fish collected upstream of LANL (<RSRLs). Similarly, all radionuclides in bottom-feeding fish collected from Cochiti Reservoir were nondetectable or below RSRLs, except for one sample that contained uranium-234 and uranium-238 just above the RSRLs. However, the isotopic uranium concentrations were far below SLs and the isotopic distribution indicates that the uranium was of natural origin. These results, with particular reference to total uranium, are similar to past years (Figure 8-2) (Fresquez and Armstrong 1996) and to other reservoir studies in Colorado (Whicker et al. 1972; Nelson and Whicker 1969) and New Mexico (Fresquez et al. 1996, Fresquez et al. 1998). In addition, the results are similar to radionuclide levels in fish collected along the length of the Rio Grande from Colorado to Texas (Booher et al. 1998) and directly downstream of LANL in 1998 (Fresquez et al. 1999a).

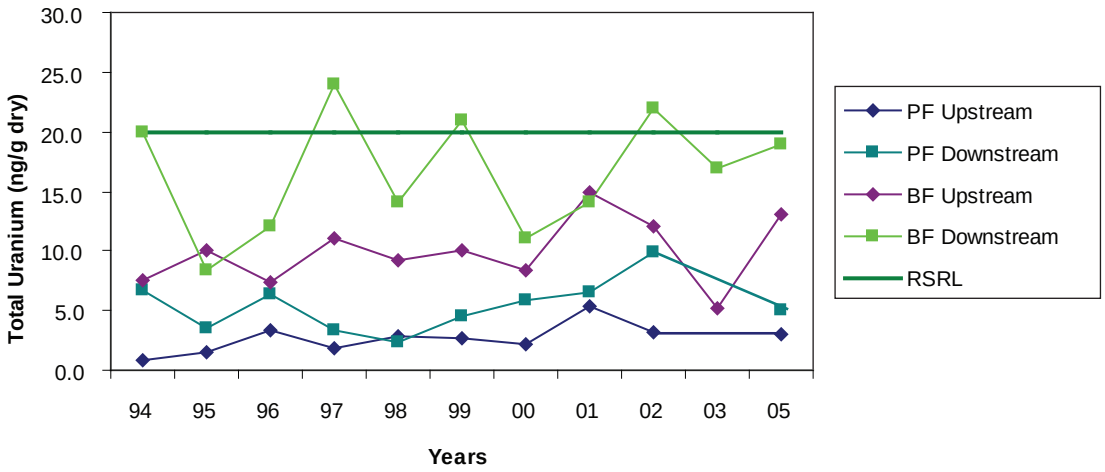


Figure 8-2. Mean total uranium in predator fish (PF) and bottom-feeding fish (BF) collected from reservoirs upstream (Abiquiu) and downstream (Cochiti) of LANL from 1994 through 2005 as compared to the regional statistical reference level (RSRL).

c. Nonradionuclide (Trace and Abundant Elements) Analytical Results

Total inorganic elemental concentrations in muscle fillets of predator and bottom-feeding fish collected upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL are presented in Tables S8-3 and S8-4. Of the 23 inorganic elements analyzed in fish samples from Cochiti Reservoir, most were either below the reporting limits (e.g., not detected) or below the RSRLs. Only manganese in most samples was detected above the RSRL in predator fish samples from Cochiti Reservoir. The levels (maximum of 2.3 mg/kg), however, were far below the levels considered toxic to fish (>2,420 mg/kg) (Schroeder et al. 1966) and are at the same levels as the bottom-feeding fish from both locations (averages were 0.54 and 0.62 mg/kg). Manganese is an essential nutrient for enzyme function in living organisms and has a low order of toxicity (Schroeder et al. 1966).

Although mercury concentrations in both fish types downstream of LANL were similar in concentrations to fish collected upstream of the Laboratory and agree with past results (Figures 8-3 and 8-4) (Fresquez 2004a, Fresquez et al. 1999b), the levels in many predator fish samples collected from both reservoirs are above the SL of 0.30 mg/kg wet. Because mercury normally biomagnifies up the food chain, the predator (carnivorous) fish would be expected to contain more mercury than the bottom-feeding (omnivorous) fish (Ochiai 1995). Also, these levels are not atypical as there are currently 26 fish consumption advisories in New Mexico, including the Rio Grande, for mercury (NMDH 1993, Bousek 1996, Torres 1998). The main sources of mercury into the water systems in New Mexico is from natural degassing of the earth's crust, the burning of fossil fuels, and the microbial conversion of mercury using carbon as an energy source from flooded vegetation (NMED 1999).

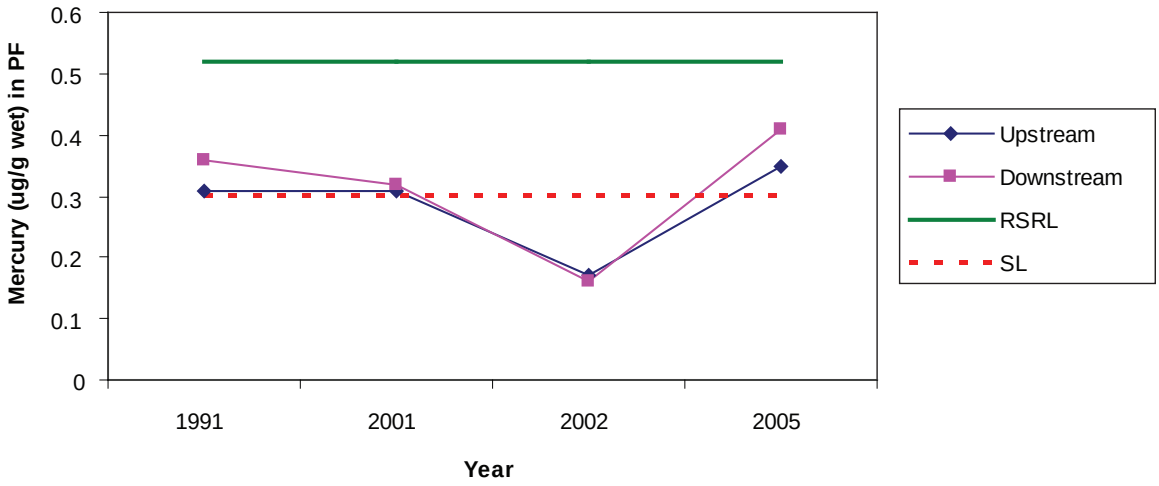


Figure 8-3. Mean mercury concentrations in predator fish (PF) collected from reservoirs upstream (Abiquiu) and downstream (Cochiti) of LANL from 1991 through 2005 as compared to the regional statistical reference level (RSRL) and screening level (SL).

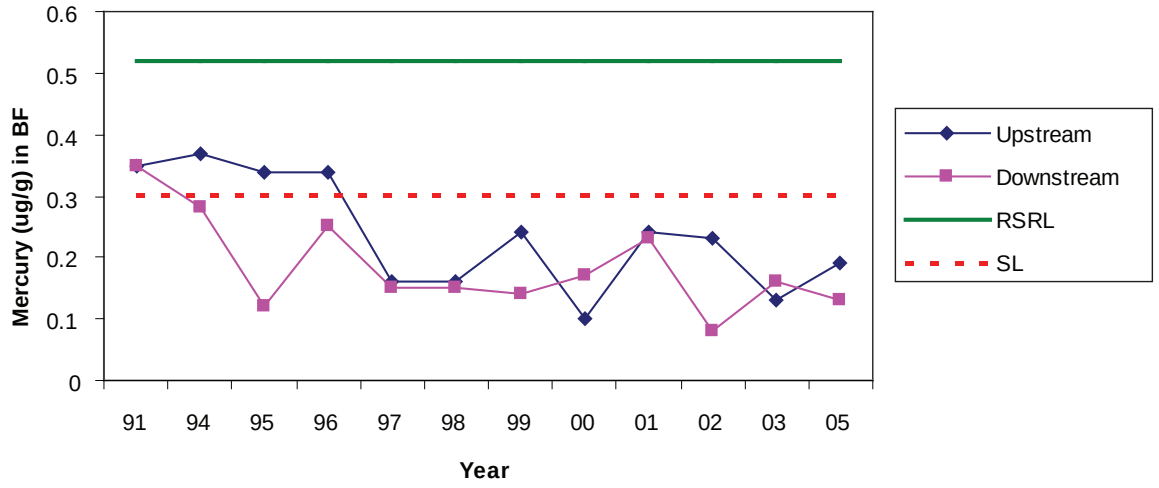


Figure 8-4. Mean mercury concentrations in bottom-feeding fish (BF) collected from reservoirs upstream (Abiquiu) and downstream (Cochiti) of LANL from 1991 through 2005 as compared to the regional statistical reference level (RSRL) and screening level (SL).

d. PCB Analytical Results

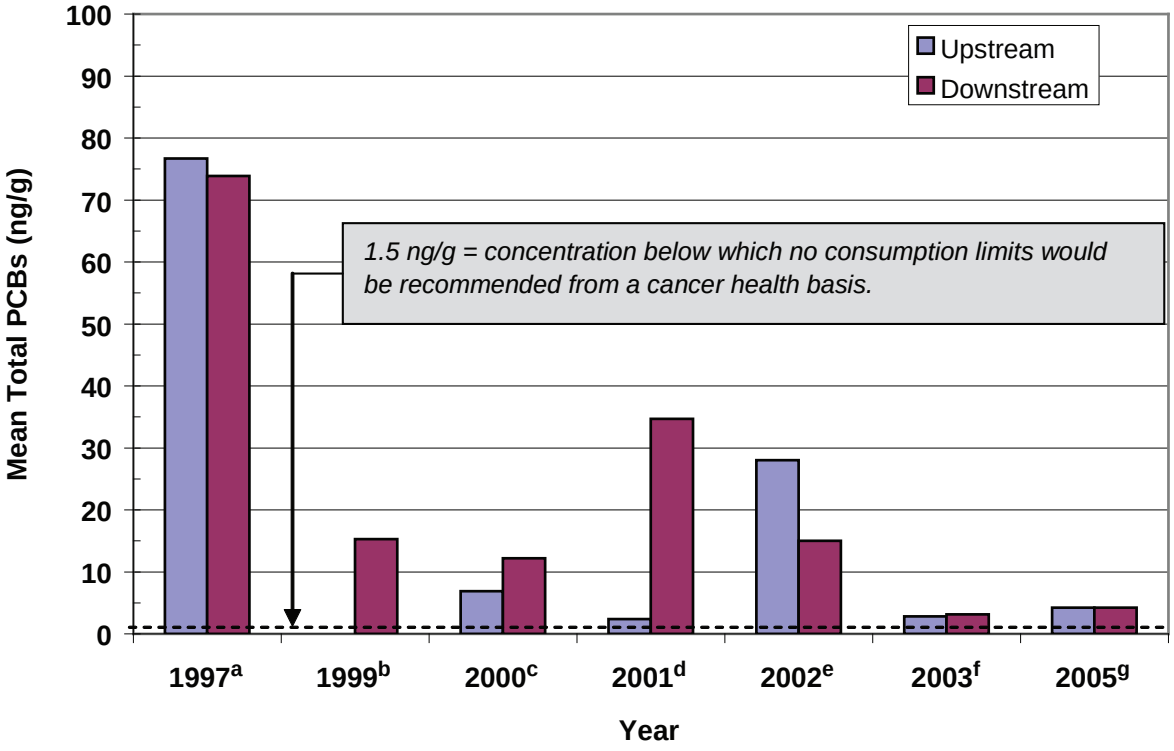
We collected six species of fish from Abiquiu (upstream of LANL) and Cochiti (downstream of LANL) Reservoirs and analyzed the edible portion (fillets) for 209 possible PCB congeners (Gonzales and Fresquez 2006). Mean total PCB concentrations in fish from Abiquiu Reservoir (μ=2.4 ng/g) were statistically similar (α=0.01) to mean total PCB concentrations in fish from Cochiti Reservoir (μ=2.7 ng/g) implying that LANL may not be the only or major source of PCBs in fish in Cochiti Reservoir (Table S8-5). The levels of PCBs in fish from Cochiti Reservoir generally appear to be declining over the years, at least since 2001 when PCB levels appeared to have peaked following the Cerro Grande Fire (Figure 8-5). Although a PCB "fingerprinting" method can be used to relate PCB "signatures" in one area to signatures in another area, this method of implicating the source of PCBs

cannot be effectively used for biota because metabolic processes alter the PCB signature. Regardless of the source of the PCBs, certain species of fish (catfish and carpsuckers) at both Abiquiu and Cochiti Reservoirs continue to harbor levels of PCBs that could be harmful to human health if they are the primary part of the diet over a long period of time. Bottom-feeding fish (carpsucker and catfish) from Cochiti Reservoir contained statistically higher levels of total PCBs (μ=4.25 ng/g-fillet-wet) than predator fish (walleye, northern pike, bass) (μ=1.67 ng/g) and the bottom-feeding fish had levels of PCBs that fall into a restricted consumption category according to EPA guidelines (Table S8-6). Similarly, bottom-feeding fish from Abiquiu Reservoir contained statistically higher levels of total PCBs (μ=4.25 ng/g-wet) than predator fish (walleye, bass) (μ=0.68 ng/g-wet) and only the bottom-feeding fish had levels of PCBs that fall into a restricted consumption category. These results are similar to previous studies showing that fish or artificial fish fat (fat bags) from downstream sources (Rio Grande and Cochiti Reservoir) contain similar PCB levels to fish collected from upstream sources (Gonzales et al. 1999, Fresquez et al. 2001, Fresquez et al. 2002, Gonzales and Fresquez 2003, Gonzales and Montoya 2005). However, like total PCBs, levels of the particular congeners (dioxin-like) that tend to dominate the risk from consuming the fish generally are decreasing over time.

4. Wild Edible Plants

a. Monitoring Network

In 2004, we collected three types of wild edible plants (common purslane [*Portulaca sp.*], wild spinach [*Spinacia sp*], and acorns [*Quercus sp.*]) from within Mortandad Canyon on Pueblo de San Ildefonso lands (Fresquez et al. 2005a). The composite samples (two of purslane and one of spinach) were collected approximately 5 to 50 m (16 to 160 ft) from the LANL boundary fence line. Also, acorns from oak trees (*Quercus sp.*) were collected about 200 m (650 ft) from the LANL boundary fence line. The analysis of these wild edible foods, particularly purslane, showed higher amounts of strontium-90, plutonium-239,240, and barium than RSRLs. (Note: Purslane was compared to RSRLs, which were determined from common produce plants and not directly from purslane plants, per se.) Although all radionuclide concentrations in purslane samples collected from within Mortandad Canyon were below SLs, we wanted to better define the reasons for these slightly higher amounts of radionuclides in these 2004 plant samples. To this end, in 2005 we collected more purslane samples (three composite samples) from the same locations as last year in Mortandad Canyon and also some purslane samples (two composite samples) from background sites in northern New Mexico. In addition, we collected soil samples from the same locations where we collected the purslane samples in Mortandad Canyon so that a source could be identified. All samples were analyzed for tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235 and uranium-238. Also, in addition to barium, 22 other trace and abundant elements were analyzed.



Upstream: Above LANL confluences (e.g., Abiquiu Reservoir, Rio Grande above Otowi bridge).

Downstream: Below LANL confluences (e.g., Cochiti Reservoir, Rio Grande below Otowi bridge).

[a] Total PCBs from summation of Aroclors from catfish collected from the Rio Grande. (Data source: Gonzales et al. 1999).

[b] Mean total PCBs in fillets was estimated from whole-body concentrations in one catfish and one carp collected from Cochiti Reservoir. (Data source: NMED 2006).

[c] Carp collected from Abiquiu (upstream of LANL) and Cochiti (downstream of LANL) Reservoirs; Mean total PCBs from summation of 209 congener analysis; Fillet concentrations estimated from ratio of fillet concentration: whole body concentration established by LANL (2002). (Data source: LANL 2001).

[d] Abiquiu and Cochiti Reservoirs; Cochiti mean total PCBs estimated for 209 total from dioxin-like total PCBs measured in catfish fillets. Abiquiu mean total PCBs estimated for catfish fillets from whole-body and estimated for 209 total from dioxin-like total. (Data source: LANL 2002).

[e] Rio Grande; Catfish; Mean total PCBs from summation of 209 congener analysis of catfish fillets from the Rio Grande. Ten catfish from four confluences downstream of LANL and five catfish upstream of LANL along San Idelfonso Pueblo. (Data source: Gonzales and Fresquez 2003).

[f] Semipermeable membrane devices (SPMDs), also referred to as "fat bags," consist of triolein-containing polyethylene membrane tube housed in perforated stainless steel canisters. SPMDs were placed in the Rio Grande above Otowi bridge (upstream of LANL) and at the confluence of Ancho Canyon (downstream of LANL) for 28-day sampling periods. SPMDs sample dissolved PCBs similar to fish. SPMDs were analyzed for 209-congener suite. (Data source: Gonzales and Montoya 2005).

[g] Catfish and carpsuckers taken from Abiquiu (upstream of LANL) and Cochiti (downstream of LANL) Reservoirs. Mean total PCBs from summation of 209 congener analysis of fillets. (Data source: Gonzales and Fresquez 2006).

Figure 8-5. Mean total PCB concentrations (from 209 congeners possible) in fillets of bottom-feeding fish from the Rio Grande and Abiquiu and Cochiti Reservoirs over time. The dotted line is equal to 1.5 ng/g and represents the lower limit of consumption restrictions.

b. Radionuclide Analytical Results

The analyses of the nine radionuclides in purslane plants collected from Mortandad Canyon on Pueblo de San Ildefonso lands show that strontium-90 was the only radionuclide that was detected in concentrations above the RSRLs (Table S8-7). These data confirm the uptake of strontium-90 by purslane plants detected in 2004 (Figure 8-6) (Fresquez et al 2005a). Although the concentrations of strontium-90 in purslane plants from Mortandad Canyon are higher than the concentrations found in purslane plants collected from background

locations, the soil samples collected from the same locations as the purslane plants in Mortandad Canyon do not directly support the plant data (Table S8-8). That is, strontium-90 in soils collected from the same locations as the purslane samples in Mortandad Canyon (0.13 and 0.19 pCi/g dry) are not elevated above background concentrations (the RSRL is 0.41 pCi/g dry). A probable reason for this lack of correlation between the higher levels of strontium-90 in purslane plants and the lower levels of strontium-90 in soils from Mortandad Canyon as compared to background may be due to the levels of calcium in the soils. Since plants do not discriminate between strontium and calcium, the tendency of strontium-90 to accumulate in biota is increased if there is a reduction of the calcium in the environment (Whicker and Schultz 1982). A study conducted in the United Kingdom showed that the amount of strontium-90 in plants increased as the amount of exchangeable calcium diminished from 3,000 or 4,000 mg/kg in the soil to less than 2,000 mg/kg (UKARC 1961). Our data shows this general relationship. Tables S8-9 (plant chemical properties) and S8-10 (soil chemical properties) show that the levels of calcium in purslane plants (7,167 mg/kg dry) and soils (1,345 mg/kg dry) from Mortandad Canyon is less than half the amounts in purslane plants (19,500 mg/kg dry) and soils (2,689 mg/kg dry) from background locations. Thus, the lower levels of soil calcium in Mortandad Canyon, compared with background levels, may be a reason we found higher levels of strontium-90 in the purslane plants. Nevertheless, the highest level of strontium-90 in purslane plants from Mortandad Canyon are still below the screening level of 1 pCi/g dry (e.g., <1 mrem).

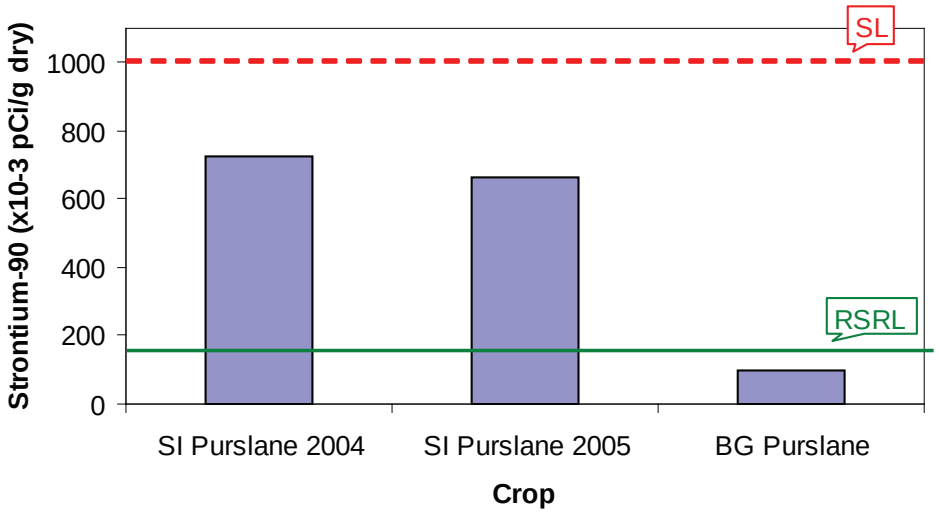


Figure 8-6. Mean strontium-90 concentrations in purslane collected from within Mortandad Canyon on Pueblo de San Ildefonso (SI) lands in 2004 and 2005 compared with background (BG), the regional statistical reference level (RSRL), and the screening level (SL).

c. Nonradionuclide (Trace and Abundant Elements) Analytical Results

All inorganic elemental concentrations, including barium, in purslane samples collected from within Mortandad Canyon on Pueblo de San Ildefonso lands were either below the reporting limits or below RSRLs (Table S8-9). Last year (2004), we reported that barium in the purslane samples collected from within Mortandad Canyon was about three times higher than the RSRLs calculated from common produce plants (e.g., apples, squash, tomatoes, etc.) and hypothesized that purslane plants were probably bio-accumulators of barium (Fresquez et al. 2005a). This year, in addition to the purslane samples collected from Mortandad Canyon, we also collected samples of purslane from background regional areas, specifically with the intention of comparing purslane to purslane (i.e., developing an RSRL from purslane plants). We also collected soil samples from the location of the purslane samples and analyzed them for a host of inorganic elements, including barium (Table S8-10). Results show that barium concentrations in purslane plants collected from background areas contained the same amount of barium as purslane plants collected from Mortandad Canyon in 2004 and 2005 (Figure 8-7). Similarly, we found normal concentrations of barium and all other elements in soil samples collected from the same location as the purslane samples.

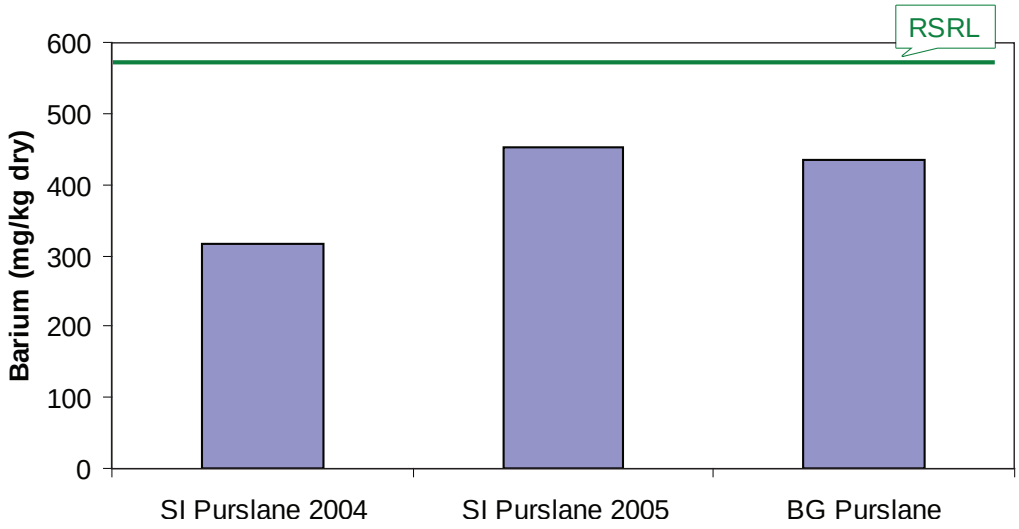


Figure 8-7. Mean barium concentrations in purslane plants collected from within Mortandad Canyon on Pueblo de San Ildefonso (SI) lands in 2004 and 2005 as compared to background (BG) and the regional statistical reference level (RSRL).

B. NONFOODSTUFFS BIOTA MONITORING

1. Introduction

DOE Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993) mandate the monitoring of nonfoodstuffs biota for the protection of ecosystems. Although monitoring of biota, mostly in the form of facility-specific or site-specific studies, began in the 1970s with the Environmental Surveillance Program, site-wide vegetation monitoring started in 1994. Laboratory personnel monitor small mammals, amphibians, reptiles, birds, and vegetation within and around LANL on a systematic basis or for special studies of radiological and nonradiological constituents.

The three objectives of the nonfoodstuffs biota program are to determine the following:

- Radionuclide and nonradionuclide concentrations in biota from on-site and perimeter areas and compare them with regional background concentrations,
- Trends over time, and
- Dose to plants and animals.

Chapter 3 includes the results of the 2005 biota dose assessments at LANL.

2. Nonfoodstuffs Biota Standards

To evaluate Laboratory impacts from radionuclides and nonradionuclides in nonfoodstuffs biota, we first compared the analytical results of biota samples collected from on-site and perimeter areas with regional or with baseline statistical reference levels (RSRLs or BSRLs, respectively). If the levels exceed RSRLs (or BSRLs), then we compare the concentrations with SLs, if available, and then to standards, if available. Table 8-2 summarizes the standards used to evaluate the biota-monitoring program. A discussion of these comparison levels is as follows:

- Regional background levels: RSRLs are the upper-level background concentrations (mean plus three standard deviations) for radionuclides and nonradionuclides calculated from nonfoodstuffs biota data collected from regional locations away from the influence of the Laboratory (>9 miles away) (DOE 1991) over the past five years. RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of this report.

Table 8-2
Standards and Other Reference Levels Applied to Nonfoodstuffs Biota

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	Terrestrial plants and aquatic biota	1.0 rad/d	0.1 rad/d	RSRLs
	DARHT	Terrestrial plants	1.0 rad/d	0.1 rad/d	BSRLs
	On-site and perimeter	Terrestrial animals	0.1 rad/d	0.01 rad/d	RSRLs
	DARHT	Terrestrial animals	0.1 rad/d	0.01 rad/d	BSRLs
Nonradionuclides	On-site and perimeter	Biota		TVs	RSRLs
	DARHT	Biota		TVs	BSRLs

- Baseline levels: BSRLs are the concentrations of radionuclides and nonradionuclides in biota within and around the DARHT facility (1996–1999) before the operation phase (as of the year 2000). The Mitigation Action Plan for the DARHT facility at LANL mandated the establishment of baseline (preoperational) concentrations for potential environmental contaminants that might result from DARHT operations (DOE 1996). These concentrations of radionuclides and trace elements are calculated from the mean DARHT facility sample concentration plus three standard deviations. (Note: Although prior evaluations of BSRLs with RSRLs show no statistical differences between the two, the use of BSRLs at DARHT is required by the Mitigation Action Plan.)
- Screening Levels: SLs are set below federal regulation standards so that potential concerns may be identified in advance of potential ecological health problems—a "yellow flag." If a constituent exceeds an SL, then the reason for that exceedance is thoroughly investigated. For radionuclides in nonfoodstuffs biota, SLs were set at 10 percent of the standard by the dose assessment team at the Laboratory to identify the potential contaminants of concern. Nonradionuclides are compared with Toxicity Values (TV) gained from the literature.
- Standards: Based on the concentrations of radionuclides in biota, we calculated a dose and compared it with the 1.0 rad/d DOE dose standard for terrestrial plants and aquatic biota and 0.1 rad/d for terrestrial animals (DOE 2002).

3. Institutional Monitoring

No institutional monitoring of vegetation was performed in 2005—samples are collected every third year in conjunction with the soil monitoring program. The next sampling period for native vegetation collections is in 2006. For a discussion of results reported in past years, see Gonzales et al. (2000) for 1998 sampling results and see Fresquez and Gonzales (2004) for 2002 and 2003 sampling results. In general, all radionuclide concentrations in vegetation sampled from perimeter and Laboratory areas are low, and most were either nondetectable or below RSRLs. Only plutonium-239,240 was detected above RSRLs in both overstory (trees) and understory (grasses/forbs) vegetation from Laboratory areas. An on-site area where plutonium-239,240 was noted to be at higher concentrations in/on native vegetation as compared with the RSRL was at TA-21 (DP Site). The values, however, were still very low (pCi range), and the difference between on-site concentrations and regional background concentrations was small. Although uranium concentrations in vegetation from all on-site areas were below RSRLs, some plants had uranium isotopic distributions indicative of depleted uranium. Depleted uranium, a less-radioactive version of the metal used as a substitute for the enriched uranium in weapons components tested at LANL, is probably a result of airborne deposition from LANL firing sites (Hansen 1974). However, since depleted uranium is about 40 percent less radioactive than natural uranium and the total uranium concentrations in plants collected from some on-site areas are still below regional background levels, no significant impacts to plants or to animals that ingest the forage are anticipated. In fact, a recent biota dose assessment of the most uranium-contaminated firing site, EF site at TA-15 (Becker 1992, LANL 1998), showed that the dose to plants and animals was 2 percent and 20 percent of the DOE limits, respectively (McNaughton 2006).

4. Facility Monitoring

a. Monitoring Network

We conduct facility-specific biota monitoring on an annual basis at the Laboratory's principal low-level radioactive waste disposal site (Area G) (Lopez 2002) and the Laboratory's principal explosive test facility (DARHT) (Nyhan et al. 2001). See Chapter 7, Section D.1, for a more complete description of Area G and DARHT and Fresquez and Lopez (2004) and Fresquez (2004b), respectively, for a description of sampling methodology. We compared radionuclide levels in biota collected at Area G with RSRLs and compared results for radionuclide and nonradionuclide levels in biota collected at DARHT with BSRLs. Samples at Area G and DARHT were analyzed for tritium, cesium-137, strontium-90, americium-241, and plutonium and uranium isotopes. In addition, DARHT samples were analyzed for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium.

b. Radionuclide Analytical Results for Area G (TA-54)

i. Vegetation. We collected unwashed overstory (trees) and understory (grass and forb) vegetation samples at up to nine locations within and around the perimeter of Area G (Figure 7-3) (Fresquez et al. 2005b). All concentrations of radionuclides in overstory (Table S8-11) and understory (Table S8-12) vegetation are very low and most were not detected or were less than the RSRLs. The exceptions were tritium in some overstory and understory vegetation collected from the south portion of Area G adjacent to the tritium shafts (Sites 1 and 2) and plutonium-238 and plutonium-239,240 in vegetation samples collected from the north (Site 7c) and northeastern (Site 4) areas of Area G. These data correlate very well with the soils data (Chapter 7, section D.2) and are similar to past years (Figures 8-8 and 8-9) (Nyhan et al. 2004, Fresquez et al. 2004a, Fresquez and Lopez 2004). All radionuclide concentrations that were detected above RSRLs were below the SL of 0.1 rad/day for terrestrial plants (e.g., <345,000 pCi/mL for tritium and <822 pCi/g ash for Pu isotopes).

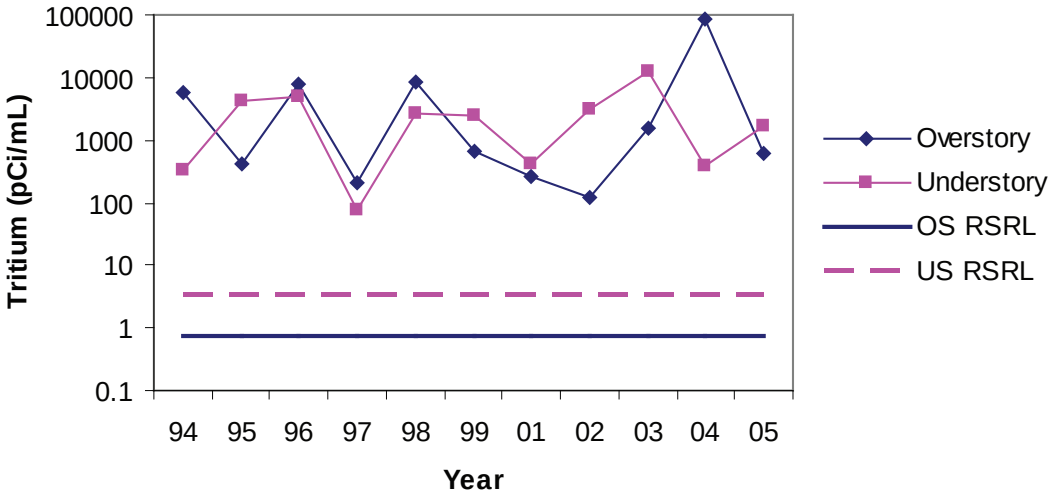


Figure 8-8. Tritium in overstory (OS) and understory (US) vegetation collected from a selected (worst case) location (site 2; see Figure 7-3 for location information) outside of Area G at TA-54 from 1994 through 2005 compared with the regional statistical reference levels (RSRLs).

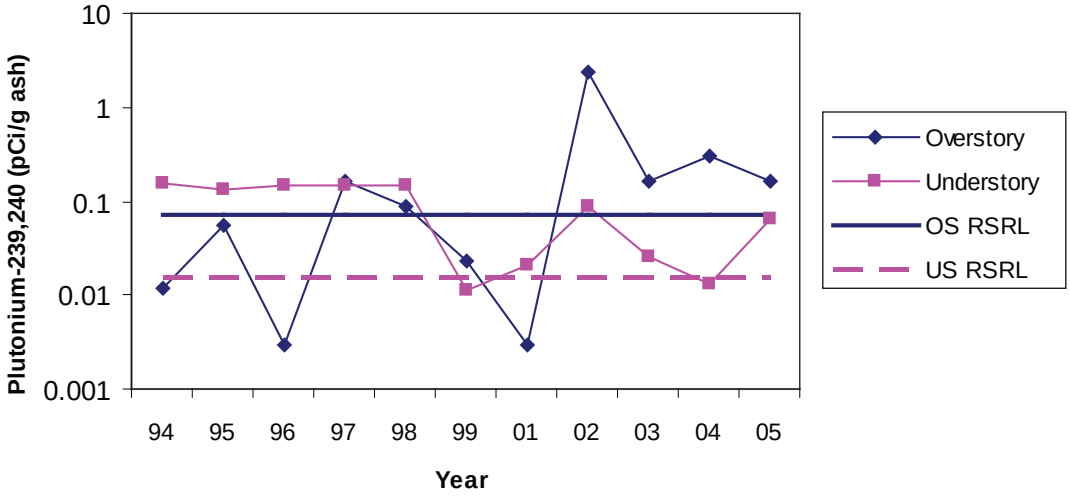


Figure 8-9. Plutonium-239,240 in overstory (OS) and understory (US) vegetation collected from a selected (worst case) location (site 4; see Figure 7-3 for location information) outside of Area G at TA-54 from 1994 through 2005 compared with the regional statistical reference levels (RSRLs).

c. Radionuclide and Nonradionuclide Analytical Results for DARHT (TA-15)

i. Vegetation. We collected unwashed overstory and understory vegetation from four locations around the DARHT facility (Fresquez 2006b) and compared the analytical results with BSRL data established for a four-year preoperational period (Fresquez et al. 2001). All radionuclides, with the exception of uranium-238 in overstory and understory vegetation, were either not detected or below BSRLs (Table S8-13). Although uranium-238 concentrations were detected above the BSRL in all of the overstory vegetation samples collected around the DARHT facility, the concentrations were below the SL (<987 pCi/g ash). The uranium in all of the overstory (and one understory) plants had uranium-234 and uranium-238 isotope distributions consistent with that of depleted uranium and the distribution correlates well to last year's results (Fresquez 2004b). Depleted uranium has also been detected in soils (Fresquez 2004a), bees (Hathcock and Haarmann 2004), and small mammals (Fresquez 2005) at DARHT in past years.

For the nonradionuclides, the concentrations of silver, beryllium, cadmium, chromium, mercury, antimony, selenium, and thallium, for the most part, were below the reporting limits (i.e., they were undetected) (Table S8-14). The nonradionuclides that we detected above the reporting limits included arsenic, barium, copper, nickel and lead; and of these, only arsenic in overstory and understory plants and copper in overstory plants were above the BSRLs. These two elements have been detected in higher concentrations than the BSRLs in the past (Nyhan et al., 2003). Although the concentrations of arsenic and copper in plant tissues collected around the DARHT facility were above the BSRLs, they are below concentrations considered to be toxic to plant growth. Concentrations of arsenic in plant tissues collected at DARHT (0.68 to 0.84 μg/g), for example, are below the range of 2.1 to 8.2 μg/g considered toxic to plants (NRC 1977). Similarly, copper, an essential plant micronutrient, in plant tissues from DARHT (7.5 to 12 μg/g) is within the recommended concentrations for adequate plant growth of 4 to 15 μg/g (Stout 1961) and below the levels considered to be excessive (>22 μg/g) (Figure 8-6) (Embleton et al. 1976, Stout 1961).

ii. Bees. During 2005, honey bees were collected from five hives located just northeast of the DARHT at LANL, analyzed for the same radionuclides and trace elements as those for soils and vegetation samples (Hathcock et al. 2006), and compared to BSRL for bees (Haarmann 2001). Most concentrations of radionuclides (Table S8-15) and all nonradionuclides (Table S8-16) were below the BSRLs. The only radionuclides that were above the BSRLs were those associated with uranium, particularly uranium-238, and the ratios showed that the uranium was of depleted grade. All concentrations of uranium isotopes, however, were still very low and below terrestrial animal dose screening levels (<0.01 rad/d) and, therefore, not a significant hazard.

C. SPECIAL NONFOODSTUFFS BIOTA MONITORING STUDIES

1. Characterization of Biotic and Abiotic Media Upgradient and Downgradient of the Los Alamos Canyon Weir

In May 2000, a prescribed burn at Bandelier National Monument went out of control and burned nearly 50,000 acres of federal and Pueblo lands, including approximately 7,500 acres on LANL property. Because the Cerro Grande Fire burned substantial amounts of vegetative cover, the Laboratory became concerned about increased sediment (and potential contaminant) transport from LANL to off-site locations. As a preventive measure, the US Army Corps of Engineers constructed a low-head weir in Los Alamos Canyon to prevent sediment transport past the northeastern boundary of LANL. Investigations of sediment and surface water within the Los Alamos Canyon watershed indicate that some inorganic, organic, and radionuclides are present in these media at concentrations above SLs (LANL 2004). The weir consists of a rock-filled gabion that lies across the stream bed in Los Alamos Canyon near the junction of N.M. 4 and N.M. 502.

As part of the Special Environmental Analysis of actions taken in response to the Cerro Grande Fire at LANL (DOE 2000), the DOE identified various mitigation measures that must be implemented under the Mitigation Action Plan as an extension of the fire suppression, erosion, and flood control actions. One of the tasks identified in the Mitigation Action Plan Section 2.1.7, "Mitigation Action for Soil, Surface and Ground Water, and Biota," mandates the monitoring of soil, surface and groundwater, and biota at areas of silt or water retention behind flood control structures, within silt retention basins, and within sediment traps to determine if there has been an increase in contaminant concentrations in these areas. We conducted this study to determine the contaminant concentrations of sediment (0- to 15-cm depth), native grasses and forbs (unwashed), and deer mice (Peromyscus sp.) (whole body) in the areas behind the Los Alamos Canyon weir. To this end, the Laboratory measured radionuclides and 23 other inorganic elements (Fresquez 2005b.)

Overall, concentrations of radionuclides and metals in sediments (Tables S7-6 and S7-7), vegetation (Tables S7-8 and S7-9), and small mammals (Table S7-10) collected behind the Los Alamos Canyon weir were very low and mostly below background concentrations (RSRLs) and do not pose significant human health or environmental hazards. These conclusions are consistent with the human health risk assessment and the baseline ecological risk assessment conducted as part of the Los Alamos Canyon Investigation (LANL 2004).

2. Determining Uptake and Distribution of Uranium Isotopes in Pinus Ponderosa at LANL Using Dendrochronogical Analysis

LANL has been conducting open-air, dynamic explosive tests since the early 1940s. We collected samples to determine whether open-air explosives tests have significantly increased uranium concentrations in ponderosa pine (Pinus ponderosa) wood pulp at an isolated site at LANL (see Vigil 2005 for all data). Most of these explosive tests involve the use of uranium and it has been estimated that nearly 100 metric tons of depleted and natural uranium have been expended by LANL since operations began (Becker 1992). We compared composites of wood pulp from pre- and post-LANL operations to determine if variations in environmental uranium concentrations from open-air dynamic explosive tests were reflected in uranium concentrations in trees. Results were that 1) on-site samples collected near a firing site where depleted uranium was expended into the environment showed slightly higher mean activity and total uranium concentrations than off-site samples, however the differences were statistically insignificant, 2) mean total uranium concentrations in post-LANL pulp (0.855 μg/g) were about two times higher than in pre-LANL pulp (0.423 μg/g) in on-site samples; however, the difference was statistically insignificant, and 3) mean total uranium concentrations in on-site post-LANL pulp (0.855 μg/g) were greater than off-site post-LANL pulp (0.257 μg/g), however the difference was statistically insignificant (Table S8-17). On-site samples tended to have lower uranium-234/uranium-238 ratios and higher total uranium concentrations, which was expected in samples containing some depleted uranium. Although the statistical analyses indicate that dynamic tests have not significantly impacted uranium concentrations in ponderosa pine pulp, the robustness of the statistical tests were low as the result of the low number of samples.

3. Cesium-137 in Moss Collected from Background Springs in Northern New Mexico

We collected moss (Bryophyte sp.) growing on the top of rocks from background springs in northern New Mexico to evaluate cesium-137 as an indicator of contamination in aquifers. The moss samples were rinsed in the field. Cesium-137 concentrations varied from -180 pCi/kg dry in the more sheltered sites to 276 pCi/kg dry in the more exposed sites (Table S8-18). The sheltered sites, as compared to the more exposed sites, contained more overstory and understory vegetation so the potential for soil contamination from wind and rain splash to the moss would be less. The weighted mean was 40 ±15 pCi/kg dry.

Results from a moss sample collected from Hemingway Spring in 2003 (24 pCi/kg dry), located approximately 78 miles north of LANL, compares well with readings from the NMED (2004) (13 pCi/kg dry) and the RadioActivist (2004) (59 pCi/kg dry). In addition, our analysis of moss collected from Big Spring, a sheltered site located approximately 44 miles north of LANL, in 2004 (-4.0 pCi/kg dry) and 2005 (-20 pCi/kg dry) showed similar concentrations to those collected by the NMED (2004) (-17 pCi/kg dry) (see Appendix B for an explanation of negative values).

Cesium-137 in the soil from global fallout in the northern hemisphere is around 400 pCi/kg (UNSCEAR 2000). Therefore, the differences in cesium-137 concentrations in moss from different background sites may result from the degree of exposure from the surrounding environment. Environmental factors that may influence the amount of cesium-137 in moss may include the distance the sample was collected downstream from the spring source, the amount of bare ground surrounding the collection points, elevational differences between the spring and higher possible wind blown contamination sources (e.g., a mesa overlooking the spring), and the amount and type of understory and overstory vegetation surrounding the sampling site. These all influence rain splash, which is a major source of contamination to plants in exposed locations (White et al. 1981, Dreicer et al. 1984, Foster et al. 1985).

In summary, cesium-137 is present in moss near several springs in northern New Mexico and the likely source is global fallout.

D. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND NONFOODSTUFFS BIOTA PROGRAM

See Chapter 7, Section E.

E. REFERENCES

Becker 1992: N. M. Becker, "Quantification of Uranium Transport Away From Firing Sites at LANL," Los Alamos National Laboratory report LA-UR-92-283 (1992).

Booher et al. 1998: J. L. Booher, P. R. Fresquez, L. F. Carter, B. M. Gallaher, and M. A. Mullen, "Radionuclide Concentrations in Bed Sediment and Fish Tissue within the Rio Grande Drainage Basin," Los Alamos National Laboratory report LA-13366 (1998).

Bousek: 1996: J. Bousek, "An Analysis of Copper, Zinc, and Mercury Concentrations in Fish Species in Santa Rosa Reservoir, New Mexico," M. S. Thesis, New Mexico Institute of Mining and Technology, Socorro, NM (1996).

Corely et al. 1981: J. P. Corely, D. H. Denham, R. E. Jaquish, D. E. Michels, A. R. Olsen, and D. A. Waite, "A Guide for Environmental Radiological Surveillance at US Department of Energy Installations," Department of Energy report DOE/EP-0023 (1981).

DOE 1991: US Department of Energy, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," US Department of Energy report DOE/EH-0173T (January 1991).

DOE 1993: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (1993).

DOE 1996: US Department of Energy, "Dual Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement Mitigation Action Plan," USDOE/EIS-0228 (1996).

DOE 2002: US Department of Energy, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," US Department of Energy Standard DOE-STD-1153-2002 (July 2002).

DOE 2003: US Department of Energy, "Environmental Protection Program," US Department of Energy Order 450.1 (2003).

Dreicer et al. 1984: M. Dreicer, T. E. Hakonson, G. C. White, and F. W. Whicker, "Rainsplash as a Mechanism for Soil Contamination of Plant Surfaces," Health Physics, Vol. 46, pp. 177–187 (1984).

Embleton et al. 1976: T. W. Embleton, W. W. Jones, and R. B. Platt, "Leaf Analysis as a Guide to Citrus Fertilization," pp. 4-9. In Reisenauer, H.M., ed., Soil and Plant-Tissue Testing in California: Univ. of Calif. Div. of Agr. Sci. Bull. 1879 (1976).

EPA 2000: Environmental Protection Agency, "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories," Vol. 2: Risk Assessment and Fish Consumption Limits, 3rd ed., EPA 823-B-00-008 (2000).

EPA 2001: Environmental Protection Agency, "Water Quality Criterion for the Protection of Human Health: Methylmercury," Office of Science and Technology, Office of Water, US EPA, Washington, DC (2001).

FDA 2000: Food and Drug Administration, "Action Levels for Poisonous or Deleterious Substance in Human Food and Animal Feed," Washington, DC (2000).

Foster et al. 1985: G. R. Foster, G. C. White, T. E. Hakonson, and M. Dreicer, "A Model for Splash and Retention of Sediment and Soil-Borne Contaminants on Plants," Transaction of the American Society of Agricultural Engineers, Vol. 28, pp 1511–1519 (1985).

Fresquez 2004a: P. R. Fresquez, "Mercury in Fish Collected Upstream and Downstream of Los Alamos National Laboratory, New Mexico: 1991–2004," Los Alamos National Laboratory report LA-14172 (2004).

Fresquez 2004b: P. R. Fresquez, "Concentrations of Radionuclides and Trace Elements in Soils and Vegetation around the DARHT Facility during 2004," Los Alamos National Laboratory report LA-14176-PR (2004).

Fresquez 2005: P. R. Fresquez, "Radionuclides in Small Mammals Collected at the Dual-Axis Radiographic Hydrodynamic Test (DARHT) Facility during 2001–2003," Los Alamos National Laboratory report LA-14192-MS (2005).

Fresquez 2006a: P. R. Fresquez, "The Characterization of Biotic and Abiotic Media Upgradient and Downgradient of the Los Alamos Canyon Weir," Los Alamos National Laboratory report LA-MS (2005).

Fresquez 2006b: P. R. Fresquez, "Vegetation," pp 17–23, In: Gonzales et al., "Concentrations of Radionuclides and Trace Elements in Environmental Media around the Dual-Axis Radiographic hydrodynamic Test Facility at Los Alamos National Laboratory during 2005," Los Alamos National Laboratory report LA-14284 (2006).

Fresquez and Armstrong 1996: P. R. Fresquez and D. R. Armstrong, "Naturally Occurring Uranium in Surface- and Bottom-Feeding Fish Upstream and Downstream of Los Alamos National Laboratory," in NORM/NARM: Regulation and Risk Assessment, Proceedings of the 29th Midyear Topical Health Physics Meeting (Scottsdale, Arizona, January 7–10, 1996), pp. 85–90.

Fresquez and Gonzales 2004: P. R. Fresquez and G. J. Gonzales, "Radionuclide Concentrations in Vegetation at the Los Alamos National Laboratory in 2002/2003," Los Alamos National Laboratory report LA-14160-PR (2004).

Fresquez and Lopez 2004: P. R. Fresquez and E. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 2004 Growing Season," Los Alamos National Laboratory report LA-14181-PR.

Fresquez et al. 1994: P. R. Fresquez, D. R. Armstrong, and J. G. Salazar, "Radionuclide Concentrations in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory: 1981 to 1993," Los Alamos National Laboratory report LA-12818-MS (1994).

Fresquez et al. 1996: P. R. Fresquez, D. R. Armstrong, and L. Naranjo, Jr., "Radionuclide and Heavy Metal Concentrations in Soil, Vegetation, and Fish Collected around and within Tsicoma Lake in Santa Clara Canyon," Los Alamos National Laboratory report LA-13144-MS (1996).

Fresquez et al. 1998: P. R. Fresquez, D. R. Armstrong, and L. Naranjo, Jr., "Radionuclides and Heavy Metals in Rainbow Trout from Tsichomo, Nana Ka, Wen Povi, and Pin De Lakes in Santa Clara Canyon," Los Alamos National Laboratory report LA-13441-MS (1998).

Fresquez et al. 1999a: P. R. Fresquez, D. H. Kraig, M. A. Mullen, and L. Naranjo, Jr., "Radionuclides and Trace Elements in Fish Collected Upstream and Downstream of Los Alamos National Laboratory and the Doses to Humans from the Consumption of Muscle and Bone," J. Environ. Sci. Heal. B 34 (5), 885–900 (1999).

Fresquez et al. 1999b: P. R. Fresquez, J. D. Huchton, and M. A. Mullen, "Trace Elements, with Special Reference to Mercury, in Fish Collected Upstream and Downstream of Los Alamos National Laboratory," Los Alamos National Laboratory report LA-13658-MS (1999).

Fresquez et al. 2001: P. R. Fresquez, J. W. Nyhan, and H. T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, and Vegetation around the DARHT Facility," in "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)," Nyhan et al., Los Alamos National Laboratory report LA-13808-MS (2001), pp. 48–76.

Fresquez et al. 2002: P. R. Fresquez, G. J. Gonzales, T. Haarmann, J. Nyhan, and B. Gallaher, "Soil, Foodstuffs, and Associated Biota," pp. 419-521, In: Environmental Surveillance at Los Alamos during 2001, Los Alamos National Laboratory report LA-13979-ENV (2002).

Fresquez et al. 2004a: P. R Fresquez, J. W. Nyhan, and E. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 2003 Growing Season," Los Alamos National Laboratory report LA-14108-PR (2004).

Fresquez et al. 2004b: P. R. Fresquez, J. K. Ferenbaugh, and L. Naranjo, Jr, "Moisture Conversion Ratios for the Foodstuffs and (Nonfoodstuffs) Biota Environmental Surveillance Programs at Los Alamos National Laboratory (Revision 2)," Los Alamos National Laboratory document LA-UR-04-4122 (2004).

Fresquez et al. 2005a: P. R. Fresquez, G. Gonzales, and C. Hathcock, "Foodstuffs and Biota Monitoring," in "Environmental Surveillance at Los Alamos during 2004," Los Alamos National Laboratory report LA-14239-ENV (2005), pp. 199–210.

Fresquez et al. 2005b: P. R. Fresquez, M.W. McNaughton, and M.J. Winch, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during 2005," Los Alamos National Laboratory report LA-14251-PR (2005).

Gonzales and Fresquez 2003: G. J. Gonzales and P. R. Fresquez, "Polychlorinated Biphenyls (PCBs) in Catfish and Carp Collected from the Rio Grande Upstream and Downstream of Los Alamos National Laboratory," Los Alamos National Laboratory report LA-14001 (February 2003).

Gonzales and Fresquez 2006: G. J. Gonzales and P. R. Fresquez, "Polychlorinated Biphenyls (PCBs) in Predator and Bottom-Feeding Fish from Abiquiu and Cochiti Reservoirs," Los Alamos National Laboratory report LA-14289-MS (2006).

Gonzales and Montoya 2005: G. J. Gonzales and J. T. Montoya, "Polychlorinated Biphenyls (PCBs) in the Rio Grande Sampled Using Semi-Permeable Membrane Devices ("Fat Bags")," Los Alamos National Laboratory report LA-14200-MS (2005).

Gonzales et al. 1999: G. J. Gonzales, P. R. Fresquez, and J. W. Beveridge, "Organic Contaminant Levels in Three Fish Species Downchannel from the Los Alamos National Laboratory," Los Alamos National Laboratory report LA13612-MS (1999).

Gonzales et al. 2000: G. J. Gonzales, P. R. Fresquez, M. A. Mullen, and L. Naranjo, Jr., "Radionuclide Concentrations in Vegetation at the Los Alamos National Laboratory in 1998," Los Alamos National Laboratory report LA-13704-PR (2000).

Gough et al. 1979: L. P. Gough, H. T. Shacklette, and A. A. Case, "Element Concentrations Toxic to Plants, Animals, and Man," Geological Survey Bulletin 1466 (US Government Printing Office, Washington, D.C.) (1979).

Haarmann 2001: T. K. Haarmann, "Baseline Concentrations of Radionuclides and Heavy Metals in Honey Bee Samples Collected near DARHT," in "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)," J. Nyhan et al., Los Alamos National Laboratory report LA-13808-MS (2001).

Hansen 1974: W. C. Hansen, "Ecological Considerations of Depleted Uranium Munitions," Los Alamos National Laboratory report LA-5559 (1974).

Hathcock and Haarmann 2004: C. D. Hathcock and T. K. Haarmann, "Concentrations of Radionuclides and Trace Elements in Honey Bee Samples Collected Near DARHT in 2003," Los Alamos National Laboratory document LA-UR-04-8349 (2004).

Hathcock et al. 2006: C. D. Hathcock, P.R. Fresquez and K. Keller, "Honey Bees," in "Concentrations of Radionuclides and Trace Elements in Environmental Media around the Dual-Axis Radiographic Hydrodynamic Test Facility at Los Alamos National Laboratory during 2005," Gonzales et al., Los Alamos National Laboratory report LA-PR. pp 25-32.

Keith 1991: L. H. Keith, Environmental Sampling and Analysis: A Practical Guide (CRC Press, Inc., Baca Raton, FL, 1991).

LANL 1998: Los Alamos National Laboratory, "Work Plan for Pajarito Canyon," Los Alamos National Laboratory report LA-UR-98-2550 (1998).

LANL 2000: Los Alamos National Laboratory, Fresquez, P. R. and G. J. Gonzales, "Soil, Foodstuffs, and Associated Biota," in "Environmental Surveillance at Los Alamos during 1999," Los Alamos National Laboratory report LA-13777-ENV (2000), pp. 309–360.

LANL 2001: Los Alamos National Laboratory, "Soil, Foodstuffs, and Associated Biota," in "Environmental Surveillance at Los Alamos during 2000," Fresquez, P., G. Gonzales, T. Haarmann, J. Nyhan, and B. Gallaher, Los Alamos National Laboratory report LA-13861-ENV (2001), pp. 407–489.

LANL 2002: Los Alamos National Laboratory, "Soil, Foodstuffs, and Associated Biota, in "Environmental Surveillance at Los Alamos during 2001," Fresquez, P., G. Gonzales, J. Nyhan, T. Haarmann, L. Soholt, and B. Gallaher, Los Alamos National Laboratory report LA-13979-ENV (2002), pp. 421–521.

LANL 2004: Los Alamos National Laboratory, "ECORISK Database (Release 2.1)," Environmental Stewardship-Remediation Services Project (2004).

Lopez 2002: E. Lopez, "MDA G and L Environmental Monitoring Plan for FY 2002," Los Alamos National Laboratory document LA-UR-02-6128 (2002).

McNaughton 2006: M. McNaughton, "Calculating Dose to Non-Human Biota," ENV-MAQ-514, R1 (2006).

Nelson and Whicker 1969: W. C. Nelson and F. W. Whicker, "Cesium-137 in Some Colorado Game Fish, 1965–66," in Symposium on Radioecology, US Atomic Energy Commission report CONF-670503 (1969).

NMDH 1993: New Mexico Department of Health, "Fish Consumption Guidelines due to Mercury Contamination," NM Department of Health, NM Environment Department, NM Department of Game and Fish (1993).

NMED 1999: New Mexico Environment Department, "A White Paper on Mercury," New Mexico Environment Department, Surface Water Quality Bureau, Santa Fe, NM (1999).

NMED 2004: New Mexico Environment Department, "Radionuclide Concentrations in Aquatic Bryophtes in Four Springs Along the Rio Grande," Data from Ralph Ford-Schmidt (NMED) to Phil Fresquez (LANL) (December 2005).

NMED 2006: New Mexico Environment Department, E-mail from Ralph Ford-Schmid (NMED) to Gil Gonzales, Los Alamos National Laboratory, on "PCBs in fish tissue data 1993–2002 6-22-04.xls," dated Jan. 27, 2006.

NRC: National Research Council, "Committee on Biologic Effects of Atmospheric Pollutants, Arsenic," pp. 332. Washington National Academy of Science (1977).

Nyhan et al. 2001: J. W. Nyhan, P. R. Fresquez, K. D. Bennett, J. R. Biggs, T. K. Haarmann, D. C. Keller, and H. T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)," Los Alamos National Laboratory report LA-13808-MS (2001).

Nyhan et al. 2003: J. W. Nyhan, P. R. Fresquez, and E. L. Taylor, "Concentrations of Radionuclides and Trace Elements in Soils and Vegetation Around the DARHT Facility during 2002," Los Alamos National Laboratory report LA-14056-PR (2003).

Nyhan et al. 2004: J. Nyhan, P. R. Fresquez, R. Velasquez, and E. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 2002 Growing Season (With a Summary of Radionuclide Concentrations in Soils and Vegetation Since 1980)," Los Alamos National Laboratory report LA-14095-PR (2004).

Ochiai 1995: E. Ochiai, "Toxicity of Heavy Metals and Biological Defense: Principles and Applications in Bioinorganic Chemistry-VII," Journal of Chemical Education 72, 479-484 (1995).

RadioActivist 2004: The RadioActivist Campaign, "Radioactivity Entering the Rio Grande: Confirmed," 7312 N.E. North Shore Road, Belfair, WA (October 19, 2004).

Schroeder et al. 1966: H. A. Schroeder, J. J. Balassa , and I. H. Tipton, "Essential Trace Metals in Man—Manganese," Journal Chronic Diseases 19:545-571 (1966).

Stout 1961: P. R. Stout, "Micronutrient Needs for Plant Growth," pp. 35-41. In Proc. 9th Annual California Fertilizer Conferences, California State Polytechnical Univ. Coop. Ext. Ser. Circ 433 (1961).

Torres 1998: P. Torres, "Metal Accumulation in Various Fish Species from Conchas Lake and Santa Rosa Lake in East Central New Mexico," M.S. Thesis, New Mexico Institute of Mining and Technology, Socorro, NM (1998).

UKARC 1961: U.K. Agricultural Research Council, "Strontium-90 in Milk and Agricultural Materials in the United Kingdom 1950-1960," U.K. Agricultural Research Council report No. 4, London, UK (1961).

UNSCEAR 2000: United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation," UNSCEAR 2000 Report to the General Assembly, United Nations publication, ISBN 92-1-142238-8 (2000).

Vigil 2005: G. G. Vigil, "Determining Uptake and Distribution Isotopes in Pinus Ponderosa at LANL Using Dendrochronogical Analysis," Los Alamos National Laboratory report LA-UR-05-3099 (2005).

Whicker and Schultz 1982: W. F. Whicker and V. Schultz, Radioecology: Nuclear Energy and the Environment (CRC Press, Inc., Boca Raton, FL, 1982).

Whicker et al. 1972: W. F. Whicker, W. C. Nelson, and A. F. Gallegos, "Fallout Cs-137 and Sr-90 in Trout from Mountain Lakes in Colorado," Health Phys. 23, 517–527 (1972).

White et al. 1981: G. C. White, T. E. Hakonson, and A. J. Ahlquist, "Factors Affecting Radionuclide Availability to Vegetables Grown at Los Alamos," Journal of Environmental Quality, 10, 294–299 (1981).

Yanicak 2001: S. Yanicak, "Cochiti Reservoir Fish Tissue Sampling Results: Dioxin/Furan and Mercury and Abiquiu Reservoir Fish Tissue PCB Sampling Results—1999 and 2000," State of New Mexico Environment Department DOE Oversight Bureau letter to Joe Vozella (April 12, 2001).

9. ENVIRONMENTAL RESTORATION

contributing author:
Rich Mirenda

To Read About **Turn to Page**

A. INTRODUCTION

This chapter summarizes the work accomplished during 2005, and in some cases in previous years, to investigate and clean up sites and facilities formerly involved in weapons research and development. This work was conducted by the former Environmental Remediation and Surveillance Program and the former Environmental Restoration Project. Starting in mid-2006, this work was managed under the new Environment and Remediation Support Services Division. The goal of the cleanup and investigation efforts is to ensure that past operations do not threaten human or environmental health and safety in and around Los Alamos County. The sites under investigation are designated as solid waste management units (SWMUs) or areas of concern (AOCs). Individual SWMUs and AOCs may be grouped into consolidated units. More information about the environmental restoration work may be found at http://www.lanl.gov/community/environment/cleanup/.

The New Mexico Environment Department (NMED) has authority under the New Mexico Hazardous Waste Act over cleanup of hazardous wastes and hazardous constituents. The US Department of Energy (DOE) has authority over cleanup of radioactive contamination. Radionuclides are regulated under DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management." Corrective actions for the releases of hazardous waste and hazardous constituents at the Laboratory are subject to the Compliance Order on Consent (the Consent Order) signed by the NMED, the DOE, the Regents of the University of California, and the State of New Mexico Attorney General on March 1, 2005. The Consent Order was issued pursuant to the New Mexico Hazardous Waste Act (New Mexico Statutes Annotated 1978, § 74-4-10) and the New Mexico Solid Waste Act (NMSA 1978, §74-9-36[D]). DOE is implementing corrective actions pursuant to the Atomic Energy Act for releases of radionuclides in conjunction with the activities required under the Consent Order.

1. 2005 Projects

The program was organized in 2005 into projects that encompassed groupings or types of sites (SWMUs and AOCs) slated for investigation and/or remediation. These projects include Watershed Integration, Townsites, Delta Prime (DP) Site, Technical Area (TA) 54 Material Disposal Areas (MDAs), and Corrective Actions. Each of these projects is briefly described below.

a. Watershed Integration

The Watershed Integration Project includes the activities in the Canyons Investigations, the required Groundwater Monitoring Project (through the Interim Facility-Wide Groundwater Monitoring Plan), and storm water monitoring and minimization of erosion and the transport of contaminants from sites by storm water runoff. The project collects, manages, and reports environmental data, and utilizes the combined data to support site decisions.

b. Townsites

The Townsites Project includes the investigation of and, as appropriate, the corrective actions for sites associated with Laboratory operations during the Manhattan Project and early Cold War era. The SWMUs or AOCs are located within the Los Alamos townsite (on property currently owned by private citizens, businesses, or Los Alamos County) and on property administered by the US Forest Service, the National Park Service, and the DOE. In addition, the Townsites Project includes the remediation and investigation of all land transfer parcels prior to transfer under Public Law 105-119.

c. DP Site

This project includes implementation of investigation work plans and evaluation and implementation of corrective measures for MDAs A, B, T, U, and V, the former process waste lines, and a broad category of environmental sites, referred to as the DP Site Aggregate (TA-21). The TA-21 site includes sanitary septic systems, pipes, drains and outfalls, a drywell sump, surface drainage and disposal areas, a polychlorinated biphenyl (PCB) container storage area, drum storage areas, the footprint of a historic waste treatment laboratory, and a sewage treatment plant, all of which served all or parts of the process facilities at DP West and DP East. Potential remedies include maintenance, excavation, engineered cover, and stabilization.

d. TA-54 MDAs

This project includes implementation of investigation work plans and evaluation and implementation of corrective measures for MDAs G, H, and L. The corrective measure evaluations will assess the potential remedies for each MDA and recommend a preferred remedy for implementation. Potential remedies include maintenance, excavation, engineered cover, stabilization, and soil vapor extraction. In addition, long-term monitoring will be conducted at each of the MDAs.

e. Corrective Actions

This project includes all investigations and subsequent remediation of SWMUs and AOCs intermixed with active Laboratory operations. The investigation and cleanup activities for these SWMUs and AOCs will be coordinated with managers for active mission projects to ensure operations are not disrupted. Soil removal, geodetic surveys, and debris pickup are a few of the activities taking place at aggregates where a corrective action is anticipated.

2. Work Plans and Reports

During calendar year 2005, a number of work plans and reports were written, reviewed, and/or approved by NMED. The work plans are proposed investigation activities designed to characterize SWMUs, AOCs, consolidated units, aggregates, and watersheds. The data are used to determine if the sites are characterized to define the nature and extent of contamination and the presence of potential unacceptable risks to human health and the environment. Depending on the data and the assessment results, sites may require additional investigation, remediation, monitoring, or no further action.

Tables 9-1 and 9-2 summarize the work plans and reports submitted and approved in 2005, the work plans and reports submitted prior to 2005 but approved in 2005, and the work plans and reports submitted in 2005 but not yet approved. The remainder of this section presents summaries of the investigations reported on in 2005.

Table 9-1
Work Plans Submitted and/or Approved in 2005

Document Title	Date Submitted	Date Approved	Status of Investigation
Work Plan for Pajarito Canyon	7/17/1998	10/17/2005[a]	Investigation activities started
Work Plan for Sandia Canyon and Canada del Buey	9/1/1999	9/23/2005	Scheduled to start in 2007
Work Plan for North Canyons	9/21/2001	7/21/2005[a]	Scheduled to start in 2006
MDA T [SWMU 21-016(a)-99] Investigation Work Plan	2/27/2004	5/23/2005[a]	Investigation activities started
DP Site Aggregate Area Investigation Work Plan	8/31/2004	4/15/2005[a]	Scheduled to start in 2006
Revisions to DP Site Aggregate Area Investigation Work Plan	7/29/2005	—[b]	Under review
MDA U [SWMU 21-017(a)-99] Investigation Work Plan	11/30/2004	3/28/2005[a]	Work plan activities completed
MDA L Investigation Work Plan, Revision 2	1/13/2005	N/A[c]	Work plan activities completed
MDA A Investigation Work Plan	1/31/2005	7/28/2005[a]	Scheduled to start in 2006
MDA A Historical Investigation Report	1/31/2005	N/A	N/A
Accelerated Corrective Action Work Plan for SWMU 33-013	3/22/2005	5/2/2005[a]	Work plan activities completed
Accelerated Corrective Action Work Plan for AOC 03-001(i) and SWMUs 03-029 and 61-002	12/2/2004	3/17/2005[a]	Work plan activities completed
Investigation Work Plan for 16-008(a)-99 [90s Line], 16-007(a)-99 [30s Line] the Ponds	3/31/2005	8/24/2005	Scheduled to start in 2006
MDA C Investigation Work Plan, Revision 1 and Supplemental Information	5/12/2005	4/13/2005[a]	N/A
MDA C Investigation Work Plan, Revision 2	10/21/2005	N/A	Investigation activities started
Investigation Work Plan for TA-16-340 Complex, Revision 1	5/13/2005	N/A	Work plan activities completed
Investigation Work Plan for Pueblo Canyon Aggregate Area	5/27/2005	9/23/2005[a]	Scheduled to start in 2006
Mortandad Canyon Biota Work Plan	5/27/2005	12/16/2005[a]	Work plan activities completed
Investigation Work Plan for Guaje, Barrancas, Rendija Canyons Aggregate Areas	7/22/2005	—	Scheduled to start in 2006
Investigation Work Plan Bayo Canyon Aggregate Area	7/29/2005	12/21/2005	Scheduled to start in 2006
Bayo Canyon Historical Investigation Report	7/29/2005	N/A	N/A
Investigation Work Plan for Middle Los Alamos Canyon Aggregate Area	12/22/2005	—	Under review

[a] Work plans approved with modifications.
[b] "—" = approval not received in 2005.
[c] N/A = not applicable.

Table 9-2
Reports Submitted and/or Approved in 2005

Document Title	Date Submitted	Date Approved	Status of Investigation
Los Alamos and Pueblo Canyons Investigation Report	4/30/2004	5/16/2005[a]	Supplemental report submitted
Los Alamos and Pueblo Canyons Supplemental Investigation Report (revised risk assessment)	12/15/2005	—[b]	Under review
VCA Completion Report using Soil Vapor Extraction System (AOC 00-027)	6/3/2005	—	Under review
Corrective Measure Study Report for SWMU 16-021(c)-99, Revision 1	6/15/2005	—	Under review
MDA H Corrective Measure Study Report, Revision 1	6/30/2005	—	Under review
Completion Report for the Voluntary Corrective Action at SWMUs 0-030(l), 0-033(a), and 0-030(a), and AOCs 0-004, 0-010(b), 0-033(b), and 0-029 (a,b,c) Supplemental Responses	7/15/2005 and 11/10/2005	12/27/2005	Completed
Remedy Completion Report for former TA-19	7/29/2005	—	Additional sampling warranted
MDA P Site Closure Certification Report, Revision 1	9/2/2005	11/10/2005	Completed
TA-53 Surface Impoundments [SWMU 53-002(a)-99 and AOC 53-008] Investigation Report, Revision 1	9/8/2005	—	Under review
MDA G Investigation Report	9/8/2005	—	Under review
MDA L Investigation Report	9/13/2005	—	Under review
VCA Completion Report for Consolidated Unit 21-013(d)-99	9/30/2003	1/22/2005	Completed
Investigation Report for Mortandad/Ten Site Canyons Aggregate Area	9/30/2005	—	Under review
VCM Completion Report for SWMU 21-011(k)	10/31/2003	8/9/2005	Completed
SWMU Assessment Report for 03-013(i)	10/26/2005	11/16/2005[a]	Completed
Remedy Completion Report for AOC 03-001(i) and SWMUs 03-029 and 61-002	12/15/2005	—	Under review

[a] Reports approved with modifications.
[b] "—"= approval not received in 2005.

B. WATERSHED INTEGRATION PROJECT

The Laboratory took the following actions in this project in 2005:

- Investigations in Pajarito Canyon were started with sediment sampling along the main channels and adjacent floodplains.
- The investigation of sediment, surface water, groundwater, and biota in Mortandad Canyon was completed.
- The work plans for investigations in Pajarito Canyon, Sandia Canyon and Cañada del Buey, and the North Canyons (Guaje, Barrancas, Rendija, and Bayo Canyons) were approved.
- A revised risk assessment for the Los Alamos and Pueblo Canyons Investigation Report was submitted in a supplemental investigation report.

The following are brief summaries of the investigation activities started or completed in 2005.

1. Pajarito Canyon

a. Site Description and History

Pajarito Canyon is located in the central part of the Laboratory (see Figure 1-2). The canyon heads in the Santa Fe National Forest west of the Laboratory boundary and empties into the Rio Grande in White Rock Canyon. The main channel is approximately 14.8 miles long and the watershed area is approximately 8 mi^2. In addition, Twomile Canyon and Threemile Canyon are major tributaries that join Pajarito Canyon and have watershed areas of 3.1 mi^2 and 1.7 mi^2, respectively. Sites within the Pajarito Canyon watershed are located at TAs -3, -12, -15, -18, -23, -27, -59, -64, -48, -55, -54, -8, -9, and -69.

b. Remediation and Sampling Activities

We conducted the first phase of the sediment investigation in 2005 according to the approved work plan for Pajarito Canyon (LANL 1998), as modified by agreements with the NMED (LANL 2005e). Field investigations included detailed geomorphic mapping, associated geomorphic characterization, and sediment sampling in the 14 reaches specified as priority reaches in the work plan (LANL 1998). The Laboratory previously conducted sediment sampling in 2000 as part of post-Cerro Grande fire sediment characterization activities in three reaches that were identified as "contingency reaches" in the work plan, in addition to five priority reaches.

In addition to the sediment investigations, surface water, springs, and groundwater will also be characterized. The Laboratory installed one regional monitoring well and one perched intermediate monitoring well in 2005. The regional well is located immediately below the flood retention structure, which is below the confluence of Pajarito and Twomile Canyons. The intermediate well is located in lower Pajarito Canyon just west of State Road 4.

c. Investigation Summary

The investigation activities in Pajarito Canyon will continue in 2006.

2. Mortandad Canyon

a. Site Description and History

Mortandad Canyon is located in the north-central part of the Laboratory and extends for 9.8 miles from Diamond Drive in TA-3 east-southeast to the Rio Grande. Mortandad Canyon has a total watershed area (excluding Cañada del Buey) of about 6.0 mi^2. Primary tributary drainages on Laboratory land are Effluent Canyon, which heads in TA-48, and Ten Site Canyon, which heads in TA-50. In addition, Cañada del Buey, a major tributary, joins with Mortandad Canyon upstream of the Rio Grande and has a watershed area of 4.3 mi^2. Technical areas in the watershed include TAs-3, -4, -5, -35, -42, -48, -50, -52, -55, -60, and -63.

b. Remediation and Sampling Activities

The third phase of sediment investigations in the Mortandad Canyon watershed were conducted in 2005 according to the approved work plan for Mortandad Canyon (LANL 1997). This phase of the sediment investigation addressed remaining uncertainties in the sources, nature, and extent of contaminants in sediment deposits in the watershed. We collected a total of 132 samples from 16 reaches in Mortandad, Effluent, and Ten Site Canyons and an unnamed tributary to Mortandad Canyon that heads in TA-5. This work completed the planned sediment investigations under the approved work plan (LANL 1997).

We conducted surface water and groundwater-related activities in Mortandad Canyon in late 2004 into 2005. The activities included drilling and monitoring of groundwater monitoring wells and piezometers, sampling of persistent surface water, drilling of characterization boreholes, an infiltration investigation, and conducting geophysical surveys (LANL 2004b). A total of eight alluvial wells, two piezometer nests, four intermediate wells, and two regional aquifer wells were drilled. Twelve characterization boreholes were drilled to assess contamination in the vadose zone beneath the canyon floor. Three additional boreholes were drilled to investigate geophysical anomalies identified in the geophysical surveys. We selected the surface water sample locations from areas where persistent surface water is present (LANL 2004b).

Our studies evaluated the potential ecological effects of contaminants through multiple lines of evidence (LANL 2005b). The studies included field surveys of small mammals (primarily mice and shrews), birds, and plants and laboratory toxicity tests of plant seedlings, earthworms, and aquatic invertebrates (chironomids). Habitat assessments and aquatic macroinvertebrate sampling were conducted at locations where surface water flow volume and persistence could support aquatic invertebrate communities. Concentrations of contaminants within insects, eggs, and small mammals were also measured. In addition, bird nestbox monitoring was conducted to measure parameters of effect (nest success, eggshell thickness, and sex ratio) and exposure (egg concentrations and insect concentrations) for avian ground invertevores (western bluebird) and for avian insectivores (southwestern willow flycatcher). Spatial modeling across the watershed will further assess the potential risk across larger areas for representative bird and mammal receptors.

c. Investigation Summary

Results of the investigation will be presented in the Mortandad Canyon investigation report in 2006.

C. TOWNSITES PROJECT

Investigations conducted on townsite SWMUs and AOCs in 2005 included the following:

- Remediation and sampling at TA-19 and the soil vapor extraction project at AOC 00-027, i.e., the Knights of Columbus.
- Work plans were submitted to NMED for investigations of the Pueblo Canyon Aggregate Area; Bayo Canyon Aggregate Area; Guaje, Barrancas, and Rendija Canyons Aggregate Areas; and the Middle Los Alamos Canyon Aggregate Area.
- The Pueblo and Bayo Canyons Aggregate Areas work plans were approved by NMED and the others were under review. No investigation activities were conducted for these aggregate areas.
- Supplemental information and assessments were submitted for the voluntary corrective action at SWMUs 0-030(l), 0-033(a), and 0-030(a), and AOCs 0-004, 0-010(b), 0-033(b), and 0-029 (a, b, c) (no field activities occurred), which was subsequently approved and the sites approved for no further action by NMED.

The following sections briefly summarize the investigations completed in 2005 and those investigations for which reports were submitted in 2005.

1. TA-19

An accelerated corrective action (ACA) was conducted for Consolidated Unit 19-001-99 in what was TA-19 (formerly known as the East Gate Laboratory) (LANL 2004a). A complete description of the field activities, data review, and risk assessments for this site are presented in the Remedy Completion Report for the Investigation and Remediation of Consolidated Unit 19-001-99 (LANL 2005d).

a. Site Description and History

The former East Gate Laboratory was used to conduct spontaneous-fission experiments and to store radioactive source material. Site operations potentially released inorganic chemicals and radionuclides to the surface and subsurface soil and tuff. Consolidated Unit 19-001-99 (comprised of septic system [SWMU 19-001]), surface disposal area [SWMU 19-002], sewer drainline and outfall [SWMU 19-003], and potential soil contamination beneath buildings [AOC C-19-001]) is located on Los Alamos Mesa east of the Los Alamos County airport and the East Gate industrial park. The consolidated unit is bounded by Pueblo Canyon on the north and by a small side canyon to Pueblo Canyon on the south/southeast. TA-19 currently includes access to, and a portion of, "Camp Hamilton Trail," a public recreational hiking trail.

b. Remediation and Sampling Activities

Soil was removed from two areas in 2004 and samples collected to confirm the effectiveness of the soil removal. Two surface soil samples from two locations were collected from the perimeter of the excavated area at one of the

soil removal locations, and four samples from two locations were collected from the perimeter of the excavated area at the other soil removal location. The soil removal locations were stabilized using straw bales and wattles around and downslope of the removal areas. Samples were also collected from the surface and subsurface soil and/or tuff.

c. Investigation Summary

The characterization sampling did not define the extent of inorganic chemical contamination for this consolidated unit.

The human health risk assessment determined that exposure point concentrations of all noncarcinogenic and carcinogenic chemicals of potential concern (COPCs) were less than their respective residential soil screening levels (SSLs). The radionuclide COPC (uranium-235) was less than the residential screening action level (SAL). The total excess cancer risk and the hazard index (HI) were below the NMED target levels (NMED 2004). The total dose was below DOE's target dose limit (DOE 2000).

The ecological risk assessment was conducted by comparing soil concentrations to ecological screening levels for terrestrial receptors. The assessment eliminated all COPCs as chemicals of potential ecological concern (COPECs) at the site.

d. Conclusions and Recommendations

Cobalt and chromium concentrations above background at depth (between 4 and 6.5 feet) on the mesa top and the south slope indicated that the vertical extent of these COPCs was not determined. To address this issue, additional samples were proposed to be collected from the mesa-top locations where the elevated chromium and cobalt concentrations were reported.

The human health screening risk assessment concluded that there is no potential unacceptable risk or dose to residential receptors. The ecological screening risk assessment concluded that the concentrations of COPECs do not pose a potential unacceptable risk to ecological receptors. However, we will re-evaluate potential risk after we receive the additional data collected at the site.

The sampling recommended in the report has been conducted and results submitted to NMED in 2006.

2. AOC 0-027

A complete description of the field activities, data review, and risk assessments for this site are presented in the Addendum to the Completion Report for the Voluntary Corrective Action Using a Soil Vapor Extraction System at Area of Concern 0-027 (LANL 2005c).

a. Site Description and History

AOC 0-027 is located in Los Alamos at the intersection of Trinity Drive and DP Road, the current site of the Knights of Columbus Hall. The Laboratory used the site as a fuel-tank farm from approximately 1946 to mid-1948. Then in 1948, the Laboratory converted the site to a drum storage area and stored 55-gal. metal drums of lubricants there for distribution to various Laboratory sites and craft shops. The Laboratory used the drum storage area until the early 1960s, when the storage area was decommissioned.

In June 1996, a soil vapor survey was conducted in the vicinity of the former fuel-tank farm and drum storage area to determine whether vapor-phase contamination existed in the subsurface soils and tuff. Soil vapor samples were analyzed for benzene, toluene, ethylbenzene, and xylene (BTEX). The survey detected elevated levels of BTEX contaminants. Subsurface core samples were collected from 20 borehole locations selected based on the locations of the former fuel-storage cells and areas of contaminated soil identified by the soil vapor survey.

b. Remediation and Sampling Activities

In 2002, the restoration program implemented a soil vapor extraction (SVE) system at the site (LANL 2005c). Eight shallow boreholes were drilled in the parking area of the Knights of Columbus property and used as

monitoring and extraction wells for the SVE system. After the SVE operation was completed, eight new shallow boreholes were drilled, each within 8 ft to the northeast of one of the boreholes drilled in 2002, as confirmatory sampling locations for the SVE process.

The SVE system operated 24 hours a day, seven days a week. After approximately 14 months of operation, the system had largely removed the highly volatile components of the contamination in the areas affected by the system air flow. When the contaminant removal rate had reached an overall asymptotic level, the SVE system operation was terminated. It is estimated that 15,877 lb of gasoline-range organics were removed by the SVE system at AOC 0-027 over the 20-month period of operation. Based on the weight ratio of benzene to gasoline-range organics in the 2002 borehole samples, the system removed an estimated 95 lb of benzene from the subsurface (LANL 2005c).

c. Investigation Summary

As a result of the removal of organic vapors, the human health risk (based on an industrial scenario) was reduced by an order of magnitude for carcinogenic contaminants and by nearly half for noncarcinogenic contaminants. The carcinogenic risk is less than the NMED target level, while the HI for noncarcinogens is slightly greater than the NMED target (NMED 2004).

Although an industrial scenario was used to calculate risk for the site, the actual use of the site is much more limited. Currently the Knights of Columbus Hall is used much less frequently than an average business or office, such that users of the building would receive less exposure than a worker who would be there 8 hr/day for 225 day/yr). The majority of the residual contamination and the highest concentrations are located beneath the concrete parking lot rather than beneath the building itself, so that users of the building are not exposed to potential contamination for extended periods of time. Land use for the site is expected to continue without significant change for the reasonably foreseeable future. For these reasons, the industrial scenario is protective and overestimates the actual risk at the site.

No complete pathways for ecological receptors occur at the site because all the contamination is in the subsurface at depth and the affected area is paved with concrete.

d. Conclusions and Recommendations

The results of confirmation sampling indicated no potential unacceptable risk to human or ecological receptors. Therefore, the corrective action at AOC 0-027 is complete and further investigation or remediation is not warranted (LANL 2005c).

These conclusions and recommendations are pending NMED approval.

D. DP SITE PROJECT

The Laboratory took the following actions in this project during 2005:

- The investigation of soil, tuff, pore gas, and groundwater at MDA U was completed.
- The investigation at MDA T started.
- The investigation and remediation of MDA V started.
- Work plan for DP Site Aggregate Area was approved and revisions to the work plan were submitted.
- The work plan for MDA A was submitted and approved.
- The voluntary corrective measure at the outfall from the industrial waste treatment plant at TA-21 (SWMU 21-011[k]) (report submitted in 2003) was approved.

The following sections summarize the investigations started or completed in 2005.

1. MDA U

NMED approved the MDA U investigation work plan with modifications (LANL 2004i) to finalize the subsurface characterization of the site. Field investigations were completed in 2005 based on the approved work plan.

a. Site Description and History

MDA U (Consolidated Unit 21-017[a]-99) is located on the northeastern section of the DP Mesa within TA-21. The site is inactive and consists of four individual SWMUs consolidated into a single unit (Consolidated Unit 21-017[a]-99). The four SWMUs are the western absorption bed (21-017[a]); the eastern absorption bed (21-017[b]); former distribution box (21-017[c]); and a sump (21-022[f]). This investigation did not address the sump. MDA U operated from 1948 to 1968 as a subsurface disposal site for radioactively contaminated liquid wastes. MDA U also received process cooling water effluent until sometime after 1976. In addition, oil from precipitrons (air filters used to remove dust, dirt, smoke, soot, and other solids from ventilating air) was disposed of at MDA U. Disposal of liquid effluent ceased in 1968, but the western absorption bed continued to receive water from a cooling tower until approximately 1976.

b. Remediation and Sampling Activities

During our investigation, we drilled a total of nine boreholes at MDA U. Eight boreholes were placed around the perimeter of MDA U to define the lateral and vertical extent of site contamination and were advanced to a depth of approximately 120 feet below ground surface (bgs). The ninth borehole, located in the center of MDA U between the absorption beds, was drilled to a depth of 360 ft bgs to define the vertical extent of contamination, the nature and depth of fracture zones, and the existence of any possible perched saturation zones.

Surface samples were collected at each of the nine borehole locations. Subsurface samples were collected from each borehole where elevated field-screening levels, fracture zones, or zones of elevated soil-moisture content were present. Subsurface pore-gas samples were collected from each of the nine boreholes after characterization drilling and geophysical logging activities were completed.

c. Investigation Summary

The Laboratory will report the results of the MDA U investigation in an investigation report and submit it to NMED in 2006.

2. MDA T

NMED approved the MDA T investigation work plan with modifications (LANL 2004c) to finalize the characterization of the site. Investigation activities at MDA T commenced in late 2005.

a. Site Description and History

MDA T (Consolidated Unit 21-016[a]-99), an area of approximately 2.2-ac located within TA-21 on DP Mesa, has both hazardous and radiological components. The SWMUs and AOCs associated with Consolidated Unit 21-016(a)-99 were operational from 1945-1986. The consolidated unit includes SWMUs and AOCs associated with the decommissioned waste treatment facilities and various disposal and storage areas adjacent to or within the boundary of MDA T. The SWMUs include inactive absorption beds, a retrievable waste storage area, asphalt-lined disposal shafts, sumps, acid holding tanks, acid sumps, effluent holding tanks, sodium hydroxide storage tank, an americium raffinate storage tank, acid valve pit manholes, underground steel tanks, a septic tank, grit chamber or settling tank, and airborne releases from incinerators used to burn waste oils and organics after testing (oil spills from the incinerators are known to have occurred). In addition, several AOCs are associated with MDA T and include an outdoor storage area used to hold containerized radioactive sludge, an acid storage tank, a former satellite accumulation action, a raffinate holding tank, aboveground acid holding tanks, and spills and other unintentional releases.

b. Remediation and Sampling Activities

The investigation at MDA T will consist of the following:

- Three deep vertical boreholes about 385 ft bgs into the Cerro Toledo interval and five deep vertical boreholes to 280 ft bgs within the boundaries of the MDA T area.
- Three contingent deep boreholes to 280 ft bgs to the north and south of MDA T if contamination is detected with field screening instruments in adjacent boreholes.
- Seven shallower vertical boreholes to 100 ft bgs around Building 257 and its associated structures.
- Three contingent 100-ft boreholes to further characterize contamination associated with Building 257 if contamination is detected with field screening instruments in adjacent boreholes.
- One 100-ft borehole and six 40-ft boreholes around the location of former Building 35.
- Three shallow boreholes to 40 ft bgs within the drainage at the north end of MDA T.
- A row of four boreholes to 30 ft bgs at each end and outside of the fenced area of MDA T to locate the paleochannel beneath MDA T.
- Up to four former surface sample locations across the site based on field surveys and screening (more surface samples will be collected as needed).
- Surface (0–0.5 ft) and shallow subsurface (1.5 ft–2.0 ft) samples from 14 locations along the top of the DP Canyon slope to the DP Canyon stream channel.

Surface samples will be collected on the canyon slope and within the MDA T boundary to characterize areas of elevated activities based on the survey. Subsurface samples will be collected from all boreholes. Subsurface pore gas samples will also be collected from the three deep vertical boreholes (385 ft bgs).

c. Investigation Summary

The Laboratory plans to report the results of the MDA T investigation in an investigation report and submit the report to NMED in 2006.

3. MDA V

NMED approved the MDA V investigation work plan (LANL 2004f) with modifications to finalize the characterization of the site. Investigation activities at MDA V began in 2005.

a. Site Description and History

MDA V, which is part of Consolidated Unit 21-018(a)-99, includes three SWMUs and one AOC in a 0.88-ac fenced area located on the south side of DP Road just west of the TA-21 main gate. These SWMUs and AOC comprise three wastewater absorption beds, a former laundry facility, a waste treatment laboratory septic system and outfall, and two surface disposal areas.

b. Remediation and Sampling Activities

Fourteen boreholes will be drilled to between 40 ft and 80 ft bgs and one borehole will be drilled near the center of MDA V to 380 ft bgs into the Cerro Toledo interval. Subsurface pore gas samples will be collected from the boreholes.

Remediation of MDA V will involve the excavation and removal of distribution pipes and absorption bed materials (soil, sand, gravel, and cobbles). Remediation activities will include the removal of buried pipes and contaminated soil beneath the lines and from the outfall area. The surface disposal areas will also be remediated and will involve the removal of debris from the slope area. Contaminated soil beneath the debris may also be removed. Following the remediation activities, confirmation samples will be collected.

c. Investigation Summary

The Laboratory will report the results of the MDA V investigation in an investigation report and submit it to NMED in 2006.

E. TA-54 MDAs PROJECT

The following actions occurred in this project:

- NMED approved the investigation work plan for MDA L with modifications to finalize the environmental characterization of the site.
- The Laboratory issued a second revision to the MDA L work plan (LANL 2005h).
- NMED approved the MDA G investigation work plan with modifications to finalize the environmental characterization of the site.
- The Laboratory issued a revised MDA G work plan (LANL 2004j).
- The investigation reports for both MDAs were submitted in 2005.
- Revision 1 of the corrective measure study report for MDA H was submitted (no investigation activities occurred in 2005) and is under review.

The following sections summarize the overall investigations that were started, continued, and completed as well as those investigations for which reports were submitted in 2005.

1. MDA L

A complete description of the field activities, data review, and risk assessments for this site are presented in the Investigation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, Technical Area 54 (LANL 2005f).

a. Site Description and History

MDA L (SWMU 54-006) is located at TA-54 in the east-central portion of the Laboratory on Mesita del Buey, within an 1,100-ft by 3,000-ft (2.5-ac) fenced area known as Area L. MDA L operated from the late 1950s until it was decommissioned in 1985. MDA L is a decommissioned area established for disposing of nonradiological liquid chemical waste, including containerized and noncontainerized liquid wastes; bulk quantities of treated aqueous waste; batch-treated salt solutions; electroplating wastes, including precipitated heavy metals; and small-batch quantities of treated lithium hydride.

The MDA L investigation reported data from one inactive subsurface disposal pit (Pit A); three inactive subsurface treatment and disposal impoundments (Impoundments B, C, and D); and 34 inactive disposal shafts (Shafts 1 through 34) excavated into the overlying soil and unit 2 of the Tshirege Member of the Bandelier Tuff. Upon decommissioning, the pit and impoundments were filled and covered with clean, crushed, consolidated tuff. When the shafts were filled to within approximately 3 ft of the surface, they were capped with a 3-ft concrete plug.

b. Remediation and Sampling Activities

One sediment sample was collected in 2005 to complete the characterization of the channel that drained storm water from the surface of MDA L before the asphalt surface was emplaced. Eight boreholes were drilled alongside the pit, impoundments, and shafts in 2004 and 2005 (LANL 2005f). Five boreholes were drilled to 150 ft bgs and another was drilled at an angle of 85º from horizontal to a vertical depth of 300 ft bgs. One borehole was drilled to 660 ft bgs with an air-rotary rig to determine whether perched groundwater is present and to collect hydrogeologic property data.

Samples of core, fracture samples, and subsurface pore-gas samples were collected from some or all of the boreholes (LANL 2005f). To supplement the current pore-gas monitoring program, boreholes were completed as vapor-monitoring boreholes by installing a FLUTe soil-gas sampling sand-filled membrane.

Tritium measurements in air were collected during two biweekly sampling events in the breathing zone for an on-site worker at the MDA L fence line. Ambient air in eight selected structures at MDA L was sampled for volatile organic compounds (VOCs) over an 8-hr period.

c. Investigation Summary

Concentrations of inorganic chemicals detected in core from beneath MDA L were indicative of natural variability within the various stratigraphic layers. Inorganic chemicals identified as COPCs in the previous investigation were detected in subsurface rock samples collected during the 2005 investigation; in addition, other inorganic chemicals were detected above background values.

Only one radionuclide (uranium-235) was reported slightly above its background level. No other radionuclides were detected or detected above background in core samples beneath MDA L.

Consistent with previous results, core samples confirmed the presence of a number of organic chemicals at trace levels (i.e., at μg/kg) beneath the former disposal units. The organic chemicals appear to be the result of multiphase partitioning from the vapor plumes. Other VOCs, semivolatile organic compounds (SVOCs), and PCBs detected beneath MDA L were at trace concentrations and appear to be isolated occurrences and not the result of a release.

Analytical results from pore-gas samples collected from the eight boreholes confirmed the presence of a vapor-phase plume. Analytical results from these boreholes and ongoing quarterly vapor-plume monitoring data confirm the eastern and western shaft fields as the sources of the plume. The data also confirm that the VOC plume is in a near steady state, and the vapor-phase concentrations do not indicate the presence of a free liquid source in the subsurface beneath MDA L. The plume is limited at depth by the Cerros del Rio basalt layer.

The collected samples confirmed tritium in all eight boreholes. The highest tritium readings were beneath the eastern portion of the facility. In addition, tritium was detected in the Cerros del Rio basalts at a depth interval of 550 to 608 ft.

Subsurface samples were collected from the deep borehole to evaluate moisture properties and to determine if perched water zones are present beneath MDA L. Perched water was not encountered in this borehole.

Ambient air was sampled in eight selected structures at MDA L. We compared the concentrations of the individual analytes and analyte mixtures with the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs) or Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs), and we found that the concentrations were below the published exposure limits.

The screening assessment for tritium in air was based on two biweekly sampling events in the breathing zone for a site worker at the MDA L fence line. The activities measured during the events were several orders of magnitude less than 1500 pCi/m^3, which US Environmental Protection Agency (EPA) has determined is equivalent to an annual radiation dose of 10 mrem/yr from inhalation, assuming the receptor is on site 24 hr/day, unshielded.

The results of the human health risk assessment indicated that noncarcinogenic and carcinogenic risks for an industrial worker were less than the NMED target levels (NMED 2004). Potential dose for an industrial worker was below the DOE's target dose limit (DOE 2000).

Contamination in channel sediment and tuff does not pose a potential risk to ecological receptors. Pore-gas VOCs may potentially impact burrowing animals based on the inhalation HI (38). No burrows are present within the fence at MDA L because the surface is paved with asphalt. The presence of active burrows outside of the fenced source area to the west of MDA L, however, indicates that pore-gas VOCs may not be a factor limiting or preventing gopher burrows.

d. Conclusions and Recommendations

Data gathered during the previous investigation, ongoing quarterly monitoring, and the recent investigation have characterized the nature and extent of contamination in the drainage and subsurface media (LANL 2005f). Subsurface samples collected to evaluate moisture properties did not identify any perched groundwater zones to a depth of 660 ft beneath MDA L. In addition, the results from human health and ecological risk assessments indicated that MDA L poses no potential unacceptable risk or dose to human and ecological receptors (LANL 2005f).

Therefore, based on the results of our field investigations, we recommended the following actions:

- Complete a corrective measure evaluation to recommend a remedy to ensure potential future releases from MDA L do not pose a potential unacceptable risk or dose to human and ecological receptors.
- Monitor the subsurface vapor plumes in accordance with a long-term monitoring plan approved by NMED.

These conclusions and recommendations are pending NMED approval.

2. MDA G

A complete description of the field activities, data review, and risk assessments for this site are presented in the Investigation Report for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99, Technical Area 54 (LANL 2005g).

a. Site Description and History

MDA G (Consolidated Unit 54-013[b]-99) is located within TA-54, Area G, in the east-central portion of the Laboratory on Mesita del Buey. Portions of MDA G started general operations, such as burning of combustibles in 1957, while other portions of MDA G started receiving low-level waste (LLW) in 1959. MDA G ceased operations in 2003. Portions of the disposal units at MDA G are covered with concrete to house ongoing waste-management activities conducted at Area G; surface runoff from the site is controlled and discharges into drainages to the north (towards Cañada del Buey) and the south (towards Pajarito Canyon).

MDA G is a decommissioned (removed from service) subsurface site at TA-54 established for disposition of LLW, certain radioactively contaminated infectious waste, asbestos-contaminated material, and PCBs. The site was also used for the retrievable storage of transuranic (TRU) waste. The site consists of inactive subsurface units that include 32 pits, 194 shafts, and four trenches. When operations ceased, the Laboratory backfilled the remaining capacity of the pits, shafts, and trenches with clean, crushed, compacted tuff, closed them, and capped the disposal shafts with a concrete plug.

b. Remediation and Sampling Activities

Sediment samples were collected from canyon reaches in Pajarito Canyon and Cañada del Buey located immediately downgradient of the easternmost tributary drainages from Area G. Sediment deposits in these reaches potentially contain contaminants transported from Area G, including MDA G, and from other upstream locations.

Thirty-nine boreholes were drilled alongside MDA G pits and shafts. Thirty-seven boreholes were proposed to be drilled to 200–300 ft bgs; actual drilling depths were approximately 68 ft to 250 ft due to refusal at some locations. Most boreholes were vertical in orientation but three boreholes were drilled at an angle of 45º from horizontal to a vertical depth of approximately 176 ft (2) to 200 ft (1) bgs. One borehole was drilled to 700 ft bgs (after a first attempt reached only 556 feet) to determine whether perched groundwater is present and to collect data on hydrogeologic properties.

Core was collected from 37 boreholes. Paired samples of fracture fill and surrounding intact tuff were collected when large fractures, or fracture zones, were encountered. Paired fracture samples were collected when sufficient, intact, nonfractured core material was available.

Subsurface pore gas samples were collected beneath MDA G from each borehole. The boreholes will be incorporated into the Laboratory's pore-gas monitoring network.

c. Investigation Summary

Inorganic chemicals, organic chemicals, and radionuclides were detected above sediment background or fallout values or were detected in samples collected from reaches in Canada del Buey and Pajarito Canyon. Many of the detected concentrations do not differ from relevant background or baseline data sets. SWMUs or AOCs up canyon from Area G in the Cañada del Buey or Pajarito Canyon watersheds may be sources for the contaminants. Possible sources for these contaminants will be further evaluated as part of canyon investigations in these watersheds.

Concentrations of inorganic chemicals detected beneath MDA G were indicative of natural variability within the various stratigraphic layers. All inorganic chemicals detected above background in the units adjacent to the base of the disposal pits, trenches, and shafts were generally less than five times the background. In addition, all inorganic chemicals detected at levels greater than background were in samples taken from intervals containing clay-filled fractures and were less than the soil background, a more representative comparison.

Several naturally occurring radionuclides and fallout radionuclides were detected or detected above background in samples collected from beneath MDA G. Naturally occurring radionuclides were detected at concentrations within the natural variability in the subsurface. Fallout radionuclides detected in subsurface samples generally occurred sporadically across the site, with detections occurring in less than one third of the boreholes.

VOCs (consisting primarily of chlorinated hydrocarbons) were detected beneath MDA G. The highest VOC concentrations are beneath the eastern, central, and western portion of the site. Tritium was detected in pore-gas samples mostly in the eastern and south-central portion of Area G. The results of quarterly monitoring show VOCs and tritium concentrations to be stable over time and do not indicate that the plume is expanding.

Results of the human health risk assessment indicated that noncarcinogenic and carcinogenic risks for an industrial worker were less than NMED's target levels (NMED 2004). Potential dose for an industrial worker at MDA G is below the DOE's target dose limit (DOE 2000).

Contamination in channel sediment does not pose a potential risk to ecological receptors. The inhalation ecological screening level comparison to pore-gas VOCs indicates no potential present-day risk to burrowing animals.

d. Conclusions and Recommendations

Data gathered during the previous investigation, data obtained from ongoing quarterly pore-gas monitoring, and data collected during the 2005 investigation have characterized the nature and extent of contamination in surface and subsurface media at MDA G (LANL 2005g). Subsurface samples collected to evaluate moisture properties did not identify any perched groundwater zones to a depth of 700 ft beneath MDA G. The results from the human health and ecological risk assessments indicated that the site poses no potential unacceptable risk/dose to human and ecological receptors (LANL 2005g).

Therefore, based on the results of the field investigations, we recommend the following actions:

- Complete an evaluation to recommend a remedy to ensure that future releases from the site pose no unacceptable risks to human and ecological receptors.
- Monitor the subsurface vapor plume in accordance with a long-term monitoring plan as approved by NMED.

These conclusions and recommendations are pending NMED approval.

F. CORRECTIVE ACTIONS PROJECT

The Laboratory took the following actions in this project in 2005:

- Initial investigation at SWMU 03-013(i) completed and reported on.
- ACA work plan for the Security Perimeter Road (SWMUs 03-029 and 61-002 and AOC 03-001[i]) was approved, the investigation and remediation completed, and the report was submitted.

- Revised work plan for the TA-16-340 Complex submitted in 2004 and the investigation completed in 2005.
- The investigation of Mortandad/Ten Site Canyons Aggregate Area was completed and the investigation report submitted.
- ACA work plan for SWMU 33-013 submitted and approved and the investigation activities completed.
- Work plan for MDA C approved and revisions 1 and 2 along with supplemental information submitted and investigation activities implemented at MDA C.
- Revisions to the closure certification report for MDA P and the investigation report for the TA-53 surface impoundments were submitted; the closure certification report for MDA P was approved.
- Work plan for the Ponds at TA-16 (Consolidated Units 16-008[a]-99 [90s Line] and 16-007[a]-99 [30s Line]) submitted and approved.

The following sections summarize the investigations started, continued, and/or completed in 2005 as well as those investigations for which reports were submitted in 2005.

1. Pull Test Facility (SWMU 03-013[i])

The Laboratory submitted an assessment plan for SWMU 03-013(i) (LANL 2004g) and NMED approved it. A complete description of the field activities, data review, and risk assessments for this site are presented in the SWMU Assessment Report for SWMU 03-013(i) (LANL 2005j).

a. Site Description and History

SWMU 03-013(i), located in TA-3, consists of soil and gravel contaminated by historical releases of hydraulic oil at the Cable Control Building (03-246) and the Cable Stress Building (03-247), collectively referred to as the Pull Test Facility. The Pull Test Facility was constructed prior to 1967 and operated until the mid-1980s when a replacement facility was constructed on Sigma Mesa. This facility was used to test the tensile strength of various steel cables used in conjunction with underground nuclear test assemblies.

In 2005, the Laboratory demolished and removed two metal buildings containing controls for the pull-test equipment, a hydraulic oil compressor and storage tank, and two hydraulic rams used to perform the tensile strength testing.

b. Remediation and Sampling Activities

Eight samples from four locations were collected following the excavation of the footprint of Building 03-246, four samples were collected from two locations downgradient of the former Building 03-246 location, and four samples were collected from two locations within the footprint of Building 03-247. A trench was also excavated into the area between the building locations and samples collected. No debris, pipelines, or staining were observed.

c. Investigation Summary

The potential present-day risk to a site worker at the former pull test facility is below NMED target levels (NMED 2004). Therefore, the screening assessment indicates that there is no potential unacceptable risk to human health.

Based on the ecological screening assessment for SWMU 03-013(i), all COPECs were eliminated. The ecological screening assessment indicates that SWMU 03-013(i) does not pose a potential ecological risk to receptors.

d. Conclusions and Recommendations

The risk assessments indicated that there are no potential unacceptable risks to human and ecological receptors at this site. However, the extent of contamination for inorganic chemicals and organic chemicals has not been determined. As part of the Upper Sandia Canyon Aggregate Area investigation, the Laboratory will conduct additional sampling to determine the extent of contamination.

These conclusions and recommendations are pending NMED approval.

2. AOC 03-001(i) and SWMUs 03-029 and 61-002

The Laboratory conducted an accelerated cleanup at AOC 03-001(i) and SWMUs 03-029 and 61-002 because these sites lie in the path of the planned TA-3 security perimeter road and may be inaccessible during and after the road's construction. A complete description of the field activities, data review, and risk assessments for this site are presented in the Remedy Completion Report for the Investigation and Remediation of Area of Concern 03-001(i) and Solid Waste Management Units 03-029 and 61-002 (LANL 2005k).

a. Site Description and History

AOC 03-001(i) in TA-3 consists of two separate, inactive material and equipment storage areas. Storage Area #1 is a 30-ft –by 30-ft, unpaved area approximately 100 yards west of Building 03-70 used to stage and dispense petroleum products from two small, aboveground storage tanks located on a small hill above a large sand-and-gravel staging area. Storage Area #2 consists of a 50-ft by 150-ft, unpaved area located behind Building 03-70 used as a staging area for old transformers and containers of roofing compound, tars, and adhesives. Dumpsters staged in the area were used for the storage of bagged and labeled asbestos before their disposal at the Los Alamos County Landfill. The area was also used as an unpaved parking area for the Laboratory's Roads and Grounds Division.

SWMU 03-029 is an inactive, 30-ft by 70-ft landfill near the rim of Sandia Canyon, approximately 300 feet south of Building 03-271. While active, the landfill was used as an asphalt cleanout area. The landfill reportedly contains small pieces of asphalt and possibly residue from asphalt emulsion.

SWMU 61-002 is a former storage area east of the Radio Repair Shop (Building 61-23) on the south side of Jemez Road. An 81-ft by 91-ft portion of the SWMU lies within a fenced area and the remainder of the SWMU extends south onto the Los Alamos County Landfill. The fenced portion was historically used as a storage area for capacitors, transformers, unmarked containers, and may also have been used to store petroleum products. Before 1985, oil contaminated with PCBs was stored in containers on the soil surface within the fenced area. The area was also used by Radio Repair Shop personnel to store large spools of wire and cable.

b. Remediation and Sampling Activities

AOC 03-001(i), Storage Area #1: During the initial characterization 18 soil samples were collected from AOC 03-001(i) Storage Area #1. Soil samples from Storage Area #1 showed elevated concentrations of petroleum hydrocarbons in the soil, indicating that additional remediation activities were necessary. Cleanup resulted in the excavation and removal of approximately 540 yd^3 of petroleum contaminated soils from an area 40 ft by 40 ft by 10 ft deep.

AOC 03-001(i), Storage Area #2: The characterization sampling included 26 samples collected from Storage Area #2. After the completion of the ACA characterization sampling, the site was excavated to the grade planned for the TA-3 security perimeter road. Twelve soil samples were collected from the base of the excavation. Approximately 1,000 yd^3 of soil was excavated from a 100-ft long by 50-ft wide by 4-ft deep area.

SWMU 03-029, Asphalt Landfill: A geophysical survey was conducted using ground-penetrating radar (GPR) and an electromagnetic (EM)-31 and EM-61 detector. The survey results identified two possible locations for the buried waste and these areas were further investigated by trenching. Subsequently, the security perimeter road construction plans were changed and it was no longer necessary to excavate SWMU 03-029. As a result, all additional accelerated cleanup activities for this site were not implemented, and the investigation of SWMU 03-029 will be completed as part of the Upper Sandia Canyon Aggregate Area investigation.

SWMU 61-002, Former Equipment and Materials Storage Area: Remediation activities included excavation; field screening; the collection of surface and subsurface confirmation samples (a total of 61 samples); and the characterization, removal, and disposal of contaminated soil. Approximately 60 yd^3 of petroleum-contaminated soil was excavated from this area. A total of 424 yd^3 of material was removed from SWMU 61-002. During the excavation of the northwestern portion of the SWMU, an area containing high levels of petroleum hydrocarbons was discovered adjacent to Building 61-23. The source of this petroleum contamination is unknown but may be

associated with the past storage of petroleum products at the site. The efforts to define the extent of the petroleum hydrocarbon contamination were unsuccessful. After collecting four confirmation samples at two locations, a second stage of drilling and characterization sampling was initiated in the northwestern area of SWMU 61-002.

c. Investigation Summary

AOC 03-001(i), Storage Areas #1 and #2: No carcinogens were detected, and the HI for the construction worker was less than the NMED target level (NMED 2004) at Storage Area #1. There is no cancer risk estimate or HI calculated for an industrial worker at Storage Area #1 because all surface and shallow-subsurface material, down to a depth of approximately 10 ft bgs, was removed and the site was backfilled with clean soil.

The risk assessment results for Storage Area #2 indicated that the total excess cancer risks and the HIs for an industrial worker and a construction worker are below the NMED target risk levels (NMED 2004).

An ecological evaluation was not performed on AOC 03-001(i) Storage Area #1 because all surface and shallow-subsurface material, down to a depth of approximately 10 ft bgs, was removed. An ecological evaluation was not performed on AOC 03-001(i) Storage Area #2 because material was excavated, and the area is disturbed and will be covered by the security perimeter road.

SWMU 61-002, Former Equipment and Materials Storage Area: The risk assessment results indicated that the total excess cancer risk for an industrial worker and a construction worker are below the NMED target risk level (NMED 2004).

The noncarcinogenic risk for an industrial worker is less than the NMED target level (NMED 2004). The HI for a construction worker is slightly above the NMED target level (NMED 2004). SWMU 61-002 will be further investigated and the risk re-evaluated for the construction worker.

The ecological screening assessment for SWMU 61-002 eliminated all of the COPECs. The ecological screening assessment indicated that this SWMU does not pose a potential ecological risk to receptors.

d. Conclusions and Recommendations

The results of the investigation indicated that the nature and extent of contamination at AOC 03-003(i) are characterized. In addition, the risk assessments found that the site does not pose a potential unacceptable risk to an industrial worker and a construction worker. Ecological receptors are also not affected because material was excavated, and the area is disturbed and will be covered by the road. Therefore, the Laboratory has completed corrective actions to the levels required for NMED to issue a Certificate of Completion (complete with controls). The Laboratory will assume responsibility for the controls specified for the site by NMED in accordance with the level of remediation performed. The Laboratory expects that such controls will be limited to institutional or administrative controls to ensure that the land use remains consistent with the residual contamination at the site.

For SWMU 61-002, the results of the human health risk assessment for an industrial worker and the ecological risk assessment indicated that the site does not pose a potential unacceptable risk to human health or the environment. However, the results of the human health risk assessment for a construction worker indicated that the levels of noncarcinogenic chemicals may pose a potential unacceptable risk. The extent of petroleum contamination in the northwestern sector of the site was not characterized with the existing site data. The Laboratory will complete the characterization to define the vertical and lateral extent of the identified petroleum contamination following the demolition and removal of the building overlying part of this SWMU.

These conclusions and recommendations are pending NMED approval.

3. TA-16-340 Complex

The investigation work plan has been approved with modifications (LANL 2004e) to characterize the site. This work plan also describes interim cleanup activities completed prior to the characterization activities. Field investigations were completed in 2005 based on the approved work plan.

a. Site Description and History

The TA-16-340 Complex is located near the eastern end of the TA-16 mesa, close to the head of a small canyon known as Fishladder Canyon, and contains Consolidated Unit 13-003(a)-99, the septic system associated with the western area of the P-Site Firing Site (at former TA-13); the sump and drainline for former Building 16-342 (Consolidated Unit 16-003[n]-99); the sumps and drainlines for former Building 16-340 (SWMU 16-003[o]); and the sump and drainline for former Building 16-345 (SWMUs 16-029[f] and 16-026[j2], respectively).

The TA-16-340 Complex operated from 1952 to 1999 and processed and produced large quantities of plastic-bonded explosives. The plastic-bonded explosives were produced by slurrying high explosives (HE) and solvents together with inert binders. HE and solvent-contaminated wash water were routed to six sumps associated with Building 16-340 and to a single sump and outfall associated with Building 16-342. Historically, discharges from the Building 16-340 and 16-342 sumps were routed to the Building 16-340 and 16-342 outfalls, respectively.

b. Remediation and Sampling Activities

Overall, during the decontamination and decommissioning operations and/or the investigation/remediation activities, the Laboratory removed and disposed of all existing fixtures and structures (Buildings 16-340, 16-342, and 16-345, sumps, drainlines, manholes, fishladder/air stripper) associated with the TA-16-340 Complex. Contaminated soil (approximately 100 yd^3) was also removed from the TA-16-340 Complex.

A total of 239 soil, fill, tuff, and sediment samples were collected from the TA-16-340 Complex.

Two intermediate-depth boreholes (200 ft bgs) were drilled near the top and bottom of the historical fishladder structure; one borehole was drilled upgradient of the fishladder, near the TA-16-340 outfall and the second borehole was drilled downgradient from the fishladder. Two shallow boreholes (approximately 12 ft bgs) were also drilled in Consolidated Unit 13-003(a)-99.

Three shallow alluvial groundwater monitoring wells (wells 16-25278, 16-25279, and 16-25280) were installed in Fishladder Canyon. Well development activities were conducted and alluvial groundwater sampling was conducted.

Flowing water was observed and sampled (as part of monitoring activities) at the confluence of Fishladder Canyon and Cañon de Valle.

Subsurface pore-gas samples were collected from the two 200-ft intermediate boreholes. Both the upgradient and downgradient boreholes were sampled at three depth intervals during two rounds of sampling.

c. Investigation Summary

The Laboratory will describe the results of this investigation in an investigation report and submit the report during early 2006.

4. Mortandad/Ten Site Canyons Aggregate Area

We conducted characterization activities to investigate an aggregate of SWMUs and AOCs in TAs-4, -5, -35, -52, -60, and -63 (LANL 2002; LANL 2004d). The SWMUs and AOCs addressed constitute the Middle Mortandad/Ten Site Canyons Aggregate Area within the Mortandad Canyon watershed. The SWMUs and AOCs occupy a narrow mesa (Ten Site Mesa) and adjacent slopes between Mortandad and Ten Site Canyons, the floor of a small tributary canyon to Ten Site Canyon (named Pratt Canyon) and adjacent Mesita del Buey and Sigma Mesa as well as part of the floor of Ten Site Canyon. For the purposes of the investigation and the report, the SWMUs and AOCs were organized into seven subareas: Mesa Top, Ten Site Slope, Mortandad Slope, Pratt Canyon, Ten Site Canyon, East Ten Site Slope, and Sigma Mesa.

The Investigation Report for the Mortandad/Ten Site Aggregate (LANL 2005h) presents a complete description of the field activities, data review, and risk assessments for this site.

a. Site Description and History

Mesa Top Subarea. The Mesa Top Subarea consists of 21 SWMUs and five AOCs. The SWMUs and AOCs in this subarea include components of the former wastewater treatment plant (WWTP), former container storage areas, an area of surface deposition from stack emissions, oil spills, septic tanks, and former oil-handling facilities. Operational histories indicate that the Mesa Top Subarea may contain a variety of inorganic, organic, and radiological contaminants.

Ten Site Slope Subarea. Ten Site Slope is the south-facing slope of Ten Site Canyon. The slope has a very steep middle section with flatter bench sections above and below, and it is marked by several distinct drainage channels. The Ten Site Slope Subarea consists of nine SWMUs and seven AOCs. The SWMUs and AOCs are outfalls, former container storage areas, inactive septic systems, and areas of stained asphalt/oil spills. The SWMUs/AOCs are either located on, or adjacent to, the north slope of Ten Site Canyon or are outfalls that discharge onto that slope. Operational histories indicate that the Ten Site Slope Subarea may contain a variety of inorganic, organic, and radiological contaminants.

Mortandad Slope Subarea. Mortandad Slope is the north-facing slope of Mortandad Canyon. The slope drops steeply from the mesa edge to a broad terrace, followed by a near-vertical drop into the incised main channel of Mortandad Canyon. The Mortandad Slope Subarea is made up of seven SWMUs and three AOCs. The SWMUs and AOCs are outfalls, former container storage areas, an inactive septic system, a canyon-side disposal area, and oil spills. Operational histories indicate that the Mortandad Slope Subarea may contain a variety of inorganic, organic, and radiological contaminants as a result of past Laboratory operations.

Pratt Canyon Subarea. Pratt Canyon is a tributary of Ten Site Canyon and is located at the east end of Ten Site Mesa. Pratt Canyon heads at the east end of the mesa at the location of the former TA-35 WWTP, several components of which were located within the upper portion of the canyon. The Pratt Canyon Subarea consists of six SWMUs and two AOCs, all within TA-35. These are cooling water and storm water outfalls, former WWTP components, an inactive septic system and leach field, and Pratt Canyon itself, which received planned and unplanned discharges from the WWTP that operated from 1951 to 1963. The potential contaminants in the Pratt Canyon Subarea are primarily related to the former WWTP operations.

Ten Site Canyon Subarea. The Ten Site Canyon Subarea includes much of the Ten Site Canyon floor extending from the west end of TA-35 to east of the confluence with Pratt Canyon. The Ten Site Canyon Subarea is made up of four SWMUs and two AOCs. In addition to receiving potential releases from hill-slope SWMUs/AOCs (e.g., Ten Site Slope Subarea) and the Pratt Canyon Subarea, the Ten Site Canyon Subarea is directly associated with components of an inactive sanitary wastewater treatment facility including three lagoons, a sand filter treatment unit, and an effluent outfall and its discharges. In addition to sanitary waste, the lagoons reportedly received small quantities of radionuclides and other chemicals as well as photographic processing wastes from TAs-35, -48, -50, and -55. The facility ceased operations in 1992, when sanitary waste was redirected to the Laboratory's sanitary wastewater treatment facility at TA-46.

East Ten Site Slope Subarea. East Ten Site Slope is the south slope of Ten Site Canyon, which extends south and east of Ten Site Mesa. The East Ten Site Slope Subarea includes 13 SWMUs and three AOCs in TAs-4, -5, -52, and- 63, including surface and canyon-side disposal areas, an outfall, former firing sites, a former wastewater treatment facility, a former French drain, inactive septic systems, and industrial waste lines. The SWMUs and AOCs are primarily related to (1) operations and processes at former Alpha (TA-4) and Beta (TA-5) firing sites, and their associated support structures, and (2) the historical UHTREX (Ultra High Temperature Reactor Experiment) facility (housed in Building 52-01) and related wastewater neutralization and septic systems. Operational history indicates that SWMUs and AOCs in the East Ten Site Slope Subarea contained inorganic and radiological contaminants.

Sigma Mesa Subarea. Sigma Mesa lies east of TA-3, between Sandia Canyon to the north and Mortandad Canyon to the south. The Sigma Mesa Subarea contains one SWMU and two AOCs. The SWMU and the AOCs (a former surface impoundment and two former storage areas) are located on the south side of Sigma Mesa, toward the eastern end. The subarea uses included outdoor storage for materials to be recycled, Laboratory maintenance

contractor utility equipment/materials storage, and minor experiments (solar pond evaporation and mud drilling). The contaminants potentially present come from residual oil from transformers and salvaged underground storage tanks and from a solar evaporation experiment with low-level radioactive liquid.

b. Remediation and Sampling Activities

Mesa Top Subarea. A total of 350 soil, tuff, sediment, and fill samples, including 24 field duplicate samples, were collected from 137 locations within the Mesa Top Subarea from 1993 to 2005.

Ten Site Slope Subarea. A total of 312 soil, fill, tuff, and sediment samples, including 19 field duplicate samples, were collected from 129 locations within the Ten Site Slope Subarea between 1993 and 2004.

Mortandad Slope Subarea. A total of 242 soil, fill, tuff, and sediment samples, including 12 field duplicate samples, were collected from 103 locations within the Mortandad Slope Subarea between 1994 and 2004.

Pratt Canyon Subarea. A total of 230 soil, fill, tuff, and sediment samples, including 20 field duplicate samples, were collected from 72 locations in the Pratt Canyon Subarea between 1994 and 2005.

Ten Site Canyon Subarea. A total of 129 soil, fill, tuff, and sediment samples, including nine field duplicate samples, were collected from 82 locations in the Ten Site Canyon Subarea between 1994 and 2004.

East Ten Site Slope Subarea. A total of 346 soil, fill, tuff, and sediment samples, including 24 field duplicate samples, were collected from 116 locations in the East Ten Site Slope Subarea in 1995 and 2004.

Sigma Mesa Subarea. Seventy-six soil, fill, and tuff samples, including four field duplicate samples, were collected from 38 locations in the Sigma Mesa Subarea in 1994, 2004, and 2005.

c. Investigation Summary

Mesa Top Subarea. The noncarcinogenic COPCs were less than their respective industrial SSLs and less than the NMED target level (NMED 2004). The total excess cancer risk under an industrial scenario is slightly above the NMED target level (NMED 2004). Much of the total excess cancer risk is due to concentrations of polyaromatic hydrocarbons (PAHs) under asphalt pavement, where no complete exposure pathway exists. These contaminants are not operational releases but are related to the asphalt. The radionuclide contaminants were below their respective industrial SALs and below the DOE target dose limit (DOE 2000).

Based on the ecological screening assessment for the Mesa Top Subarea, all of the COPCs were eliminated. Therefore, no potential unacceptable ecological risk exists in the Mesa Top Subarea.

Mortandad Slope Subarea. The noncarcinogenic COPCs were less than their respective recreational SSLs and less than the NMED target level (NMED 2004). The carcinogenic COPCs were less than their respective recreational SSLs but slightly above the NMED target level (NMED 2004). The radionuclide COPCs were less than their respective recreational SALs and below the DOE target dose limit (DOE 2000).

Because the carcinogenic risk was slightly higher than the NMED target level, the dose, risk, and HI for each individual SWMU or AOC in the subarea were calculated using the maximum detected concentrations, to further refine the assessment.

The carcinogenic risk above the NMED target level is the result of PAHs detected at SWMU 35-016(p) and SWMU 35-016(o). At SWMU 35-016(p), 45 percent of the risk is from benzo(a)pyrene and 99 percent of the total is from PAHs. The PAHs that are driving the cancer risk at this SWMU are located on a steep slope. They are inaccessible to recreational users. However, to reduce the potential cancer risk and to prevent transport of contaminants to more accessible areas on the slope, we recommended that the PAH-contaminated soil from the three locations at SWMU 35-016(p) be removed.

At SWMU 35-016(o), 68 percent of the risk is from benzo(a)pyrene and 86 percent of the total is from PAHs. The PAHs that are driving the cancer risk at these SWMUs are located on a steep slope. They are inaccessible to recreational users. However, to reduce the potential cancer risk and prevent transport of contaminants to more accessible areas on the lower slope, we recommended that the PAH-contaminated soil from the five locations at SWMU 35-016(o) be removed.

The ecological screening assessment will be re-evaluated following the removal activities and the collection of confirmatory samples as described previously for human health.

Ten Site Slope, Pratt Canyon, Ten Site Canyon, East Ten Site Slope, and Sigma Mesa Subareas. All carcinogenic and noncarcinogenic COPCs were less than their respective recreational or industrial SSLs and less than the NMED target level and the total potential excess cancer risk is less than or equivalent to the NMED target level (NMED 2004). The radionuclide COPCs were less than their respective recreational or industrial SALs and below the DOE target dose limit (DOE 2000).

Based on the ecological screening assessment for the Pratt Canyon Subarea, most or all of the COPECs were eliminated. Any remaining COPECs do not present a potential unacceptable ecological risk to receptors.

d. Conclusions and Recommendations

The Laboratory has determined the vertical extent of contamination for all SWMUs and AOCs, with the exception of SWMUs 35-016(o and p) in the Mortandad Slope Subarea (PAHs only), Consolidated Unit 35-016(k)-00 in the Pratt Canyon Subarea (PAHs only), and AOC 05-001(c) in the East Ten Site Slope Subarea (uranium isotopes only). In several of the subareas (Ten Site Slope, Mortandad Slope, Pratt Canyon, Ten Site Canyon, and East Ten Site Slope), measurable concentrations of a few contaminants, primarily radionuclides, persist downslope. In these cases, the Laboratory will determine the lateral extent of contamination during our Mortandad Canyon investigations.

The risk assessment results indicated that no potential unacceptable human or ecological risks exist in any of the seven subareas, with the following exceptions:

- Slight excess potential cancer risk above the NMED target level exists due to elevated concentrations of PAHs in SWMUs 35-016(o) and 35-016(p) within the Mortandad Slope Subarea.
- Slight excess potential cancer risk above the NMED target level exists due to elevated concentrations of PAHs underneath asphalt at SWMU 35-018(a) within the Mesa Top Subarea; however, the PAHs are not due to an operational release, and there is no complete exposure pathway to site workers.

We recommended the following actions to address the remaining issues and potential excess cancer risk:

- To determine the vertical extent of PAHs within the Mortandad Slope and Pratt Canyon Subareas, we recommended that additional sampling be conducted at SWMUs 35-016(o and p) (Mortandad Slope Subarea) and Consolidated Unit 35-016(k)-00 (Pratt Canyon Subarea).
- To reduce the potential for excess cancer risk in the Mortandad Slope Subarea and prevent the migration of PAHs down-canyon, we recommended that surface material be excavated from the locations with the highest concentrations of PAHs in SWMUs 35-016(o) and 35-016(p). Screening assessments for the Mortandad Slope Subarea will be re-evaluated, incorporating the results of confirmation sampling, following excavation.
- To determine the extent of radionuclide contamination in the East Ten Site Slope Subarea, we recommended that additional sampling be conducted at SWMU 05-001(c).

The Laboratory requested that NMED issue a Certificate of Completion (complete with control) for the SWMUs and AOCs for which the Laboratory has completed corrective actions. The control for the SWMUs and AOCs identified will be the maintenance of the land use (industrial or recreational), which was the basis for the completion of activity. The Laboratory will assume responsibility for the controls specified for the site by NMED in accordance with the level of remediation performed. The Laboratory requested that this Certificate of Completion state that "Corrective Action is Complete with Controls."

These conclusions and recommendations are pending NMED approval.

5. SWMU 33-013

NMED approved the accelerated cleanup work plan (LANL 2005a) with modifications. The investigation and remediation activities were conducted in accordance with the approved work plan.

a. Site Description and History

SWMU 33-013 is situated in an area of proposed construction of the Laboratory's High Bay Complex within the northern portion of TA-33. SWMU 33-013 was an uncovered surface storage area for items such as vacuum pumps, drums containing oil contaminated with tritium and possibly with metals and solvents, and dumpsters of miscellaneous materials awaiting disposal. The exact date that storage operations began is not known, but Building 33-86 began operation in June 1955. Storage activities were moved to a fenced site at the southeast end of Building 33-86 in the spring of 1989. The storage area was approximately 50 ft by 50 ft and was located on the asphalt surface inside the northeast corner of the fence surrounding the former TA-33 tritium facility (Building 33-86).

b. Remediation and Sampling Activities

The investigation of SWMU 33-013 included geodetic surveys, field screening, removal of asphalt and contaminated soil, collection of confirmation samples, and site restoration. The base course covering the site, the asphalt pad, and the first 6 in. of soil beneath the asphalt pad were excavated and removed. Confirmation samples were collected after remediation was completed. Following completion of field activities, the excavation was backfilled with clean fill and base course brought in from an off-site source.

c. Investigation Summary

The Laboratory will report the results of the ACA investigation in a remedy completion report and submit the report to NMED early in 2006.

6. MDA C

NMED has approved the MDA C investigation work plan with modifications to finalize the characterization of the site. The Laboratory issued a second revision to the MDA C work plan (LANL 2005i) and began investigation activities at MDA C in 2005.

a. Site Description and History

MDA C (SWMU 50-009) is located in the east-central portion of the Laboratory near the west end of Mesita del Buey at the head of Ten Site Canyon. Wastes disposed of at MDA C consisted of liquids, solids, and containerized gases generated from a broad range of nuclear energy research and development activities conducted at the Laboratory. MDA C was established in May 1948 to replace MDA B (SWMU 21-015). The landfill was used until April 1974 but received waste only intermittently from 1968 to 1974. These wastes included uncontaminated classified materials, metals, hazardous materials, and radioactively contaminated materials. MDA C is an 11.8-ac fenced, radiologically controlled area containing seven subsurface disposal pits and 108 shafts of various dimensions. The pits and shafts were excavated into the overlying soil and unit 3 of the Tshirege Member of the Bandelier Tuff and were unlined, except for 10 shafts in Shaft Group 3 that were lined with concrete.

b. Remediation and Sampling Activities

Forty-two vertical boreholes will be installed surrounding the disposal pits and shafts. Four perimeter boreholes will be drilled to the south and east of MDA C to assist in determining the lateral extent of potential contamination from MDA C and will be located approximately 250 ft away from the nearest disposal pit. A single, vertical borehole will be drilled to a depth of approximately 800 ft bgs through the Cerro Toledo interval in the area north of Pit 5 near the head of Ten Site Canyon to determine whether perched groundwater is present beneath MDA C. A minimum of five tuff samples will be collected from each borehole.

Subsurface pore-gas samples will be collected during two rounds of sampling from each borehole. The second round of pore-gas sampling will be conducted approximately one month after drilling activities are completed at each borehole. In addition, two rounds of pore-gas sampling will be conducted at previous boreholes.

A gamma survey will be performed to determine the extent of radionuclide contamination in surface soil along the eastern boundary of MDA C. Based on the results of the survey, surface soil samples will be collected. The locations of these samples will be biased towards both the highest radionuclide concentration and from bounding locations on the grid perimeter.

c. Investigation Summary

The Laboratory will report the results of the MDA C investigation in an investigation report and submit the report to NMED in 2006.

G. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

The program's quality assurance objectives are to perform work in a quality manner while minimizing potential hazards to the environment, public, or facility workers. All program work is performed by using approved instructions, procedures, and other appropriate means that implement regulatory or contractual requirements for technical standards, administrative controls, and other hazard controls. The Quality Management Plan (QMP) for the environmental program establishes the principles, requirements, and practices necessary to implement an effective quality assurance program. The QMP defines the "what" of the quality management system (i.e., quality program). The "how" is detailed in one or more implementing procedures.

Each program participant is responsible for the quality of his or her own work. Quality specialists are available to help program participants determine the applicability of requirements to program activities. However, it is the responsibility of each person to be aware of the program's quality requirements and to perform all activities in accordance with current and approved procedures. All personnel are encouraged, expected, and required to identify and report opportunities for improvement as well as any deficiencies or conditions that do not conform to the requirements of the QMP. The improvement process has the objective of preventing problems and improving the quality of products and services.

The scope, depth, and rigor of implementing the quality assurance criteria for a specific activity are determined by the use of a graded approach. Activities are managed through systems that are adequate and commensurate with the quality requirements, risk, and hazards involved in the activity. Such a selective approach allows for the application of extensive controls to certain elements of activities and limited controls to others. The control measures applied to any particular activity (e.g., the procurement of items or services, conducting a field sampling campaign, or training), are covered in documents such as procedures, statements of work, project-specific work plans, and procurement contracts associated with the activity.

2. Field Sampling Quality Assurance

Overall quality of this portion of the program is maintained through the rigorous use of carefully documented procedures that govern all aspects of the sample-collection program.

Soil, water, sub-atmospheric vapor, and biota samples are (1) collected under common EPA chain-of-custody procedures using field notebooks and sample collection logs and (2) prepared and stored in certified pre-clean sampling containers in a secure and clean area for shipment. They are delivered to internal and external analytical laboratories under full chain-of-custody including secure FedEx shipment to all external vendors and tracked at all stages of their collection and analysis through the program's relational database.

Field-sampling quality assurance is performed and assessed by trained staff for constraints of the database and completeness.

3. Analytical Laboratory Quality Assessment

Specific statements of work are written to govern the acquisition and delivery of analytical chemistry services after the project needs are defined through the Data Quality Objective process. These statements of work are sent to potentially qualified suppliers who are National Environmental Laboratory Accreditation Conference (NELAC)

Certified for a pre-award assessment by experienced and trained quality systems and chemistry laboratory assessors. Statement of work specifications, professional judgment, and quality system performance at each laboratory (including recent past performance on nationally conducted performance-evaluation programs) are primarily used to award contracts for specific types of radiochemical, organic chemical, and inorganic chemical analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. The analytical laboratory also submits a full paper set of records that serves as the legally binding copy of the data. Each set of samples contains all the internal quality assurance and quality control data the analytical laboratory generates during each phase of chemical analysis (including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the database and are then verified and validated according to its corresponding variety of quality and consistency checks. All parts of the data-management process are tracked electronically in each database, and periodic reports to management are prepared.

4. Analytical Laboratory Assessments

The environmental restoration program has 14 contracts with outside analytical laboratories. The laboratories are on a three-year rotating audit schedule as long as they keep their NELAC and DOE laboratory certifications. During 2005, four external laboratory audits were performed for all chemical analyses reported for most samples; Paragon Analytics, Inc., General Engineering Laboratories, Pacific Ecorisk, and American Radiation Services. All laboratories participated in national performance-evaluation studies during 2005 and the results are included in the assessment report. Overall, the study sponsors judged the analytical laboratories to have acceptable performance for almost all analytes attempted in all matrices.

5. Program Audits and Assessments

No assessments of the overall program were conducted in 2005.

H. REFERENCES

DOE 2000: "Procedure for the Release of Residual Radioactive Material from Real Property," Department of Energy memorandum (ESHD:RJB) to D. Glenn and I. Tray from C.L. Soden, M. Zamorski, and E. Sellers, Albuquerque, New Mexico. (June 2000)

LANL 1997:. "Work Plan for Mortandad Canyon," Los Alamos National Laboratory document LA-UR-97-3291, Los Alamos, New Mexico. (September 1997)

LANL 1998: "Work Plan for Pajarito Canyon," Los Alamos National Laboratory document LA-UR-98-2550, Los Alamos, New Mexico. (July 1998)

LANL 2002: "Sampling and Analysis Plan for the Middle Mortandad/Ten Site Aggregate," Los Alamos National Laboratory document LA-UR-02-0244, Los Alamos, New Mexico. (March 2002)

LANL 2004a: "Accelerated Corrective Action Work Plan for the Investigation and Remediation of Consolidated Solid Waste Management Unit 19-001-99," Los Alamos National Laboratory document LA-UR-04-0199, Los Alamos, New Mexico. (January 2004)

LANL 2004b: "Mortandad Canyon Groundwater Work Plan, Revision 1," Los Alamos National Laboratory document LA-UR-04-0165, Los Alamos, New Mexico. (January 2004)

LANL 2004c: "Investigation Work Plan for Material Disposal Area T, Solid Waste Management Unit 21-016(a)-99," Los Alamos National Laboratory document LA-UR-04-0559, Los Alamos, New Mexico. (February 2004)

LANL 2004d: "Addendum to Sampling and Analysis Plan for the Middle Mortandad/Ten Site Aggregate," Los Alamos National Laboratory document LA-UR-04-1714, Los Alamos, New Mexico. (March 2004)

LANL 2004e: "Investigation Work Plan For: The TA-16-340 Complex: SWMUs 13-003(a)-99, 16-003(n)-99, 16-003(o), 16-026(j2), and 16-029(f) at TA-16," Los Alamos National Laboratory document LA-UR-04-1466, Los Alamos, New Mexico. (March 2004)

LANL 2004f: "Investigation Work Plan for Solid Waste Management Unit 21-018(a)-99, Material Disposal Area V, at Technical Area 21," Los Alamos National Laboratory document LA-UR-04-3699, Los Alamos, New Mexico. (June 2004)

LANL 2004g: "Solid Waste Management Unit (SWMU) Assessment Plan for SWMU 03-013(i)," Los Alamos National Laboratory document LA-UR-04-6783, Los Alamos, New Mexico. (September 2004)

LANL 2004h: "Investigation Work Plan for MDA L, SWMU 54-006 at TA-54, Revision 2," Los Alamos National Laboratory document LA-UR-04-8245, Los Alamos, New Mexico. (November 2004)

LANL 2004i: "Investigation Work Plan for MDA U, SWMU 21-017(a)-99, Technical Area 21," Los Alamos National Laboratory document LA-UR-04-7268, Los Alamos, New Mexico. (November 2004)

LANL 2004j: "Investigation Work Plan for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99 at Technical Area 54, Revision 1," Los Alamos National Laboratory document LA-UR-04-3742, Los Alamos, New Mexico. (December 2004)

LANL 2005a: "Accelerated Corrective Action Work Plan for Solid Waste Management Unit 33-013, a Former Storage Area at Technical Area 33 (TA-33)," Los Alamos National Laboratory document LA-UR-05-1104, Los Alamos, New Mexico. (March 2005)

LANL 2005b: "Mortandad Canyon Biota Investigation Work Plan," Los Alamos National Laboratory document LA-UR-05-2231, Los Alamos, New Mexico. (May 2005)

LANL 2005c: "Addendum to the Completion Report for the Voluntary Corrective Action using a Soil Vapor Extraction System at Area of Concern 00-027," Los Alamos National Laboratory document LA-UR-05-0583, Los Alamos, New Mexico. (June 2005)

LANL 2005d: "Remedy Completion Report for the Investigation and Remediation of Consolidated Unit 19-001-99," Los Alamos National Laboratory document LA-UR-05-0975, Los Alamos, New Mexico. (July 2005)

LANL 2005e: "Response to the Notice of Disapproval for the Work Plan for Pajarito Canyon, Los Alamos National Laboratory, EPA ID No. NM0890010515 HWB-LANL-03-007," Los Alamos National Laboratory document LA-UR-05-5600, Los Alamos, New Mexico. (July 2005)

LANL 2005f: "Investigation Report for Material Disposal Area L, Solid Waste Management Unit 54-006 at Technical Area 54," Los Alamos National Laboratory document LA-UR-05-5777, Los Alamos, New Mexico. (September 2005)

LANL 2005g: "Investigation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99 at Technical Area 54," Los Alamos National Laboratory document LA-UR-05-6398, Los Alamos, New Mexico. (September 2005)

LANL 2005h: "Investigation Report for the Middle Mortandad/Ten Site Aggregate," Los Alamos National Laboratory document LA-UR-05-6135, Los Alamos, New Mexico. (September LANL 2005)

LANL 2005i: "Investigation Work Plan for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50, Revision 2," Los Alamos National Laboratory document LA-UR-05-7363, Los Alamos, New Mexico. (October 2005)

LANL 2005j: "Solid Waste Management Unit (SWMU) Assessment Report for SWMU 03-013(i)," Los Alamos National Laboratory document LA-UR-05-7420, Los Alamos, New Mexico. (October 2005)

LANL 2005k: "Remedy Completion Report for the Investigation and Remediation of Area of Concern 03-001(i) and Solid Waste Management Units 03-029 and 61-002," Los Alamos National Laboratory document LA-UR-05-8863, Los Alamos, New Mexico. (December 2005)

NMED 2004: "NMED HWB Ground Water Quality Bureau and Voluntary Remediation Program, Technical Background Document for Development of Soil Screening Levels, Revision 2.0, "Volume 1, Tier 1: Soil Screening Guidance Technical Background Document, Santa Fe, New Mexico. (February 2004)

APPENDIX A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with the pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, or foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 450.1, "Environmental Protection Program;" 5400.5, "Radiation Protection of the Public and the Environment;" and 231.1A, "Environmental Safety and Health Reporting."

Radiation Standards

DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using the EPA dose factors from EPA 1988. The dose factors EPA adopted are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP 1988).

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard for the public (NCRP 1987). Table A-1 lists currently applicable radiation protection standards, now referred to as public dose limits, for operations at the Laboratory. DOE's comprehensive public dose limit for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 mrem per year. The public dose limits and the DOE occupational dose limits are based on recommendations in ICRP (1988) and the National Council on Radiation Protection and Measurements (NCRP 1987).

The EDE is the hypothetical whole-body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure to an individual organ. It is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the ICRP. The EDE includes doses from both internal and external exposure.

Radionuclide concentrations in water are compared with DOE's Derived Concentration Guides (DCGs) to evaluate potential impacts to members of the public. The DCGs for water are those concentrations in water that if consumed at a maximum rate of 730 liters per year, would give a dose of 100 mrem per year. Table A-2 shows the DCGs. For comparison with drinking water systems, the DCGs are multiplied by 0.04 to correspond with the EPA limit of 4 mrem per year.

In addition to DOE standards, in 1985 and 1989, the EPA established the National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities, 40 CFR 61, Subpart H. This regulation states that emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr. DOE has adopted this dose limit (Table A-1). This dose is calculated at the location of a residence, school, business, or office. In addition, the regulation requires monitoring of all release points that can produce a dose of 0.1 mrem to a member of the public.

Table A-1
DOE Dose Limits for External and Internal Exposures

Exposure pathway	Dose Equivalent[a] at Point of Maximum Probable Exposure
Exposure of Any Member of the Public[b]	
All Pathways	100 mrem/yr[c]
Air Pathway Only[d]	10 mrem/yr
Drinking Water	4 mrem/yr
Occupational Exposure[b]	
Stochastic Effects	5 rem/yr (TEDE)[e]
Nonstochastic Effects	
Lens of eye	15 rem/yr
Extremity	50 rem/yr
Skin of the whole body	50 rem/yr
Skin of the whole body	50 rem/yr
Embryo/Fetus of Declared Pregnant Worker	0.5 rem/gestation period

[a] Refer to Glossary for definition.

[b] In keeping with DOE policy, exposures must be limited to as small a fraction of the respective annual dose limits as practicable. DOE's public dose limit applies to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, and global fallout; self-irradiation; and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from DOE Order 5400.5 (DOE 1990). Limits for occupational exposure are taken from 10 CFR 835, Occupational Radiation Protection.

[c] Under special circumstances and subject to approval by DOE, this limit on the EDE may be temporarily increased to 500 mrem/yr, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem per year.

[d] This level is from EPA's regulations issued under the Clean Air Act, (40 CFR 61, Subpart H) (EPA 1989a).

[e] Refer to Glossary for definition.

Table A-2
DOE's Derived Concentration Guides for Water[a]

Nuclide	DCGs for Water Ingestion in Uncontrolled Areas (pCi/L)	DCGs for Drinking Water Systems (pCi/L)[b]
^{3}H	2,000,000	80,000
^{7}Be	1,000,000	40,000
^{89}Sr	20,000	800
^{90}Sr	1,000	40
^{137}Cs	3,000	120
^{234}U	500	20
^{235}U	600	24
^{238}U	600	24
^{238}Pu	40	1.6
^{239}Pu	30	1.2
^{240}Pu	30	1.2
^{241}Am	30	1.2

[a] Guides for uncontrolled areas are based on DOE's public dose limit for the general public (DOE 1990). Guides apply to concentrations in excess of those occurring naturally or that are due to worldwide fallout.

[b] Drinking water DCGs are 4% of the DCGs for non-drinking water.

Nonradioactive Air Quality Standards

Table A-3 shows federal and state ambient air quality standards for nonradioactive pollutants.

Table A-3
National (40 CFR 50) and New Mexico (20.2.3 NMAC) Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	Secondary
Sulfur dioxide	Annual	ppm	0.02	0.030	
	24 hours	ppm	0.10	0.14	
	3 hours	ppm			0.5
Hydrogen sulfide	1 hour	ppm	0.010		
Total reduced sulfur	1/2 hour	ppm	0.003		
Total suspended particulates	Annual	µg/m3	60		
	30 days	µg/m3	90		
	7 days	µg/m3	110		
	24 hours	µg/m3	150		
PM10a	Annual	µg/m3		50	50
	24 hours	µg/m3		150	150
PM2.5b	Annual	µg/m3		15	15
	24 hours	µg/m3		65	65
Carbon monoxide	8 hours	ppm	8.7	9	
	1 hour	ppm	13.1	35	
Ozone	1 hour	ppm		0.12	0.12
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and lead compounds	Calendar quarter	µg/m3		1.5	1.5

[a] Particles ≤10 µm in diameter.
[b] Particles ≤2.5 µm in diameter.

National Pollutant Discharge Elimination System

The types of monitoring required under National Pollutant Discharge Elimination System (NPDES) and the limits established for sanitary and industrial outfalls can be found at http://www.lanl.gov/community/environment/h2o/.

Drinking Water Standards

For chemical constituents in drinking water, regulations and standards are issued by the Environmental Protection Agency (EPA) and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico Drinking Water Regulations (NMEIB 1995). To view the New Mexico Drinking Water Regulations go to http://www.nmenv.state.nm.us/Common/regs_idx.html#DrinkH2O. EPA's secondary drinking water standards, which are not included in the New Mexico Drinking Water Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water (EPA 1989b). There may be health effects associated with considerably higher concentrations of these contaminants.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141 (EPA 1989b) and New Mexico Drinking Water Regulations, Sections 206 and 207 (NMEIB 1995). These regulations provide that combined radium-226 and radium-228 may not exceed 5 pCi per liter. Gross alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi per liter.

A screening level of 5 pCi per liter for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

For man-made beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem per year, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem per year. DCGs for drinking water systems based on this requirement are in Table A-2.

Surface Water Standards. Concentrations of radionuclides in surface water samples may be compared with either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the state's radiation protection regulations. However, New Mexico radiation levels are in general two orders of magnitude greater than DOE's DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC Livestock Watering and Wildlife Habitat stream standards (NMWQCC 1995) (http://www.nmenv.state.nm.us/swqb/index.html). The NMWQCC groundwater standards can also be applied in cases where discharges may affect groundwater.

Organic Analysis of Surface and Groundwaters: Methods and Analytes. Organic analyses of surface waters, groundwaters, and sediments are made using SW-846 methods. The specific compounds analyzed in each suite are listed in the supplemental tables for Chapters 5 and 6.

REFERENCES

DOE 2003a: US Department of Energy, "Environmental Protection Program," US Department of Energy Order 450.1 (January 15, 2003).

DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 8, 1990).

DOE 2003b: US Department of Energy, "Environment, Safety, and Health Reporting," US Department of Energy Order 231.1A (August 19, 2003).

EPA 1988: US Environmental Protection Agency, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors For Inhalation, Submersion And Ingestion, Federal Guidance Report No. 11," EPA-520/1-88-020 (September 1988).

EPA 1989a: US Environmental Protection Agency, "40CFR 61, National Emission Standards for Hazardous Air Pollutants, Radionuclides; Final Rule and Notice of Reconsideration," Federal Register 54, 51 653-51 715 (December 15, 1989).

EPA 1989b: US Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," Code of Federal Regulations, Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143 (1989).

ICRP 1988: International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Parts 1, 2, and 3, and their supplements, Annals of the ICRP 2(3/4) -8(4) (1979-1982), and Publication 30, Part 4, 19(4) (1988).

NCRP 1987: National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).

NMEIB 1995: New Mexico Environmental Improvement Board, "New Mexico Drinking Water Regulations," (as amended through January 1995).

NMWQCC 1995: New Mexico Water Quality Control Commission, "State of New Mexico Water Quality Standards for Interstate and Intrastate Streams," Section 3-101.K (as amended through January 23, 1995).

APPENDIX B

UNITS OF MEASUREMENT

Throughout this report the International System of Units (SI) or metric system of measurements has been used, with some exceptions. For units of radiation activity, exposure, and dose, US Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively.

Table B-1 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0×10^{3}, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the right of its present location. The number would then read 2,000. If the value given is 2.0×10^{-5}, the decimal point should be moved five numbers to the left of its present location. The result would be 0.00002.

Table B-1
Prefixes Used with SI (Metric) Units

Prefix	Factor	Symbol
mega	1 000 000 or 10^{6}	M
kilo	1 000 or 10^{3}	k
centi	0.01 or 10^{-2}	c
milli	0.001 or 10^{-3}	m
micro	0.000001 or 10^{-6}	μ
nano	0.000000001 or 10^{-9}	n
pico	0.000000000001 or 10^{-12}	p
femto	0.000000000000001 or 10^{-15}	f
atto	0.000000000000000001 or 10^{-18}	a

Table B-2 presents conversion factors for converting SI units into US Customary Units. Table B-3 presents abbreviations for common measurements.

Data Handling of Radiochemical Samples

Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the analytical technique. Consequently, individual measurements can result in values of positive or negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

Table B-2
Approximate Conversion Factors for Selected SI (Metric) Units

Multiply SI (Metric) Unit	by	to Obtain US Customary Unit
Celsius (°C)	9/5 + 32	Fahrenheit (°F)
centimeters (cm)	0.39	inches (in.)
cubic meters (m^3)	35.3	cubic feet (ft^3)
hectares (ha)	2.47	acres
grams (g)	0.035	ounces (oz)
kilograms (kg)	2.2	pounds (lb)
kilometers (km)	0.62	miles (mi)
liters (L)	0.26	gallons (gal.)
meters (m)	3.28	feet (ft)
micrograms per gram (μg/g)	1	parts per million (ppm)
milligrams per liter (mg/L)	1	parts per million (ppm)
square kilometers (km^2)	0.386	square miles (mi^2)

Table B-3
Common Measurement Abbreviations and Measurement Symbols

aCi	attocurie	mrem	millirem
Bq	becquerel	mSv	millisievert
Btu/yr	British thermal unit per year	nCi	nanocurie
Ci	curie	nCi/dry g	nanocurie per dry gram
cm^3/s	cubic centimeters per second	nCi/L	nanocurie per liter
cpm/L	counts per minute per liter	ng/m^3	nanogram per cubic meter
fCi/g	femtocurie per gram	pCi/dry g	picocurie per dry gram
ft	foot	pCi/g	picocurie per gram
ft^3/min	cubic feet per minute	pCi/L	picocurie per liter
ft^3/s	cubic feet per second	pCi/m^3	picocurie per cubic meter
kg	kilogram	pCi/mL	picocurie per milliliter
kg/h	kilogram per hour	pg/g	picogram per gram
lb/h	pound per hour	pg/m^3	picogram per cubic meter
lin ft	linear feet	PM_{10}	small particulate matter (less than 10 μm diameter)
m^3/s	cubic meter per second		
μCi/L	microcurie per liter	$PM_{2.5}$	small particulate matter (less than 2.5 μm diameter)
μCi/mL	microcurie per milliliter		
μg/g	microgram per gram		
$\mu g/m^3$	microgram per cubic meter	R	roentgen
mL	milliliter	s, SD, or σ	standard deviation
mm	millimeter	s.u.	standard unit
μm	micrometer	sq ft (ft^2)	square feet
μmho/cm	micro mho per centimeter	TU	tritium unit
mCi	millicurie	>	greater than
mg	milligram	<	less than
mR	milliroentgen	≥	greater than or equal to
m/s	meters per second	≤	less than or equal to
mrad	millirad	±	plus or minus
		~	approximately

Standard deviations for the station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the standard equation:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{1/2}$$

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples in the station or group.

This value is reported as one standard deviation (1s) for the station and group means.

REFERENCE

Gilbert 1975: R. O. Gilbert, "Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group," Battelle Pacific Northwest Laboratories report BNWL-B-368 (September 1975).

APPENDIX C

DESCRIPTION OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Figure 1-2. The main programs conducted at each of the areas are listed in this Appendix.

TA-0: The Laboratory has about 180,000 sq ft of leased space for training, support, architectural engineering design, and unclassified research and development in the Los Alamos townsite and White Rock. The publicly accessible Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos townsite.

TA-2, Omega Site: Omega West Reactor, an 8-MW nuclear research reactor, was located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor was decontaminated and decommissioned in 2002.

TA-3, Core Area: The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in this main TA of the Laboratory. Other buildings house central computing facilities, chemistry and materials science laboratories, earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA-3 contains about 50 percent of the Laboratory's employees and floor space.

TA-5, Beta Site: This site contains some physical support facilities such as an electrical substation, test wells, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, Twomile Mesa Site: The site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending disposal.

TA-8, GT Site (or Anchor Site West): This is a dynamic testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (X-ray machines with potentials up to 1,000,000 V and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East: At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site: Facilities are located here for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q Site: This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.

TA-15, R Site: This is the home of PHERMEX (the pulsed high-energy radiographic machine emitting x-rays), a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for weapons development testing. It is also the site where DARHT (the dual-axis radiographic hydrotest facility) is located. This site is also used for the investigation of weapons functioning and systems behavior in nonnuclear tests, principally through electronic recordings.

TA-16, S Site: Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons warhead systems. TA-16 is the site of the Weapons Engineering Tritium Facility for tritium handled in gloveboxes. Development and testing of high explosives, plastics, and adhesives and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18, Pajarito Laboratory Site: This is a nuclear facility that studied both static and dynamic behavior of multiplying assemblies of nuclear materials. Near-critical experiments were conducted by remote control using low-power reactors called critical assemblies. The special nuclear materials at this site have been relocated to the Nevada Test Site.

TA-21, DP Site: This site has two primary research areas: DP West and DP East. DP West has been in the D&D program since 1992, and six buildings have been demolished. The programs conducted at DP West, primarily in inorganic and biochemistry, were relocated during 1997, and the remainder of the site was scheduled for D&D in future years. DP East is a tritium research site.

TA-22, TD Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-28, Magazine Area A: This is an explosives storage area.

TA-33, HP Site: An old, high-pressure, tritium-handling facility located here is being phased out. An intelligence technology group and the National Radio Astronomy Observatory's Very Large Baseline Array Telescope are located at this site.

TA-35, Ten Site: Work here includes nuclear safeguards research and development that are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research is also done on reactor safety, laser fusion, optical sciences, pulsed-power systems, high-energy physics, tritium fabrication, metallurgy, ceramic technology, and chemical plating.

TA-36, Kappa Site: Phenomena of explosives, such as detonation velocity, are investigated at this dynamic testing site.

TA-37, Magazine Area C: This is an explosives storage area.

TA-39, Ancho Canyon Site: The behavior of nonnuclear weapons is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, explosions involving other materials, shock wave physics, equation state measurements, and pulsed-power systems design.

TA-40, DF Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with the physics of explosives.

TA-41, W Site: Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.

TA-43, Health Research Laboratory: This site is adjacent to the Los Alamos Medical Center in the townsite. Research performed at this site includes structural, molecular, and cellular radiobiology, biophysics, mammalian radiobiology, mammalian metabolism, biochemistry, and genetics. The Department of Energy Los Alamos Area Office is also located within TA-43.

TA-46, WA Site: Activities include applied photochemistry research including the development of technology for laser isotope separation and laser enhancement of chemical processes. A new facility completed during 1996 houses research in inorganic and materials chemistry. The Sanitary Wastewater System Facility is located at the east end of this site. Environmental management operations are also located here.

TA-48, Radiochemistry Site: Laboratory scientists and technicians perform research and development activities at this site on a wide range of chemical processes including nuclear and radiochemistry, geochemistry, biochemistry, actinide chemistry, and separations chemistry. Hot cells are used to produce medical radioisotopes.

TA-49, Frijoles Mesa Site: This site is currently restricted to carefully selected functions because of its location near Bandelier National Monument and past use in high-explosive and radioactive materials experiments. The Hazardous Devices Team Training Facility is located here.

TA-50, Waste Management Site: This site is divided into two facility management units, which include managing the industrial liquid and radioactive liquid waste received from Laboratory technical areas and activities that are part of the waste treatment technology effort.

TA-51, Environmental Research Site: Research and experimental studies on the long-term impact of radioactive waste on the environment and types of waste storage and coverings are performed at this site.

TA-52, Reactor Development Site: A wide variety of theoretical and computational activities related to nuclear reactor performance and safety are done at this site.

TA-53, Los Alamos Neutron Science Center: The Los Alamos Neutron Science Center, including the linear proton accelerator, the Manuel Lujan Jr. Neutron Scattering Center, and a medical isotope production facility, is located at this TA. Also located at TA-53 are the Accelerator Production of Tritium Project Office, including the Low-Energy Demonstration Accelerator, and research and development activities in accelerator technology and high-power microwaves.

TA-54, Waste Disposal Site: This site is divided into two facility management units for the radioactive solid and hazardous chemical waste management and disposal operations and activities that are part of the waste treatment technology effort; includes Area G.

TA-55, Plutonium Facility Site: Processing of plutonium and research on plutonium metallurgy are done at this site.

TA-57, Fenton Hill Site: This site is located about 28 miles west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains and was the location of the Laboratory's now decommissioned Hot Dry Rock geothermal project. The site is used for the testing and development of downhole well-logging instruments and other technologies of interest to the energy industry. The high elevation and remoteness of the site make Fenton Hill a choice location for astrophysics experiments. A gamma ray observatory is located at the site.

TA-58: This site is reserved for multiuse experimental sciences requiring close functional ties to programs currently located at TA-3.

TA-59, Occupational Health Site: Occupational health and safety and environmental management activities are conducted at this site. Emergency management offices are also located here.

TA-60, Sigma Mesa: This area contains physical support and infrastructure facilities, including the Test Fabrication Facility and Rack Assembly and the Alignment Complex.

TA-61, East Jemez Road: This site is used for physical support and infrastructure facilities, including the Los Alamos County sanitary landfill.

TA-62: This site is reserved for multiuse experimental science, public and corporate interface, and environmental research and buffer zones.

TA-63: This is a major growth area at the Laboratory with expanding environmental and waste management functions and facilities. This area contains physical support facilities operated by KSL Services.

TA-64: This is the site of the Central Guard Facility and headquarters for the Laboratory Hazardous Materials Response Team.

TA-66: This site is used for industrial partnership activities.

TA-67: This is a dynamic testing area that contains significant archeological sites.

TA-68: This is a dynamic testing area that contains archeological and environmental study areas.

TA-69: This undeveloped TA serves as an environmental buffer for the dynamic testing area.

TA-70: This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-71: This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-72: This is the site of the Protective Forces Training Facility.

TA-73: This area is the Los Alamos Airport.

TA-74, Otowi Tract: This large area, bordering the Pueblo de San Ildefonso on the east, is isolated from most of the Laboratory and contains significant concentrations of archeological sites and an endangered species breeding area. This site also contains Laboratory water wells and future well fields.

APPENDIX D

RELATED WEBSITES

For more information on environmental topics at Los Alamos National Laboratory, access the following websites:

Environmental Surveillance reports and supplemental data tables	http://www.lanl.gov/community/environment/docs/reports/esr.shtml
Los Alamos National Laboratory website	http://www.lanl.gov
DOE/NNSA Los Alamos Site Office website	http://www.doeal.gov/laso/default.aspx
Department of Energy website	http://www.energy.gov
University of California-managed laboratories	http://labs.ucop.edu
LANL's air quality pages	http://www.lanl.gov/community/environment/air/
LANL's water quality pages	http://www.lanl.gov/community/environment/h2o/
LANL's waste pages	http://www.lanl.gov/community/environment/waste/
LANL's ecology pages	http://www.lanl.gov/community/environment/eco/
LANL's risk reduction pages	http://www.lanl.gov/community/environment/risk/
LANL's clean-up pages	http://www.lanl.gov/community/environment/cleanup/

GLOSSARY

activation products	Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.
albedo dosimeters	Albedo dosimeters are used to measure neutrons around TA 18. They use a neutron-sensitive polyethylene phantom to capture neutron backscatter to simulate the human body.
alpha particle	A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
ambient air	The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.
aquifer	A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.
artesian well	A well in which the water rises above the top of the water-bearing bed.
background radiation	Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; worldwide fallout; and radiation from medical diagnostic procedures.
beta particle	A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.
biota	The types of animal and plant life found in an area.
blank sample	A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. The measured value or signals in blanks for the analyte is believed to be caused by artifacts and should be subtracted from the measured value. This process yields a net amount of the substance in the sample.
blind sample	A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

BOD	Biochemical (biological) oxygen demand. A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.
CAA	Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state and local governments to develop and execute air pollution prevention and control programs.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also known as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.
CFR	Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the Federal Register.
contamination	(1) Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.
controlled area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
Ci	Curie. Unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.
cosmic radiation	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
CWA	Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.
DOE	US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production. Los Alamos National Laboratory is managed by the NNSA, an agency within the DOE.
dose	A term denoting the quantity of radiation energy absorbed.
absorbed dose	The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).
dose equivalent	The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

EDE	Effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100-mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to 100 × 0.12 = 12 mrem.
maximum individual dose	The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.
population dose	The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)
whole body dose	A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).
EA	Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.
effluent	A liquid waste discharged to the environment.
EIS	Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.
emission	A gaseous waste discharged to the environment.
environmental compliance	The documentation that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of the Laboratory's environmental monitoring and surveillance programs.
environmental monitoring	The sampling of contaminants in liquid effluents and gaseous emissions from Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.
environmental surveillance	The sampling of contaminants in air, water, sediments, soils, foodstuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.

EPA	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
exposure	A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
groundwater	Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains (1/2 × 1/2), after three half-lives, one-eighth (1/2 × 1/2 × 1/2), and so on.
hazardous waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.
hazardous waste constituent	The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.
HSWA	Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.

hydrology	The science dealing with the properties, distribution, and circulation of natural water systems.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.
ionizing radiation	Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.
isotopes	Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors. ▪ long-lived isotope - A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years). ▪ short-lived isotope - A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).
MCL	Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-6). The MCLs are specified by the EPA
MEI	Maximally exposed individual. The average exposure to the population in general will always be less than to one person or subset of persons because of where they live, what they do, and their individual habits. To try to estimate the dose to the MEI, one tries to find that population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc. This becomes the MEI.
mixed waste	Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).
mrem	Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.
NEPA	National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment before decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.

NESHAP	National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.
NNSA	National Nuclear Security Agency. An agency with the DOE that is responsible for national security through the military application of nuclear energy.
nonhazardous waste	Chemical waste regulated under the Solid Waste Act, Toxic Substances Control Act, and other regulations, including asbestos, PCB, infectious wastes, and other materials that are controlled for reasons of health, safety, and security.
NPDES	National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.
nuclide	A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content—or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.
outfall	The location where wastewater is released from a point source into a receiving body of water.
PCB	Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976.
PDL	Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).
perched groundwater	A groundwater body above a slow-permeability rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.
person-rem	A quantity used to describe the radiological dose to a population. Population doses are calculated according to sectors, and all people in a sector are assumed to get the same dose. The number of person-rem is calculated by summing the modeled dose to all receptors in all sectors. Therefore, person-rem is the sum of the number of people times the dose they receive.

pH	A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.
pollution	Levels of contamination that may be objectionable (perhaps because of a threat to health [see contamination]).
point source	An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.
ppb	Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as μg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or μg/kg.
ppm	Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L. Also used to express the weight/weight ratio as μg/g or mg/kg.
QA	Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.
QC	Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.
rad	Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body. 1 rad = 1,000 millirad (mrad)
radionuclide	An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.
RESRAD	A computer modeling code designed to model radionuclide transport in the environment.
RCRA	Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.
release	Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.

rem	Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) from the different types of radiation. rem = rad × quality factor 1 rem = 1,000 millirem (mrem)
SAL	Screening Action Limit. A defined contaminant level that if exceeded in a sample requires further action.
SARA	Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title III of this act is known as the Emergency Planning and Community Right-to-Know Act of 1986.
saturated zone	Rock or soil where the pores are completely filled with water, and no air is present.
SWMU	Solid waste management unit. Any discernible site at which solid wastes have been placed at any time, regardless of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released, such as waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, canyons around LANL, and contaminated areas resulting from leaking product storage tanks (including petroleum).
terrestrial radiation	Radiation emitted by naturally occurring radionuclides such as internal radiation source; the natural decay chains of uranium-235, uranium-238, or thorium-232; or cosmic-ray-induced radionuclides in the soil.
TLD	Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that emits a light signal when heated to approximately 300°C. This light is proportional to the amount of radiation (dose) to which the dosimeter was exposed.
TRU	Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and Nuclear Regulatory Agency. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium, that have activities greater than 100 nanocuries per gram.
TSCA	Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is required by the act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this act for controlling substances found to be detrimental to human health or to the environment.

tuff	Rock formed from compacted volcanic ash fragments.
uncontrolled area	An area beyond the boundaries of a controlled area (see controlled area in this glossary).
unsaturated zone	See vadose zone in this glossary.
UST	Underground storage tank. A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10 percent or more of the volume of the tank system is below the surface of the ground.
vadose zone	The partially saturated or unsaturated region above the water table that does not yield water for wells. Water in the vadose zone is held to rock or soil particles by capillary forces and much of the pore space is filled with air.
water table	The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.
watershed	The region draining into a river, a river system, or a body of water.
wetland	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.
wind rose	A diagram that shows the frequency and intensity of wind from different directions at a particular place.
worldwide fallout	Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

ACRONYMS AND ABBREVIATIONS

AIRNET	Ambient Air Monitoring Network
AOC	area of concern
AQA	Analytical Quality Associates
BCG	Biota Concentration Guides
BSRL	baseline statistical reference level
CFR	Code of Federal Regulations
CGP	Construction General Permit
CMR	Chemistry and Metallurgy Research (LANL building)
CWA	Clean Water Act
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
DOB	DOE Oversight Bureau
DOE	Department of Energy
DRO	diesel-range organic compound
DU	depleted uranium
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
ENV	Environmental Stewardship Division
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ES&H	environment, safety, & health
EU	enriched uranium
FY	fiscal year
GEL	General Engineering Laboratory
GMAP	gaseous mixed air activation products
HE	high-explosive
HMX	cyclotetramethylenetetranitramine
HSWA	Hazardous and Solid Waste Amendments
HT	elemental tritium
HTO	tritium oxide
ISM	Integrated Safety Management (LANL)

LANL	Los Alamos National Laboratory (or the Laboratory)
LANSCE	Los Alamos Neutron Science Center (TA-53)
LASO	Los Alamos Site Office (DOE)
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
MAPEP	Mixed-Analyte Performance Evaluation Program
MCL	maximum contaminant level
MDA	material disposal area
MDL	method detection limit
MEI	maximally exposed individual
NCRP	National Council on Radiation Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
P2	Pollution Prevention Program
PCB	polychlorinated biphenyls
PERC	perchloroethylene
PM	particulate matter
ppb	parts per billion
PSTB	Petroleum Storage Tank Bureau (NMED)
P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite)
RLWT	Radioactive Liquid Waste Treatment Facility (LANL)
RSRL	regional statistical reference level
SA	supplement analysis
SAL	screening action level
SL	screening level
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
SWEIS	Site-Wide Environmental Impact Statement

SWPP	Storm Water Prevention Plan
SWMU	solid waste management unit
TA	Technical Area
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substances Control Act

ELEMENTAL AND CHEMICAL NOMENCLATURE

Actinium	Ac
Aluminum	Al
Americium	Am
Argon	Ar
Antimony	Sb
Arsenic	As
Astatine	At
Barium	Ba
Berkelium	Bk
Beryllium	Be
Bicarbonate	HCO_3
Bismuth	Bi
Boron	B
Bromine	Br
Cadmium	Cd
Calcium	Ca
Californium	Cf
Carbon	C
Cerium	Ce
Cesium	Cs
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Curium	Cm
Cyanide	CN
Carbonate	CO_3
Dysprosium	Dy
Einsteinium	Es
Erbium	Er
Europium	Eu
Fermium	Fm
Fluorine	F
Francium	Fr
Gadolinium	Gd
Gallium	Ga
Germanium	Ge
Gold	Au
Hafnium	Hf
Helium	He
Holmium	Ho
Hydrogen	H
Hydrogen oxide	H_2O
Indium	In
Iodine	I
Iridium	Ir
Iron	Fe
Krypton	Kr
Lanthanum	La
Lawrencium	Lr (Lw)
Lead	Pb
Lithium	Li
Lithium fluoride	LiF
Lutetium	Lu
Magnesium	Mg
Manganese	Mn
Mendelevium	Md
Mercury	Hg
Molybdenum	Mo
Neodymium	Nd
Neon	Ne
Neptunium	Np
Nickel	Ni
Niobium	Nb
Nitrate (as Nitrogen)	NO_3-N
Nitrite (as Nitrogen)	NO_2-N
Nitrogen	N
Nitrogen dioxide	NO_2
Nobelium	No
Osmium	Os
Oxygen	O
Palladium	Pd
Phosphorus	P
Phosphate (as Phosphorus)	PO_4-P
Platinum	Pt
Plutonium	Pu
Polonium	Po
Potassium	K
Praseodymium	Pr
Promethium	Pm
Protactinium	Pa
Radium	Ra
Radon	Rn
Rhenium	Re
Rhodium	Rh
Rubidium	Rb
Ruthenium	Ru
Samarium	Sm
Scandium	Sc
Selenium	Se
Silicon	Si
Silver	Ag
Sodium	Na
Strontium	Sr
Sulfate	SO_4
Sulfite	SO_3
Sulfur	S
Tantalum	Ta
Technetium	Tc
Tellurium	Te
Terbium	Tb
Thallium	Tl
Thorium	Th
Thulium	Tm
Tin	Sn
Titanium	Ti
Tritiated water	HTO
Tritium	^3H
Tungsten	W
Uranium	U
Vanadium	V
Xenon	Xe
Ytterbium	Yb
Yttrium	Y
Zinc	Zn
Zirconium	Zr

ACKNOWLEDGEMENTS

The following Los Alamos National Laboratory organizations perform environmental surveillance, ensure environmental compliance, and provide environmental data for this report:

- *Environment and Remediation Support Services Division (Terry Morgan, David B. Rogers, and Rich Mirenda, Coordinators)*
- *Water Quality and RCRA Group (Luciana Vigil-Holterman and Robert Beers, Coordinators)*
- *Air Quality and Ecology Group (Gil Gonzales, Coordinator)*

The beginning of each chapter credits the primary authors.

Previous reports in this series are LA-13633-ENV, LA-13775-ENV, LA-13861-ENV, LA-13979-ENV, LA-14085-ENV, LA-14162-ENV, and LA-14239-ENV.

Technical coordination by Terry Morgan, ERSS Division

Cover Design by Carrie Dittmer and Trisha Johansen, ERSS Division

Composition by Carrie Dittmer and Teresa Hiteman, ERSS Division

Edited by Caroline Spaeth, Group IRM-CAS

An Affirmative Action/Equal Opportunity Employer

This report has been reproduced directly from the best available copy.

It is available electronically on the Web at http://www.lanl.gov/community/environment/docs/reports/esr.shtml

It is available to DOE and DOE contractors from
Office of Scientific and Technical Information,
P.O. Box 62,
Oak Ridge, TN 37831.
(423) 576-8401.

It is available to the public from
National Technical Information Service,
US Department of Commerce,
5285 Port Royal Rd.,
Springfield, VA 22616.

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither The Regents of the University of California, the United States Government, nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by The Regents of the University of California, the United States Government, or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of The Regents of the University of California, the United States Government, or any agency thereof. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

Los Alamos
NATIONAL LABORATORY
EST.1943