



3. Radiological and Non-Radiological Dose Assessment



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A. INTRODUCTION

This chapter presents the results of the calculation of doses to the public and biota from Laboratory operations in 2007 and reports whether the doses are below specified limits. This chapter also provides a measure of the significance of environmental radioactivity in the context of its importance to humans and biota. In this respect, the human dose assessment provides a different perspective from the biota dose assessment. The calculated human dose is received near the publicly accessible Laboratory boundaries, whereas the biota dose is potentially received throughout the interior of the Los Alamos National Laboratory (LANL or the Laboratory) property, usually at locations rarely visited by humans. In addition, the potential risks from nonradiological materials detected during 2007 and previous years' sampling activities are summarized.

As defined by US Department of Energy (DOE) Standard 1153-2002 (DOE 2002), biota are divided into plants and animals. Plants receive the highest dose because they live in one location. Most animals range over a wider area, which usually minimizes their dose. Humans receive the lowest dose because they limit their time in areas with residual contamination and do not typically eat the vegetation or drink the water in these areas. Therefore, locations with no significant human dose may have a higher biota dose.

B. HUMAN DOSE ASSESSMENT

1. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented are calculated using standard methods specified in guidance documents (DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997, 1999; ICRP 1996; NRC 1977). The “effective dose equivalent,” referred to here as “dose,” is calculated using radiation weighting factors and tissue weighting factors to adjust for the various types of radiation and the various tissues in the body. The final result, measured in millirem (mrem), is a measure of the overall dose to an individual, whether from external radiation or contact with radioactive material. For example, 1 mrem of direct gamma radiation is effectively equivalent to 1 mrem from inhalation of plutonium.

Federal government standards limit the dose that the public may receive from Laboratory operations. The DOE public dose limit to any individual is 100 mrem/yr (DOE 1993) received from all pathways (i.e., all ways in which a person can be exposed to radiation, such as inhalation, ingestion, and direct radiation). Furthermore, doses to members of the public must be reduced to low levels consistent with a documented as low as reasonably achievable (ALARA) process and generally not exceeding a dose constraint of one-quarter of the primary dose limit, or 25 mrem/yr (DOE 1999). The dose received from airborne emissions of radionuclides is further restricted by the US Environmental Protection Agency (EPA) dose standard of 10 mrem/yr (EPA 1986), also known as the RAD-NESHAP (National Emission Standards for Hazardous Air Pollutants) dose limit.

3. Radiological Dose Assessment

These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from community drinking water supplies are limited in accordance with the Clean Water Act, either by established maximum contaminant levels (MCLs) for some radionuclides or by dose (4 mrem/yr for man-made radionuclides) (DOE 1993; EPA 2000).

2. Public Dose Calculations

a. Scope

The objective of our public dose calculations is to report incremental (above-background) doses caused by LANL operations. Therefore, we don't include dose contributions from radionuclides present in our natural environment or from radioactive fallout.

Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, ingestion, and direct (or external) radiation. We calculate doses for the following cases:

1. The entire population within 80 km of the Laboratory
2. The maximally exposed individual (MEI) who is not on LANL property for the airborne pathway dose only and compared to the EPA RAD-NESHAP dose limit of 10 mrem/year
3. The MEI not on LANL property for the all-pathways dose and compared to the DOE Order 5400.5 dose limit of 100 mrem/year
4. Residents in Los Alamos and White Rock

b. General Considerations

We began with environmental measurements of air, water, soil, foodstuffs, sediment, and non-foodstuffs biota and convert these measurements to dose using the standard methods specified above.

As discussed in Section B.4, the dose rate from naturally occurring radioactivity is approximately 450 mrem/yr (additional man-made sources of radiation, such as medical/dental uses of radiation and building products such as stone walls, raise the total background dose to 500 mrem/yr on average). It is extremely difficult to measure doses from LANL less than 0.1% (one one-thousandth) of natural doses. As the dose rates become smaller, the estimates become less certain and less significant. Generally, we conclude that a dose rate less than 0.1 mrem/yr is essentially zero and cannot be distinguished from natural background radiation.

i. Direct Radiation Exposure

The Laboratory monitors direct radiation from gamma photons or neutrons at about 100 locations in and around LANL (Chapter 4, Section C). Direct radiation doses above natural background are measured near Technical Area (TA) -54, but elsewhere there are no other sources of external radiation to off-site areas.

To receive a measurable dose, a member of the public must be within a few hundred meters of the source of external radiation. At distances more than one kilometer, the decrease in radiation dose rate with increasing distance from the radiation source (inverse-square law), combined with scattering and attenuation or shielding in the air, reduces the dose to much less than 0.1 mrem/yr, which cannot be distinguished from natural background radiation. This means the only significant above-background doses from direct radiation are measured near TA-54 (Section B.3.c of this chapter).



To estimate the dose to the public near TA-54, we combined the measurements of gamma and neutron dose with an occupancy factor of 1/16 (NCRP 1976). The direct radiation measurements reported in Chapter 4 would apply to an individual who is at a particular location continuously (i.e., 24 hours/day and 365 days/yr). We followed standard guidance and assumed continuous occupancy for residences and places of business. For all other locations, we multiplied the measured dose by the 1/16 occupancy factor.

ii. Airborne Radioactivity (Inhalation Pathway)

At distances more than a few hundred meters from LANL sources, the dose to the public is almost entirely from airborne radioactive material. Whenever possible, we used the direct measurements of airborne radioactivity concentrations measured by the Ambient Air Sampling Network (AIRNET) and reported in Chapter 4, Section A. Where local concentrations are too small to measure, we calculated the doses using the CAP88 model (EPA 2007a), an atmospheric dispersion and dose calculation computer code that combines stack radionuclide emissions information with meteorological data to estimate where the released radioactive material went and the dose from that radioactive material. The estimation of dose for this chapter was performed using CAP88-PC Version 3.0 (EPA 2007a).

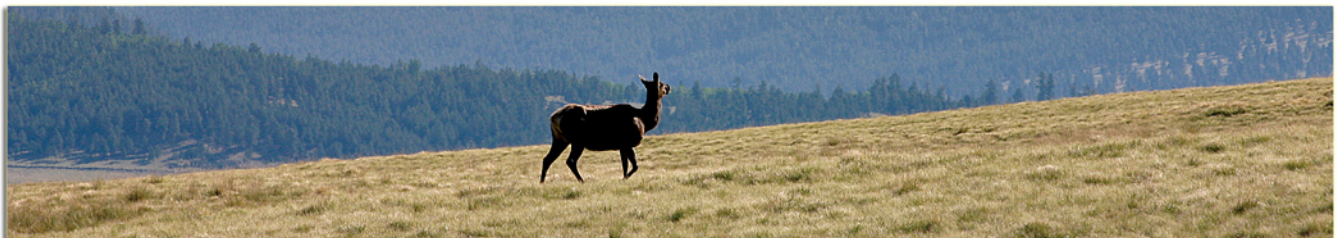
In particular, some of the radionuclide emissions from the Los Alamos Neutron Science Center (LANSCE) are not measured by AIRNET. These emissions are measured at the stacks (Chapter 4, Section B), and the resulting doses are calculated with CAP88. These doses decrease substantially with distance from the stack because the radioactive half-lives are short (mostly 20 minutes or less).

iii. Water (Ingestion Pathway)

The majority of radionuclides detected in groundwater samples collected from known or potential drinking water sources (i.e., Los Alamos County drinking water supply wells and natural springs) in 2007 resulted from the presence of natural radioactivity in these sources. These radionuclides include natural uranium and its decay products, such as radium-226. However, several radionuclides attributable to Laboratory operations were measured in samples from an on-site alluvial spring in upper Los Alamos Canyon (DP Spring), which is not a recognized drinking water source. Strontium-90 and tritium were measured in DP Spring samples at maximum concentrations of 62 pCi/L and 191 pCi/L, respectively. The maximum dose from ingesting one liter of water from this spring would be approximately 0.02 mrem. The highest concentration of tritium detected in a Los Alamos County drinking water supply well was 14 pCi/L in a sample collected from the Otowi-1 well located in Pueblo Canyon and is well within the range of tritium concentrations found in rain water (16 to 35 pCi/L) (Holloway 1993). This concentration is far below the EPA MCL of 20,000 pCi/L and would result in a dose of less than 0.001 mrem/yr if this water were to be ingested for an entire year (assumes 730 L ingested for the year). However, this well was not used by Los Alamos County as a drinking water source during 2007.

iv. Soil (Direct Exposure Pathway)

We reported measurements of radionuclide concentrations in surface soil in Chapter 7. As described in Chapter 7, Section C.1, soil samples were collected on the perimeter of the Laboratory and at regional and on-site locations. No regional samples had radionuclide concentrations above the Regional Statistical Reference Levels (RSRLs). RSRLs represent background radionuclide concentrations plus three standard deviations in media, such as soil, sediment, and crops, collected or harvested in regional areas far from the influence of the Laboratory averaged over a period of five years.



Soil concentrations measured in samples from previous years are above the RSRL at some perimeter locations. For example, plutonium-239/240 is above the RSRL at locations near TA-1 in the Los Alamos town site, near TA-21 along DP Road, and at TA-73 along State Route 502. In Chapter 7, Section D.2.b, new data are reported at the Laboratory boundary between TA-54 and the San Ildefonso sacred area. At this location, the plutonium-239/240 concentration was 0.2 pCi/g, which corresponds to a dose of 0.01 mrem/year.

In summary, we conclude that the LANL contribution to the dose from soil around the perimeter of the Laboratory is less than 0.1 mrem/yr, and the majority of the radionuclides detected are primarily due to world-wide fallout and historical operations at the Laboratory.

v. Food (Ingestion Pathway)

We report measurements of the radioactive content of foods, mostly crops, in Chapter 8. Most concentrations in crops were below the RSRLs and are consistent with results from previous years. For the few cases above the RSRL, the dose is much less than 0.1 mrem/year, which is very small relative to the all-pathways dose limit of 100 mrem/yr and the 25 mrem/yr dose constraint.

vi. Release of Items

The Laboratory releases miscellaneous surplus items of salvageable office and scientific equipment to the general public. The requirements for release of such items are found in LANL 2006a. All items destined for release from known or potentially contaminated areas are screened for radioactive contamination in accordance with procedures of LANL's Health Physics Operations Group. Any items with surface contamination or dose levels above the authorized release limits for uncontrolled use are not released to the public. Items from a known or potentially contaminated area that cannot be completely surveyed are also not released. The authorized release limits for items (LANL 2006a) are the limits in Figure IV-1 of DOE requirements (DOE 1993, DOE 1995). In 2007, no items were released to the public with contamination or dose levels approaching the authorized release limits. Therefore, the dose to the public from this pathway is negligible.

The transfer of real property (land) from DOE to the public is allowed if the modeled dose is no greater than 15 mrem/yr. In January of 2007, the transfer of Tract A8a (located south of MDA B and DP Road) to Los Alamos County was finalized. In addition to ensuring that the modeled dose was less than the authorized release limit of 15 mrem/yr, an ALARA (as low as reasonably achievable) dose optimization analysis was performed to determine if further remediation efforts were warranted from a cost-benefit perspective. The highest dose rate calculated for an individual residing on the land was estimated to be 4.1 mrem/yr (0.0041 rem/yr). This was a very conservative estimate, as the measured radionuclide concentrations used to perform the dose calculation were not background-corrected and were the maximum concentrations measured on the land tract. Assuming a dose integration period of 200 years and that 500 persons would reside on the tract at any one time, the collective dose was estimated to be 410 person-rem ($0.0041 \text{ rem/yr} \times 200 \text{ years} \times 500 \text{ persons} = 410 \text{ person-rem}$). Assuming \$2,000 as the nominal value recommended by DOE (DOE 1997) that should be spent to avert one person-rem, the total funds that should be spent to avert the collective dose of 410 person-rem were estimated to be \$820,000. The estimated cost of remediating the tract of land down to fallout background levels was approximately \$25 million. Because the projected cost of remediation far exceeds the funds that should be spent to avert the collective dose, the projected collective dose had been optimized and no further action was needed.

3. Dose Calculations and Results

a. Population within 80 Kilometers

We used the local population distribution to calculate the dose from 2007 Laboratory operations to the population within 80 km (50 miles) of LANL. Approximately 280,000 persons live within an 80-km radius of the Laboratory. We used county population estimates provided by the University of New Mexico Bureau of Business and Economic Research (available at <http://www.unm.edu/~bber/>).

The collective dose from Laboratory operations is the sum of the estimated doses for each member of the public within an 80-km radius of LANL. For example, if two persons each receive three mrem, the collective dose is six person-mrem. This dose results from airborne radioactive emissions. Other potential sources, such as direct radiation, are essentially zero. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88.

The 2007 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was 0.36 person-rem, which is slightly lower than the dose of 0.6 person-rem reported for 2006. Tritium contributed 42% of the dose, and short-lived air activation products such as carbon-11 from LANSCE contributed 54% of the dose. The decrease in the 2006-2007 collective population dose compared to 2005 (2.46 person-rem) is primarily attributable to the repair of a leak at LANSCE in December 2005 and to an additional delay line installed at LANSCE in 2005. LANSCE has historically been the major contributor to the collective population dose. Collective population doses for the past 14 years have generally declined from a high of four person-rem in 1994 to less than one person-rem in 2007 (Figure 3-1). It is expected that future collective population doses will be less than one person-rem. No observable health effects in the local population are expected from this dose.

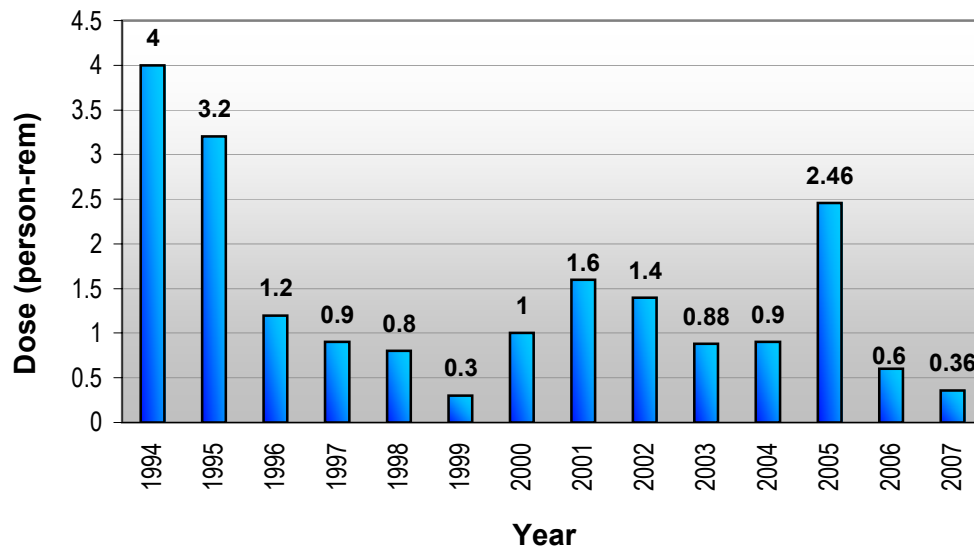


Figure 3-1. Annual collective dose (person-rem) to the population within 80 km of LANL.

b. Maximally Exposed Individual

The MEI is a hypothetical member of the public who, while not on DOE/LANL property, receives the greatest dose from LANL operations. For most of the past 14 years, the airborne pathway (RAD-NESHAP) MEI location has been at 2470 East Road, usually referred to as “East Gate.” East Gate has normally been the location of greatest exposure because of its proximity to LANSCE and the prevailing wind direction. During LANSCE operations, short-lived positron emitters, such as carbon-11, nitrogen-13, and oxygen-15, are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential radiation dose.

i. Airborne Pathway (RAD-NESHAP) MEI Dose

We modeled the dose at East Gate from LANSCE and from the LANL stacks using CAP88. The CAP88-modeled doses (Stavert 2007) were 0.11 mrem/yr from LANSCE and 0.29 mrem/yr from other LANL stacks. We added 0.01 mrem/yr calculated from the airborne radionuclide concentrations measured at the East Gate AIRNET station, though this dose includes tritium, which was also in the CAP88 modeled doses (thus, tritium dose is conservatively included twice). Therefore, the total dose at East Gate was approximately 0.41 mrem/yr.

3. Radiological Dose Assessment

Because the LANSCE emissions for 2007 were reduced compared to previous years (Figure 3-2), the location of the 2007 MEI was not as readily apparent as in the past and required more detailed calculations, as described below.

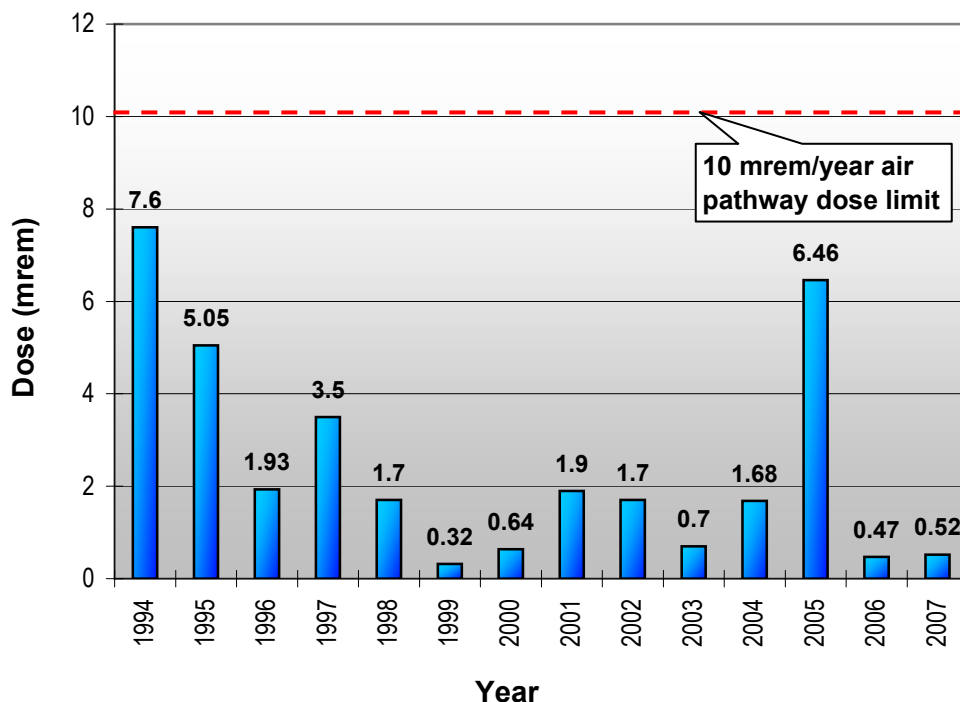


Figure 3-2. Annual airborne pathway (RAD-NESHAP) dose (mrem) to the maximally exposed individual off-site over the past 14 years.

To determine the RAD-NESHAP MEI location, we compared the dose at East Gate with doses at other locations. At AIRNET station #71 on DP Road (Figure 4-3 in Chapter 4) the LANSCE dose was 0.01 mrem/yr, the dose from other stacks was 0.29 mrem/yr, and the AIRNET dose was 0.22 mrem/yr, for a total of 0.52 mrem/yr, which is larger than the dose at East Gate. At 26 other locations, the AIRNET and LANSCE doses were smaller while the dose from other stacks was essentially the same, so the total dose was smaller than the dose measured at AIRNET station #71.

AIRNET station #71 is adjacent to Material Disposal Area B (MDA B), which is a Manhattan-Project-era waste disposal site being prepared for cleanup. The AIRNET dose was primarily the result of plutonium re-suspended during these preparations. There are two buildings adjacent to this AIRNET station, so to be conservative we are using the location of the station itself as the location of the MEI. Thus, the air-pathway MEI location in 2007 was AIRNET station #71 on DP Road with a total dose of 0.52 mrem/yr (Figure 3-2).

ii. All-Pathways MEI Dose

The location evaluated in 2007 as the potential all-pathways MEI is the Laboratory boundary near the Pueblo de San Ildefonso sacred area north of TA-54, Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant (WIPP) emits neutrons. The measured neutron dose at the boundary was 14 mrem/yr. After subtracting a 2-mrem/yr neutron background dose and applying the standard occupancy factor of 1/16 (NCRP 1976), the individual neutron dose was $12 \text{ mrem}/16 = 0.75 \text{ mrem/yr}$. The gamma dose was calculated to be less than 0.01 mrem and was not included because it cannot be distinguished from the much larger gamma background measured at this and the other nearby monitoring locations. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the LANL stacks as $0.02 \text{ mrem}/16 = 0.001 \text{ mrem/yr}$. We added the dose derived from measurements at the AIRNET station along the northern boundary of Area G (0.02 mrem/yr) close to where the neutron dose was measured and applied the occupancy factor of 1/16 to obtain a dose of 0.001 mrem/yr. This resulted in a dose at this location of approximately 0.8 mrem/yr, which is greater than the airborne pathway MEI dose at DP Road.

iii. Dose Summary

The airborne pathway MEI dose of 0.52 mrem/yr at DP Road is below the 10 mrem/yr EPA airborne emissions dose limit for the public (40 CFR 61, EPA 1986), and based on previous studies, we conclude it causes no observable health effects (BEIR 1990). The all-pathways MEI dose of 0.8 mrem/yr at the Laboratory boundary of the Pueblo de San Ildefonso sacred area north of Area G is below the 100 mrem/yr DOE limit for all pathways and the 25 mrem/yr dose constraint (DOE Order 5400.5, DOE 1993, DOE 1999), and, again, we conclude it causes no observable health effects.

In most past years, LANSCE has been the major contributor to the MEI dose. Future operations of the facility and associated emissions are expected to stay consistent with 2007 levels. Because stack emissions are expected to remain low, the major contributor to the air pathway MEI dose will most likely be from the suspension of low levels of transuranic radionuclides in soil from environmental remediation projects.

c. Doses in Los Alamos and White Rock

We used background-corrected AIRNET data (reported in Chapter 4, Section A) and the factors in EPA guidance (EPA 1986) to calculate an annual dose at each of the perimeter AIRNET stations that represent the Los Alamos resident and the White Rock resident. To these doses, we added the contributions from LANSCE and other stacks, calculated using CAP88 for two representative locations: 5 km northwest of LANSCE in Los Alamos and 6.8 km southeast of LANSCE in White Rock.

i. Los Alamos

During 2007, the Laboratory contributions to the dose at an average Los Alamos residence were 0.006 mrem/yr from tritium, 0.013 mrem/yr from uranium, and 0.003 mrem/yr from LANSCE. Other radionuclides contributed less than 0.001 mrem/yr. This results in a total dose to an average Los Alamos resident of approximately 0.022 mrem/yr.

ii. White Rock

During 2007, the Laboratory contributions to the dose at an average White Rock residence were 0.013 mrem/yr from tritium, 0.006 mrem/yr from uranium, and 0.003 mrem/yr from LANSCE. Other radionuclides contributed 0.002 mrem/yr. This results in a total dose to an average White Rock resident of approximately 0.024 mrem/yr.

iii. Dose Summary

The contributions from direct radiation, food, water, and soil are discussed in Section B.2 of this chapter; each contribution is considered to be essentially a zero dose. In summary, the total annual dose in 2007 to an average Los Alamos/White Rock resident from all pathways was about 0.02 mrem and is well below the all-pathways dose limit of 100 mrem/yr and the 25 mrem/yr dose constraint. No observable health effects are expected from this dose.

4. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

In this section, we discuss the LANL contribution relative to natural radiation and radioactive materials in the environment (NCRP 1975, 1987a, 1987b).

External radiation comes from two sources that are approximately equal: cosmic radiation from space and terrestrial gamma radiation from naturally occurring radionuclides. Doses from cosmic radiation range from 50 mrem/yr at lower elevations near the Rio Grande to about 90 mrem/yr in the higher elevations west of Los Alamos (Bouville et al 1988). In addition, as reported in Chapter 4, Section C, doses from terrestrial radiation range from about 50 to 150 mrem/yr.

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products. Nationwide, the average dose from radon is about 200 to 300 mrem/yr (NCRP 1987b.) In northern New Mexico, the radon concentrations and doses are higher than average. For more information, refer to the radon section of the EPA website (<http://www.epa.gov/radon/>) and the map of radon zones (<http://www.epa.gov/radon/zonemap.html>). An additional 40 mrem/yr results from naturally occurring radioactive materials in the body, primarily potassium-40, which is present in all food and living cells.

3. Radiological Dose Assessment

In addition, members of the US population receive an average dose of 50 mrem/yr from medical and dental uses of radiation, 10 mrem/yr from man-made products, such as stone or adobe walls, and less than 1 mrem/yr from global fallout from nuclear-weapons tests (NCRP 1987a). Therefore, the average total annual dose from sources other than LANL is approximately 500 mrem. Refer to Figure 3-3 for a comparison of the natural radiation background (and other sources) in Los Alamos to the United States average background. The estimated LANL-attributable 2007 all-pathways MEI dose, 0.8 mrem/yr, is about 0.2% of this dose.

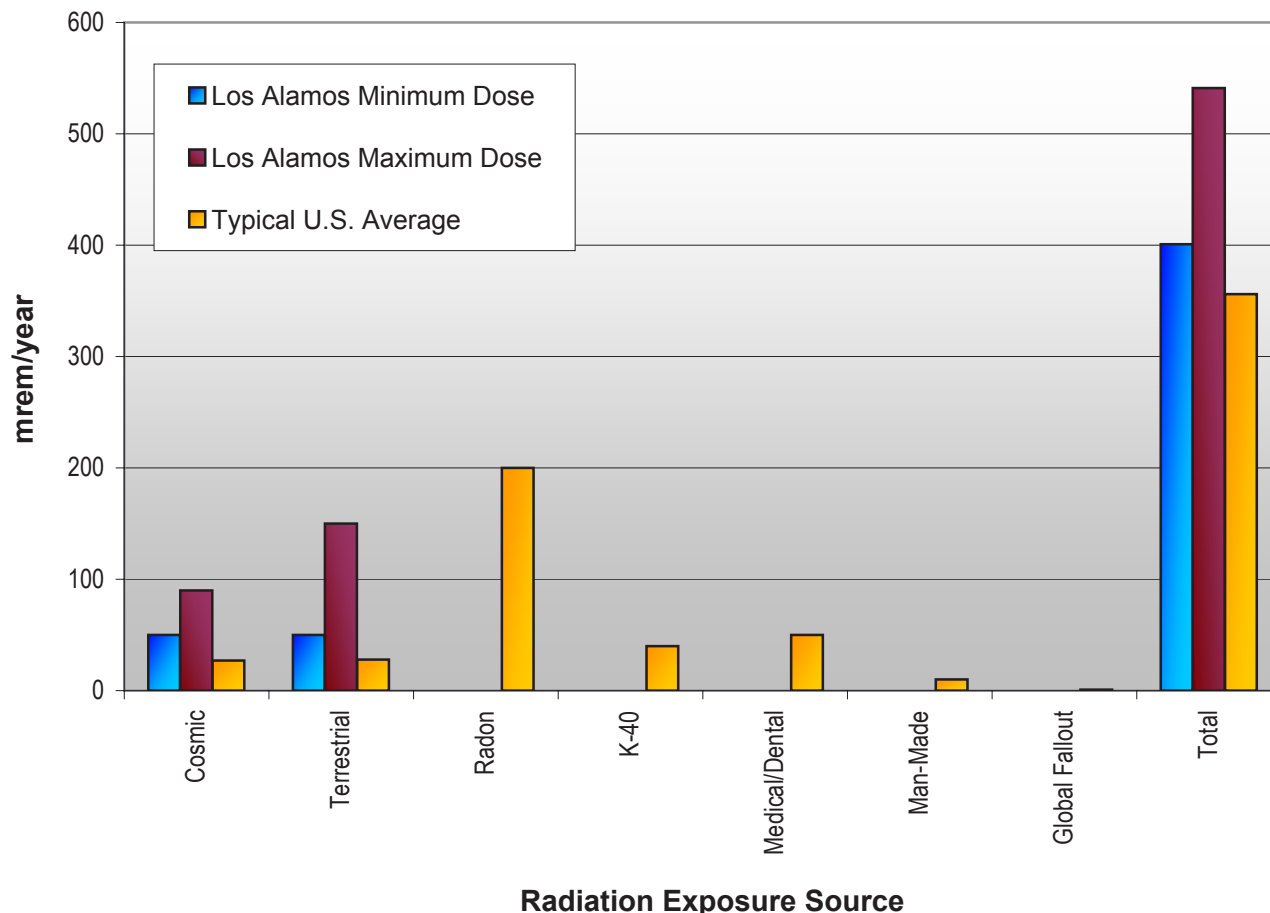


Figure 3-3. Los Alamos County radiation background compared to average US background. Los Alamos County-specific background doses have not been determined for radon, potassium-40, medical/dental exposures, man-made radiation, and global fallout and are assumed to be the same as the US average in this figure.



5. Effect to an Individual from Laboratory Operations

Health effects from radiation exposure have been observed in humans at doses in excess of 10 rem (10,000 mrem) (BEIR 1990). However, doses to the public from LANL operations are much smaller (Table 3-1). According to the 1996 Position Statement of the Health Physics Society (HPS 1996), “Below 10 rem, risks of health effects are either too small to be observed or are nonexistent.” Therefore, the doses presented in this chapter are not expected to cause observable health effects.

Table 3-1
LANL Radiological Dose for Calendar Year 2007

Pathway	Dose to Maximally Exposed Individual mrem/yr	% of DOE 100 mrem/year Limit	Estimated Population Dose person-rem	Population within 80 km	Estimated Background Radiation Population Dose person-rem
Air	0.52 ^a	0.52%	0.36	NA ^b	NA
Water	<0.1	<0.1%	0	NA	NA
Other Pathways (foodstuffs, soils)	<0.1	<0.1%	0	NA	NA
All Pathways	0.8 ^c	1%	0.36	~280,000	~140,000 ^d

^a This is the RAD-NESHAP MEI dose measured at AIRNET station #71 on DP Road.

^b NA = Not applicable. Pathway-specific populations are not specified, and pathway-specific background doses have not been determined, as allowed by DOE guidance.

^c This is the all-pathways MEI dose at the boundary of the Pueblo de San Ildefonso sacred area north of Area G.

^d Based on 200–300 mrem/yr from inhalation of radon and its decay products, 70 mrem/yr from cosmic radiation, 100 mrem/yr from terrestrial radiation, 40 mrem/yr from potassium-40, 50 mrem/yr from medical and dental uses of radiation, and 10 mrem/yr from man-made products (see Section B.4).

C. BIOTA DOSE ASSESSMENT

1. Biota Dose Assessment Approach

a. Overview

The biota dose assessment methods are described in detail in the DOE Standard 1153-2002 (DOE 2002) and in the computer program RESRAD-BIOTA (<http://web.ead.anl.gov/resrad/home2/biota.cfm>). The DOE methods are general in nature and allow specific parameters to be adjusted according to local conditions because the calculations apply to all types of biota and all types of ecosystems. The site-specific methods used at LANL are specified in the quality assurance project plan for Biota Dose Assessment (available at <http://www.lanl.gov/environment/air/qa.shtml?2>), and McNaughton 2005 describes in detail the application of these methods to specific locations at LANL.

We calculate the dose to selected plants and animals following the guidance of DOE Standard 1153-2002 (DOE 2002) and LANL (LANL 2004). Trees of the pine family (pinaceae) are representative of terrestrial plants because they are radiosensitive (UNSCEAR 1996), and because their deep roots might tap into buried contamination (Foxx et al. 1984a, b; Tierney et al. 1987). Deer mice are representative of terrestrial animals because of their relatively small home range, which means the maximally exposed mouse might spend a large fraction of its time in the most contaminated location. These plants and animals are common and widespread at LANL and the surrounding area. Other plants and animals (including aquatic plants and animals) may be collected and analyzed to estimate biota dose depending on availability and locations of interest.

b. Biota Dose Limits

The DOE biota dose limits (DOE 2002) are applied to representative biota populations rather than to the maximally exposed individuals because it is the goal of DOE to protect populations, especially with respect to preventing the impairment of reproductive capability within the population. For animals, we used the population area for deer mice of 3 ha (30,000 m²) (Ryti et al. 2004; LANL 2004). We also averaged the dose to plants over this same area (McNaughton 2005).

The DOE dose limits to biota populations are

- Terrestrial animals: 0.1 rad/day (100 mrad/day)
- Terrestrial plants: 1 rad/day (1,000 mrad/day)
- Aquatic animals: 1 rad/day (1,000 mrad/day)

c. Methods

To ensure that the assessment is comprehensive, we began with an initial screening (DOE 2002) comparing the maximum radionuclide concentrations in soil, sediment, and surface water with the DOE Biota Concentration Guides (BCGs). The DOE Standard (DOE 2002) states, “An important point is that exceeding the BCGs should not force a mandatory decision regarding remediation of the evaluation area, but rather is an indication that further investigation is likely necessary.” If the BCGs are exceeded, a site-specific assessment is conducted that uses average concentrations and incorporates site-specific bioaccumulation factors. Following the guidance of the DOE Standard (DOE 2002), we did not include external-radiation dose from experimental facilities such as the Dual Axis Radiographic HydroTest (DARHT) facility and LANSCE. As described in DOE 2002, we began with a general screening. Any case that fails the general screening was subjected to a site-specific screening or analysis.

2. Biota Dose Results

As reported in Chapters 5 through 8, we collected water, soil, sediment, vegetation (overstory and/or understory), and small mammals in 2007 from several locations. All radionuclide concentrations in vegetation sampled were far below the plant 0.1 rad/day biota dose screening level (10% of 1 rad/day dose limit), and all radionuclide concentrations in terrestrial animals sampled were far below the terrestrial animal 0.01 rad/day biota dose screening level (10% of 0.1 rad/day dose limit). As previously mentioned in the soil pathway section of this chapter (Section B.2.iv.), certain perimeter and on-site sample locations had soil radionuclide concentrations above RSRLs attributable to historical Laboratory operations. However, none of these concentrations exceeded the limiting terrestrial animal BCG screening levels.

As reported in Chapter 6, there were two cases for which surface water concentrations failed the general screening. These are discussed in the following section.

In Potrillo Canyon at storm-water monitoring station PT-SMA-1 south of the TA-15 firing sites, the maximum uranium concentration in unfiltered water, 945 pCi/L, exceeded the DOE-default BCG of 200 pCi/L for aquatic systems. Similarly, in Three Mile Canyon at 3M-SMA-0.6, northeast of the TA-15 firing sites, the maximum unfiltered concentration was 790 pCi/L. These data fail the general screening and so trigger a site-specific biota dose assessment.

Following the guidance of the DOE Standard, DOE-STD-1153-2002, Module 2, Section 4, we considered the intersection of the contaminated area and the various types of habitat. The stream types are shown in Figure 6-3 and the monitoring stations are shown in Figure 6-7 in Chapter 6. The DOE standard is designed to assess chronic dose so, following New Mexico State guidance (Table 6-1), ephemeral and intermittent streams were assessed for dose from livestock watering but only perennial streams were assessed for chronic dose to aquatic animals.

The nearest aquatic habitat is at the perennial stream several miles from the contaminated areas, so there is no intersection between the contaminated areas in Potrillo and Three Mile Canyons and the aquatic habitat. The nearest riparian habitat in Three Mile Canyon is 1 km upstream and there are no nearby riparian areas in Potrillo Canyon, so there is no intersection between the contaminated areas and riparian habitat. The only habitat that intersects the contaminated area is terrestrial.

In New Mexico, storm water runoff generally flows for less than an hour. Furthermore, if the runoff water accumulates in pools, the sediment will settle and the concentration will quickly approach that of filtered water. Therefore, the concentrations reported above are available to biota for only a small fraction of the time. Nevertheless, to be conservative, we used the maximum concentrations for a terrestrial assessment. The resulting doses are 0.5 mrad/day to terrestrial animals and 0.1 mrad/day to terrestrial plants, mostly from uranium. These doses are less than 1% of the DOE Standard 1153-2002 limits (DOE 2002).

For a complete assessment, we include both water and soil concentrations. The worst-case soil concentrations at TA-15 were assessed in 2005 (the most recent data available) (McNaughton 2005) and the worst-case doses were at a TA-15 firing site (called EF-site) where the doses were 100 mrad/day to the maximally-exposed plant, 70 mrad/day to the maximally-exposed mouse, and 20 mrad/day to an average individual representative of either the mouse or plant population. As a result, the worst-case doses are less than the DOE Standard 1153-2002 limits (DOE 2002) and the storm-water monitoring locations in TA-15 pass the site-specific screening.

D. NON-RADIOLOGICAL DOSE ASSESSMENT

1. Overview

We have concluded that dose to members of the public and the environment from LANL radiological hazards is well understood and extensively documented. We place equal emphasis on the risk to members of the public and the environment from non-radiological hazards present at LANL, such as heavy metals and organic compounds.

This section assesses the potential human health risk from non-radiological materials released from LANL either during 2007 or during the previous 64 years of operations at LANL. Non-radiological air pollutants are regulated by the Clean Air Act, as discussed in Chapter 2, Section 6. The applicable standards for other media are summarized in Table 5-1, Table 6-1, Table 8-1, and Appendix A. Air emissions data are reported in Chapter 2, ambient air data are reported in Chapter 4, and the data for other environmental media are reported in Chapters 5 through 8. The resulting potential public health risks are summarized below.

2. Results

a. General Considerations

The emissions from LANL and the associated off-site concentrations of non-radiological contaminants in air, water, soil, and food are well below the applicable standards or risk-based concentrations (EPA 2007b, NMED 2006). Nevertheless, members of the public could potentially be exposed to hazardous materials from each of the environmental media discussed in the following sections.

i. Air (Inhalation Pathway)

The assessment of the ambient air impacts of high explosives testing, reported in Chapter 4 Section D.5, indicates no adverse impacts to the public. The beryllium concentrations reported in Chapter 4, Section D.6, appear to be of natural origin.

ii. Groundwater (Ingestion)

Groundwater results are reported in Chapter 5. The only Laboratory impact on a potential drinking water supply is at well Otowi-1 in Pueblo Canyon. For 2007, groundwater samples from this well had an average perchlorate

3. Radiological Dose Assessment

concentration of 2 µg/L, which is about 1/10 of EPA's Drinking Water Equivalent Level of 24.5 µg/L. However, this well is not used by Los Alamos County for its drinking water supply and therefore does not present a potential risk to human health.

LANL has detected hexavalent chromium in the Mortandad Canyon regional aquifer monitoring well samples at levels above the New Mexico groundwater standard and at about 70% of the standard in a Sandia Canyon regional aquifer monitoring well. However, hexavalent chromium has not been detected in Los Alamos County and Santa Fe Buckman drinking water supply wells above natural levels, so there is no health risk from ingestion of water from the drinking water supply wells.

iii. Surface Water and Sediment

The concentrations of chemicals in surface water and sediment are reported in Chapter 6. No potentially hazardous chemicals of LANL origin were detected off-site, and we conclude there is no current hazard to the public from surface water and sediment exposure.

Polychlorinated biphenyls (PCBs) are present in the on-site sediment, especially in the upper portion of Sandia Canyon, but there is no pathway for ingestion by humans. The usual pathway to humans is ingestion of fish, but there are no fish in Sandia Canyon. More generally, there are no aquatic organisms within the LANL boundaries that are part of a food ingestion pathway to humans.

PCBs are carried in sediment by storm water runoff to the Rio Grande. However, the PCB concentrations in fish (sampled in 2005) are not measurably different upstream (e.g., Abiquiu Reservoir, Rio Grande above Otowi bridge) and downstream of LANL (e.g., Cochiti Reservoir, Rio Grande below Otowi bridge).

iv. Soil

Soil concentrations are reported in Chapter 7. The concentrations are far below their soil screening levels and, therefore, do not pose a potential human health risk.

v. Foodstuffs (Ingestion)

The concentrations of nonradioactive materials in foodstuffs are reported in Chapter 8. The data show that there are no potentially hazardous materials from LANL detected in off-site foodstuffs, so there is no potential human health risk.

vi. Potential Future Risks

The possibility of hexavalent chromium and perchlorate entering the drinking-water supply in the future is being evaluated. Our goal is to assess both present and future risk. Models to calculate future risks are being developed.

3. Conclusion

The environmental data collected in 2007 show that there is no potential public-health risk from non-radiological materials released from LANL.

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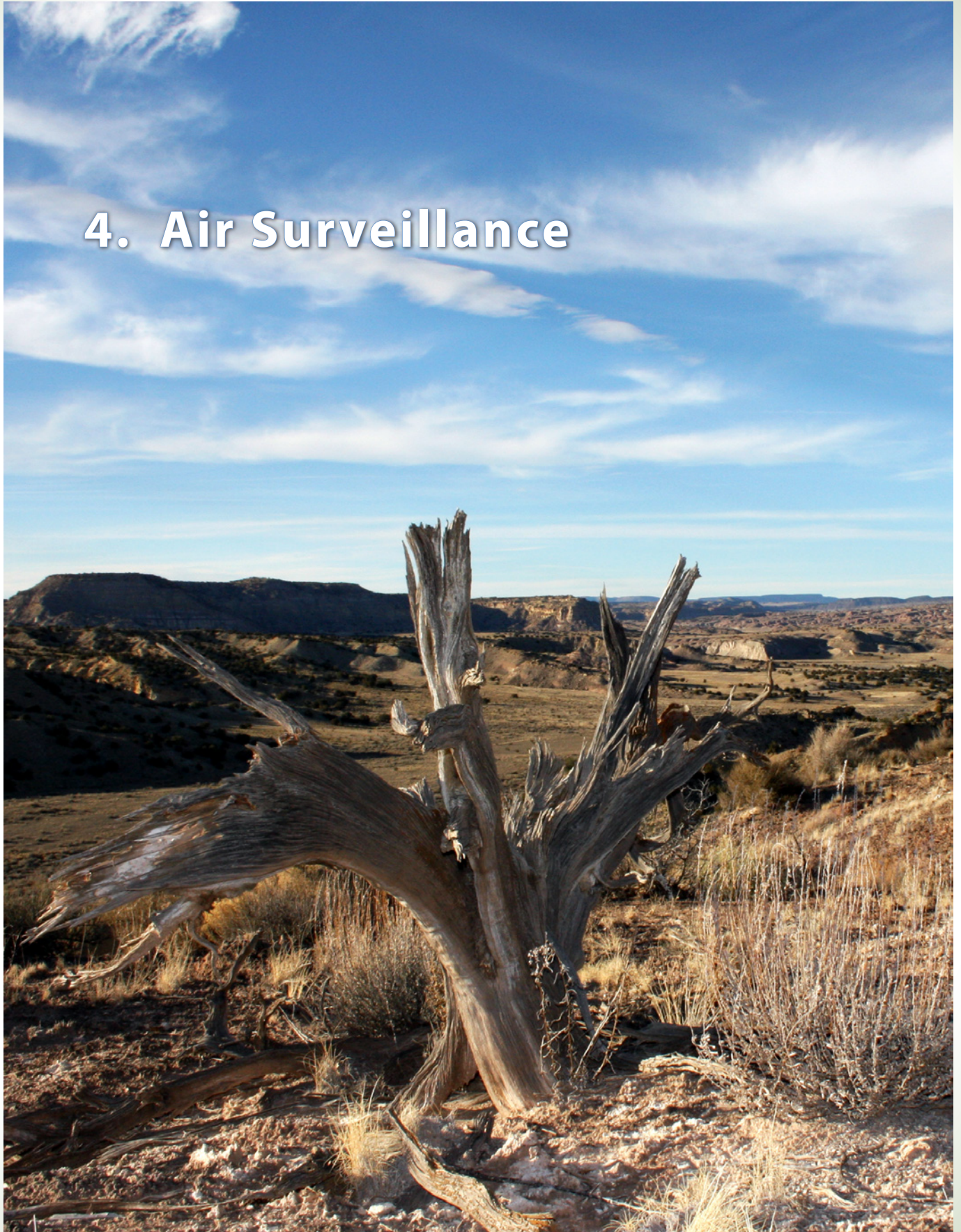
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4. Air Surveillance



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A. AMBIENT AIR SAMPLING**1. Introduction**

The radiological ambient air sampling network, referred to as AIRNET, measures environmental levels of airborne radionuclides, such as plutonium, americium, uranium, tritium, and some activation products, that may be released from Los Alamos National Laboratory (LANL or the Laboratory) operations. Natural atmospheric and fallout radioactivity levels can vary and affect measurements made by LANL's air sampling program. Most of the regional airborne radioactivity comes from the following sources: (1) fallout from past atmospheric nuclear weapons tests conducted by several countries, (2) natural radioactive constituents in particulate matter, such as uranium and thorium, (3) terrestrial radon diffusion out of the earth and its subsequent decay products, and (4) material formation from interactions with cosmic radiation, such as natural tritiated water vapor produced by interactions of cosmic radiation and common atmospheric gases. Table 4-1 summarizes regional levels of radioactivity in the atmosphere for the past five years, which can be useful in interpreting current air sampling data.

Table 4-1
Average Background Concentrations of Radioactivity in the Regional^a Atmosphere

Analyte	Units	EPA Concentration Limit ^b	Annual Averages ^c				
			2003	2004	2005	2006	2007
Alpha	fCi/m ³	NA ^d	0.8	1.1	0.9	1.0	1.0
Beta	fCi/m ³	NA	13.9	18.3	16.3	17.0	19.1
Tritium ^e	pCi/m ³	1500	-0.1	0.1	0.1	-0.2	0.2
Pu-238	aCi/m ³	2100	0.0	0.1	0.0	0.1	-0.3
Pu-239	aCi/m ³	2000	-0.2	-0.1	0.1	0.2	0.6
Am-241	aCi/m ³	1900	-0.8	-0.5	0.1	-0.3	-0.1
U-234	aCi/m ³	7700	21.4	17.7	12.4	16.6	15.3
U-235	aCi/m ³	7100	2.2	1.2	1.2	0.8	0.8
U-238	aCi/m ³	8300	21.4	17.4	13.2	16.1	14.7

^a Data from regional air sampling stations operated by LANL during the last five years (locations can vary by year).

^b Each EPA Concentration Limit is from 10 CFR 40 and corresponds to 10 mrem/year.

^c Gross alpha and beta annual averages are calculated from gross air concentrations. All other annual averages are calculated from net air concentrations.

^d NA = Not available.

^e Tritium annual averages have been corrected for the tritium lost to bound water in the silica gel.

Particulate matter in the atmosphere is primarily caused by aerosolized soil. Windy, dry days can increase soil entrainment, but precipitation can wash particulate matter out of the air. Meteorological conditions often cause large daily and seasonal fluctuations in airborne radioactivity concentrations. Forest fires can dramatically increase short-term ambient concentrations of particulate matter.

LANL's air quality personnel compared ambient air concentrations, as calculated from the AIRNET sample measurements, with environmental compliance standards for publicly accessible locations or with workplace exposure standards for on-site locations. We compare concentrations in areas accessible to the public with the 10-mrem annual dose equivalent concentration established by the US Environmental Protection Agency (EPA) (EPA 1989). Concentrations in controlled access areas are compared with Department of Energy (DOE) Derived Air Concentrations (DACs) for workplace exposure (DOE 1988a).

2. Air Monitoring Network

During 2007, LANL operated at least 60 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-4) are categorized as regional, pueblo, perimeter, waste site (Technical Area [TA] -54), decontamination and decommissioning (D&D) at MDA B, or other on-site locations.

3. Sampling Procedures, Data Management, and Quality Assurance

a. Sampling Procedures

Generally, each AIRNET sampler continuously collects particulate matter and water vapor samples for approximately two weeks per sample. Particulate matter is collected on 47-mm polypropylene filters at airflow rates of about 0.11 m³ per minute. These filters are analyzed using gamma spectroscopy for various radionuclides.

Vertically mounted canisters that contain about 135 grams of silica gel, with an airflow rate of about 0.0002 m³ per minute, are used to collect water vapor samples. We dry this silica gel in a drying oven to remove most residual water before use in the field. The silica gel is a desiccant that removes moisture from the sampled air. After use in the field, the silica gel is removed from the canister and shipped to the analytical laboratory where the moisture is distilled, condensed, and collected as a liquid. This liquid is analyzed for the presence of tritium. The AIRNET quality assurance project plan and the numerous procedures through which the plan is implemented provide details about the sample collection, sample management, chemical analysis, and data management activities.

b. Data Management

In the field, personnel record the sampling data on a palm-held microcomputer, including timer readings, volumetric airflow rates at the start and end of the sampling period, and comments pertaining to these data. Personnel transfer these data to an electronic table within the AIRNET database.

c. Analytical Chemistry

A commercial laboratory analyzed each particulate-matter filter for gross alpha and gross beta activities. These filters were also grouped by region across sites, designated as "clumps," and analyzed for gamma-emitting radionuclides. Clumps usually ranged from four to nine filters. To prepare a quarterly composite for isotopic gamma analyses for each AIRNET station, half-filters from the six or seven sampling periods at each site were combined. Analysts at the laboratory dissolved these composites, separated them chemically, and analyzed them for isotopes of americium, plutonium, and uranium using alpha spectroscopy. After a two week collection period, water was distilled from the silica gel that had been used to collect water vapor in the field. A commercial laboratory used liquid scintillation spectrometry to analyze this distillate for tritium. All analytical procedures met the requirements of Title 40 Code of Federal Regulations (CFR) Part 61, Appendix B. The AIRNET quality assurance project plan provides a summary of the target minimum detectable activity for the biweekly and quarterly samples.

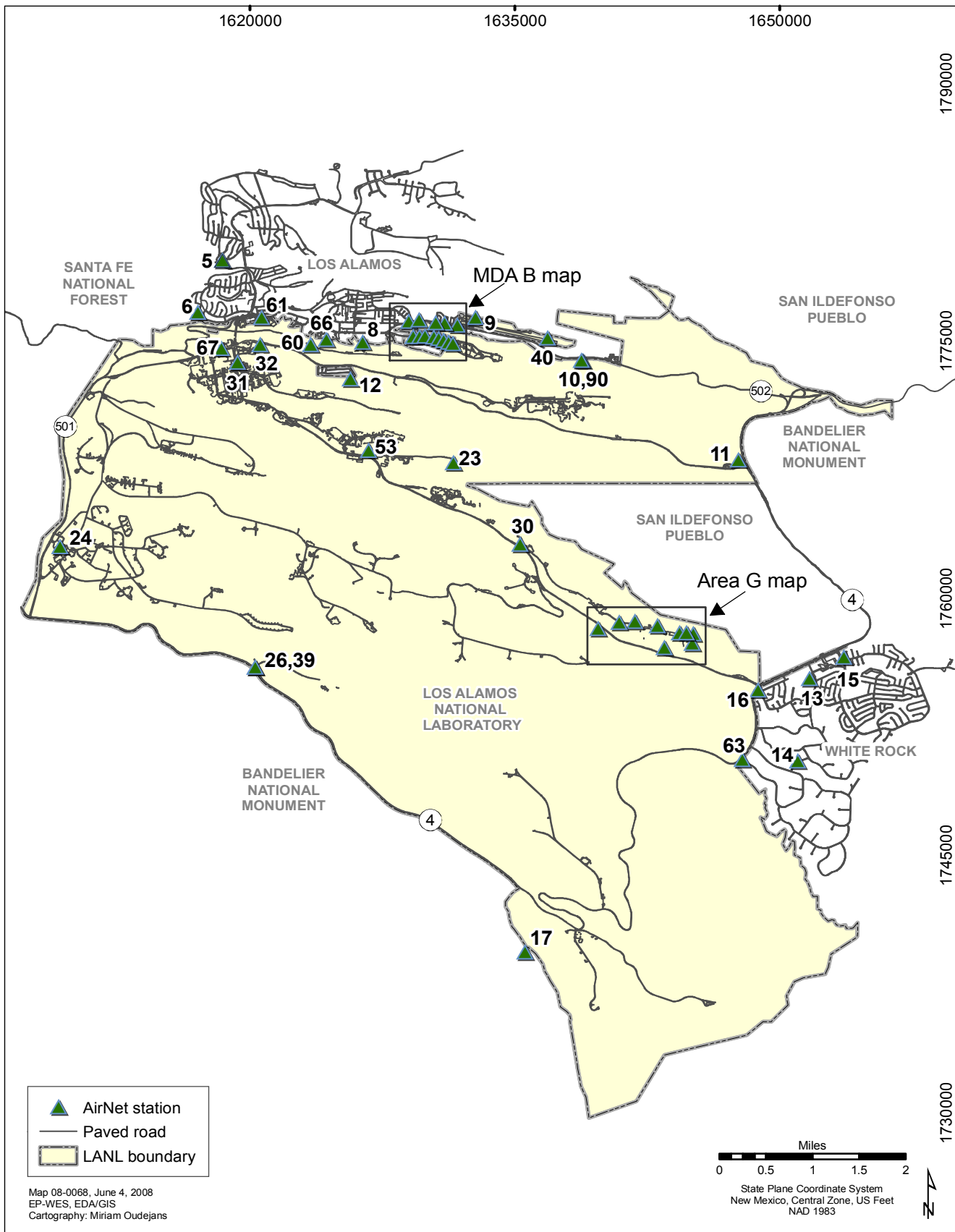


Figure 4-1. Off-site perimeter and on-site LANL AIRNET locations.

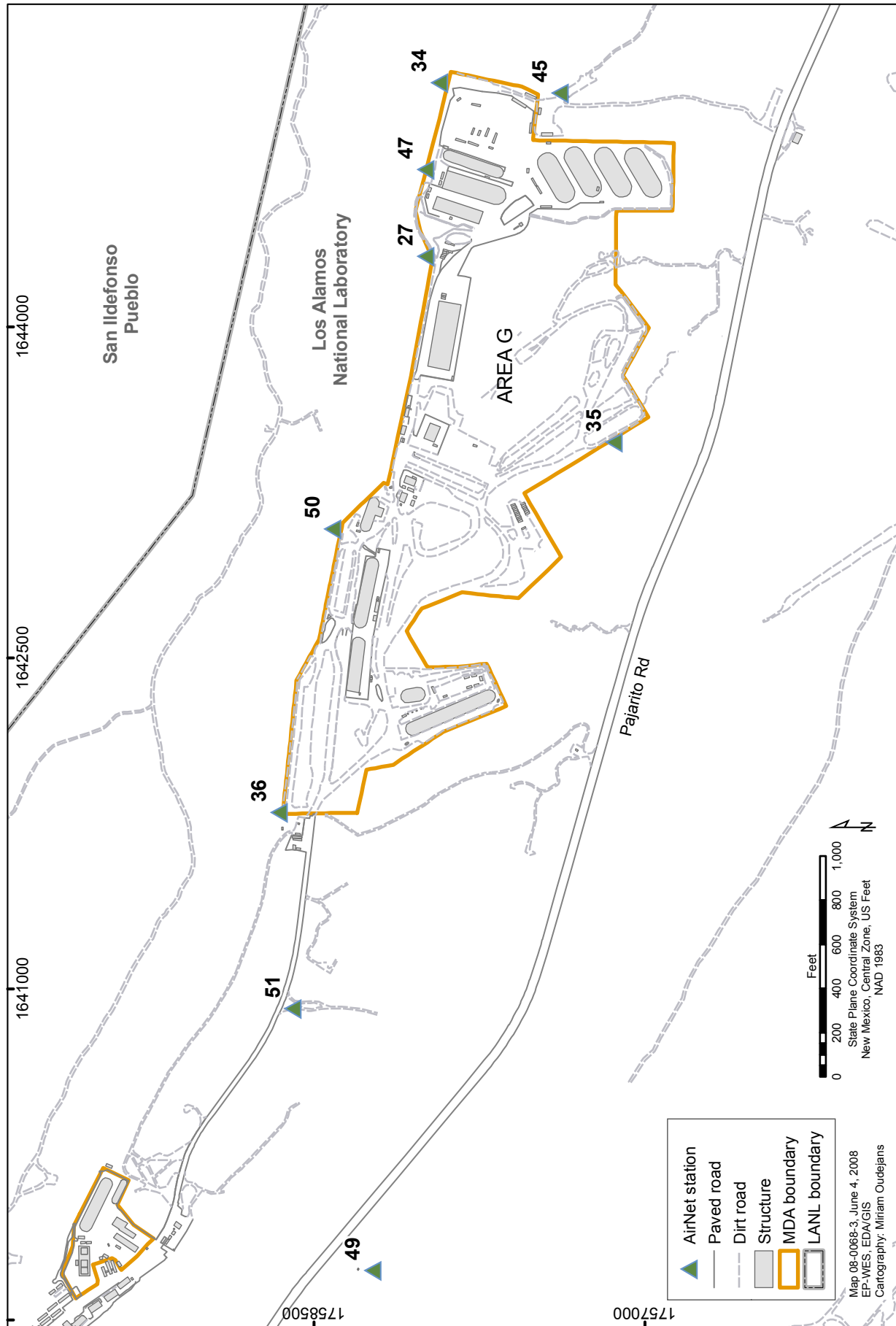


Figure 4-2. AIRNET station locations at TA-54, Area G.

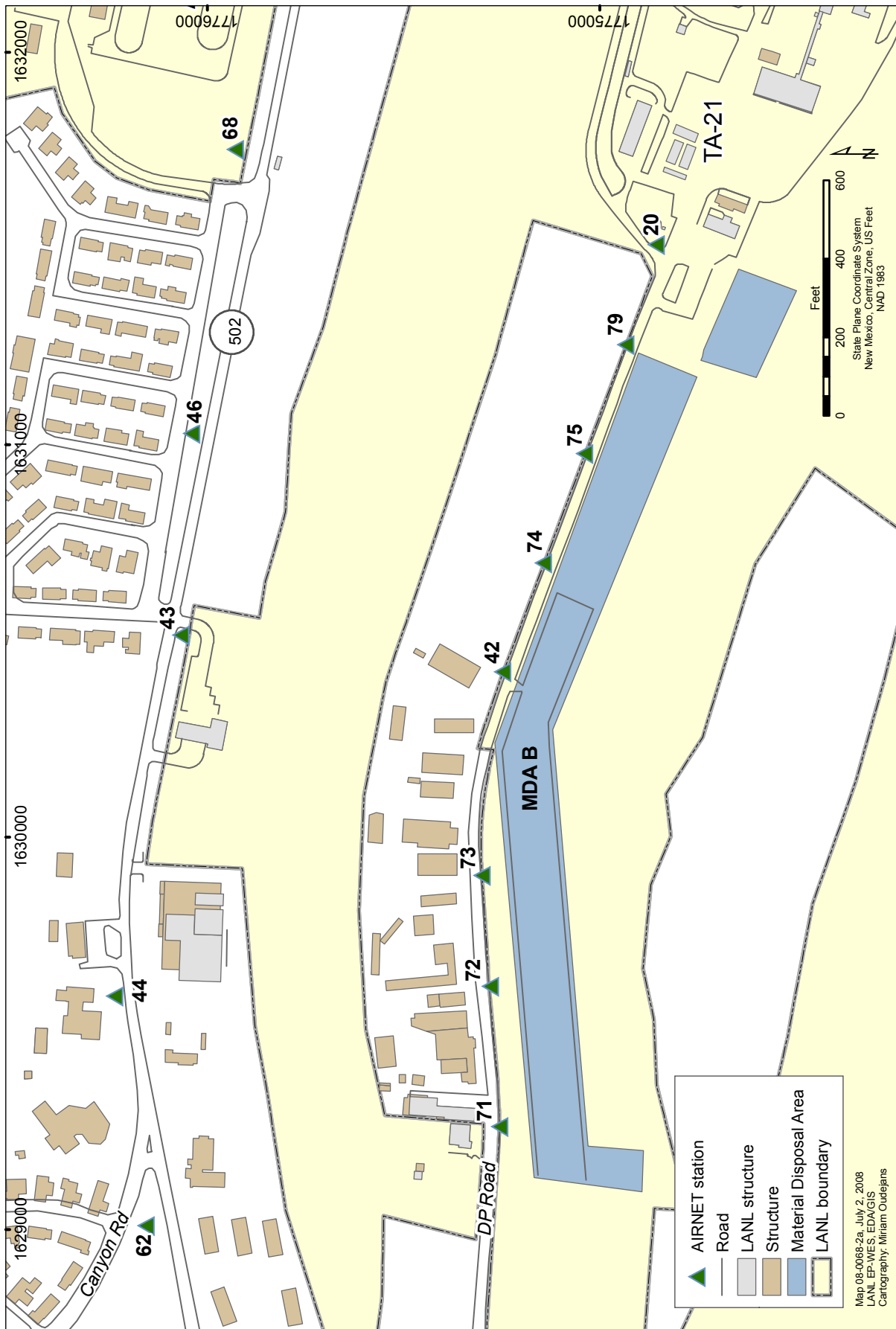


Figure 4-3. AIRNET station locations at TA-21, MDA-B.

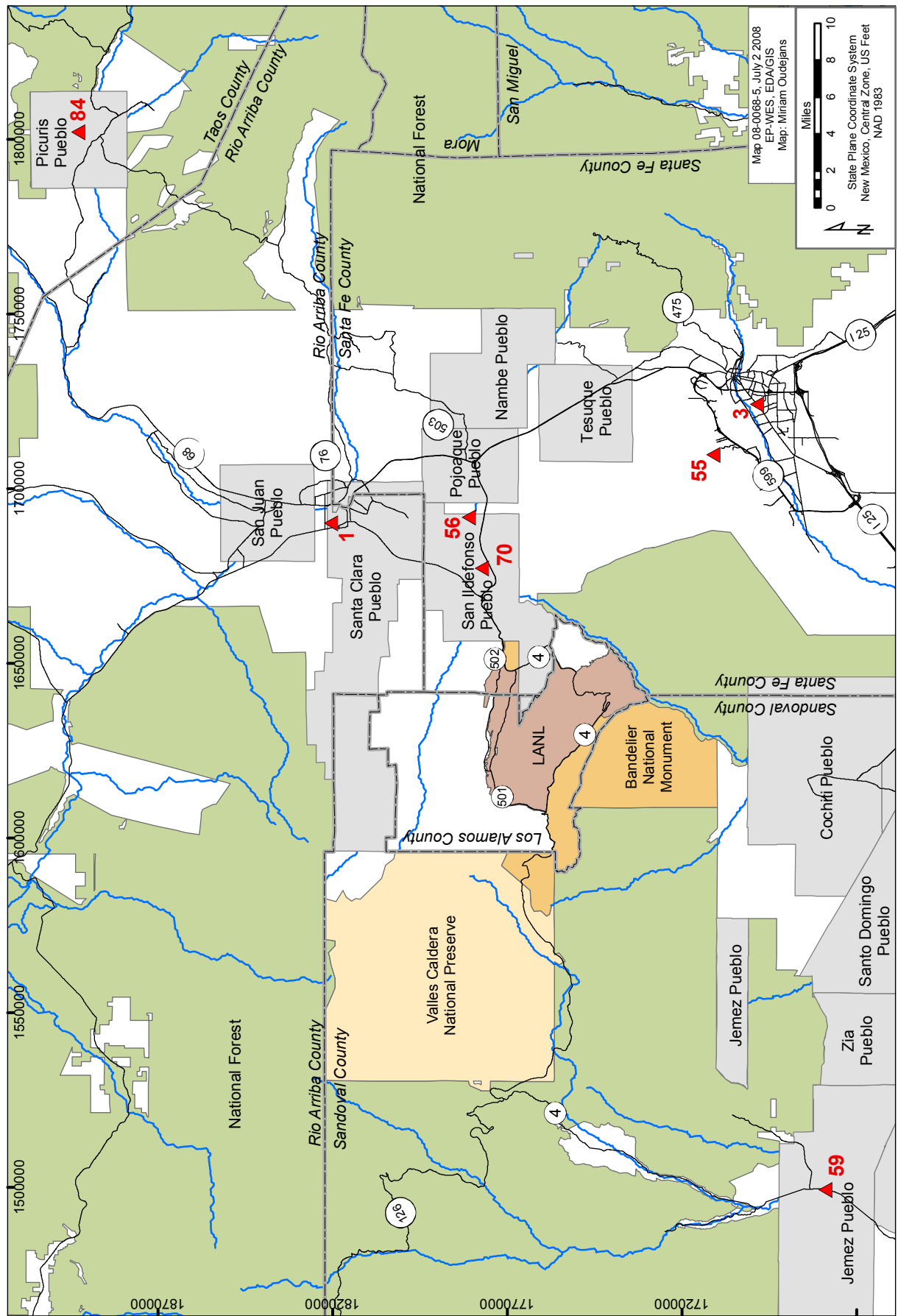


Figure 4-4. Regional and pueblo AIRNET locations.

d. Laboratory Quality Control Samples

The air sampling team and the analytical laboratories maintain a program of blank, spike, duplicate, and replicate analyses. This program provides information on the quality of the data received from analytical laboratories. These data are reviewed by technical staff to ensure the sample data met all quality assurance requirements.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations

Tables 4-2 through 4-10 summarize the 2007 ambient air concentrations calculated from the field and analytical data. In the Data Supplement, Tables S4-1 through S4-9 provide data from individual sites. The number of measurements is normally equal to the number of samples analyzed. Measurements containing measurable amounts of the material of interest are those in which the value is greater than three times the standard deviation (s = standard deviation, or sigma) of the measurement's uncertainty. The minimum detectable activities are the levels that the instrumentation could detect under ideal conditions. All AIRNET concentrations are total measurements without any type of regional background subtractions. However, the air concentrations include corrections for radioactivity from the filter material and the analytical process. The net concentrations are usually somewhat lower than the gross because small amounts of radioactivity are present in the filter material, the acids used to dissolve the filter, and the tracers added to determine recovery efficiencies. The net uncertainties include the variation added by correcting for the blank measurements.

Table 4-2
Airborne Long-Lived Gross Alpha Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (fCi/m ³)	Interval ^a (fCi/m ³)	Station	(fCi/m ³)
Regional	104	104	104	1.0	±0.1	01	1.09
Pueblo	72	72	72	1.0	±0.1	59	1.26
Perimeter	702	702	702	0.9	±0.0	44	1.05
Waste Site	208	208	208	0.9	±0.0	51	1.01
On-Site	132	132	132	0.9	±0.1	30	0.95
D&D	112	112	112	1.1	±0.1	72	1.38

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-3
Airborne Long-lived Gross Beta Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (fCi/m ³)	Interval ^a (fCi/m ³)	Station	(fCi/m ³)
Regional	104	104	104	19.1	±1.1	01	20.7
Pueblo	72	72	72	18.7	±1.3	70	19.3
Perimeter	702	702	702	17.7	±0.4	44	19.0
Waste Site	208	208	208	17.8	±0.7	51	18.3
On-Site	132	132	132	17.8	±0.7	30	18.5
D&D	112	112	112	19.0	±1.2	73	20.9

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-4
Airborne Tritium as Tritiated Water Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean	Interval ^a	Station	(pCi/m ³)
				(pCi/m ³)	(pCi/m ³)		
Regional ^b	104	9	4	0.2	±0.2	56	0.3
Pueblo ^b	77	4	1	0.5	±0.2	59	0.8
Perimeter ^b	697	95	46	0.7	±0.1	16	3.5
Waste Site ^c	208	197	192	170	±95	35	1107
On-Site ^c	131	43	23	4.0	±2.6	53	14.4
D&D	110	17	7	1.3	±0.3	75	3.7

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

^b EPA 40 CFR Part 61 Appendix E Concentration Limit is 1,500 pCi/m³.

^c DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 pCi/m³.

Table 4-5
Airborne Plutonium-238 Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean	Interval ^a	Station	(aCi/m ³)
				(aCi/m ³)	(aCi/m ³)		
Regional ^b	16	0	0	-0.3	±0.3	55	-0.14
Pueblo ^b	12	0	0	-0.2	±0.3	70	-0.1
Perimeter ^b	108	0	0	-0.1	±0.1	17	0.4
Waste Site ^c	32	2	0	0.4	±0.2	34	1.0
On-Site ^c	21	0	0	0.1	±0.2	52	0.4
D&D ^c	20	1	1	-0.2	±0.5	71	1.2

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

^b EPA 40 CFR Part 61 Appendix E Concentration Limit is 2,100 aCi/m³.

^c DOE Derived Air Concentration (DAC) Guide for workplace exposure is 3,000,000 aCi/m³.

Table 4-6
Airborne Plutonium-239/240 Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean	Interval ^a	Station	(aCi/m ³)
				(aCi/m ³)	(aCi/m ³)		
Regional ^b	16	4	1	0.6	±0.4	56	0.8
Pueblo ^b	12	4	0	0.5	±0.6	84	1.1
Perimeter ^b	108	26	10	1.5	±1.0	66	18.9
Waste Site ^c	32	17	12	5.5	±3.8	36	16.3
On-Site ^c	21	4	1	3.4	±7.0	30	17.7
D&D	20	14	12	8.4	±6.7	71	33.1

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

^b EPA 40 CFR Part 61 Appendix E Concentration Limit is 2,000 aCi/m³.

^c DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m³.

Table 4-7
Airborne Americium-241 Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m ³)	Interval ^a (aCi/m ³)	Station	(aCi/m ³)
Regional ^b	16	4	1	-0.1	±0.5	01	0.5
Pueblo ^b	12	5	2	0.3	±0.9	84	0.9
Perimeter ^b	108	32	4	0.2	±0.2	64	1.7
Waste Site ^c	32	12	5	0.9	±0.4	36	1.8
On-site ^c	21	6	1	1.5	±1.5	52	6.4
D&D	20	7	1	1.2	±0.9	71	4.1

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

^b EPA 40 CFR Part 61 Appendix E Concentration Limit is 1,900 aCi/m³.

^c DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m³.

Table 4-8
Airborne Uranium-234 Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m ³)	Interval ^a (aCi/m ³)	Station	(aCi/m ³)
Regional ^b	16	16	16	15.3	±4.7	03	25.2
Pueblo ^b	12	11	11	14.3	±5.9	59	24.2
Perimeter ^b	108	106	99	7.2	±1.2	32	28.7
Waste Site ^c	32	32	32	12.0	±3.9	51	23.6
On-Site ^c	21	20	19	5.9	±2.7	53	13.9
D&D	20	20	19	10.7	±2.5	75	13.7

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

^b EPA 40 CFR Part 61 Appendix E Concentration Limit is 7,700 aCi/m³.

^c DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m³.

Table 4-9
Airborne Uranium-235 Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m ³)	Interval ^a (aCi/m ³)	Station	(aCi/m ³)
Regional ^b	16	3	0	0.8	±0.6	03	1.6
Pueblo ^b	12	2	0	0.5	±0.5	59	1.3
Perimeter ^b	108	23	3	0.6	±0.2	11	2.8
Waste Site ^c	32	7	2	0.8	±0.5	51	2.2
On-Site ^c	21	6	2	0.9	±0.8	53	1.7
D&D	20	2	2	0.5	±0.6	71	2.5

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

^b EPA 40 CFR Part 61 Appendix E Concentration Limit is 7,100 aCi/m³.

^c DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m³.

Table 4-10
Airborne Uranium-238 Concentrations for 2007 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m ³)	Interval ^a (aCi/m ³)	Station	(aCi/m ³)
Regional ^b	16	16	16	14.7	±4.1	03	23.9
Pueblo ^b	12	11	11	14.7	±5.7	59	23.4
Perimeter ^b	108	107	102	9.6	±1.6	32	30.4
Waste Site ^c	32	32	32	14.4	±4.3	51	30.7
On-Site ^c	21	20	20	9.5	±4.1	53	15.0
D&D	20	20	20	14.4	±5.0	20	21.9

^a 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

^b EPA 40 CFR Part 61 Appendix E Concentration Limit is 8,300 aCi/m³.

^c DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m³.

All data in this ambient air sampling section, whether in the tables or the text, that are expressed as a value plus or minus (\pm) another value represent a 95% confidence interval. Because the confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurements and analytical errors but also seasonal and spatial variations. As such, the calculated 95% confidence intervals are overestimated for the average concentrations and probably represent confidence intervals approaching 100%. All ambient concentrations are activities per cubic meter of sampled air. Some values in the tables are negative. See Appendix B for an explanation of negative values.

Air concentrations greater than their 3s uncertainties are used to identify samples of interest or detected concentrations. Other multiples of uncertainties could be used, but 3s is consistent with the widely accepted practice of using 3s control limits for statistical quality control charts (Duncan 1986, Gilbert 1987). It also eliminates most of the false positives or detections that occur about 5% of the time at 2s, but less than 0.3% of the time at 3s.

b. Gross Alpha and Gross Beta Radioactivity

We use gross alpha and gross beta analyses primarily to (1) evaluate general radiological air quality, (2) identify potential trends, and (3) detect sampling problems. If the gross analytical results appear to be elevated, analyses for specific radionuclides may be performed to investigate a potential problem, such as an unplanned release.

The National Council on Radiation Protection and Measurements (NCRP) estimated the national average concentration of long-lived gross alpha activity in air to be two femtocuries (fCi)/m³. Polonium-210, a decay product of radon, and other naturally occurring radionuclides are the primary sources of alpha activity (NCRP 1975, NCRP 1987a). The NCRP also estimated the national average concentration levels of long-lived gross beta activity in air to be 20 fCi/m³. The presence of lead-210 and bismuth-210, also decay products of radon, and other naturally occurring radionuclides are the primary sources of this activity.

In 2007, we collected and analyzed approximately 1,350 air samples for gross alpha and gross beta activity. The annual mean for all of the stations is about half of the NCRP's estimated average for gross alpha concentrations (Table 4-2). At least two factors contribute to these lower concentrations: (1) the use of actual sampled air volumes instead of standard temperature and pressure volumes and (2) the burial of alpha emitters in the filter that are not measured by front-face counting. Gross alpha activity is dependent on variations in natural conditions, such as atmospheric pressure, atmospheric mixing, temperature, and soil moisture.

Table 4-3 shows gross beta concentrations within and around LANL. These data show variability similar to the gross alpha concentrations. The annual average is below the NCRP-estimated national average, but the gross beta measurements include little if any lead-210 because of its low-energy beta emission. We calculate the gross beta measurements on the actual sampled air volumes instead of standard temperature and pressure volumes. The primary source of measured gross beta activity in particulate matter is the bismuth-210 in the radon-222 decay chain.

Figures 4-5 and 4-6 show the temporal variability of gross alpha and beta activities in air, respectively. Variability among sites within AIRNET is usually much less than variability over time. For example, in winter, at lower elevations around LANL, the radon may be trapped below an inversion layer, resulting in higher levels of radon near the ground and, therefore, higher gross alpha and gross beta count rates.

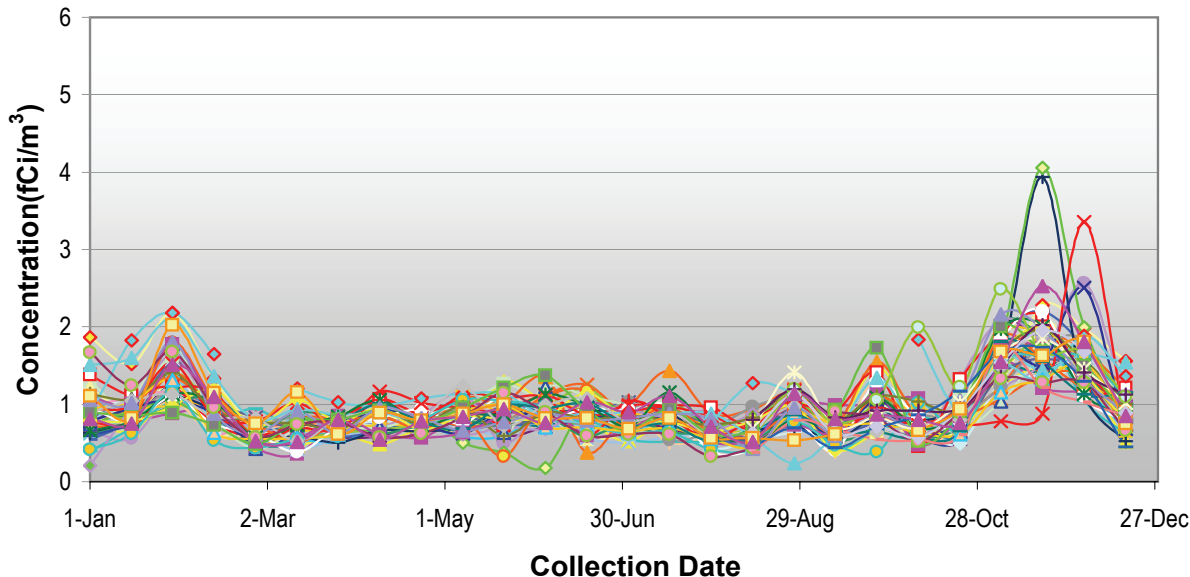


Figure 4-5. Gross alpha measurements (fCi/m^3) for all sampling sites by date collected in 2007.

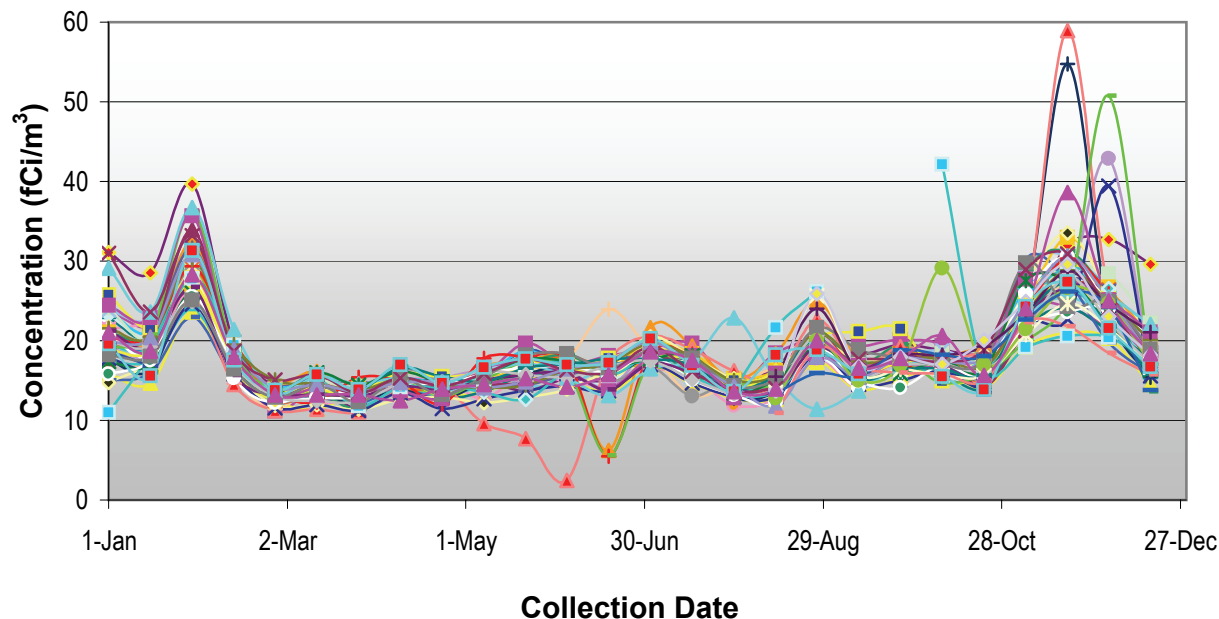


Figure 4-6. Gross beta measurements (fCi/m^3) for all sampling sites by date collected in 2007.

c. Tritium

Tritium is present in the environment primarily as the result of nuclear weapons tests and natural production by cosmogenic processes (Eisenbud and Gesell 1997). We measure the tritium in water (HTO or tritiated water) because the dose impact is about 14,000 times higher than if it were hydrogen gas (HT or tritium) (DOE 1988b).

Water-vapor concentrations in the air and tritium concentrations in the water vapor were used to calculate ambient levels of tritium. Corrections for blanks, bound water in the silica gel, and isotopic distillation effects are included in this calculation.

The annual concentrations of tritium for 2007 at the regional stations were not significantly greater than zero (Table 4-4). The average concentration of tritium for the perimeter, on-site, and D&D samplers was significantly greater than zero. The highest concentrations were measured at the TA-54 waste site in Area G. All annual mean concentrations at all sampling stations were well below the applicable EPA and DOE guidelines.

The highest off-site annual tritium concentration in 2007, 3.5 picocuries (pCi)/m³ at station 75, is equivalent to about 0.25% of the EPA public dose limit of 1,500 pCi/m³. We measured elevated tritium concentrations at a number of on-site stations, with the highest annual concentration (1,100 pCi/m³) at TA-54, Area G. This annual mean concentration is less than 0.001% of the DOE DAC for worker exposure of 20,000,000 pCi/m³ and is measured at a location near a pit containing tritium-contaminated waste.

d. Plutonium

While plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997), this element is not naturally present in measurable quantities in the ambient air. All measurable sources in air are from plutonium research-and-development activities, nuclear weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, worldwide fallout from atmospheric testing of nuclear explosives is the primary source of plutonium in ambient air.

Table 4-5 summarizes the plutonium-238 data for 2007. One occurrence of plutonium-238 greater than 3s was measured. This was during road construction in preparation for clean-up at MDA-B. The highest quarterly concentration was at this site and was 2.6 aCi/m³.

Seven quarterly concentrations at station 66 and temporary station 64 (both near the Ashley Hotel and Suites [formerly the Los Alamos Inn]) were above their 3s uncertainties (Table 4-6). The annual mean concentration at station 66 was 19 aCi/m³, or about 1% of the EPA public dose limit. These higher ambient concentrations are from historical activities at LANL's old main Technical Area (TA-1) that deposited plutonium on the hillside to the south of the Los Alamos Inn. Twelve quarterly concentrations above 3s were measured off-site near the MDA-B cleanup. This fact should be viewed in light of our conservative choice of baseline levels for new stations which have yet to accumulate historical data. There were four other off-site measurements above 3s but they all had average annual concentrations below 4 aCi/m³.

Finally, 12 quarterly concentrations at or near Area G exceeded 3s. All on-site and waste site concentrations were below 0.005% of the DOE DAC for workplace exposure.

e. Americium-241

As with plutonium isotopes, americium is present in very low concentrations in the environment. Eight off-site quarterly samples with a concentration greater than 3s were measured. Table 4-7 summarizes the americium-241 data. Six on-site quarterly samples, all near Area G, with a concentration of greater than 3s were measured. The highest quarterly off-site and on-site concentrations were less than 0.5% and 0.001% of public and worker limits, respectively.

f. Uranium

Three isotopes of uranium are normally found in nature: uranium-234, uranium-235, and uranium-238. In natural uranium, relative isotopic abundances are constant and well characterized. Uranium-238 and uranium-234 are

essentially in radioactive equilibrium, with a measured uranium-238 to uranium-234 isotopic activity ratio of 0.993 (Walker et al., 1989). Comparisons of isotopic concentrations are used to estimate LANL contributions because known LANL emissions in the past 50 years are not of natural uranium, but are of enriched uranium (EU—enriched in uranium-234 and -235) or depleted uranium (DU—depleted of uranium-234 and -235). No EU was detected during 2007.

All annual mean concentrations of the three uranium isotopes were below 1% of the applicable EPA and DOE guidelines (Tables 4-8 to 4-10). The highest annual uranium concentrations are typically at locations with high dust levels from local soil disturbances.

During 2007, there were seven detections of DU as shown in Figure 4-7. Their locations were at stations 20, 23, 40, 46, 49, 68, and 71 all on Laboratory property or close to the perimeter and within Los Alamos County. Legacy DU dust at the Laboratory can be resuspended by strong winds.

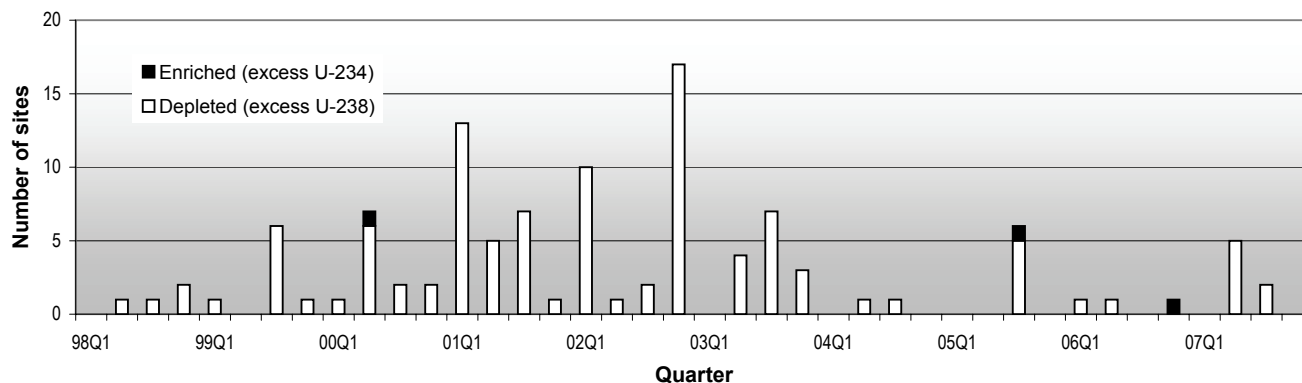


Figure 4-7. Number of sites where enriched or depleted uranium has been detected from 1998 through 2007.

Elevated uranium-238 concentrations were identified by statistically comparing the uranium-234 and uranium-238 concentrations. If the concentrations in a sample were more than 3s apart, the sample was considered to have significant concentrations of EU or DU (see Section A.6). Off-site concentrations of DU are comparable to, or less than, historical natural uranium concentrations. No EU was detected during 2007.

g. Gamma Spectroscopy Measurements

The filters are grouped across sites for each sampling period and are identified as “clumps”. The following analytes are routinely requested: arsenic-73, arsenic-74, cadmium-109, cobalt-57, cobalt-60, cesium-134, cesium-137, manganese-54, sodium-22, rubidium-83, rubidium-103, selenium-75, and zinc-65. None of these analytes were detected in 2007 or in the preceding three years. Our practice is to investigate the measurement of any of these analytes above its minimum detectable activity.

Beryllium-7 and lead-210 were also analyzed but we do not investigate detected quantities of beryllium-7, potassium-40, and lead-210, which are natural radionuclides normally present in measurable concentrations, unless they are seen in levels elevated over previous years. During 2007, beryllium-7 was routinely detected at concentrations similar to previous years.

5. Investigation of Elevated Air Concentrations

Two action levels have been established to determine the potential occurrence of an unplanned release: “investigation” and “alert.” Investigation action levels are based on historical measurements and are designed to indicate that an air concentration is higher than expected. These levels are set at values equal to a five-year rolling average plus 3s. Alert action levels are based on allowable EPA and DOE annual doses and require a more thorough and immediate follow-up.

4. Air Surveillance

When a measured air concentration exceeds an action level, the air quality team verifies that the calculations were done correctly and that the sampled air concentrations are representative, i.e., there is no cross contamination. Next, we work with personnel from the appropriate operations to assess potential sources and possible mitigation for the elevated concentrations.

In 2007, air sampling values for plutonium, americium and uranium did not exceed alert action levels.

Tritium alert levels were not exceeded at any off-site station. Elevated levels were observed at Area G near a pit containing tritium-contaminated items.

6. Long-Term Trends

a. Uranium

Each year peak concentrations for all three uranium isotopes typically occur during the windier second quarter (Figure 4-8). Typically, the uranium-238 concentrations are consistently higher than those of uranium-234. Uranium levels have been in general decline since the Cerro Grande fire in 2000.

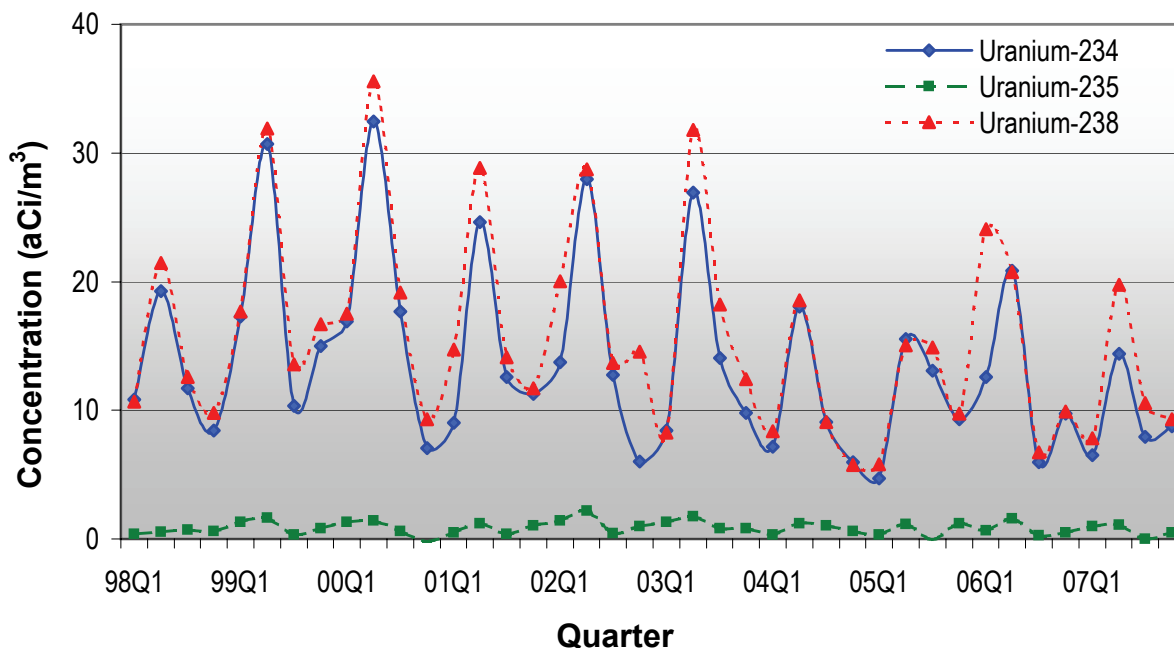


Figure 4-8. AIRNET quarterly uranium isotopic concentrations

b. Plutonium and Americium

No quarterly measurements during the last 10 years for the regional and pueblo samples were above their 3s analytical uncertainties. However, on-site measurements of plutonium-238, plutonium-239, and americium-241 are clearly higher for the waste site sampling stations at TA-54 Area G, where about one-fifth of the measurements exceed 3s. Perimeter samplers are somewhere in between, with occasional samples having detected concentrations. Figures 4-9, 4-10, and 4-11 are graphs of the annual concentrations by isotope and station location grouping. The increased concentration at the TA-54 waste site in 2006 was due to operations involving the transfer of cleanup waste from TA-21 to Area G. Remediation activities at TA-21 raised the on-site americium-241 and plutonium-239 annual averages. Annual average concentrations of plutonium-239 and americium-241 are close to but above zero at Area G, except for plutonium-239 last year (Figure 4-12).

c. Tritium

Tritium concentrations are strongly influenced by current operations so emissions show no distinctive trends (Figure 4-13). In 2006, tritiated waste near a few samplers raised the annual average. This waste, from a decommissioned tank, was subsequently buried at Area G, leading to the lower releases seen in 2007.

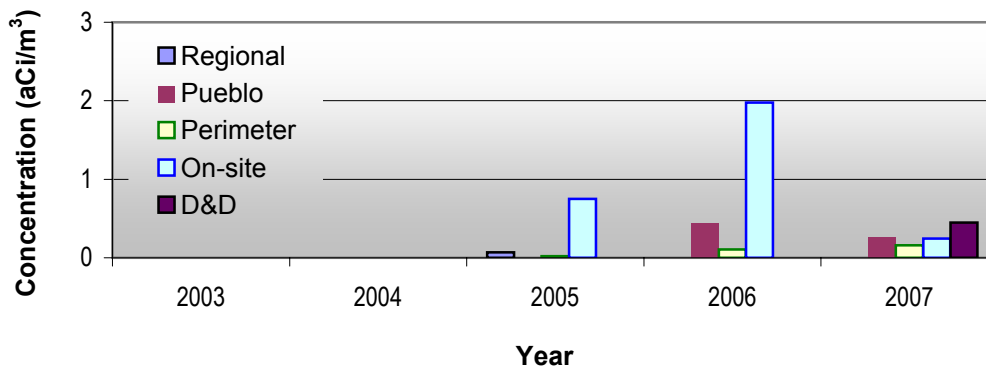


Figure 4-9. Americium-241 concentration trends.

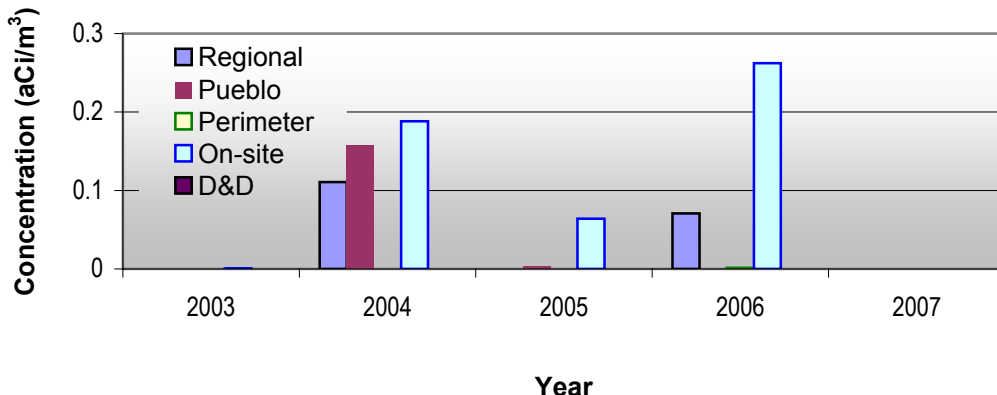


Figure 4-10. Plutonium-238 concentration trends.

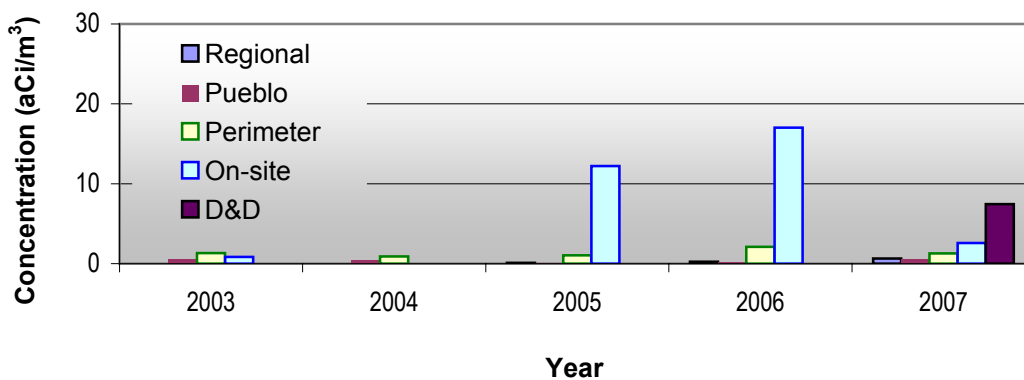


Figure 4-11. Plutonium-239/240 concentration trends.

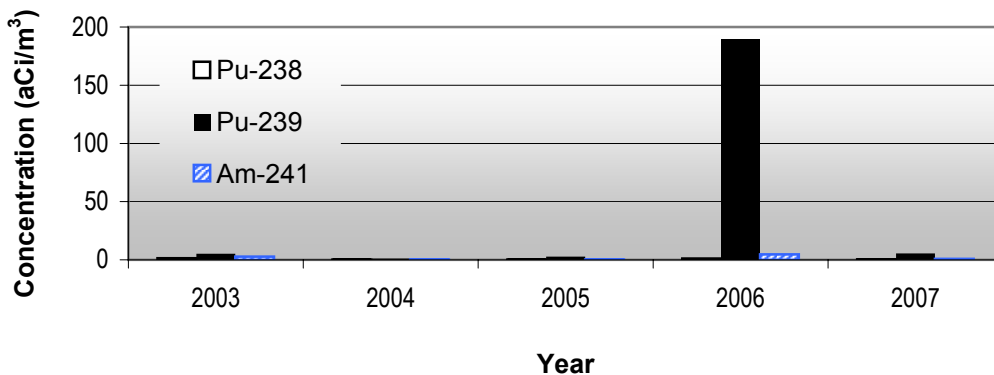


Figure 4-12. Americium and plutonium concentration trends for TA-54, Area G.

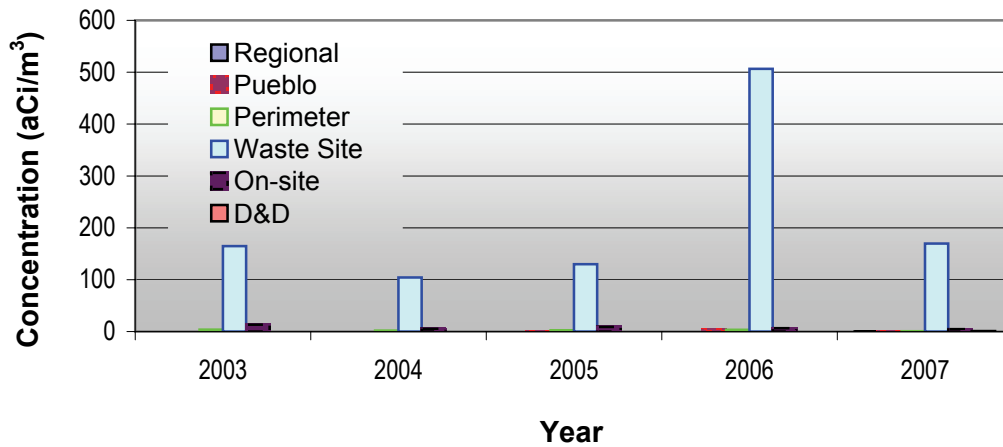


Figure 4-13. Tritium concentration trends.

B. STACK SAMPLING FOR RADIONUCLIDES

1. Introduction

Radioactive materials are an integral part of many activities at LANL. Some operations involving these materials may be vented to the environment through a stack or other forced air release point. Members of the Rad-NESHAP team at LANL evaluate these operations to determine potential impacts to the public and the environment. Emissions are estimated using engineering calculations and radionuclide materials usage information with the assumption there are no emission controls in place, such as the high-efficiency particulate air filters which are present on most stacks. If this evaluation shows that emissions from a stack may potentially result in a member of the public receiving as much as 0.1 mrem in a year, LANL must sample the stack in accordance with 40 CFR Part 61, Subpart H, “National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities” (Rad-NESHAP) (EPA 1989). During 2007, we identified 27 stacks meeting this criterion.

2. Sampling Methodology

In 2007, we continuously sampled 27 stacks for the emission of radioactive material to the ambient air. LANL categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products (GMAP). For each of these emission types, LANL employs an appropriate sampling method, as described below.

Emissions of radioactive particulate matter generated by operations at facilities such as the Chemistry and Metallurgy Research Building and the TA-55 Plutonium Facility are sampled using a glass-fiber filter. A continuous sample of stack air is pulled through a filter that captures small particles of radioactive material. These samples are collected weekly and shipped to an off-site analytical laboratory. The analytical laboratory uses gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, the laboratory composites these samples and analyzes them to determine the cumulative activity on all the filters of radionuclides such as uranium-234, -235, and -238, plutonium-238 and -239/240, and americium-241. The isotopic data are used to calculate emissions from the stack for the six-month period.

A charcoal cartridge samples emissions of vapors, such as bromine-82, and highly volatile compounds, such as selenium-75, generated by operations at the Los Alamos Neutron Science Center (LANSCE) and hot cell activities at the Chemistry and Metallurgy Research Building and TA-48. A continuous sample of stack air is pulled through a charcoal filter that adsorbs vaporous emissions of radionuclides. This charcoal filter is mounted downstream of a glass-fiber filter (discussed above) that removes any particulates from this sample media. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present on the filter.

We measure tritium emissions from LANL's tritium facilities with a collection device known as a bubbler. This device enables us to determine not only the total amount of tritium released but also whether it is in the elemental (HT) or oxide (HTO) form. The bubbler pulls a continuous sample of air from the stack, which is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects the water vapor from the sample of air, including any tritium that may be part of a water molecule (HTO). "Bubbling" through these three vials removes essentially all HTO from the air, leaving only HT. The air is then passed through a palladium catalyst that converts the HT to HTO. The sample is pulled through three additional vials containing ethylene glycol, which collect the newly formed HTO. The vials of ethylene glycol are sent to an analytical laboratory for liquid scintillation counting to determine the amount of HTO and HT.

In previous years, stacks at LANSCE were monitored for tritium. After an historical evaluation of HTO emissions from LANSCE in 2001, we discontinued sampling tritium following the July 2001 report period based on the low historical emissions of HTO from TA-53 and the low relative contribution of tritium to the off-site dose from TA-53 emissions. Emissions of tritium reported in 2007 from LANSCE are based on 2001 tritium generation rates.

We measure GMAP emissions from LANSCE activities using real-time monitoring data. A sample of stack air is pulled through an ionization chamber that measures the total amount of radioactivity in the sample. Gamma spectroscopy and decay curves are used to identify specific radioisotopes and the quantity of each. From these data, the total emissions of each radionuclide are calculated.

3. Sampling Procedures and Data Analysis

a. Sampling and Analysis

Analytical methods used comply with EPA requirements (40 CFR 61, Appendix B, Method 114). Section F of this chapter presents the results of analytical quality assurance measurements. General discussions on the sampling and analysis methods for each of LANL's emissions are described here.

b. Particulate Matter Emissions

We remove and replace the glass-fiber filters that each week sample facilities with significant potential for radioactive particulate emissions and ship them to an off-site analytical laboratory. Prior to shipping, each sample filter is screened with a hand-held instrument to determine if there are any unusually high levels of alpha or beta radioactivity. The laboratory performs analyses for the presence of alpha and beta radioactivity after the sample has been allowed to decay for approximately one week (to allow short-lived radon progeny to decay). In addition to alpha and beta analyses, the laboratory performs gamma spectroscopy analysis to identify specific isotopes in the sample. The glass-fiber filters are composited every six months for radiochemical analysis because gross alpha/beta counting cannot identify specific radionuclides. We use the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. The Rad-NESHAP team compares the results of the isotopic analysis with gross activity measurements to ensure that the requested analyses (e.g., uranium-234, -235, and -238; and plutonium-238 and -239/240, etc.) identify all significant activity in the composites.

For particulate filters from the LANSCE accelerator facility, the analytical laboratory only performs gamma spectroscopy analyses based on the anticipated suite of emissions from this facility. Again, hand-screening of each filter is performed the day of change-out prior to shipment to the off-site analytical laboratory.

c. Vaporous Activation Products Emissions

We remove and replace the charcoal canisters weekly at facilities with the potential for significant vaporous activation products emissions and then ship the samples to the off-site analytical laboratory where gamma spectroscopy identifies and quantifies the presence of vaporous radioactive isotopes.

d. Tritium Emissions

Tritium bubbler samples, used to sample facilities with the potential for significant elemental and oxide tritium emissions, are collected weekly and transported to LANL's Health Physics Analytical Laboratory. The Health Physics Analytical Laboratory adds an aliquot of each sample to a liquid scintillation cocktail and determines the amount of tritium in each vial by liquid scintillation counting.

e. Gaseous Mixed Activation Products (GMAP) Emissions

To record and report GMAP emissions, we used continuous monitoring, rather than off-line analysis, for two reasons. First, the nature of the emissions is such that standard filter paper and charcoal filters will not collect the radionuclides of interest. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed off-line. The GMAP monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. Total GMAP emissions are measured with the ionization chamber. The real-time current this ionization chamber measured is recorded on a strip chart and the total amount of charge collected in the chamber over the entire beam operating cycle is integrated on a daily basis. The gamma spectroscopy system analyzes the composition of these GMAP emissions. Using decay curves and energy spectra to identify the various radionuclides, we determine the relative composition of the emissions. Decay curves are typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes are made at LANSCE, new decay curves and energy spectra are recorded.

4. Analytical Results

Measurements of LANL stack emissions during 2007 totaled approximately 477 Ci. Of this total, tritium emissions composed approximately 260 Ci, and air activation products from LANSCE stacks contributed nearly 218 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium were less than 0.000012 Ci. Emissions of particulate matter plus vaporous activation products (P/VAP) were about 0.016 Ci, which is about a 100-fold decrease from 2006 but consistent with years prior to 2006.

Table 4-11 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-12 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP.

Table 4-13 presents the half-lives of the radionuclides typically emitted by LANL. During 2007, the LANSCE facility non-point source emissions of activated air comprised approximately 79.7 Ci of carbon-11 and 3.32 Ci of argon-41.

5. Long-Term Trends

Figures 4-14 to 4-17 present radioactive emissions from sampled LANL stacks and illustrate trends in measured emissions for plutonium, uranium, tritium, and GMAP emissions, respectively. As the figures demonstrate, emissions from plutonium and uranium isotopes stayed relatively steady over recent years, varying slightly each year but staying in the low-microcurie range. Tritium emissions showed a major decrease from 2006 due to a maintenance upgrade at the main tritium facility that limited operations for much of 2007. In 2007, emissions of GMAP dropped further from the very low levels in 2006, following a one-year elevation in 2005, as described below.

Site-wide tritium emissions are staying low due to the consolidation of most tritium operations at TA-16. In 2006, source removal activities were completed at buildings TA-21-155 and TA-21-209. Continued emissions from these facilities result from off-gassing of contaminated equipment remaining in the building. Following removal of the majority of the tritium source term, monitoring continued until we had a clear grasp of the emissions potential from these two stacks. At the end of September 2006, monitoring activities at these two stacks ceased. Until these stacks are fully decommissioned and torn down, the future emissions will be calculated based on emissions rates measured in the summer and early fall of 2006.

Table 4-11
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2007 (Ci)

TA-Bldg	H-3 ^a	Am-241	Pu ^b	U ^c	Th ^d	P/VAP ^e	GMAP ^f	Sr-90 ^g
TA-03-029		1.71 x 10 ⁻⁸	1.12 x 10 ⁻⁶	9.63 x 10 ⁻⁶	6.66 x 10 ⁻⁷	1.85 x 10 ⁻⁵		
TA-03-102				3.66 x 10 ⁻⁹				
TA-16-205/450	2.42 x 10 ²							
TA-48-001					1.64 x 10 ⁻⁹	9.95 x 10 ⁻³		
TA-50-001					3.60 x 10 ⁻⁸			
TA-50-037			1.15 x 10 ⁻⁹		5.33 x 10 ⁻⁹			
TA-50-069		1.10 x 10 ⁻⁹	2.76 x 10 ⁻⁹		7.47 x 10 ⁻¹⁰			
TA-53-003	6.43					1.82 x 10 ⁻⁵	1.88 x 10 ¹	
TA-53-007	4.68					6.05 x 10 ⁻³	1.99 x 10 ²	
TA-55-004	6.29		1.02 x 10 ⁻⁹	1.92 x 10 ⁻⁸	4.78 x 10 ⁻⁸			
Total^h	2.60 x 10 ²	1.82 x 10 ⁻⁸	1.13 x 10 ⁻⁶	9.66 x 10 ⁻⁶	7.57 x 10 ⁻⁷	1.60 x 10 ⁻²	3.01 x 10 ² ⁱ	0.00

NOTE: Some buildings have more than one sampled stack.

^a Includes both gaseous and oxide forms of tritium.

^b Includes Pu-238, Pu-239, and Pu-240.

^c Includes U-234, U-235, and U-238. Does not include radioactive progeny of U-238.

^d Includes Th-228, Th-230, and Th-232.

^e P/VAP—Particulate/vapor activation products (with measured radionuclides and short-lived radioactive progeny).

^f GMAP—Gaseous mixed activation products.

^g Strontium-90 values include yttrium-90 short-lived radioactive progeny.

^h Some differences may occur because of rounding.

ⁱ Total for GMAP includes 83.0 curies released from diffuse sources at TA-53.

LANSCE operated in the same configuration as recent years, with continuous beam operations to the 1L Target and the Lujan Neutron Scattering Center causing the majority of radioactive air emissions. Operations to the 1L Target took place from late spring of 2007 through the end of the calendar year.

The emissions control system at the LANSCE 1L Target is a “delay line,” which retains the short-lived activation products for a short time before release out the stack. This time interval allows decay of the short-lived radionuclides to non-radioactive components. A cracked valve in the inlet of this delay system caused substantially elevated emissions in 2005, compared to previous years. Additional delay line sections were installed in May and November of 2005 and the defective valve was fixed in late 2005. The additional delay line contributed to the relatively low emissions since 2005. In all years, emissions were below all regulatory limits.

Figure 4-18 shows the individual contribution of each emission type to total LANL emissions. It clearly shows that GMAP emissions and tritium emissions make up the vast majority of radioactive stack emissions. This plot does not directly relate to off-site dose because some radionuclides have a higher dose impact per curie released than others. GMAP and tritium remain the highest contributors to the total curies released. These gas-phase nuclides are not easily removed from an exhaust stack air stream by standard control techniques, such as filtration. GMAP and tritium emissions continue to fluctuate as the major emissions type; tritium cleanup operations and LANSCE operations vary from year to year. GMAP emissions are normally the greatest source of off-site dose from the airborne pathway because of the close proximity of the LANSCE facility to the LANL boundary.

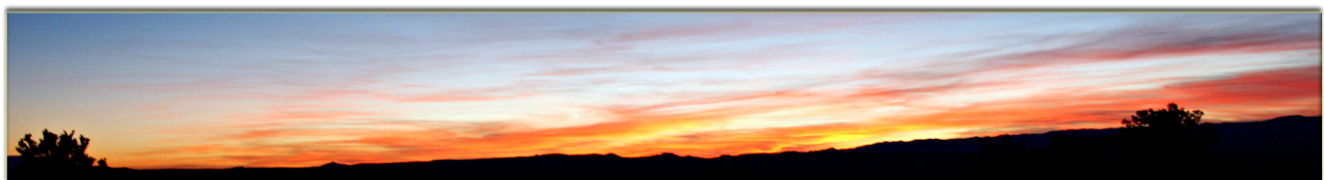


Table 4-12
Detailed Listing of Activation Products Released from
Sampled LANL Stacks in 2007 (curies)

TA-Building	Nuclide	Emission (Ci)
TA-03-0029	Br-82	0.0000185
TA-48-0001	As-72	0.00000432
TA-48-0001	As-73	0.000910
TA-48-0001	As-74	0.00000114
TA-48-0001	Br-76	0.000425
TA-48-0001	Br-77	0.000453
TA-48-0001	Br-82	0.00000493
TA-48-0001	Ga-68	0.00390
TA-48-0001	Ge-68	0.00390
TA-48-0001	Hg-197	0.0000404
TA-48-0001	Hg-197m	0.0000404
TA-48-0001	Se-75	0.000276
TA-53-0003	Ar-41	0.752
TA-53-0003	Br-82	0.0000182
TA-53-0003	C-11	18.0
TA-53-0007	Ar-41	10.1
TA-53-0007	Be-7	0.00000162
TA-53-0007	Br-76	0.000760
TA-53-0007	Br-77	0.0000950
TA-53-0007	Br-82	0.00215
TA-53-0007	C-10	0.233
TA-53-0007	C-11	127.0
TA-53-0007	Hg-197	0.00150
TA-53-0007	Hg-197m	0.00150
TA-53-0007	N-13	21.8
TA-53-0007	Na-24	0.00000211
TA-53-0007	O-14	0.390
TA-53-0007	O-15	39.5
TA-53-0007	Os-191	0.0000160
TA-53-0007	Se-75	0.0000229

Table 4-13
Radionuclide Half-Lives

Nuclide	Half-Life
H-3	12.3 yr
Be-7	53.4 d
C-10	19.3 s
C-11	20.5 min
N-13	10.0 min
N-16	7.13 s
O-14	70.6 s
O-15	122.2 s
Na-22	2.6 yr
Na-24	14.96 h
P-32	14.3 d
K-40	1,277,000,000 yr
Ar-41	1.83 h
Mn-54	312.7 d
Co-56	78.8 d
Co-57	270.9 d
Co-58	70.8 d
Co-60	5.3 yr
As-72	26 h
As-73	80.3 d
As-74	17.78 d
Br-76	16 h
Br-77	2.4 d
Br-82	1.47 d
Se-75	119.8 d
Sr-85	64.8 d
Sr-89	50.6 d
Sr-90	28.6 yr
I-131	8 d
Cs-134	2.06 yr
Cs-137	30.2 yr
Os-183	13 h
Os-185	93.6 d
Os-191	15.4 d
Hg-193	3.8 h
Hg-195	9.5 h
Hg-195m	1.67 d
Hg-197	2.67 d
Hg-197m	23.8 h
U-234	244,500 yr
U-235	703,800,000 yr
U-238	4,468,000,000 yr
Pu-238	87.7 yr
Pu-239	24,131 yr
Pu-240	6,569 yr
Pu-241	14.4 yr
Am-241	432 yr

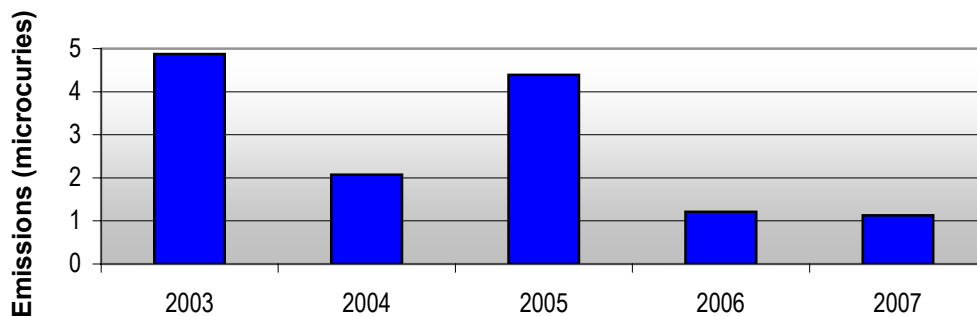


Figure 4-14. Plutonium emissions from sampled LANL stacks.

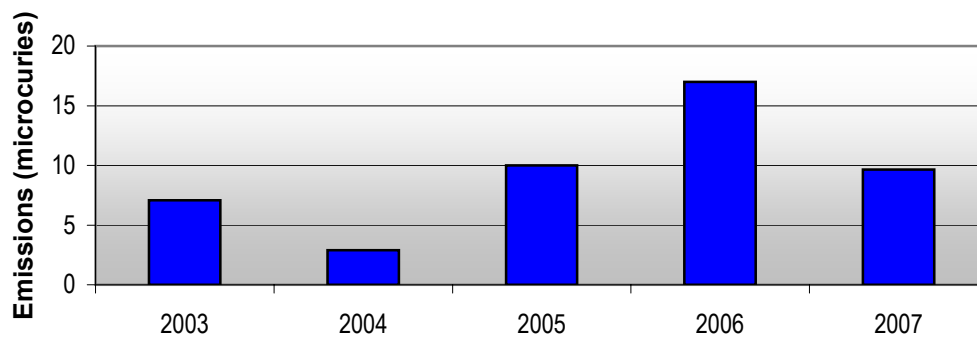


Figure 4-15. Uranium emissions from sampled LANL stacks.

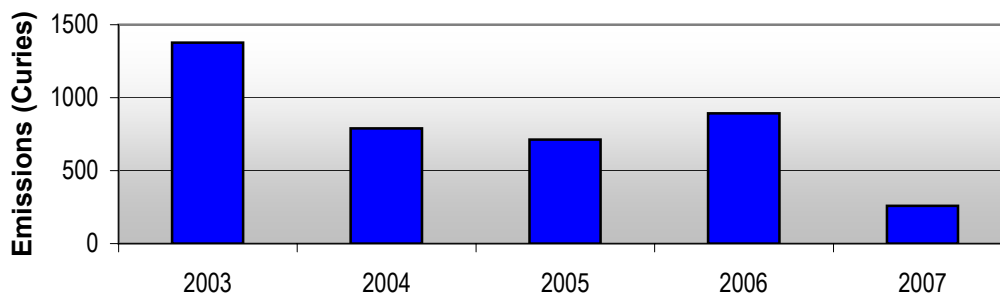


Figure 4-16. Tritium emissions from sampled LANL stacks.

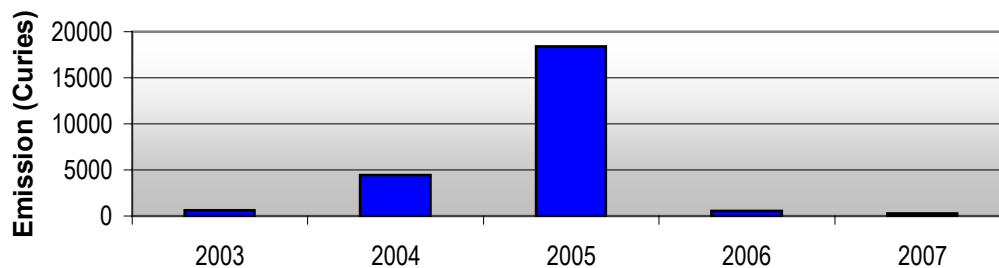


Figure 4-17. GMAP emissions from sampled LANL stacks.

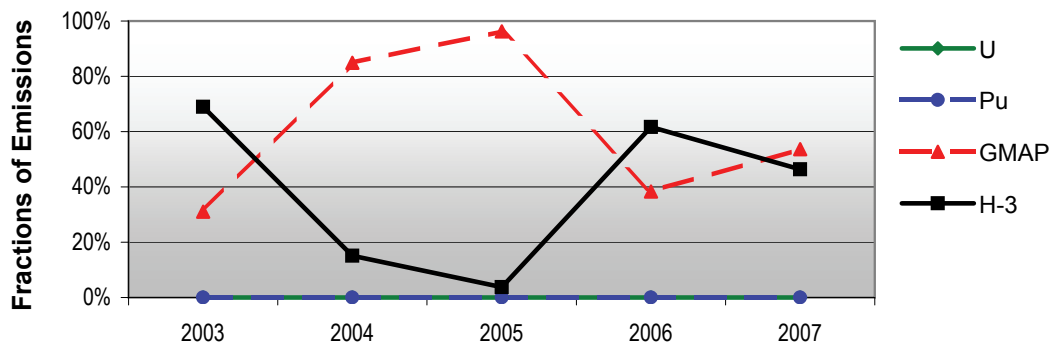


Figure 4-18. Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP.

C. GAMMA AND NEUTRON RADIATION MONITORING PROGRAM

1. Introduction

We monitor gamma and neutron radiation in the environment—that is, outside of the workplace—according to the criteria specified in McNaughton et al. (2000) as part of our Direct Penetrating Radiation Monitoring Network (DPRNET). Naturally occurring radiation originates from terrestrial and cosmic sources. It is extremely difficult to distinguish man-made sources from the natural background because the natural radiation doses are generally much larger than those from man-made sources. The dose rate from natural terrestrial and cosmic sources measured by the dosimeters (does not include radon and internal sources) varies from approximately 100 to 200 mrem/yr.

2. Monitoring Network

a. Dosimeter Locations

In an attempt to distinguish any impact from LANL operations on the public, we located 85 thermoluminescent dosimeter (TLD) stations around LANL and in the surrounding communities. There is a TLD at every AIRNET station shown in Figures 4-1 and 4-3; the corresponding TLD station numbers are listed in Supplementary Data Table S4-10. Additional stations are around TA-54, Area G (shown in Figure 4-19); at LANSCE (eight stations); at Santa Clara Pueblo (two stations); and inside the San Ildefonso Sacred Area (two stations).

b. Neutron Dosimeters

We monitor potential neutron doses with 47 albedo TLD stations near known or suspected sources of neutrons: TA-53 (Area G) and TA-54 (LANSCE). Albedo dosimeters are sensitive to neutrons and use a hydrogenous material that causes neutron backscatter to simulate the human body.

c. Neutron Background

Natural cosmic rays result in a neutron background dose of approximately 10 mrem/yr (NCRP 1987b). However the neutron dosimeters record a dose of approximately 2 mrem/yr because the environmental dosimeters are calibrated with a D₂O-moderated neutron source with a different energy spectrum from cosmic-ray neutrons. Therefore, a neutron reading of 2 mrem/yr indicates a normal background reading.

3. Quality Assurance

The calibration laboratory at LANL's Health Physics Measurements Group (RP-2) calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited the dosimeters that RP-2 provides, and RP-2 provides quality assurance (QA) for the dosimeters. The uncertainty in the TLD data is estimated from the standard deviation of data from dosimeters exposed to the same dose. The overall 1s uncertainty is similar to previous data and is 9%.

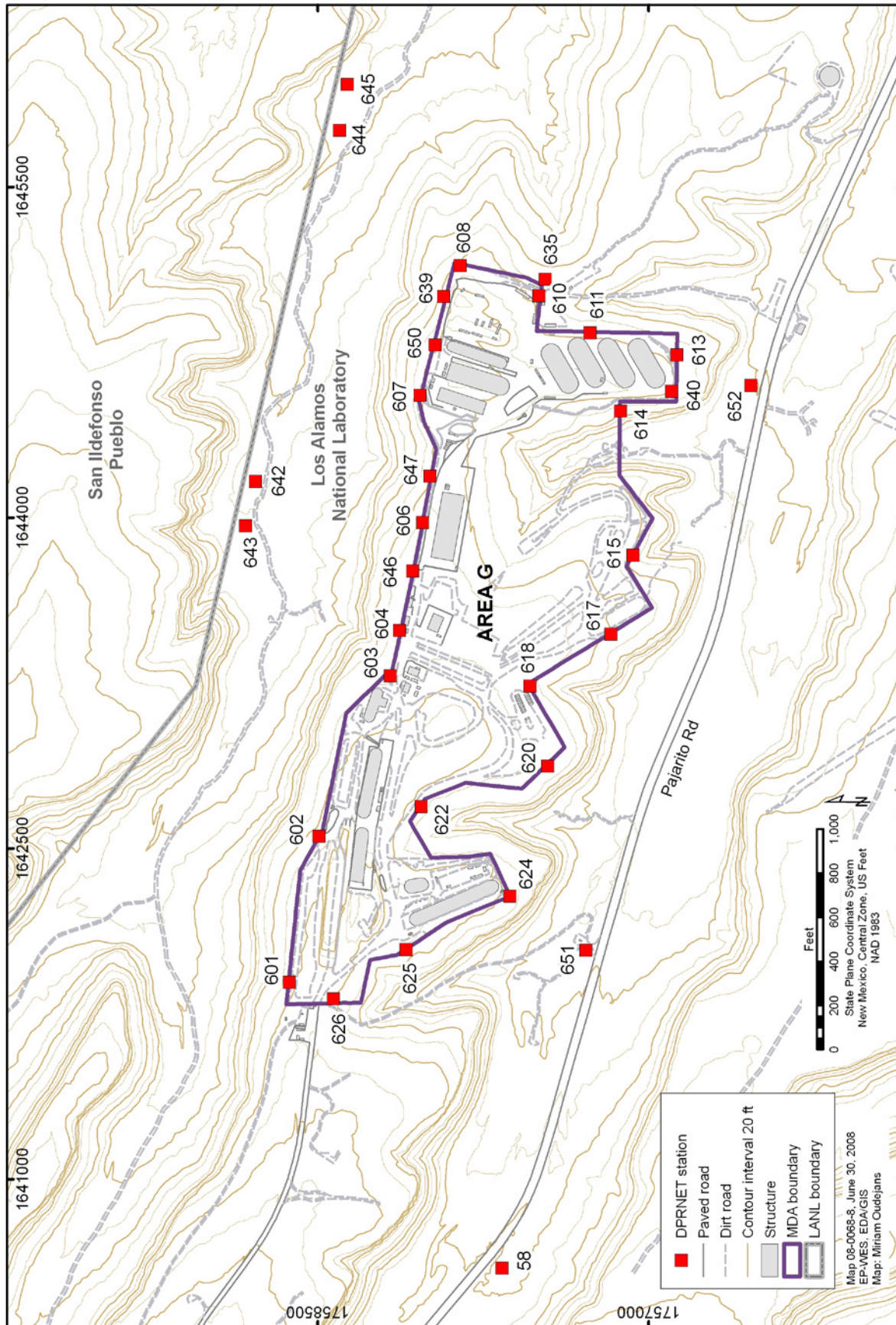


Figure 4-19. Thermoluminescent dosimeter locations at TA-54, Area G.

4. Results

The annual dose equivalents at all stations except those within or near Area G are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Supplemental Data [Table S4-10](#). The only location with a measurable contribution from LANL operations is near TA-54, Area G. Figure 4-19 shows the locations of the stations at TA-54, Area G.

South of the line of TLDs from #601 to #608, Area G is a controlled-access area, so these data are not representative of a potential public dose. However, TLDs #642 and #643 are close to the boundary of the Pueblo de San Ildefonso sacred area, which is accessible to members of the Pueblo. Furthermore, TLDs #133 and #134 are deployed by Pueblo staff within the boundaries of the sacred area. After subtracting background, the annual doses measured by TLDs #134, #642, and #643 were 12 mrem, 9 mrem, and 9 mrem, respectively. The dose measured by TLD #134 is higher than the others because TLDs #642 and #643 are in Cañada del Buey and are partially shielded by the rim of the canyon. These are the doses that would be received by a person who is at the location of the TLDs 24 hours per day and 365 days per year. As discussed in Chapter 3, we apply an occupancy factor of 1/16 (NCRP 1976) so the public dose near TLD #134 is calculated to be 0.75 mrem/yr.

TLDs #133, #644, and #645 are located several hundred meters further from Area G and measure nothing above the terrestrial and cosmic-ray natural background. This is expected because of the distance and the shielding provided by the air. Annual doses of 9 mrem were measured by TLDs #651 and #652, which are located along Pajarito Road, south of Area G. This section of Pajarito Road is controlled to limit public access.

D. NON-RADIOLOGICAL AMBIENT AIR MONITORING

1. Introduction

The nonradioactive ambient air monitoring network (NonRadNet) continued to develop a database of typical background levels of selected nonradiological species in the communities nearest LANL and measured LANL's potential contribution to nonradiological air pollution in the surrounding communities. The program consists of six ambient particulate matter monitoring units at three locations plus selected AIRNET samples, which are analyzed for the nonradiological constituents aluminum, calcium, and beryllium.

2. Air Monitoring Network

During 2007, ambient particulate matter monitoring continued at three locations—one in White Rock and two in Los Alamos. The White Rock sampling location is at the White Rock Fire Station (at AIRNET station 15). One Los Alamos sampling station is at the Los Alamos Medical Center (at AIRNET station 61) and the other is near 48th Street (at AIRNET station 6). Both of the Los Alamos locations lie between TA-3 and the population center of the Los Alamos town site. Two monitors are operated at each location: one for particles with diameters of 10 micrometers (μm) or less (PM-10), and another for particles with diameters of 2.5 μm or less (PM-2.5).

3. Sampling Procedures, Data Management, and Quality Assurance

A tapered-element oscillating microbalance ambient particulate monitor, fitted with either a PM-10 or a PM-2.5 sample inlet, continuously measures PM-10 and PM-2.5 concentrations. The microbalance has an oscillating ceramic “finger” with a filter that collects particles. The added mass of the particles changes the resonant frequency of the oscillator. As the change in frequency is measured, an associated mass of accumulated particulate matter is recorded and saved. The data are later downloaded to a database. Personnel use these data as an indicator of natural dust loading in the atmosphere. The sampled air volumes are calculated and the ambient air concentrations derived.

4. Ambient Air Concentrations

For particulate matter, we achieved an overall data collection efficiency of approximately 75% during 2007.

Annual averages and 24-hour maxima for both particle sizes at the three locations are shown in Table 4-14. The annual average for PM-10 is about 14 $\mu\text{g}/\text{m}^3$ at all locations; the annual average for PM-2.5 is about 8 $\mu\text{g}/\text{m}^3$. The annual averages and the 24-hour maxima for both PM-2.5 and PM-10 are well below EPA standards for all three locations.

Table 4-14
PM-2.5 and PM-10 Concentration Data Summary for 2007 ($\mu\text{g}/\text{m}^3$)

Station Location	Constituent	Maximum 24-Hour ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
48th Street, Los Alamos	PM-10	53	12
	PM-2.5	19	8
Los Alamos Medical Center	PM-10	66	15
	PM-2.5	18	8
White Rock Fire Station	PM-10	46	15
	PM-2.5	18	7
EPA Standard	PM-10	150	50 ^a
	PM-2.5	65	15 ^a

^a EPA 40 CFR Part 50

5. Detonation and Burning of Explosives

LANL tests explosives by detonating them at firing sites operated by the Dynamic and Energetic Materials Division and the Hydrodynamic Experiments Division. LANL maintains records that include the type of explosives used and other material expended at each site. The Data Supplement Table S4-11 (on the included compact disc) summarizes the amounts of expended materials for the last five years. LANL also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2007, LANL burned roughly 12,000 kilograms of high explosives. An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicates no adverse air-quality impacts.

6. Beryllium Sampling

During 2007, we analyzed quarterly composite samples from 35 sites for beryllium, aluminum, and calcium (Table S4-12 in the Data Supplement). These sites are located near potential beryllium sources at LANL or in nearby communities.

The State of New Mexico has no ambient air quality standard for beryllium. For comparison purposes, we use the NESHAP standard of 10 ng/m^3 (40 CFR Part 61). All measured values were less than 1% of this standard. Beryllium air concentrations for 2007 were similar to those measured in recent years.

E. METEOROLOGICAL MONITORING

1. Introduction

Data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. To accommodate the broad demands for weather data at the Laboratory, the meteorology team measures a wide variety of meteorological variables across the network, including wind, temperature, pressure, relative humidity and dew point, precipitation, and solar and terrestrial radiation. The Meteorological Monitoring Plan (Rishel et al. 2003) provides details of the meteorological monitoring program. An electronic copy of the “Meteorological Monitoring Plan” is available online at <http://www.weather.lanl.gov/documentation.asp>.

2. Monitoring Network

A network of seven towers gathers meteorological data at the Laboratory (Figure 4-20). Four of the towers are located on mesa tops (TA-6, TA-49, TA-53, and TA-54), two are in canyons (TA-41 in Los Alamos Canyon and MDCN in Mortandad Canyon), and one is on top of Pajarito Mountain (PJMT). The TA-6 tower is the official meteorological measurement site for the Laboratory. A sonic detection and ranging (SODAR) instrument is located adjacent to the TA-6 meteorological tower. Precipitation is also measured in North Community (NCOM) of the Los Alamos town site.

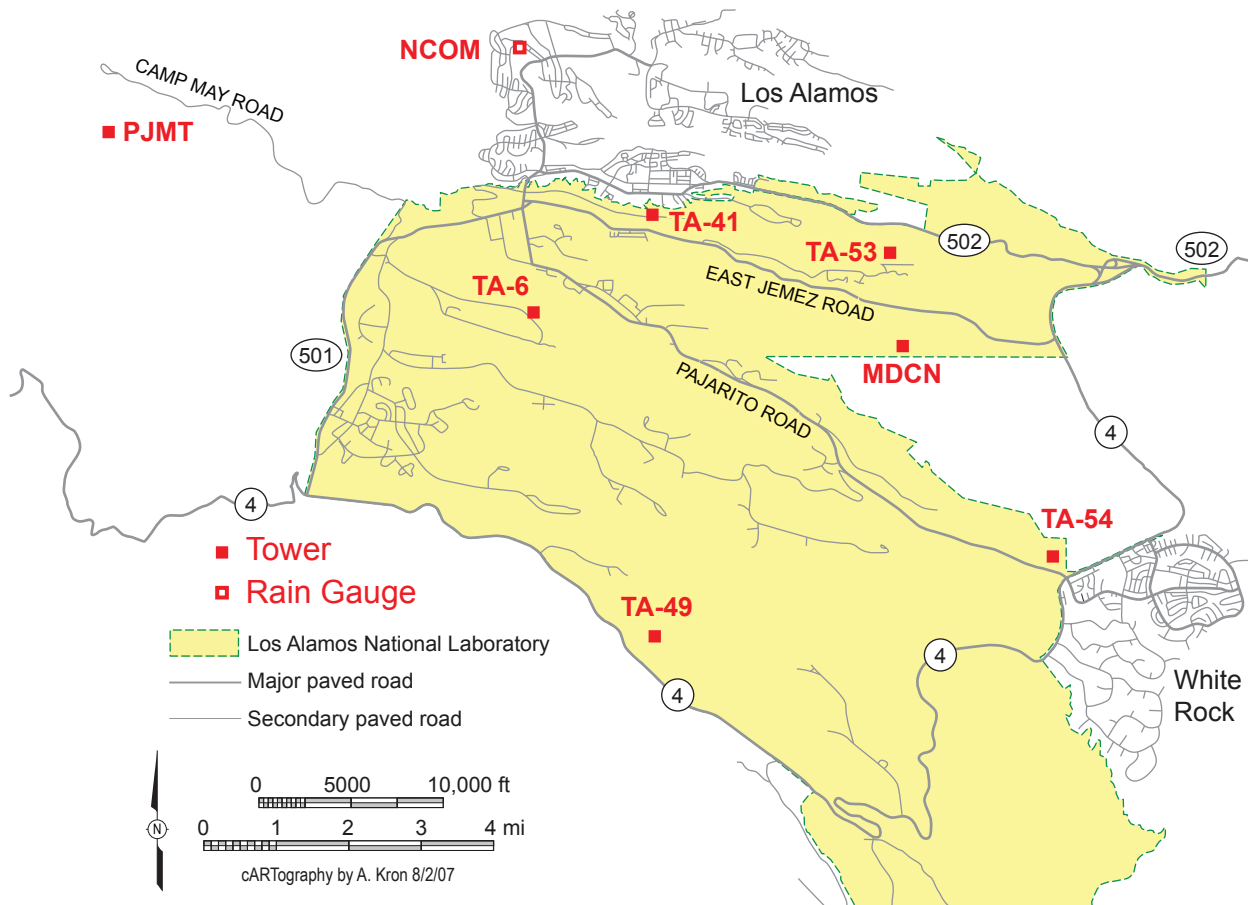


Figure 4-20. Location of meteorological monitoring towers and rain gauges.

3. Sampling Procedures, Data Management, and Quality Assurance

We place instruments in the meteorological network in areas with good exposure to the elements being measured, usually in open fields, to avoid wake effects (from trees and structures) on wind and precipitation measurements. Temperature and wind are measured at multiple levels on open lattice towers. The multiple levels provide a vertical profile of conditions important in assessing boundary layer flow and stability conditions. The multiple levels also provide redundant measurements that support data quality checks. The boom-mounted temperature sensors are shielded and aspirated to minimize solar-heating effects.

Data loggers at the tower sites sample most of the meteorological variables at 0.33 hertz (Hz), store the data, average the samples over a 15-min period, and transmit the data to a Hewlett-Packard workstation located at the Meteorology Lab (TA-59) by telephone or cell phone. The workstation automatically edits measurements that fall outside of realistic ranges. Time-series plots of the data are also generated for a meteorologist's data-quality

review. Daily statistics of certain meteorological variables (e.g., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. During the past 50 years, a similar once-daily set of statistics has been telephoned to the National Weather Service. Observers log cloud type and percentage cloud cover three times daily.

All meteorological instruments are biennially refurbished and calibrated during an internal audit/inspection. Field instruments are replaced with backup instruments, and the replaced instruments are checked to verify they remained in calibration while in service. An external audit is typically performed once every two to three years. The most recent audit was an “assist visit” by the DOE Meteorological Coordinating Council in August 2006. The report can be requested at <http://www.weather.lanl.gov/>.

4. Climatology

Los Alamos has a temperate, semiarid mountain climate. Atmospheric moisture levels are low, and clear skies are present about 75% of the time. These conditions lead to high solar heating during the day and strong long-wave radiative cooling at night. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm. The climate statistics summarized here are from analyses of historical meteorological databases maintained by the meteorology team and following Bowen (1990 and 1992).

The years from 1971 to 2000 represents the time period over which the climatological standard normal is defined. The standard should be 1961-1990, according to the World Meteorological Organization, until 2021 when 1991-2020 will become the standard, and so on every 30 years (WMO 1984). In practice, however, normals are computed every decade, and so 1971-2000 is generally used. Our averages are calculated according to this widely followed practice.

December and January are the coldest months. The majority (90%) of minimum temperatures during December and January range from 4°F to 31°F. Minimum temperatures are usually reached shortly before sunrise. Ninety percent (90%) of maximum temperatures, which are usually reached in mid-afternoon, range from 25°F to 55°F. The record low temperature of -18°F was recorded on January 13th 1963. Wintertime arctic air masses that descend into the central United States tend to have sufficient time to heat before they reach our southern latitude so the occurrence of local subzero temperatures is rare. Winds during the winter are relatively light, so extreme wind chills are uncommon.

Temperatures are highest from June through August. Ninety percent (90%) of minimum temperatures during these months range from 45°F to 61°F and 90% of maximum temperatures range from 67°F to 89°F. The record high temperature of 95°F was recorded on June 29, 1998.

The average annual precipitation, which includes both rain and the water equivalent from frozen precipitation, is 18.95 in. The average annual snowfall is 58.7 in. Winter precipitation in Los Alamos is often caused by storms approaching from the Pacific Ocean. Large snowfalls may occur locally as a result of orographic lifting of the storms by the high terrain. The record single-day snowfall is about 39 in., which occurred between 11 a.m. January 15, 1987, and 11 a.m. the next day. The record single-season snowfall is 153 in. set in 1986–87.

Precipitation in July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in mid September. Afternoon thunderstorms form as moist air from the Gulf of California and the Gulf of Mexico is convected and/or orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning.

The complex topography of the Pajarito Plateau influences local wind patterns, notable in the absence of large-scale disturbances. Often a distinct diurnal cycle of winds occurs. As air close to the ground is heated during the day, it tends to flow upslope along the ground. This is called anabatic flow. During the night, cool air

4. Air Surveillance

that forms close to the ground tends to flow downslope and is known as katabatic flow. As the daytime anabatic breeze flows up the Rio Grande valley, it adds a southerly component to the prevailing westerlies of the Pajarito Plateau. Nighttime katabatic flow enhances the local westerly winds. Flow in the east-west-oriented canyons of the Pajarito Plateau is generally aligned with the canyons, so canyon winds are usually from the west at night as katabatic flow and from the east during the day.

5. 2007 in Perspective

Figure 4-21 presents a graphical summary of Los Alamos weather for 2007. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals compared to monthly normals (averages during the 1971–2000 time period).

The year 2007 was warmer and wetter than normal. The average annual temperature in 2007 of 49.2°F exceeded the normal annual average of 47.9°F by 1.3°F. The total precipitation in 2007 of 20.31 in. was 107% of normal (18.95 in.). Summer and autumn were particularly warm, while January, February, and December were cooler than normal. The pace of precipitation held close to normal until about July, when it was clear that the monsoon would miss the average starting date of approximately July 7. Late monsoons are often weak monsoons and the end of August seemed to confirm this rule of thumb. An unusually wet September, however, brought the annual rainfall total back to normal. October and November were unseasonably warm and also very dry. A massive system from the tropical Pacific Ocean arrived from the south and delivered a 25-year rainfall event from November 30 through December 1, bringing rainfall totals for both months to well above normal. Winter arrived approximately one week into December, with snow and cold temperatures to close out the year.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-22 shows the historical record of temperatures in Los Alamos from 1927 through 2007. The annual average temperature is not the average temperature per se, but rather the mid-point between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-22. Every year since 1998 has been warmer than the 1971-2000 normal, just under 48°F. To aid in showing longer-term trends, the five-year running mean is also shown. With five-year averaging, for example, it can be seen that the warm spell during the past decade is not as extreme as the warm spell during the early-to-mid 1950s. On the other hand, the current warming trend is longer-lived.

Figure 4-23 shows the historical record of the annually summed total precipitation. The drought appears to have ended in 2003, and 2004 and 2005 brought surplus precipitation to help restore normal conditions. The moist trend did not continue in 2006, but returned again in 2007 with just over 20 inches, where the norm is 19 inches. As with the historical temperature profile, the five-year running mean is also shown. The five-year average indicates not only that the recent drought is behind us, but that it was the most severe drought on the 80-year record in Los Alamos.

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-24. Wind roses depict the percentage of time that wind blows from each of 16 direction bins. For example, winds are directly from the south at TA-6 over 12% of the time during days in 2007. Winds are directly from the north about 3% of the time during the day. Wind roses also show the distribution of wind speed. About 8% of the time, for example, winds at TA-6 are from the south and range from 2.5 to 5 meters per second. Winds from the south at TA-6 exceed 7.5 meters per second only a fraction of 1% of the time.



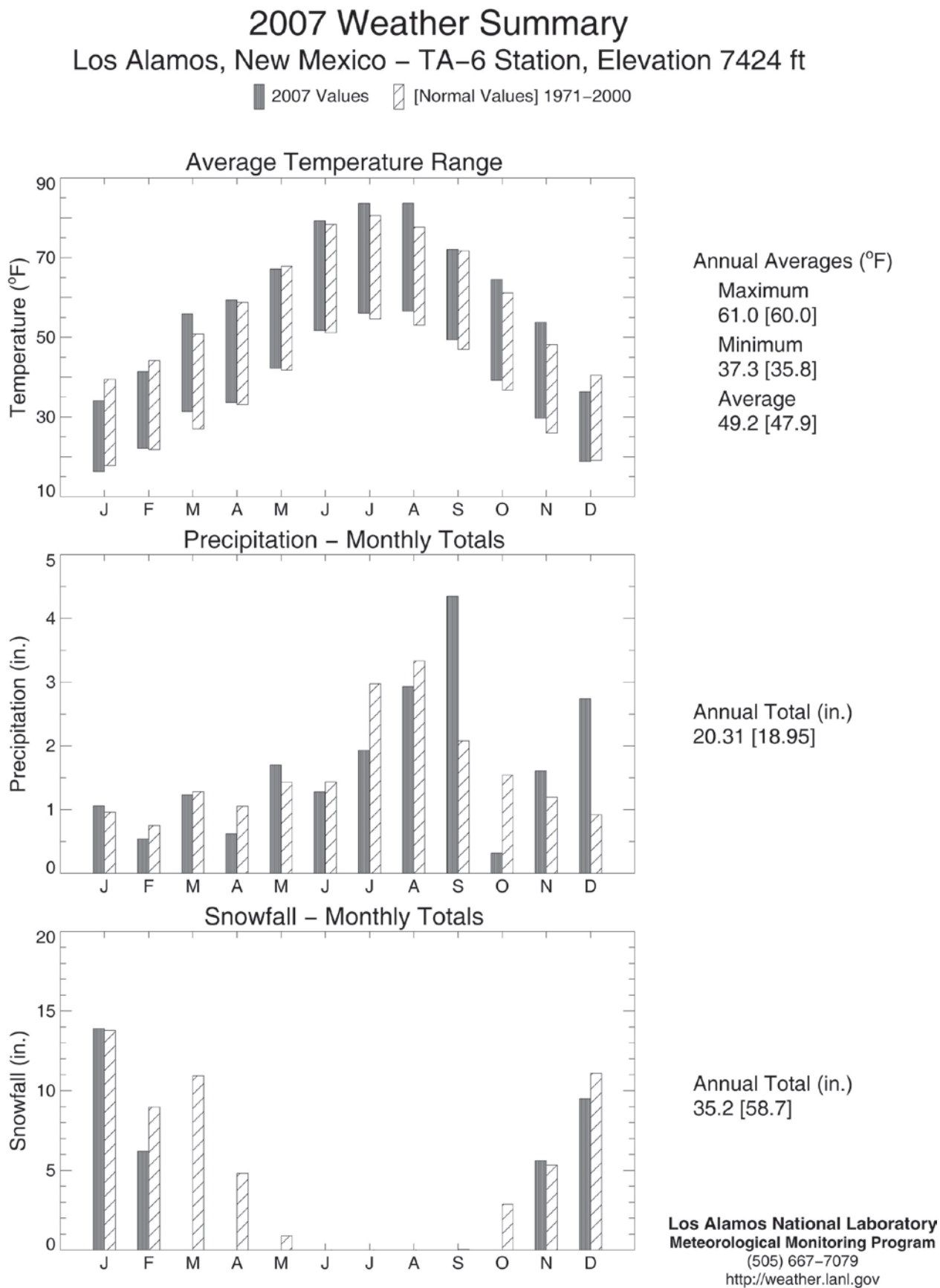


Figure 4-21. Weather summary for Los Alamos for 2007 at the TA-6 meteorology station.

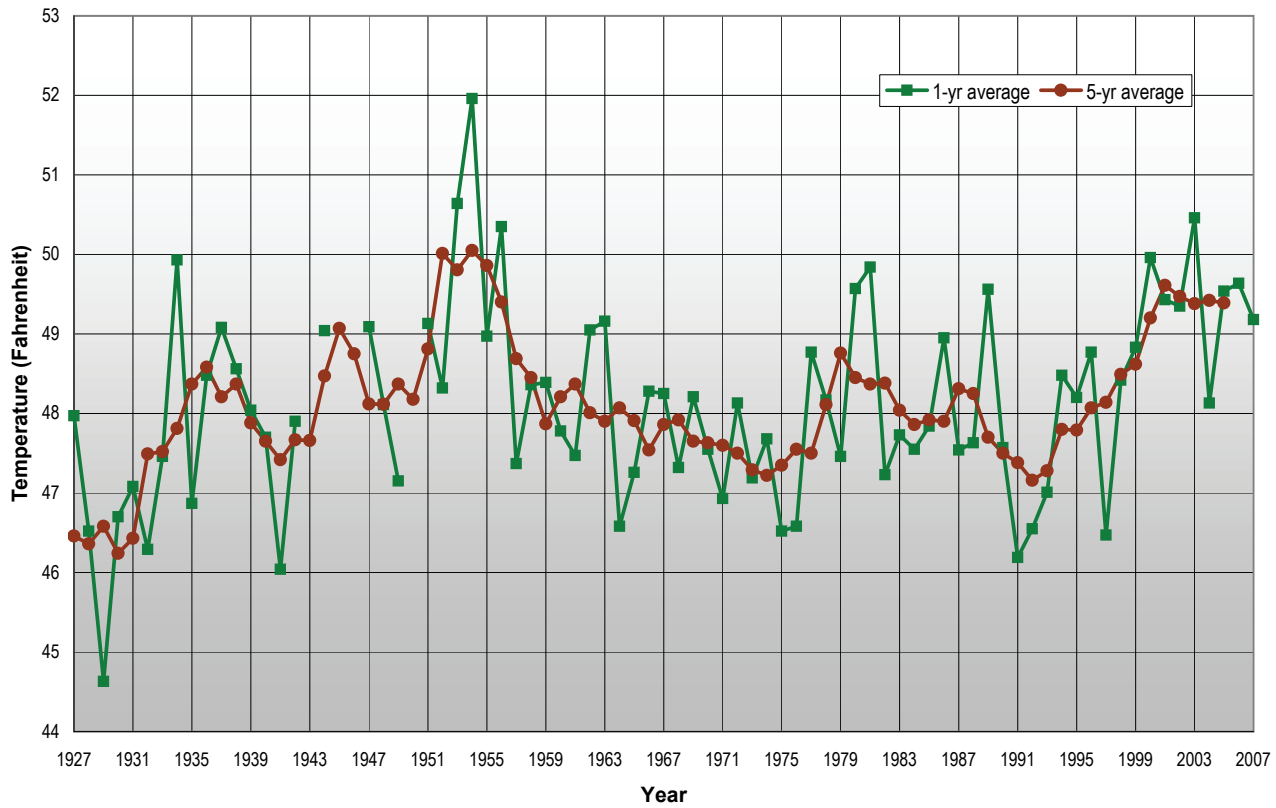


Figure 4-22. Temperature history for Los Alamos.

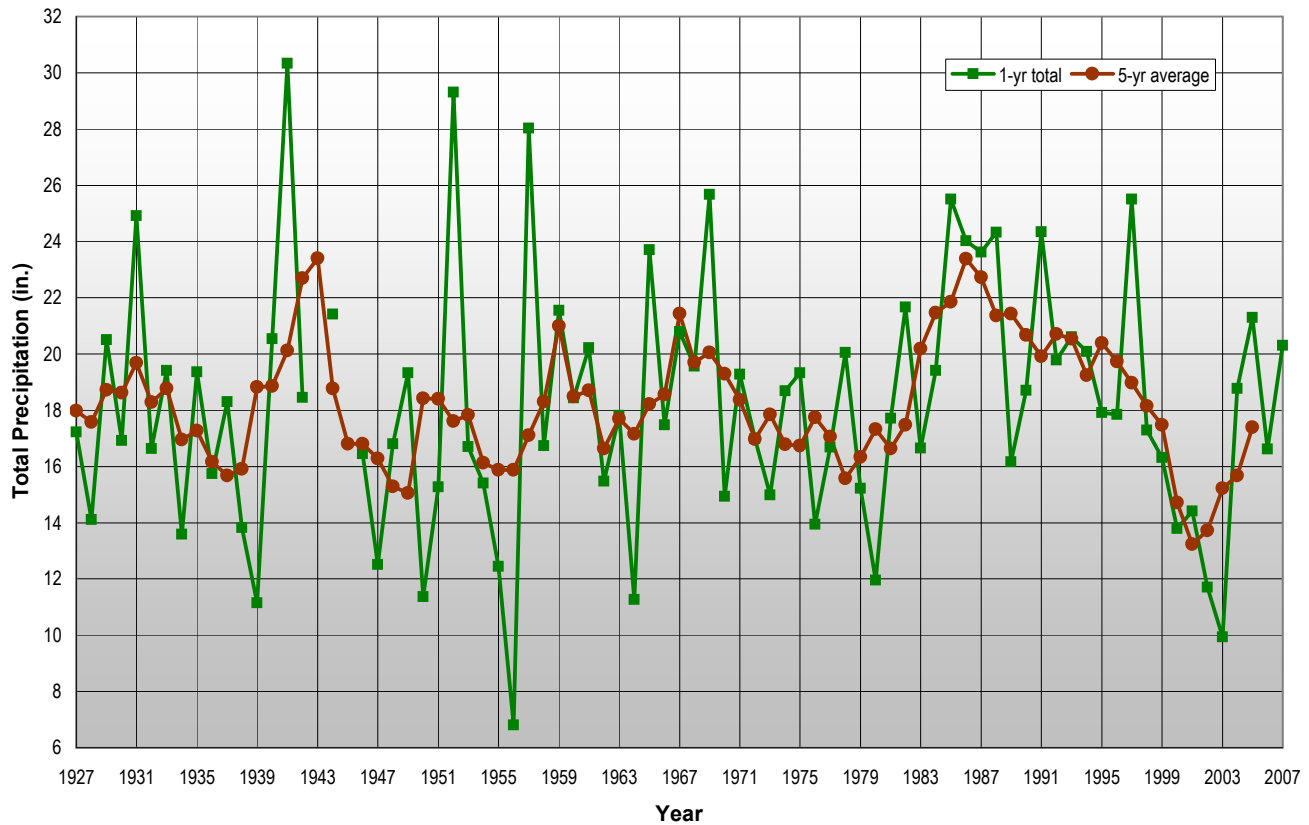


Figure 4-23. Total precipitation history for Los Alamos.

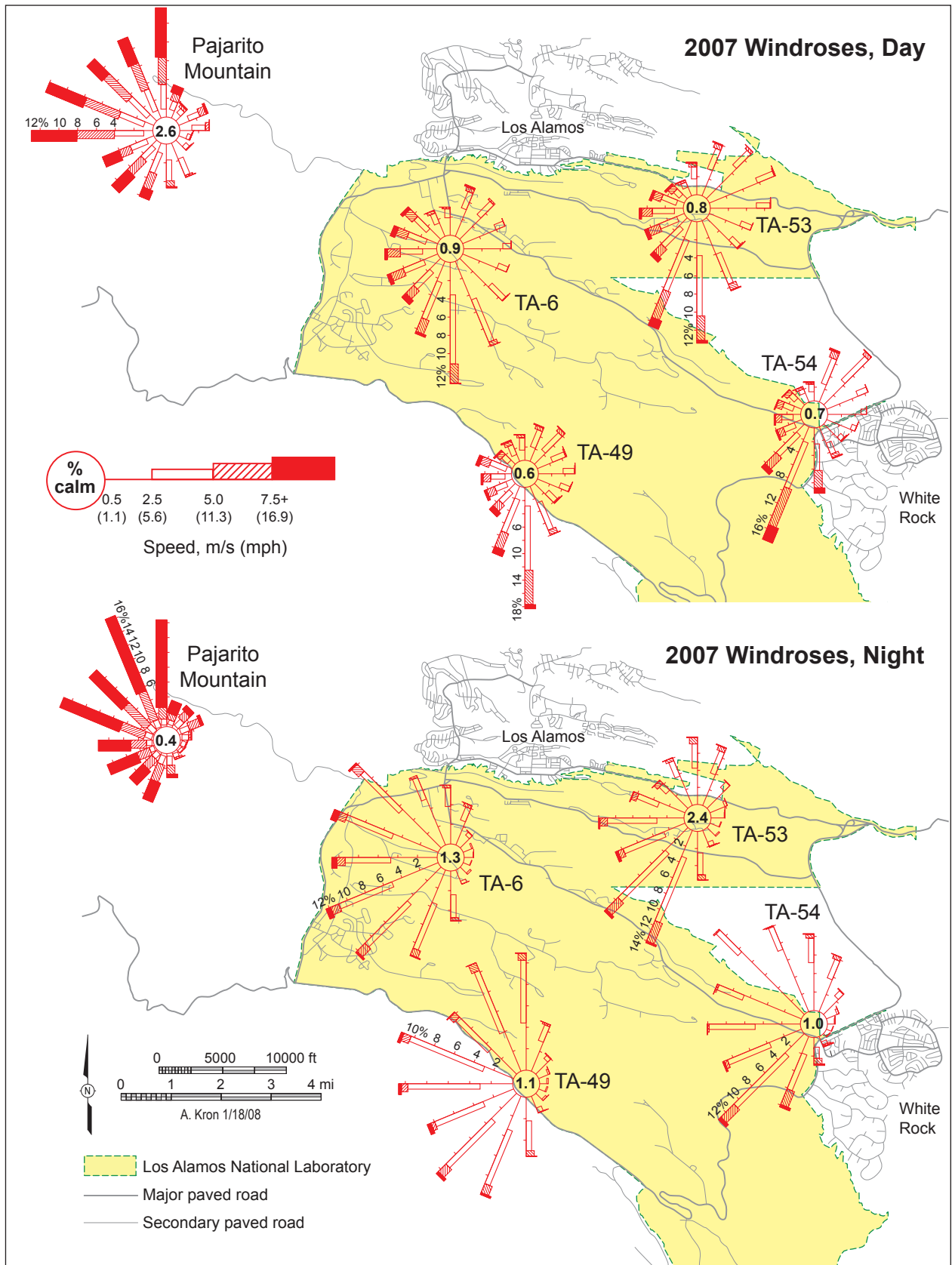


Figure 4-24. Daytime and nighttime wind roses for 2007.

4. Air Surveillance

The wind roses are based on 15-minute-averaged wind observations for 2007 at the four Pajarito Plateau towers and the Pajarito Mountain tower. Interestingly, wind roses from different years are almost identical, indicating that wind patterns are constant when averaged over a year.

Daytime winds measured by the four Pajarito Plateau towers are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley. Nighttime winds on the Pajarito Plateau are lighter and more variable than daytime winds and typically have a westerly component, resulting from a combination of prevailing westerly winds and downslope katabatic flow of cooled mountain air.

Winds atop Pajarito Mountain are more representative of upper-level flows and primarily range from the northwest to the southwest, reflecting the prevailing westerlies. The thick, red barbs of the Pajarito Mountain roses reveal that winds there are much faster than on the Pajarito Plateau and are faster at night than during the day.

Winds on the Pajarito Plateau are faster during the day than at night due to vertical mixing which is driven by sunshine. During the day, the mixing is strong and brings momentum down to the surface. This results in slower wind aloft, at the level of Pajarito Mountain, and faster wind at the surface. At night, there is little mixing so wind aloft remains fast - hence faster nighttime wind at Pajarito Mountain. Wind at the surface receives little boosting from aloft and so is slower on the Pajarito Plateau at night than during the day.

F. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

During 2007, the air quality monitoring and compliance organizations revised approximately 35 procedures and one quality assurance project plan to reflect constant improvements in the processes. Together, these plans and procedures describe or prescribe all the planned and systematic activities necessary to provide confidence that processes perform satisfactorily. All current quality-related documents are available online at <http://www.lanl.gov/environment/air/qa.shtml>.

2. Field Sampling Quality Assurance

a. Methods

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

Particulate and water-vapor samples are (1) collected from commercially available media of known performance, (2) collected under common chain-of-custody procedures using field-portable electronic data systems to minimize the chances of data transcription errors, and (3) prepared in a secure and radiologically clean laboratory for shipment. The samples 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 AIRNET and RADAIR relational databases.

Field-sampling completeness is assessed every time the analytical laboratory returns the AIRNET biweekly gross alpha/beta data. RADAIR field-sampling completeness is evaluated each week upon receipt of the gross alpha/beta and tritium bubbler data. All these calculations are performed for each ambient air and stack sampling site and are included in the quality assessment memo prepared by stack monitoring staff to evaluate every data group received from a supplier.

b. Results

Field sample completeness for AIRNET was 99.5% for filters and 99.2% for silica gel (tritium samples). Sample run time was greater than 98.5% for AIRNET and 99.46% for stacks.

3. Analytical Laboratory Quality Assessment

a. Methods

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 our program objectives. These statements of work are sent to potentially qualified suppliers who 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 laboratory, including recent past performance on nationally conducted performance evaluation programs, are primarily used to award contracts for specific types of radiochemical and inorganic chemical analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. We submit independently prepared blind spiked samples with each sample set to be analyzed for tritium. Preliminary data are returned by email in an electronic data deliverable of specified format and content. 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 QA/QC data the analytical laboratory generates during each phase of analysis, including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable. The electronic data are uploaded into either the AIRNET or RADAIR 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 tracking information documented in the quality assessment memo mentioned in the field sampling section. All parts of the data management process are tracked electronically in each database, and periodic reports to management are prepared.

b. Results

Analytical data completeness was 99.4% for AIRNET filters, 99.5% for AIRNET silica gel, and 99.91% for stacks. The overall results of the quality monitoring in 2007 indicate that all analytical laboratories maintained the same high level of control observed in the past several years.

4. Analytical Laboratory Assessments

During 2007, one internal and one external laboratory performed all analyses reported for AIRNET and stack samples. Paragon Analytics, Inc., Fort Collins, Colorado, provided the following analyses:

- Biweekly gross alpha, gross beta, and gamma analyses of filters for AIRNET.
- Biweekly analyses for tritium in AIRNET silica gel.
- Weekly gross alpha, gross beta, gamma, and stable beryllium analyses on stack samples.
- Quarterly analyses for alpha-emitting isotopes (americium, plutonium, and uranium) and stable beryllium, calcium, and aluminum on AIRNET quarterly composite samples.
- Semester analyses of composites of stack filters for gross alpha, gross beta, americium-241, gamma-emitting isotopes, lead-210, polonium-210, plutonium isotopes, strontium-90, thorium isotopes, and uranium isotopes.

The Laboratory's on-site Health Physics Analytical Laboratory (HSR-4) performed instrumental analyses of tritium in stack emissions.

Paragon Analytics was assessed during 2006 and the laboratory was found to provide very high quality work in compliance with all LANL requirements. This laboratory has consistently performed well. The laboratory annually participates in two national performance evaluation studies and the study sponsors have consistently judged the analytical laboratory to have acceptable performance for all analytes attempted in all air sample matrices.

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5. Groundwater Monitoring



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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor water quality beneath the Pajarito Plateau and the surrounding area. The Laboratory conducts groundwater monitoring and characterization programs to comply with the requirements of the Department of Energy (DOE) Orders and New Mexico (NM) and federal regulations. The objectives of the Laboratory's Water Stewardship Program are to determine compliance with waste discharge requirements and to evaluate any impact of Laboratory activities on groundwater resources. This program addresses regulatory compliance, environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations (LANL 1996, 1998).

Because of the Laboratory's semiarid, mountainside setting, significant groundwater is found only at depths of more than several hundred feet. The Los Alamos County public water supply comes from supply wells that draw water from the regional aquifer, found at depths of 600 to 1,200 ft. Groundwater protection efforts at the Laboratory focus on the regional aquifer underlying the area and also include the shallow perched groundwater found within canyon alluvium and the perched groundwater at intermediate depths above the regional aquifer.

Groundwater monitoring conducted during 2007 was carried out according to the Interim Sitewide Monitoring Plan approved by the New Mexico Environment Department (NMED) under the Compliance Order on Consent (Consent Order) (LANL 2006). The Water Stewardship Program collected groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo de San Ildefonso.

B. HYDROGEOLOGIC SETTING

The following sections describe the hydrogeologic setting of the Laboratory and include a summary of groundwater contaminant sources and distribution. Additional detail can be found in LANL (2005a), which summarizes results of investigations conducted under the Hydrogeologic Workplan from 1998 through 2004.

1. Geologic Setting

The Laboratory is located in northern NM on the Pajarito Plateau, which extends eastward from the Sierra de los Valles, the eastern range of the Jemez Mountains (Figure 5-1). The Rio Grande borders the Laboratory on the east. Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff was formed from volcanic ashfall deposits and pyroclastic flows that erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. The tuff is more than 1,000 ft thick in the western part of the plateau and thins eastward to about 260 ft adjacent to the Rio Grande.

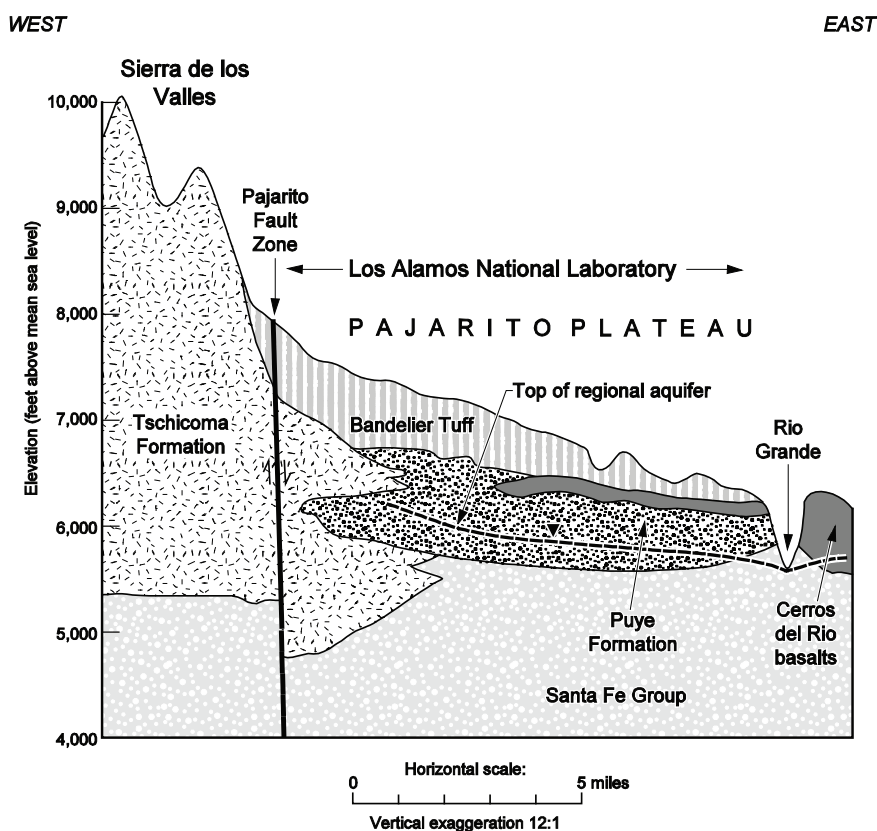


Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains (Figure 5-1). The Puye Formation conglomerate underlies the tuff beneath the central and eastern portion of the plateau. The Cerros del Rio basalt flows interfinger with the Puye Formation conglomerate beneath the Laboratory. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

2. Groundwater Occurrence

Due to its location on a semiarid mountainside, the Laboratory land sits atop a thick zone of mainly unsaturated rock, with the regional aquifer found 600 to 1,200 ft below the ground surface. Groundwater beneath the Pajarito Plateau occurs in three modes, two of which are perched (Figure 5-2). Perched groundwater is retained above less permeable layers and is separated from underlying groundwater by unsaturated rock.

The three modes of groundwater occurrence are (1) perched alluvial groundwater in canyon bottoms, (2) discontinuous zones of intermediate-depth perched groundwater whose location is controlled by availability of recharge and by subsurface changes in rock type and permeability, and (3) the regional aquifer beneath the Pajarito Plateau. The regional aquifer extends throughout the neighboring Española Basin.

Stream runoff may be supplemented or maintained by Laboratory discharges. Many relatively dry canyons have little surface water flow and little or no alluvial groundwater. Streams have filled some parts of canyon bottoms with alluvium up to 100-ft thick. In wet canyons, runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff or other rocks, maintaining shallow bodies of perched groundwater within the alluvium. These saturated zones have limited extent, as evapotranspiration and percolation into underlying rocks deplete the alluvial groundwater as it moves down the canyon.

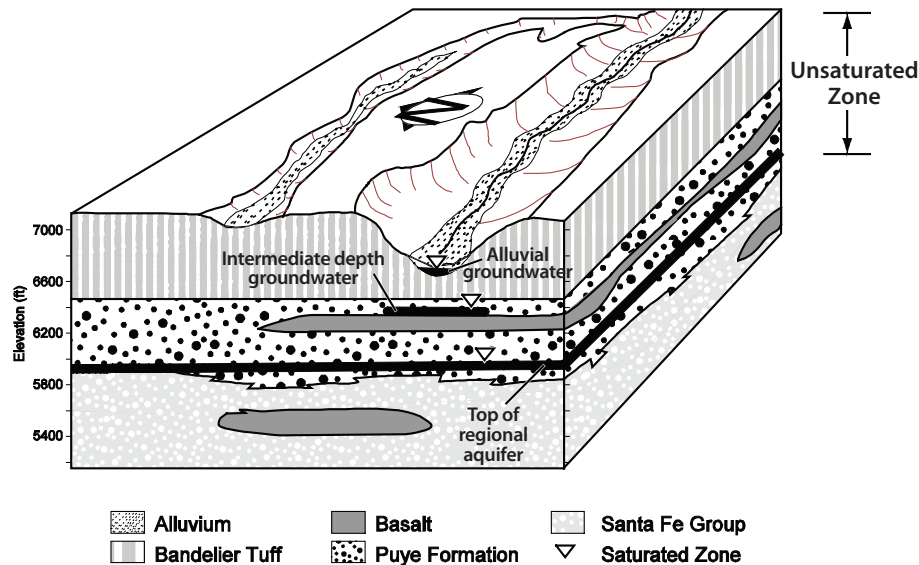


Figure 5-2. Illustration of geologic and hydrologic relationships in the Pajarito Plateau, showing the three modes of groundwater occurrence.

Underneath portions of Pueblo, Los Alamos, Mortandad, Sandia, and other canyons, intermediate perched groundwater occurs within the lower part of the Bandelier Tuff and within the underlying Puye Formation and Cerros del Rio basalt (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by recharge from the overlying perched alluvial groundwater. The intermediate groundwater is discontinuous; occurrence is controlled by availability of recharge and variations in permeability of the rocks underlying the plateau. Depths of the intermediate perched groundwater vary: approximately 120 ft in Pueblo Canyon, 450 ft in Sandia Canyon, and 500–750 ft in Mortandad Canyon.

Some intermediate perched groundwater occurs in volcanic rocks on the flanks of the Sierra de los Valles to the west of the Laboratory. This water discharges at several springs and yields a significant flow from a gallery in Water Canyon. Intermediate groundwater also occurs in the southwest portion of the Laboratory just east of the Sierra de los Valles. A number of intermediate springs, fed by local recharge, discharge from mesa edges along canyons. Other intermediate groundwater is found in the Bandelier Tuff at a depth of approximately 700 ft. The source of this deeper perched groundwater may be percolation from streams that discharge from canyons along the mountain front, or underflow of recharge from the Sierra de los Valles.

The regional aquifer occurs at a depth of 1,200 ft along the western edge of the plateau and 600 ft along the eastern edge (Figures 5-1 and 5-3). The regional aquifer lies about 1,000 ft beneath the mesa tops in the central part of the plateau. This is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer generally flows east or southeast toward the Rio Grande. Groundwater model studies indicate that underflow of groundwater from the Sierra de los Valles is the main source of regional aquifer recharge (LANL 2005a). Groundwater velocities vary spatially but are typically 30 ft/yr.

The surface of the aquifer rises westward from the Rio Grande within the Tesuque Formation, part of the Santa Fe Group (Figure 5-1). Underneath the central and western part of the plateau the aquifer rises farther into the Cerros del Rio basalt and the lower part of the Puye Formation.

The regional aquifer is separated from alluvial and intermediate perched groundwater by approximately 350 to 620 ft of unsaturated tuff, basalt, and sediments with generally low (<10%) moisture content. Water lost by downward seepage from alluvial and intermediate groundwater zones travels through the underlying rock by unsaturated flow. This percolation is a source of certain contaminants, mobile in water, which may reach the regional aquifer within a few decades. The limited extent of the alluvial and intermediate groundwater bodies, along with the dry rock that underlies them, restricts their volumetric contribution to recharge reaching the regional aquifer.

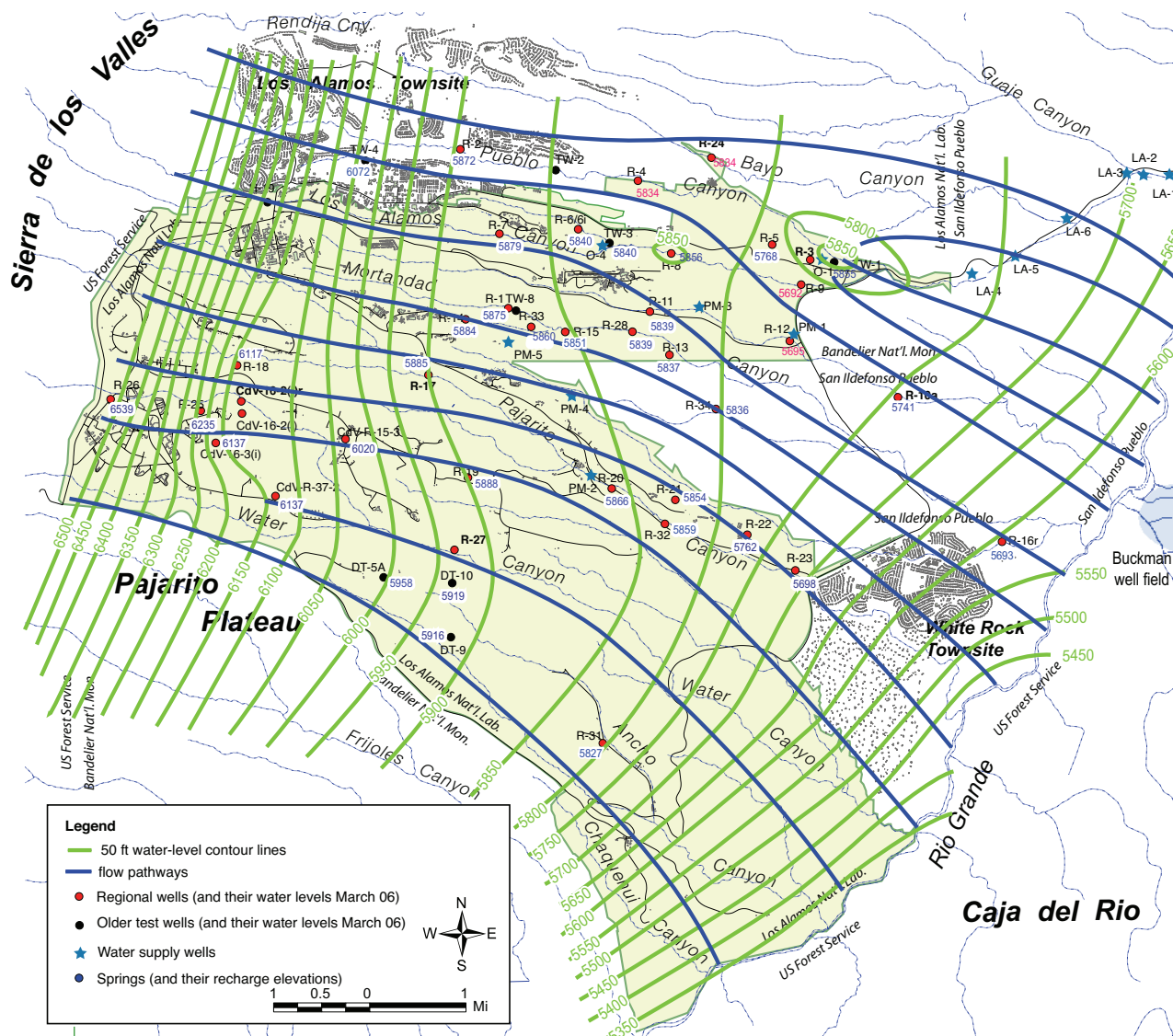


Figure 5-3. Contour map of average water table elevations in March 2006 for the regional aquifer (LANL 2007a).

3. Overview of Groundwater Quality

Since the 1940s, liquid effluent discharge by the Laboratory has affected water quality in the shallow perched groundwater that lies beneath the floor of a few canyons. Liquid effluent discharge is also the primary means by which Laboratory contaminants have affected the quality of intermediate perched zones and the regional aquifer. Where contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location beneath a mesa-top site where large amounts of liquid effluent have been discharged.

The discharge of effluents to canyons or mesa-top locations in the Laboratory’s semiarid setting initiates or increases downward percolation of water. Even under unsaturated flow conditions, this percolation may move water and contaminants to the regional aquifer within a few decades.

The contaminated alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so recharge from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer than is found in the shallow perched groundwater bodies, and impacts on the regional aquifer are reduced or not significant.

Liquid effluent discharge at the Laboratory has impacted the quality of alluvial groundwater in several canyons. Drainages that received liquid radioactive effluents include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon (Figure 5-4). Rogers (2001) and Emelity (1996) summarize radioactive effluent discharge history at the Laboratory.

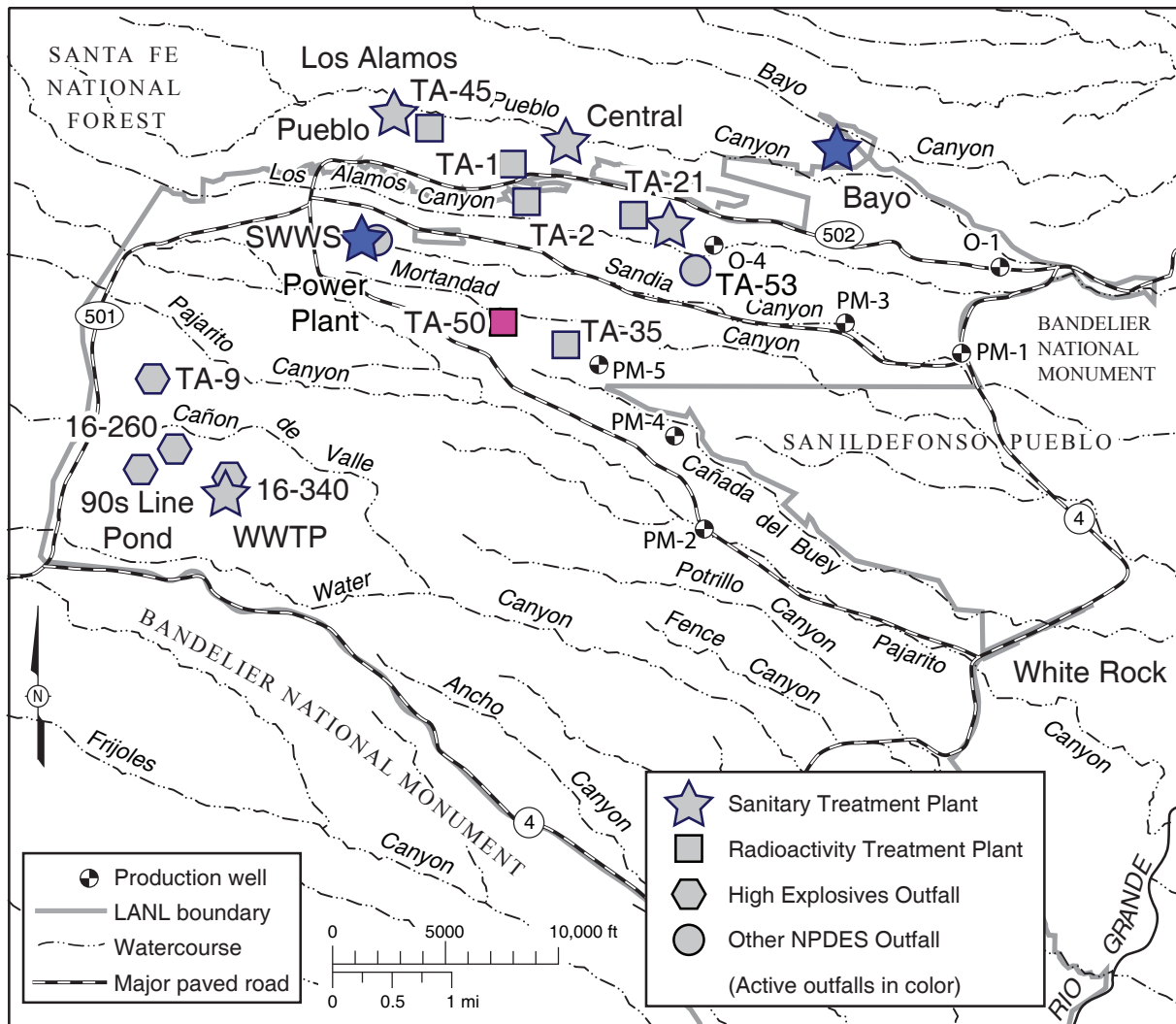


Figure 5-4. Major liquid release sources (effluent discharge) potentially affecting groundwater. Most outfalls shown are inactive.

Because of releases of power plant cooling water and water from the Laboratory's Sanitary Wastewater Systems (SWWS) Plant, Sandia Canyon has received the largest liquid discharge volumes of any canyon in recent decades. Water Canyon and its tributary Cañon de Valle have received effluents produced by high explosives (HE) processing and experimentation (Glatzmaier 1993; Martin 1993).

Over the years, Los Alamos County has operated several sanitary wastewater treatment plants in Pueblo Canyon (ESP 1981). Only the new Los Alamos County Wastewater Treatment Plant (LACWTP) is currently operating. The Laboratory has also operated numerous sanitary treatment plants, three of which are shown in Figure 5-4.

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls (from 141 to 17) and the volume of water released (by more than 80%). For 1993 to 1997, total estimated average flow was 1,300 M gal/yr; flow decreased to 230 M gal/yr for 1998 to 2005 (Rogers 2006). The quality of the remaining discharges has been improved through treatment process improvements so that the discharges meet applicable standards.

Certain chemicals are good indicators of the possible presence of Laboratory effluents in groundwater. These chemicals are described as being chemically conservative, that is, their concentrations are usually not affected by chemical reactions. Examples of these conservative chemicals include perchlorate, tritium, hexavalent chromium, and, to a lesser extent, nitrate. Nitrate is often conservative but its concentration may be affected by bacterial activity. Because these chemicals travel readily in groundwater and are indicators of effluents, groundwater that has background concentrations of perchlorate, tritium, hexavalent chromium, and nitrate is likely to be unaffected by LANL discharges.

Liquid effluent discharges have affected intermediate perched groundwater and the regional aquifer to a lesser degree than the alluvial groundwater. The intermediate groundwater in various locations shows localized radioactive (tritium), organic (Royal Demolition Explosive [RDX], chlorinated organic chemicals, dioxane[1,4-]), and inorganic (hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate) contamination from Laboratory operations.

In 2007, the high explosives compound RDX continued to be detected in the regional aquifer at Pajarito Canyon regional aquifer well R-18. RDX is listed as a toxic pollutant in the New Mexico groundwater regulations (NMWQCC 2002). The RDX concentration was near the detection limit and at 2% of the Environmental Protection Agency's (EPA's) 10^{-5} excess cancer risk tap water screening level of 6.1 $\mu\text{g/L}$. Earlier detection of RDX in the regional aquifer at regional aquifer well R-25 (to the south of R-18) was probably due to cross-contamination from shallower well screens caused by well construction delays. The Laboratory is investigating these issues in cooperation with NMED.

Hexavalent chromium and nitrate have been found in several regional monitoring wells. Hexavalent chromium is at concentrations above the NM groundwater standard in one regional aquifer well and at 70% of that standard in another. Nitrate (as nitrogen) concentrations reach 50% of the NM groundwater standard in two regional aquifer monitoring wells and fluoride is at 50% of the standard in one well. Traces of tritium and perchlorate are also found in the regional aquifer.

With one exception, Los Alamos County drinking water supply wells in the Los Alamos area have not been impacted by Laboratory discharges. The exception is well O-1 in Pueblo Canyon, where perchlorate is found at concentrations that average 1/10th of the Environmental Protection Agency's (EPA's) Drinking Water Equivalent Level (DWEL) of 24.5 $\mu\text{g/L}$. Consequently, this well is not used by Los Alamos County for water supply. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water standards.

C. GROUNDWATER STANDARDS

In evaluating groundwater samples, we applied regulatory standards and risk levels as described in Table 5-1. For drinking water supply wells, which draw water from the regional aquifer, we compared concentrations of radionuclides in samples to (1) the derived concentration guides (DCGs) for ingested water calculated from DOE's 4-mrem drinking water dose limit and (2) the EPA maximum concentration levels (MCLs). For radioactivity in groundwater other than water supply wells, there are NM groundwater standards for uranium and radium. For risk-based screening of other radioactivity, groundwater samples from sources other than water supply wells may be compared with DOE's 4-mrem drinking water DCGs and with EPA MCLs. The DCGs for the 100-mrem public dose limit apply as effluent release guidelines. Where used in this chapter for such comparison purposes, in assessing water samples from sources other than water supply wells, these DCGs and EPA MCLs are referred to as screening levels.

The NM drinking water regulations and EPA MCLs apply as regulatory standards to nonradioactive constituents in water supply samples. They may be used as risk-based screening levels for other groundwater samples. The New Mexico Water Quality Control Commission (NMWQCC) groundwater standards (NMWQCC 2002) apply to concentrations of nonradioactive chemical quality parameters in all groundwater samples. NMWQCC (2002) specifies how to determine standards for the toxic pollutants listed in the NMWQCC groundwater standards, if they have no other state or federal standard. Accordingly, we screened results for these compounds at a risk level of 10^{-5} for cancer-causing substances or a hazard quotient of one ($HQ = 1$) for non-cancer-causing substances.

Table 5-1
Application of Standards to LANL Groundwater Monitoring Data

Constituent	Sample Location	Standard or DCG	Risk-Based Screening Level	Reference	Location	Notes
Radionuclides	Water supply wells	DOE 4-mrem DCGs, EPA MCLs	None	DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	A 4-mrem/year dose rate limit and EPA MCLs apply to drinking water systems
Radionuclides	Effluent samples	DOE 100-mrem DCGs	None	DOE Order 5400.5	On-site	DOE public dose limit is 100 mrem/yr, applies to effluent discharges
Radionuclides	Other groundwater samples	None	4-mrem DCGs EPA MCLs	DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	A 4-mrem/year dose rate limit and EPA MCLs are for comparison purposes because they apply only to drinking water systems
Non-radionuclides	Water supply wells	EPA MCLs, NM groundwater standards, EPA 10^{-5} , and HQ = 1 risk levels for NM toxic pollutants with no standard	None	40 CFR 141-143, 20.6.2 NM Administrative Code, http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm	On-site and off-site	EPA MCLs apply to drinking water systems. Use EPA Region 6 table for 10^{-5} and HQ = 1 risk levels
Non-radionuclides	Other groundwater samples	NM groundwater standards, EPA 10^{-5} and HQ = 1 risk levels for NM toxic pollutants with no standard	EPA MCLs	40 CFR 141-143, 20.6.2 NM Administrative Code, http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm	On-site and off-site	NMED regulations apply to all groundwater. EPA MCLs are for comparison purposes because they apply only to drinking water systems. Use EPA Region 6 table for 10^{-5} and HQ = 1 risk levels

A HQ of one or less indicates that no (noncancer) adverse human health effects are expected to occur from that chemical. We used the EPA Region 6 tap water screening levels to screen these toxic pollutant compounds (http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm). For cancer-causing substances, the EPA Region 6 tap water screening levels are at a risk level of 10^{-6} , so we use 10 times the values to screen at a risk level of 10^{-5} .

Groundwater is a source of flow to springs and other surface water that neighboring tribal members and wildlife use. NMWQCC's surface water standards (NMWQCC 2000), including the wildlife habitat standards, also apply to this surface water (for a discussion of surface water, see Chapter 6).

D. MONITORING NETWORK

In 2005, DOE and its Operations and Management Contractor and NMED signed a Compliance Order on Consent (Consent Order), which specifies the process for conducting groundwater monitoring at the Laboratory. The Consent Order requires that the Laboratory submit annually an Interim Facility-Wide Groundwater Monitoring Plan (Interim Plan) to NMED for its approval. The first Interim Plan was approved in June 2006 (LANL 2006). Groundwater monitoring conducted during calendar year 2007 was carried out according to two Interim Plans approved by NMED under the Consent Order (LANL 2006, LANL 2007b).

Groundwater sampling locations are divided into three principal groups related to the three modes of groundwater occurrence: perched alluvial groundwater in the bottom of some canyons, localized intermediate-depth perched groundwater systems, and the regional aquifer (Figures 5-5 through 5-9).

To document the potential impact of Laboratory operations on Pueblo de San Ildefonso land, the DOE signed a memorandum of understanding in 1987 with the Pueblo and the Bureau of Indian Affairs to conduct environmental sampling on Pueblo land. Groundwater monitoring stations at Pueblo de San Ildefonso are shown in Figure 5-9 and mainly sample the regional aquifer. Basalt Spring, Los Alamos Spring, GU-0.01 Spring, and Pine Rock Spring are intermediate groundwater sampling points, and wells LLAO-1B and LLAO-4 sample alluvial groundwater. Figure 5-9 also shows the location of three City of Santa Fe water supply wells monitored by the Laboratory.

Water quality monitoring results are given in accompanying supplemental data tables (on included compact disc), which include results for several boreholes. The water quality results from borehole samples are for screening purposes and used to guide further investigation. Borehole samples cannot be used to accurately evaluate aquifer conditions because they are a mixture of high-turbidity water affected by drilling fluids and sample over a large portion of the borehole. Following well installation, well development is used to remove aquifer and drilling materials from the well before sampling.

LANL conducts a regular program of water level measurements for monitoring wells. A summary of groundwater level measurements for 2007 is given in Allen et al. (2008).

1. Regional Aquifer and Intermediate Perched Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring wells, water supply wells, and springs. Wells recently constructed under the Hydrogeologic Workplan (LANL 1998), and planned for the future under the Consent Order, are intended for additional groundwater characterization efforts and to extend the Laboratory's groundwater monitoring system. Several of these wells were added to the monitoring well network beginning in 2002. New wells completed in 2007 are described in Chapter 2, Section B.9.b. A column on the supplemental data tables for Chapter 5 (on the included compact disc) identifies the groundwater zones sampled by different ports of these wells and gives the depth of the port or top of the well screen.

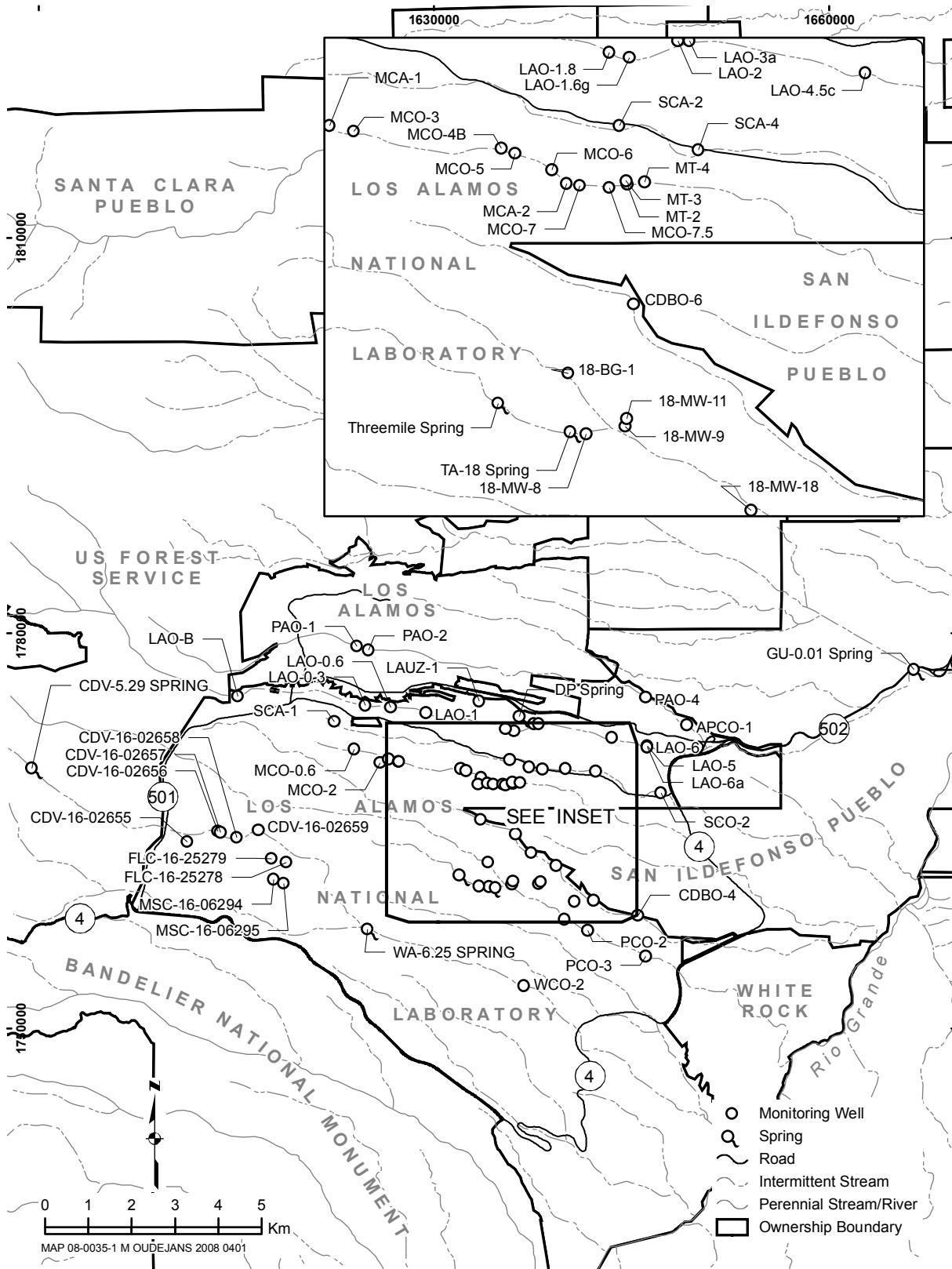


Figure 5-5. Springs and wells used for alluvial groundwater monitoring.

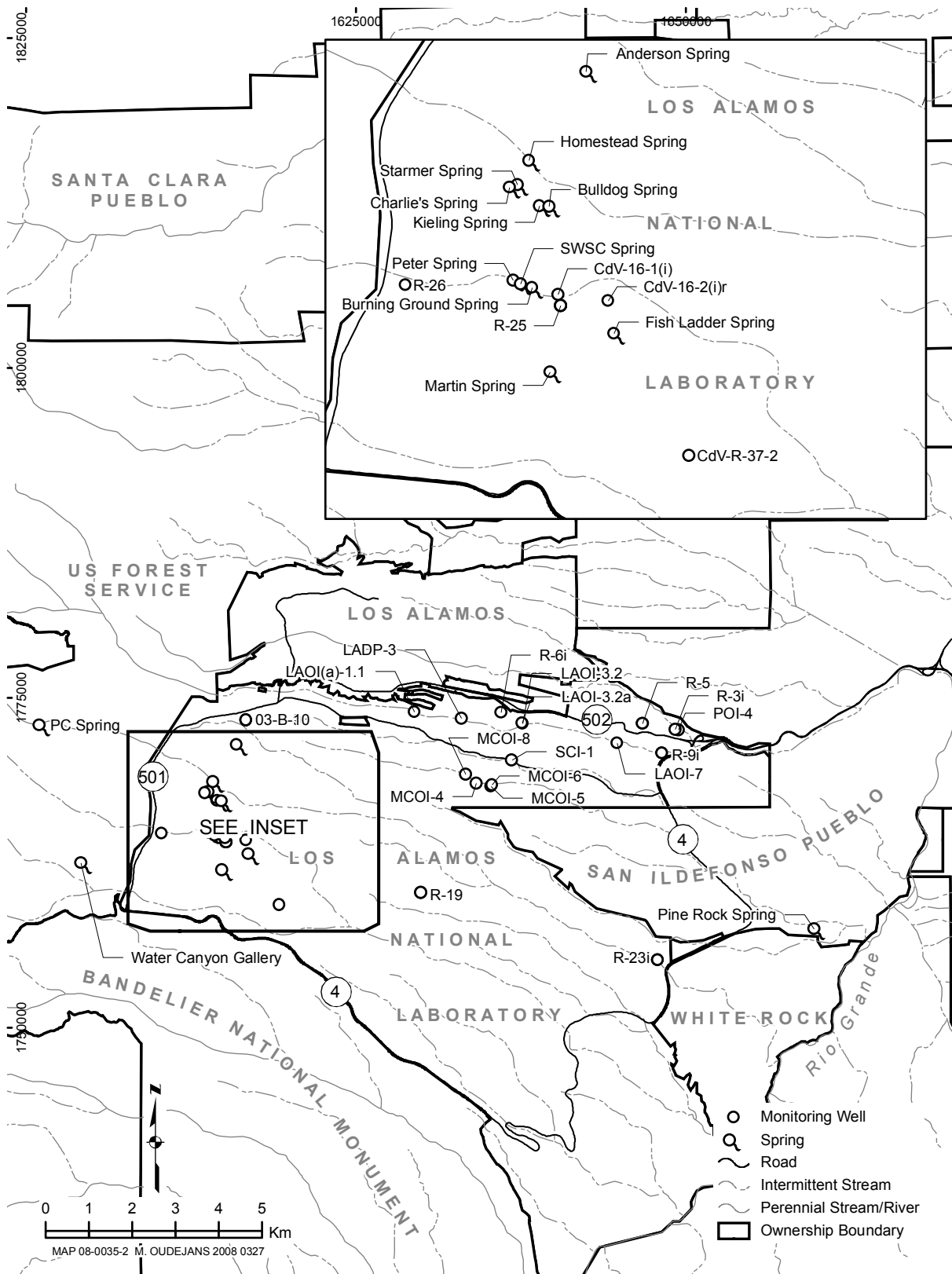


Figure 5-6. Springs and wells used for intermediate-depth perched zone monitoring.

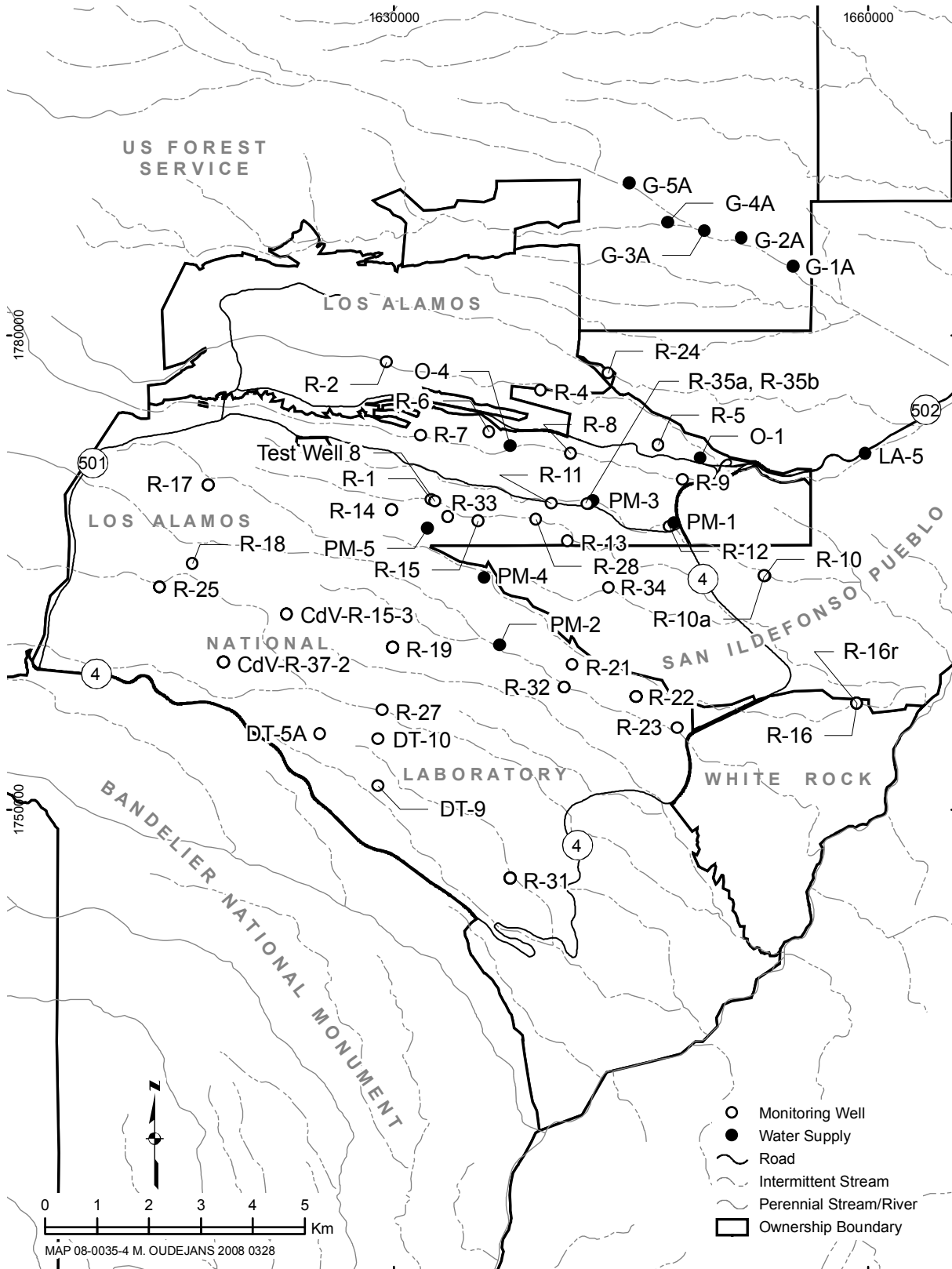


Figure 5-7. Wells used for regional aquifer monitoring.

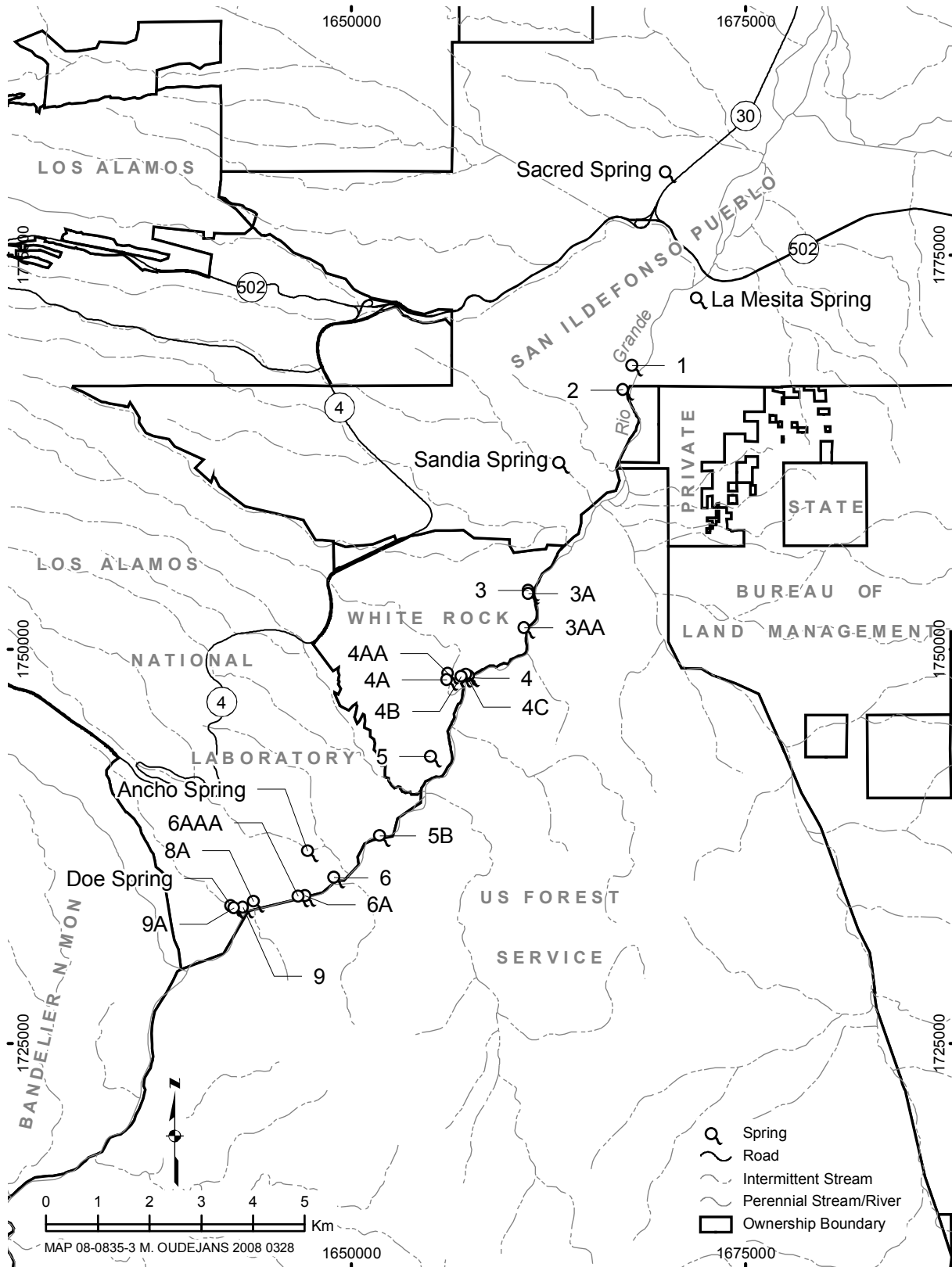


Figure 5-8. Springs used for regional aquifer monitoring.

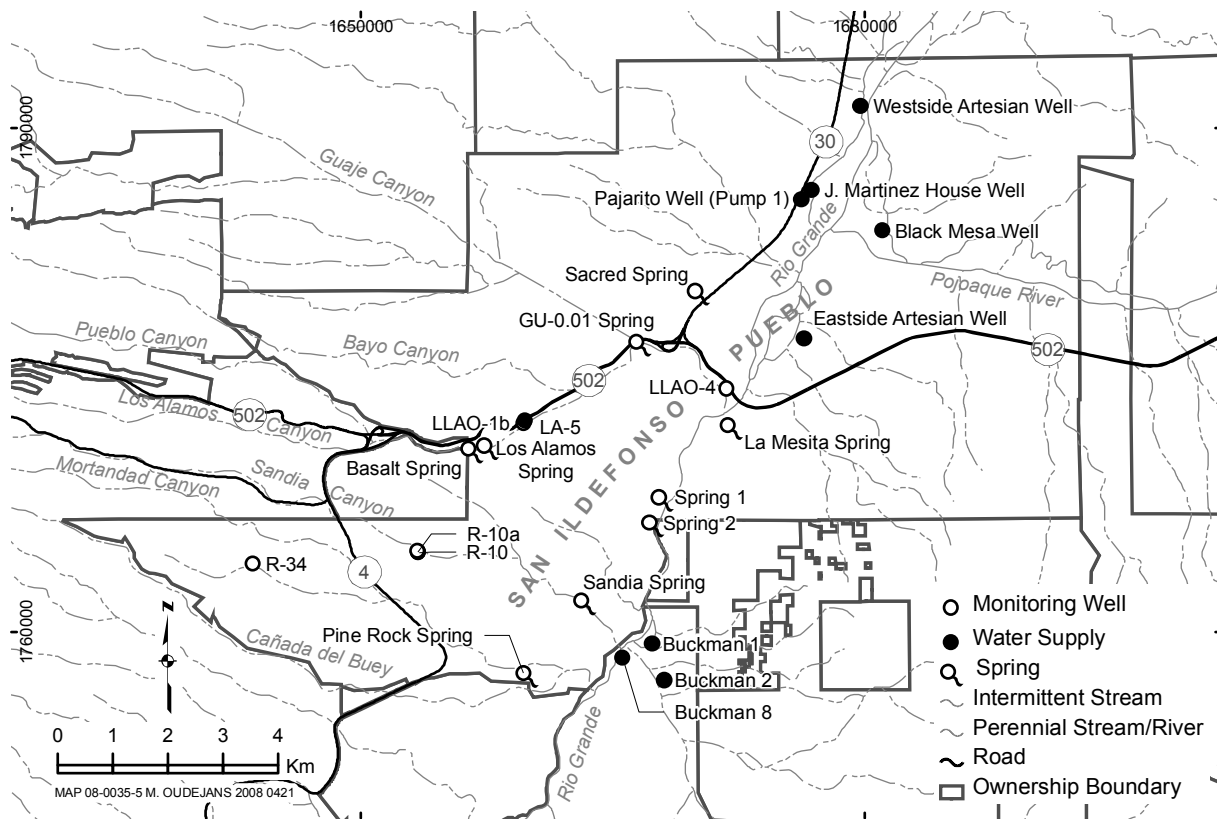


Figure 5-9. Springs and wells used for groundwater monitoring at the City of Santa Fe Buckman well field and on Pueblo de San Ildefonso lands.

The Laboratory collected samples from 12 Los Alamos County water supply wells in three well fields that produce drinking water for the Laboratory and the community. The water supply wells are screened up to lengths of 1,600 ft within the regional aquifer, and the wells draw samples that integrate water over a large depth range. Los Alamos County owns and operates these wells. The County is responsible for demonstrating that the supply system meets Safe Drinking Water Act requirements. This chapter reports on supplemental sampling of those wells by the Laboratory.

Additional regional aquifer samples came from wells located on Pueblo de San Ildefonso lands and from the Buckman well field operated by the City of Santa Fe.

We sample numerous springs near the Rio Grande because they represent natural discharge from the regional aquifer (Purtymun et al., 1980). Sampling the springs allows us to detect possible discharge of contaminated groundwater from underneath the Laboratory into the Rio Grande.

2. Alluvial Groundwater Monitoring

To determine the effect of present and past industrial discharges on water quality, we used shallow wells and some springs to sample perched alluvial groundwater in several canyons. In any given year, some of these alluvial observation wells may be dry, and water samples cannot be obtained. Some observation wells in Water, Fence, and Sandia Canyons have been dry most often since their installation in 1989. All but one of the wells in Cañada del Buey are generally dry.

3. Well Sampling Issues

In some LANL characterization wells, the use of fluids to assist well drilling has affected the chemistry of groundwater samples. From 1998 through 2006, more than 40 new wells were drilled for hydrogeologic characterization beneath the Pajarito Plateau as part of the Laboratory's Hydrogeologic Workplan (LANL 1998) or as part of corrective measures. Of these wells, some have screens in perched intermediate zones, most have screens in the regional aquifer, and a few have screens in both perched intermediate zones and the regional aquifer. Concerns about the reliability or representativeness of the groundwater quality data obtained from these wells stem from the potential for residual drilling fluids and additives to mask the present and future detection of contaminants.

New wells (e.g., regional aquifer wells R-35 and R-36 drilled in 2007 and 2008, respectively) are drilled without the use of drilling fluids and also undergo extensive well development to reduce the turbidity of water samples.

NMED approved a well screen analysis methodology set forth in the Well Screen Analysis Report (LANL 2007c). The methodology relies on comparing well water quality data for certain chemical species that can be affected by drilling fluids at their natural background ranges. The well screen analysis methodology now provides a means of (1) marking historical data for drilling fluid effects, (2) determining trends in improvement of degradation of well screen water quality for monitoring purposes, and (3) determining the condition of screens undergoing redevelopment and rehabilitation.

In 2007, three wells underwent redevelopment: R-32, R-12, and R-20. These wells were selected for redevelopment because of their important locations for groundwater monitoring. Physical redevelopment methods included jetting, swabbing, and extensive pumping. All of the wells were converted to dual- or single-screen wells. The preferred sampling system installed in dual-screen wells is the Baski system, which allows active purging while sampling, as do submersible pumps in single-screen wells. A summary of redevelopment results for each of the wells is as follows:

- R-32 was converted from a three-screen well to a single-screen well with a dedicated submersible pump. Its water quality is very good (that is, unaffected by drilling impacts), as determined by analysis of geochemical parameters (LANL 2007d).
- R-12 was converted from a three-screen to a dual-screen well with a Baski sampling system. The top two screens that were retained improved in water quality and the top screen also improved in hydraulic properties. Their water quality is now good (LANL 2008a).
- R-20 was converted from a three-screen to a dual-screen well with a Baski sampling system. The top two screens that were retained improved in water quality and in hydraulic properties. Their water quality is now very good (LANL 2008b).

E. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables for this chapter present groundwater monitoring data for 2007. Columns on the data tables identify the groundwater zones sampled—whether alluvial, intermediate, or regional; the latter includes water supply wells—or indicate if the location is a spring. For wells with several sampling ports, the depth and groundwater zone sampled for each port appear in the table. For single-screen wells, the depth of screen top is given. Springs have a depth of 0 ft, and wells with unknown depth list a value of -1. Supplemental Data Table S5-1 provides definitions for sample description codes used in the data tables.

Table S5-2 lists the results of radiochemical analyses of groundwater samples for 2007. The table also gives the total propagated one-sigma (one standard deviation) analytical uncertainty and the analysis-specific minimum detectable activity (MDA), where available. A "<" symbol indicates that based on the analytical laboratory or secondary validation qualifiers the result was a nondetect. Uranium was analyzed by chemical methods and by isotopic methods. Table S5-3 shows low-detection-limit tritium results from analyses done by the University of Miami.

Table S5-4 lists radionuclides detected in groundwater samples, as reported by the analytical laboratory. For most radionuclide measurements, we reported a detection as an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (which indicates that the result is a nondetect). The analytical laboratory reports a result as detected that is greater than the measurement-specific MDA. University of Miami contract laboratory tritium data do not have laboratory qualifiers; in that case, a result is reported as detected when analytical results are greater than three times the reported (one-sigma) uncertainty.

Data with qualifier codes other than X or U are shown in Table S5-4 to provide additional information on analytical results; in some cases, for example, the analyte was found in the laboratory blank, or there were other analytical quality issues. The table shows two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Table S5-5, Table S5-6, and Table S5-7). After we received the analytical laboratory data packages, an independent contractor performed a secondary validation on the packages, Analytical Quality Associates, Inc. (AQA). The reviews by AQA include verifying that holding times were met, that all documentation is present, and that analytical laboratory quality control measures were applied, documented, and kept within contract requirements.

Because uranium, gross alpha, and gross beta are usually detected in water samples and to focus on the higher measurements, Table S5-4 only includes occurrences of these measurements above threshold values (all of the results are included in Table S5-2). We selected threshold levels of 5 µg/L for uranium, 5 pCi/L for gross alpha, and 20 pCi/L for gross beta, which are lower than the respective EPA MCLs or screening levels (30 µg/L for uranium, 15 pCi/L for gross alpha, and 50 pCi/L for gross beta). The right-hand columns of Table S5-4 compare results with the regulatory standards or screening levels listed on the table.

Table S5-8 lists the results of general chemical analyses of groundwater samples for 2007. Table S5-9 lists groundwater perchlorate results. We analyzed samples for perchlorate using two methods. This table includes all perchlorate results determined by the liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) method (now EPA 6850 Modified, formerly SW-846:8321A[M]) and all detections by the ion chromatography (IC) method (EPA:314.0). The method detection limit (MDL) for the IC method is 4 µg/L; the LC/MS/MS method MDL is 0.05 µg/L or larger if the sample had higher concentrations and was analyzed using sample dilution. During part of 2007, we used both methods until LC/MS/MS by SW-846 6850 (or EPA 6850 Modified) for perchlorate was officially promulgated by the EPA. The results of trace metal analyses appear in Table S5-10.

As part of the well rehabilitation project discussed earlier, three wells (R-32, R-20, R-12) underwent redevelopment, testing, or sampling during 2007 to improve and evaluate water sample quality. Results for those tests and accompanying sampling are covered in separate reports (LANL 2007d, 2008a, 2008b, 2008c) but are not included here.

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that cross the Laboratory. The accompanying maps depict the location of detected groundwater contaminants. The maps provide a spatial context for distribution of groundwater contamination. Rather than showing data for 2007 alone, the maps represent a synthesis of the last several years of groundwater data collected by Laboratory groundwater monitoring and characterization programs.

The contaminant distribution maps show contaminant locations extrapolated beyond the area covered by monitoring wells. This extrapolation takes into account the location of contaminant sources and direction of groundwater flow. Question marks on the maps indicate where contaminant extent is inferred but not confirmed by monitoring coverage. For alluvial groundwater in canyons, the extent of contamination lateral to the canyon is not to scale; contaminated groundwater is confined to the canyon bottom alluvium and is quite narrow at the map scale.

1. Organic Chemicals in Groundwater

In 2007, we analyzed samples from selected springs and monitoring wells for organic chemicals. Table S5-11 summarizes the stations sampled and organic chemical suites for which samples were analyzed. These samples were analyzed for some or all of the following organic chemical suites: volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls (PCBs), pesticides, diesel-range organics (DRO), and HE. The Quality Assurance (QA) section of this chapter (Section G) covers analytes and analytical methods. Many of the possible organic chemical detections that the analytical laboratory reported were rejected because the compounds were either detected in method blanks (that is, they were introduced during laboratory analysis) or were detected in field quality control (QC) samples, including equipment, field, and trip blanks. Equipment blanks use distilled water with which sampling equipment is rinsed before sampling to check for organic chemical contamination acquired during sampling. Trip blanks accompany samples during sample storage, and shipment to determine if organic contamination occurs. Table S5-12 shows organic chemicals detected in 2007 and results from field QC samples.

A large number of groundwater samples were analyzed for dioxins and furans in 2007. Only two of these compounds (hexachlorodibenzodioxin[1,2,3,7,8,9-] and tetrachlorodibenzodioxin[2,3,7,8]) have screening levels or regulatory standards. These screening values are about the same magnitude as the detection limits. The analytical method is quite sensitive and these compounds were found near the detection limit in a large number of samples. See Section G, Quality Assurance, below, for more discussion on this topic.

a. Organic Chemical Sample Quality Control Program

Because of the sensitive nature of organic chemical sampling and analysis, a carefully designed field and analytical laboratory quality control program is essential for evaluating the presence of organic chemicals in environmental samples. Organic analytes may be detected in field quality control samples such as field blanks or equipment blanks, indicating that they are not truly present in associated groundwater samples. These analytes may be present in the quality control samples because of inadvertent contamination of sampling or analytical laboratory equipment by organic chemicals that come from other sources.

Most analytical methods require the analysis of laboratory-prepared method blanks or instrument blanks with each batch of samples. Target organic chemicals that are detected in these blanks indicate contamination from the sampling or analytical environments. Certain organic compounds used in analytical laboratories are frequently detected in laboratory blanks, that is, contamination introduced by the analytical process is common for these compounds. These compounds include acetone, methylene chloride, toluene, 2-butanone, di-n-butyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl)phthalate (Fetter 1993). Numerous field, trip, and equipment blanks collected during this reporting period contained toluene, acetone, butanone[2-], and hexanone[2-], which indicates inadvertent sample contamination in either the field or analytical laboratory.

2. Radioactivity in Groundwater

The principal radioactive element detected in the regional aquifer is naturally occurring uranium, found at higher concentrations in springs and wells throughout the Rio Grande Valley. The large gross alpha values found in samples from these springs and wells result from the decay of naturally occurring uranium in the water. Other naturally occurring radioactivity in groundwater samples comes from members of the uranium-235, uranium-238, and thorium-232 decay chains. Potassium-40 is also a source of natural radioactivity.

In 2007, other than for naturally occurring radionuclides (for example, radium-226, and uranium-234), no water supply radioactivity analyte activity or concentration value exceeded any regulatory standard including the 4-mrem DOE DCGs applicable to drinking water. While there are no applicable standards for radioactivity from a DOE (LANL) source in the regional aquifer, other radioactivity results greater than standards are shown in Table 5-2.

Table 5-2
Radioactivity Results Near Screening Levels in Regional Aquifer Groundwater for 2007

Chemical	Location	Result	Trends
Americium-241	R-18 in Pajarito Canyon	1.31 pCi/L, above 4-mrem DCG screening level of 1.2 pCi/L	False positive; not found in reanalysis or nine other samples analyzed in 2007
Gross beta	R-22 at 1273 ft in Pajarito Canyon	71 pCi/L, above EPA drinking water screening level of 50 pCi/L	False positive; average of four other results for 2007 is 6.7 pCi/L
Radium-228	R-25 at 1796 ft in Water Canyon	14.5 pCi/L, above EPA MCL screening level of 5 pCi/L	Naturally occurring; first measurement in well; shallower screens all nondetect
Gross alpha and uranium	City of Santa Fe Buckman well field	Results above EPA MCLs	Uranium is naturally occurring; drinking water system compliance achieved by mixing with water from other wells

Pine Rock Spring, which flows from intermediate groundwater on Pueblo de San Ildefonso lands, had a uranium concentration near the NM groundwater standard. The high uranium value may be due to dissolution of uranium from the bedrock by sanitary effluent, which is used to water athletic fields at nearby Overlook Park (Teerlink 2007). While there are no applicable standards for radioactivity from a DOE (LANL) source in intermediate groundwater, other radioactivity results near standards are shown in Table 5-3. For well and spring samples from intermediate perched groundwater, only a gross beta result at Charlie's Spring in Pajarito Canyon exceeded the 4-mrem DOE DCG screening levels.

Table 5-3
Radioactivity Results Near Screening Levels in Intermediate Groundwater for 2007

Chemical	Location	Result	Trends
Gross beta	Charlie's Spring in Pajarito Canyon	55 pCi/L, above EPA drinking water screening level of 50 pCi/L	High value; four other results for 2007 are mainly nondetect
Tritium	MCOI-4, MCOI-5, MCOI-6 in Mortandad Canyon	4,000 to 13,000 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values steady over three years of sampling; wells sample separate isolated perched zones
Uranium	Pine Rock Spring (Pueblo de San Ildefonso)	29.6 µg/L, below NM groundwater standard of 30 µg/L	Steady over two years, may be leached from bedrock by percolation of sanitary effluent used to irrigate Overlook Park athletic fields

There are no applicable groundwater standards for radioactivity from a DOE (LANL) source in perched alluvial groundwater. However, for comparison purposes, results for strontium-90 in Los Alamos and Mortandad Canyons were near or exceeded the 4-mrem DOE DCGs and EPA MCL screening levels (Table 5-4, Figures 5-10 and 5-11). The gross beta activity in these wells and spring is likely due to presence of strontium-90. Strontium-90 has a half-life of approximately 28.8 years, slightly more than twice as long as the half-life of tritium (12.3 years).

3. Tritium in Groundwater

Tritium is an important contaminant to monitor at LANL because it was discharged in some effluents and travels readily through groundwater. However, tritium activity decreases rapidly due to radioactive decay, with a half-life of 12.3 years. Groundwater with tritium activity below approximately 1.6 pCi/L is probably old and isolated from surface recharge. The age of such groundwater is more than 3,000 years, but large dating uncertainties may be associated with small tritium activities (Blake et al., 1995).

Table 5-4
Radioactivity Results Near Screening Levels in Alluvial Groundwater for 2007

Chemical	Location	Result	Trends
Strontium-90	One spring and four wells in DP and Los Alamos Canyons	8 pCi/L to 62 pCi/L, above EPA drinking water screening level of 50 pCi/L and 40 pCi/L 4-mrem DOE DCG screening level	Decreased since cessation of discharges in 1986, now stable due to retention on sediments
Gross beta	One spring and two wells in DP and Los Alamos Canyons	53 pCi/L to 143 pCi/L, above EPA drinking water screening level of 50 pCi/L	Gross beta mainly due to presence of strontium-90
Strontium-90	Three wells in Mortandad Canyon	41 pCi/L to 65 pCi/L, above EPA drinking water screening level of 50 pCi/L and 40 pCi/L 4-mrem DOE DCG screening level	Fairly stable for 10 years due to retention on sediments
Gross beta	Three wells in Mortandad Canyon	105 pCi/L to 150 pCi/L, above EPA drinking water screening level of 50 pCi/L	Gross beta mainly due to presence of strontium-90

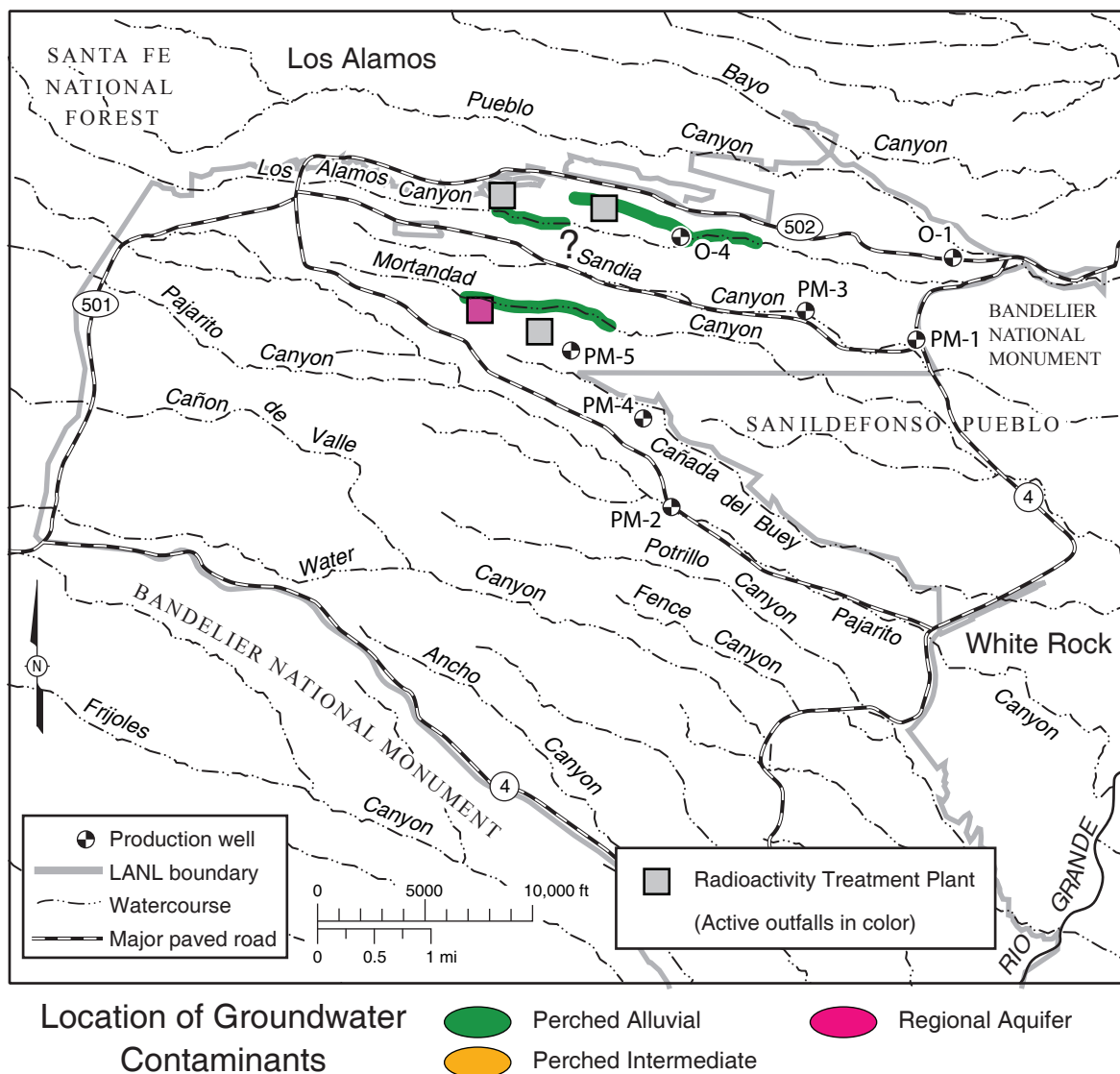


Figure 5-10. Location of groundwater contaminated by strontium-90: while there is no applicable groundwater standard, for comparison purposes, the area indicated has Sr-90 activity above the 8 pCi/L EPA MCL screening level. Different colors indicate the affected groundwater zones. Along canyons, the extent of alluvial groundwater contamination lateral to the canyon is not to scale; contamination is confined to the alluvium within the canyon bottom and is narrow at the map scale.

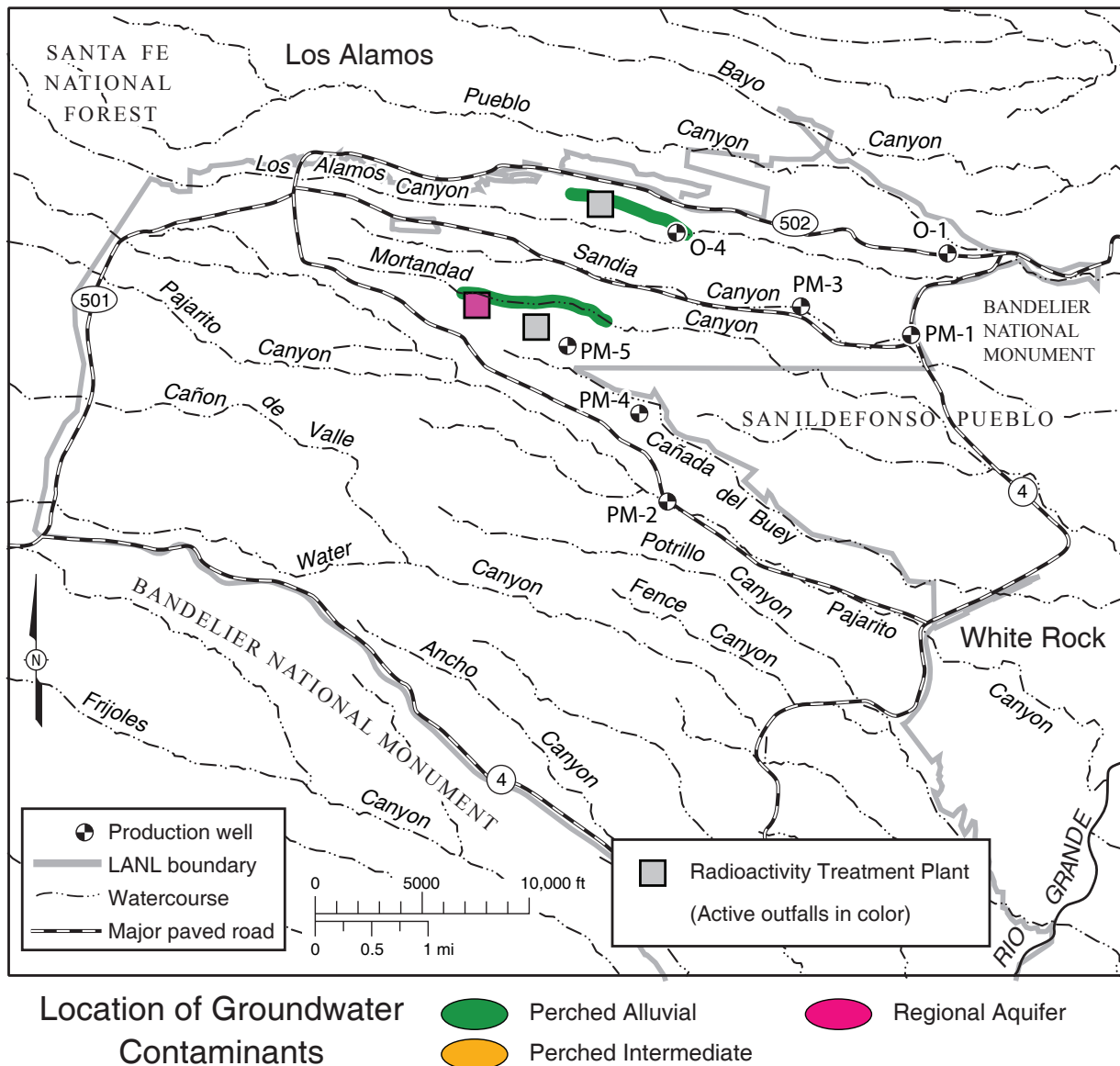


Figure 5-11. Location of groundwater contaminated by radioactivity. While there is no applicable groundwater standard, for comparison purposes, samples from the area indicated have the sum of Sr-90, Pu-238, Pu-239/240, and Am-241 above the 4-mrem DOE DCG screening level. Different colors indicate the affected groundwater zones.

4. Perchlorate in Groundwater

Perchlorate is an important contaminant to monitor at LANL because it was discharged in some effluents and travels readily through groundwater. During the last decade, the EPA recognized the potential for perchlorate toxicity at concentrations in the range of $1\ \mu\text{g/L}$ to $100\ \mu\text{g/L}$. Based on a recent toxicity assessment by the National Academy of Sciences, the EPA set a DWEL of $24.5\ \mu\text{g/L}$ for perchlorate in 2006. The Consent Order mandates a $4\ \mu\text{g/L}$ screening level for perchlorate. Several studies indicate that perchlorate occurs naturally in groundwater of arid regions due to atmospheric deposition and other sources. Plummer et al. (2006) found perchlorate concentrations ranging from $0.12\ \mu\text{g/L}$ to $1.8\ \mu\text{g/L}$ in samples of north-central NM groundwater that have ages predating anthropogenic influence and that are not affected by industrial perchlorate sources. Perchlorate concentrations in Mortandad Canyon groundwater are considerably above background as a result of past effluent discharges. Otherwise perchlorate concentrations are near the values found by Plummer et al. (2006).

5. Metals in Groundwater

In 2005, LANL found hexavalent chromium in Mortandad Canyon regional aquifer monitoring well samples at levels above the NM groundwater standard and in intermediate-depth groundwater at levels just below the NM groundwater standard. Hexavalent chromium has also been found in Sandia Canyon regional aquifer well R-11 as discussed below. In alluvial groundwater beneath Cañon de Valle, barium occurs at concentrations above the NM groundwater standard. Molybdenum concentrations have been near the NM groundwater standard (for irrigation use) in Los Alamos Canyon alluvial groundwater for more than a decade. Other metals occur in groundwater at concentrations near or above regulatory standards. This may be because of issues related to well sampling and well construction, rather than being from LANL releases.

In addition to the effect of drilling fluids, well samples may have relatively high turbidity. The presence of residual aquifer or soil material in groundwater samples leads to detection of metals such as aluminum, iron, and manganese, which are primary constituents of the silicate and other minerals that make up the aquifer framework. The effects of turbidity on water quality are also seen in many samples from alluvial wells and springs (in the case of springs, because they incorporate surrounding soil material).

The older LANL test wells (Test Well 8, DT-5A, DT-9, and DT-10) have steel casings and galvanized metal well fittings that are subject to rust and metal flaking. Over time and with wear, corrosion, and work on the wells, water samples have shown increasing content of metals like iron, lead, manganese, and zinc.

F. GROUNDWATER SAMPLING RESULTS BY WATERSHED

1. 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 (Table 5-5). The Guaje well field, located northeast of the Laboratory, contains five water supply wells. Naturally occurring arsenic has been found in this well field at similar levels since the field was developed in the early 1950s (Table 5-6). Rendija and Barrancas Canyons have seen little past Laboratory activity, have only ephemeral surface water, and have no known alluvial or intermediate groundwater.

Table 5-5
Summary of Groundwater Contamination in Guaje Canyon (includes Rendija and Barrancas Canyons)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Guaje, Rendija, and Barrancas Canyons	Minor dry sources	None, alluvial groundwater only in upper Guaje Canyon	No intermediate groundwater	Natural arsenic above EPA MCL

Table 5-6
Groundwater Quality in Guaje Canyon (includes Rendija and Barrancas Canyons)

Chemical	Location	Result	Trends
Arsenic	Regional aquifer water supply well G-2A	10.4 µg/L, above EPA MCL of 10 µg/L; NM groundwater standard is 100 µg/L	Sporadic values above EPA MCL for many years in this well field

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

Bayo Canyon contained a now-decommissioned firing site. The canyon has only ephemeral surface water, and no known alluvial or intermediate groundwater (Table 5-7).

Table 5-7
Summary of Groundwater Contamination in Los Alamos Canyon
(includes Bayo, Acid, Pueblo, and DP Canyons)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Bayo Canyon	Minor past dry and liquid sources	No alluvial groundwater	No intermediate groundwater	None
Pueblo and Acid Canyons	Multiple past effluent discharges, current sanitary effluent	Chloride at 50% and total dissolved solids (TDS) at 80% of NM groundwater standard	Nitrate at 75% of NM GW Std., fluoride at 70% of NM GW Std.	Trace fluoride, perchlorate, and nitrate
Los Alamos and DP Canyons	Multiple past effluent discharges	Strontium-90 above 4 mrem DCG screening level, chloride and TDS above NM groundwater standard, fluoride at 50% of NM groundwater standard, trace perchlorate and molybdenum	Tritium at 20% of EPA MCL screening level, trace nitrate, fluoride, perchlorate	None
Lower Los Alamos Canyon	Multiple past effluent discharges	Nitrate above NM groundwater standard	Nitrate at 70% of NM groundwater standard, natural fluoride at 55% of NM groundwater standard	None

Pueblo Canyon receives effluent from the LACWTP. Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Little radioactivity is found in current groundwater samples. Tritium, nitrate, fluoride, and perchlorate results from regional aquifer groundwater in this canyon, though below standards, indicate the lingering influence of past discharges from radioactive wastewater outfalls in Acid Canyon. In the case of nitrate in regional aquifer wells, the source may also be from past sanitary effluent discharges in the upper part of the canyon. High nitrate concentrations found in alluvial and intermediate groundwater in lower Pueblo Canyon and downstream in lower Los Alamos Canyon may be due to sanitary effluent from the former Los Alamos County Bayo Sewage Treatment Plant.

Los Alamos Canyon received releases of radioactive effluents during the earliest Manhattan Project operations at Technical Area (TA)-1 (1942–1945) and until 1993 from nuclear reactors at TA-2. From 1952 to 1986, a liquid-waste treatment plant discharged effluent containing radionuclides from the former plutonium-processing facility at TA-21 into DP Canyon, a tributary to Los Alamos Canyon. Los Alamos Canyon also received radionuclides and metals in discharges from the sanitary sewage lagoons and cooling towers at the Los Alamos Neutron Science Center (LANSCE) at TA-53. Except for strontium-90, contaminant concentrations in shallow groundwater have decreased dramatically over the years.

a. Pueblo Canyon

The levels of tritium, perchlorate, and nitrate for water supply well O-1, though below standards or screening levels, indicate the presence of past effluent and surface water recharge in the regional aquifer (Table 5-8). Because of the perchlorate concentrations, the well is not used by Los Alamos County for water supply, although the concentrations are below the EPA DWEL of 24.5 µg/L.

Only one Pueblo Canyon regional aquifer monitoring well, R-4, located downstream from the former Acid Canyon outfall, shows low-detection-limit tritium values indicative of past discharges. The values range up to 53 pCi/L. Two regional aquifer wells (R-4 and R-5) show fluoride values higher than those in unaffected wells, but the results are below the NM groundwater standard (Figure 5-12).

Table 5-8
Groundwater Quality in Pueblo Canyon (includes Acid Canyon)

Chemical	Location	Result	Trends
Tritium	Water supply well O-1	14 pCi/L, below EPA MCL of 20,000 pCi/L	Reduced from about 40 pCi/L since 2004
Tritium	Regional aquifer monitoring well R-4	53 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Results higher than unaffected wells, fairly steady for three years of sampling
Perchlorate	Water supply well O-1	1.3 µg/L to 2.3 µg/L, below EPA DWEL of 24.5 µg/L	Small decrease since 2004
Perchlorate	Regional aquifer monitoring well R-4	2.5 µg/L to 4.3 µg/L, below EPA DWEL of 24.5 µg/L	Results higher than unaffected wells, vary by factor of two during five years of sampling
Fluoride	Regional aquifer monitoring wells R-4 and R-5	0.66 mg/L to 0.71 mg/L, below NM groundwater standard of 1.6 mg/L	Results higher than unaffected wells, fairly steady for three to four years of sampling
Nitrate (as Nitrogen [N])	Regional aquifer monitoring wells R-4 and R-5	1.0 mg/L to 2.4 mg/L, below NM groundwater standard of 10 mg/L	Results higher than unaffected wells, fairly steady for three to four years of sampling
Uranium	Intermediate monitoring well R-3i	8.5 µg/L to 10 µg/L, below NM groundwater standard of 30 µg/L	May be leached from bedrock by percolation of sanitary effluent; steady over two years of sampling
Fluoride	Intermediate monitoring well R-5 at 384 ft	1.05 mg/L, below NM groundwater standard of 1.6 mg/L	Results fairly steady for four years of sampling
Nitrate (as N)	Intermediate monitoring well POI-4	7.5 mg/L, below NM groundwater standard of 10 mg/L	Concentrations nearly doubled over 11 years of sampling
Perchlorate	Alluvial monitoring wells PAO-4, APCO-1	4.4 µg/L to 15.7 µg/L, below EPA DWEL of 24.5 µg/L	False positives by IC method due to analytical interference; results by more sensitive LC/MS/MS method were nondetections; results with latter method below 0.1 µg/L for three to four years at each location
Chloride	Alluvial monitoring well PAO-2	135 mg/L, below NM groundwater standard of 250 mg/L	Highest result in two years of sampling; four measurements; no trend
Total Dissolved Solids (TDS)	Alluvial monitoring well PAO-1	773 mg/L, below NM groundwater standard of 1,000 mg/L	Highest result in four years of sampling, otherwise steady at about 240 mg/L
Turbidity	Alluvial monitoring wells PAO-1, PAO-2, APCO-1	1.1 Nephelometric Turbidity Units (NTU) to 8.8 NTU	Lower than flood-affected 2006 results of 10.7 NTU to 84.5 NTU
Plutonium-239/240	Alluvial monitoring wells PAO-2, APCO-1	Unfiltered results of 0.14 to 0.24 pCi/L	Lower than flood-affected 2006 results of 1.2 to 1.5 pCi/L, above earlier values, which are mainly nondetections over seven and 10 years of samples

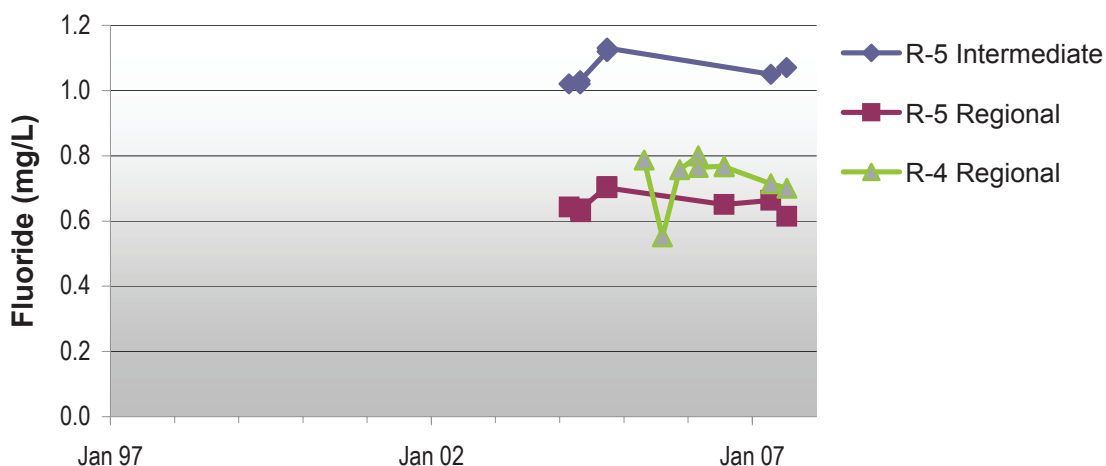


Figure 5-12. Fluoride in Pueblo Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 1.6 mg/L.

Intermediate groundwater also shows the effects of past effluent releases, with concentrations near standards of nitrate and fluoride (Figures 5-13 and 5-14). The nitrate concentration in intermediate well POI-4 has nearly doubled over 11 years of sampling (Figure 5-15). An intermediate port in regional aquifer well R-5 shows fluoride values higher than that in unaffected wells, but the results are below the NM groundwater standard (Figure 5-12). The uranium concentrations in samples from Pueblo Canyon intermediate well R-3i ranged from 8.5 $\mu\text{g/L}$ to 10 $\mu\text{g/L}$, above levels in unaffected wells but below standards. The higher uranium may result from dissolution of uranium from surrounding bedrock by sanitary or other effluent (Teerlink 2007).

On several days in August 2006 (including August 7, 8, and 25) large rainstorms caused significant runoff in Pueblo Canyon. All of the alluvial wells were flooded and PAO-3 was washed away. Several of these wells were sampled immediately after flooding (on August 8 and 10, 2006). The samples showed unusually high turbidity and unfiltered plutonium-239/240 results. Turbidity measured in 2007 had returned to usual ranges. The 2006 unfiltered plutonium-239/240 activities in PAO-2 and APCO-1 were, for comparison purposes in absence of an applicable groundwater standard, near or above the 4-mrem DOE DCG screening level of 1.2 pCi/L. The 2007 plutonium-239/240 results were much lower, but were still above prior results. Prior samples had plutonium-239/240 results that were mainly nondetections.



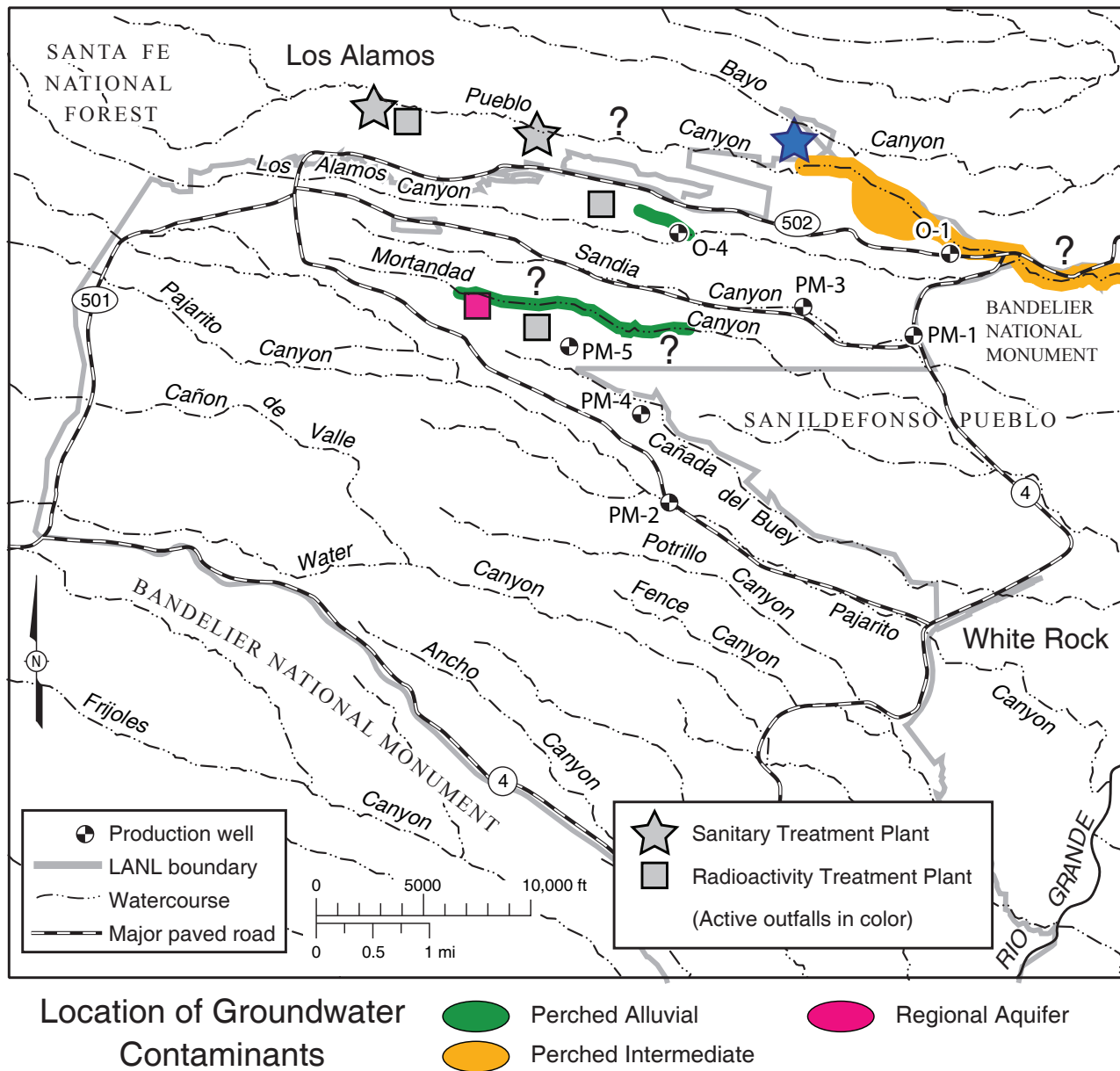


Figure 5-13. Location of groundwater containing fluoride above one half of the 1.6 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

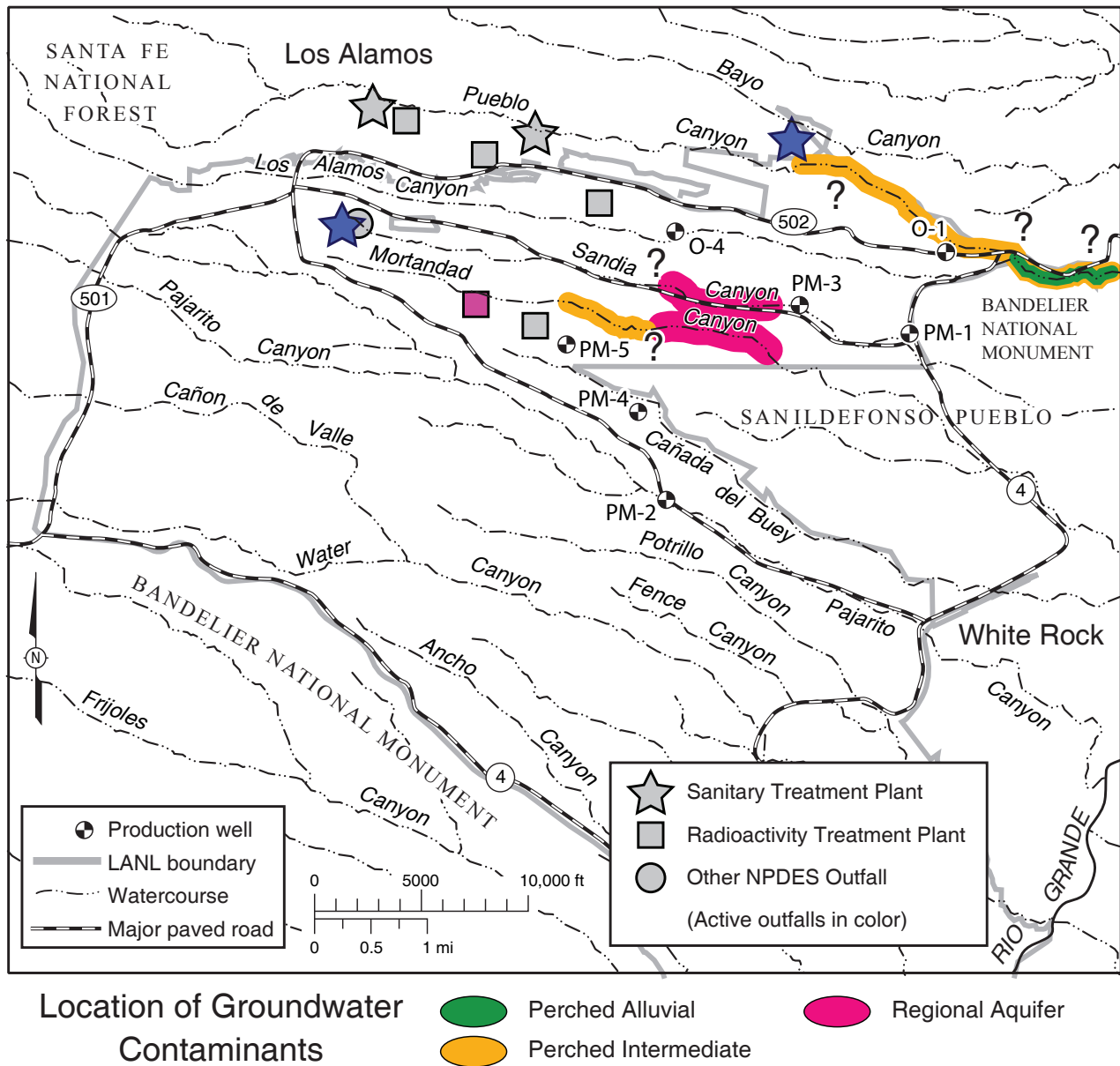


Figure 5-14. Location of groundwater containing nitrate (as nitrogen) above one half of the 10 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones.

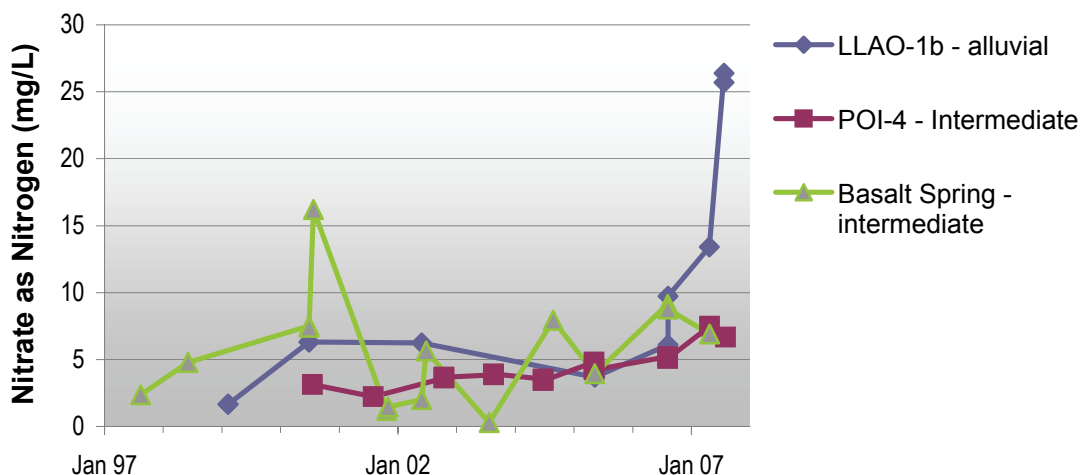


Figure 5-15. Nitrate (as nitrogen) in Pueblo and lower Los Alamos Canyon alluvial and intermediate groundwater. The NM groundwater standard is 10 mg/L.

b. Los Alamos Canyon

Alluvial and intermediate groundwater in Los Alamos Canyon show effects of past effluent releases (Table 5-9).

Table 5-9
Groundwater Quality in Los Alamos Canyon (includes DP Canyon)

Chemical	Location	Result	Trends
Tritium	Five intermediate wells	150 pCi/L to 4250 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Highest activities in R-6i, LAOI-3.2, LAOI-3.2a; increasing in LAOI-3.2
Nitrate (as N)	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a	2.3 mg/L to 4.8 mg/L, below NM groundwater standard of 10 mg/L	Increasing in LAOI-3.2
Perchlorate	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a	3.4 µg/L to 9.0 µg/L, below EPA DWEL of 24.5 µg/L	Increasing in LAOI-3.2
Strontium-90	One alluvial spring and four alluvial wells	8 pCi/L to 62 pCi/L, above EPA drinking water screening level of 50 pCi/L and 40 pCi/L 4-mrem DOE DCG screening level	Decreased since cessation of discharges in 1986, now stable due to retention on sediments
Gross beta	One alluvial spring and two alluvial wells	53 pCi/L to 143 pCi/L, above EPA drinking water screening level of 50 pCi/L	Gross beta mainly due to presence of strontium-90
Fluoride	Alluvial wells LAUZ-1, LAO-2, LAO-3a	0.6 to 0.81 mg/L, below NM groundwater standard of 1.6 mg/L	Some fluctuation but present in each well for 10 years
Chloride	Alluvial well LAUZ-1	506 mg/L, above NM groundwater standard of 250 mg/L	Highest result in 12 years of monitoring, second result above standard
TDS	Alluvial well LAUZ-1	1,160 mg/L, above NM groundwater standard of 1000 mg/L	Highest result in three years of measurement, twice prior values
Perchlorate	Alluvial well LAO-0.6	0.15 µg/L to 8.5 µg/L, below EPA DWEL of 24.5 µg/L	Highest results over three total sample events
Molybdenum	Alluvial wells LAO-2, LAO-3a	338 µg/L to 350 µg/L, below NM groundwater standard of 1,000 µg/L	Last above standard in 2004; concentrations decreasing due to outfall improvement
Nitrate (as N)	Intermediate Basalt Spring	6.9 mg/L, below NM groundwater standard of 10 mg/L	Apparent result of discharge from Bayo Sanitary Treatment Plant (STP)
Nitrate (as N)	Alluvial well LLAO-1b	13 mg/L to 26 mg/L, above NM groundwater standard of 10 mg/L	Large increase in last two years; apparent result of discharge from Bayo STP

Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 4,250 pCi/L of tritium. These moderate values indicate a residual impact of past effluent discharges; the wells lie downstream from the former radioactive liquid waste discharge from TA-21 in DP Canyon (Figure 5-16). Nitrate (as nitrogen) concentrations in these wells have increased over the period of sampling (Figure 5-17) but are below the 10 mg/L NM groundwater standard.

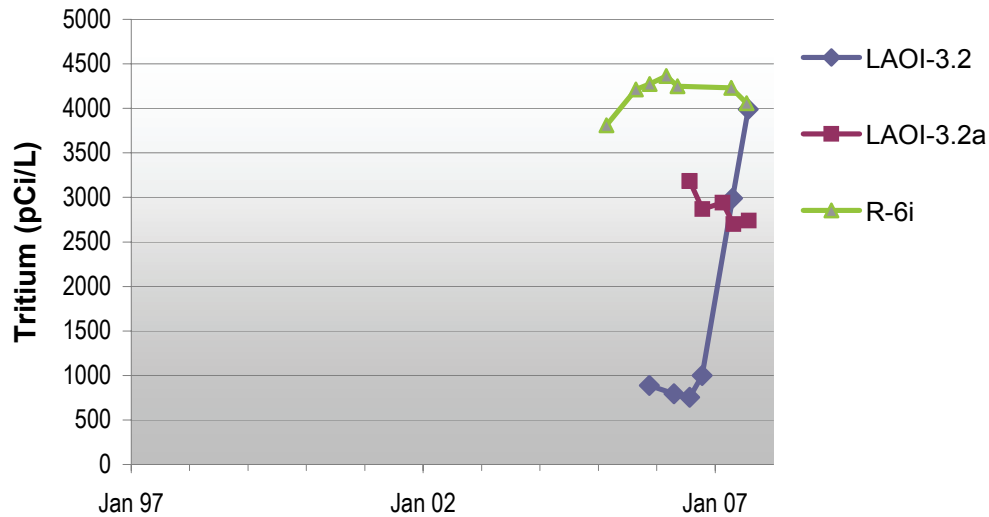


Figure 5-16. Tritium in Los Alamos Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level (which does not apply to these samples) is 20,000 pCi/L.

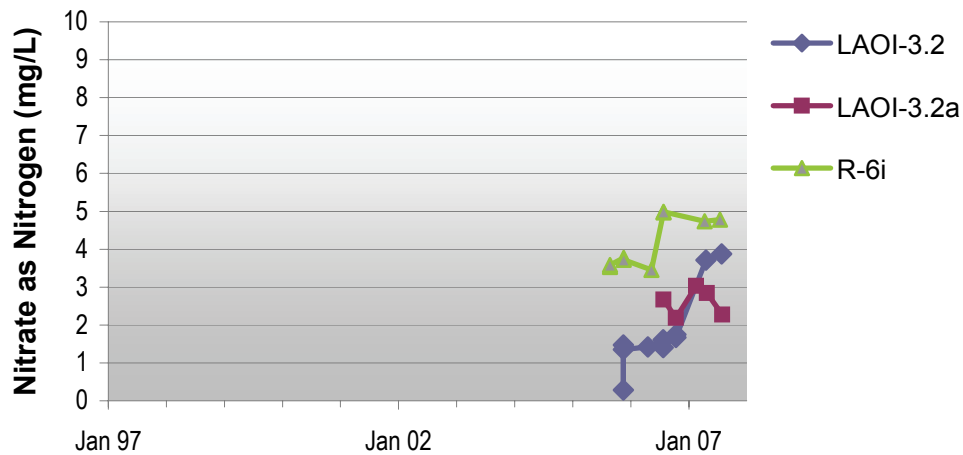


Figure 5-17. Nitrate (as nitrogen) in Los Alamos Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L.

Alluvial groundwater in DP and Los Alamos Canyons continues to show strontium-90; although there is no applicable groundwater standard, for comparison purposes, the values range up to and above the 8-pCi/L EPA MCL screening level (Figure 5-10, Figure 5-18). Fluoride is also present in samples as a result of past effluent release but at concentrations below the NM groundwater standard of 1.6 mg/L (Figure 5-19).

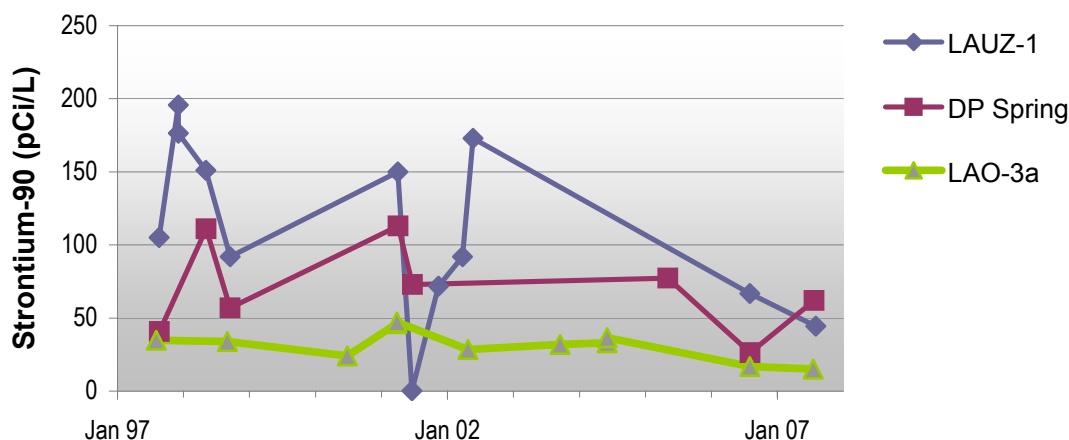


Figure 5-18. Strontium-90 in Los Alamos Canyon alluvial groundwater. For comparison purposes, the EPA MCL screening level (which does not apply to these samples) is 8 pCi/L.

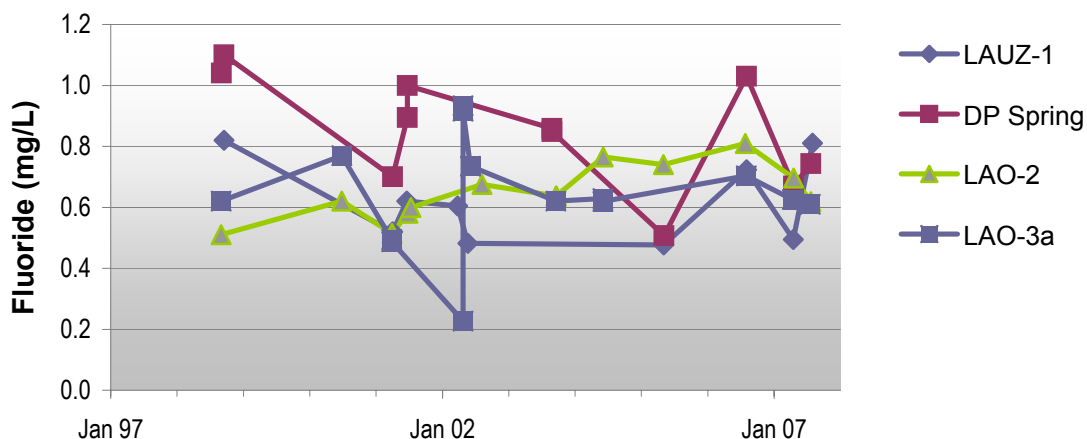


Figure 5-19. Fluoride in Los Alamos Canyon alluvial groundwater. The NM groundwater standard is 1.6 mg/L.

Basalt Spring, which is fed by intermediate groundwater, is in lower Los Alamos Canyon on Pueblo de San Ildefonso land. Alluvial well LLAO-1b is located nearby. The nitrate (as nitrogen) results from samples at both locations were near or above the NM groundwater standard of 10 mg/L (Figure 5-14, Figure 5-15). The source of nitrate may be releases into Pueblo Canyon from the present and former Los Alamos County sanitary treatment plants.

In Los Alamos Canyon, molybdenum in LAO-2 and LAO-3a has dropped to 30% of the NM groundwater standard, which is for irrigation use. The molybdenum came from cooling towers at TA-53 (LANSCE). Use of sodium molybdate was discontinued in June 2002. Molybdenum concentrations in Los Alamos Canyon alluvial groundwater have been quite variable in recent years, perhaps because of large variation in stream flow caused by drought conditions.

3. Sandia Canyon

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives the largest liquid discharges of any canyon at the Laboratory from the cooling tower at the TA-3 power plant (Table 5-10). Treated effluents from the TA-46 SWWS Plant have been routed to Sandia Canyon since 1992. Chromate was used to treat cooling water at the power plant until 1972 (ESP 1973). These earlier discharges are tentatively identified as the source for hexavalent chromium concentrations discovered in the regional aquifer beneath Sandia and Mortandad Canyons that are above the NM groundwater standard (Figure 5-20). The standard of 50 µg/L applies to dissolved chromium (regardless of the chemical form). Sandia and Mortandad Canyons lie close together, and water percolating downward beneath Sandia Canyon may have been diverted to the south by southwesterly dipping basalts prior to reaching the regional aquifer (ERSP 2006).

Table 5-10
Summary of Groundwater Contamination in Sandia Canyon

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Sandia Canyon	Multiple liquid discharges	Chloride at 80%, fluoride at 65%, TDS at 53%, and chromium at 65% of NM groundwater standard; lead and arsenic above EPA MCL screening levels	TDS at 54% of NM groundwater standard	Chromium at 70% of NM groundwater standard; nitrate at 75% of NM groundwater standard

In 2007, chromium concentrations in samples from regional aquifer well R-11 in Sandia Canyon were 35 µg/L or 70% of the groundwater standard; other analyses show the chromium is in the hexavalent form (Table 5-11, Figure 5-21). Nitrate (as nitrogen) in R-11 was up to 74% of the NM groundwater standard, apparently due to past Laboratory sanitary effluent releases (Figure 5-14, Figure 5-22).

Newly sampled intermediate well SCI-1 had total dissolved solids (TDS) up to 53% of the NM groundwater standard. Two new alluvial wells, SCA-1 and SCA-2, had results for chloride and TDS that approached values for standards. These findings likely relate to quality of effluent discharged in upper Sandia Canyon. The dissolved chromium concentration in one sample at SCA-1 was 64% of the NM groundwater standard and was the highest of four measurements made in 2006 and 2007.



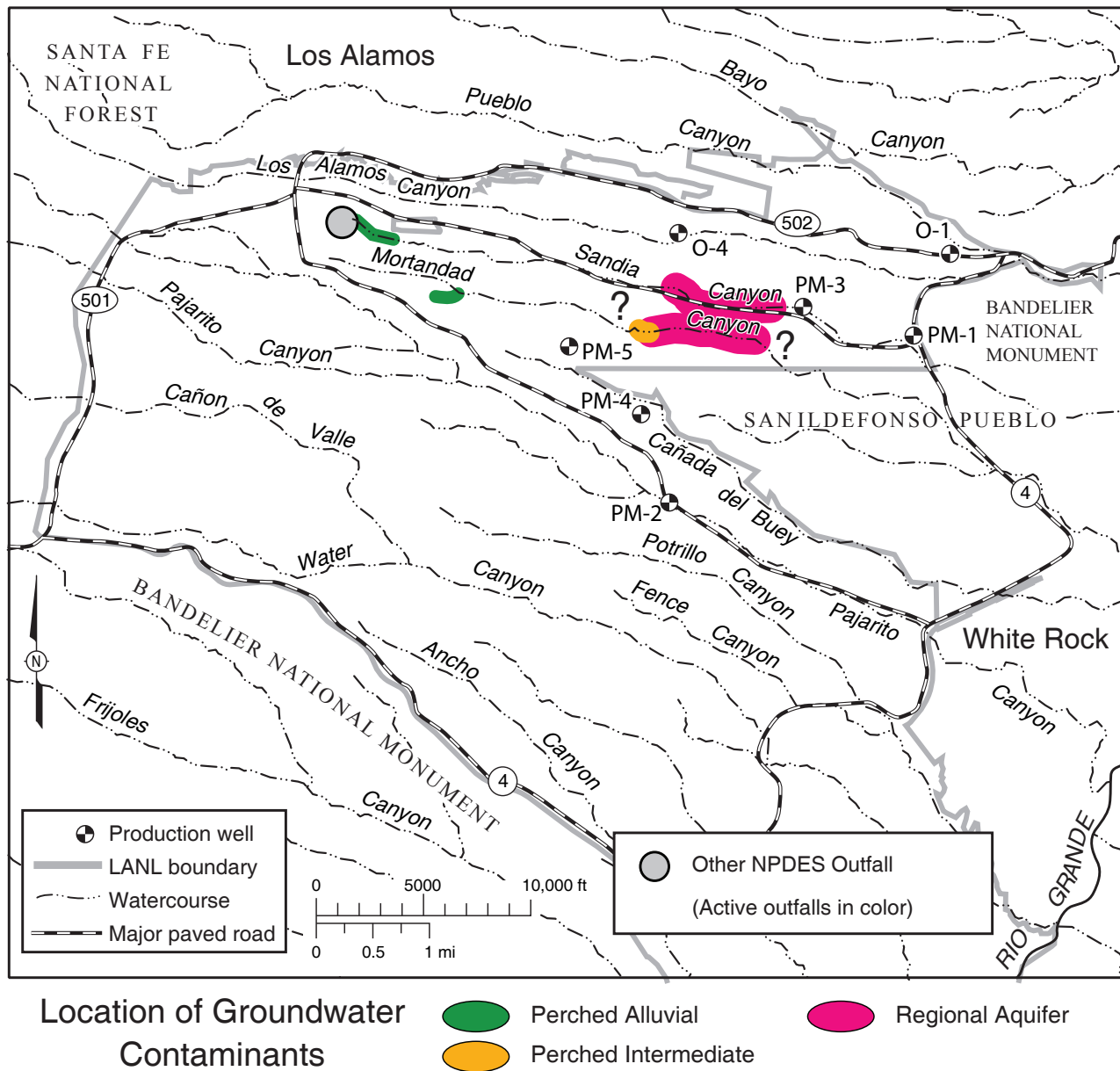


Figure 5-20. Location of groundwater containing dissolved or hexavalent chromium above one half of the 50 µg/L NM groundwater standard. Different colors indicate the affected groundwater zones.

Table 5-11
Groundwater Quality in Sandia Canyon

Chemical	Location	Result	Trends
Chromium	Regional aquifer monitoring well R-11	35 µg/L, below NM groundwater standard of 50 µg/L	Increased by 75% over three years of sampling
Nitrate (as N)	Regional aquifer monitoring well R-11	4.5 mg/L to 7.4 mg/L, below NM groundwater standard of 10 mg/L	Highest value to date, results have doubled over three years of sampling
TDS	Intermediate well SCI-1	455 mg/L to 536 mg/L, below NM groundwater standard of 1,000 mg/L	First sampled in 2007, values fairly steady
Chloride	Alluvial wells SCA-1 and SCA-2	84 mg/L to 197 mg/L, below NM groundwater standard of 250 mg/L	Variable results over one or two years of samples
TDS	Alluvial wells SCA-1 and SCA-2	498 mg/L to 531 mg/L, below NM groundwater standard of 1000 mg/L	Steady results over one or two years of samples
Nitrate (as N)	Alluvial well SCA-4	729 mg/L in November, above NM groundwater standard of 10 mg/L	Field preservation error, result is above TDS of 312 mg/L
Fluoride	Alluvial well SCA-4	1.04 mg/L and 1.07 mg/L, below NM groundwater standard of 1.6 mg/L	Two measurements at location
Perchlorate	Alluvial well SCA-1	6.2 µg/L, below EPA DWEL of 24.5 µg/L	False positive due to analytical interference- result by more sensitive method was nondetect
Chromium	Alluvial well SCA-1	Filtered result of 32 µg/L, below NM groundwater standard of 50 µg/L	Highest value in two years of samples
Chromium	Alluvial wells SCA-2 and SCA-4	Unfiltered concentrations of 552 µg/L and 90 µg/L, near or above EPA drinking water screening level of 100 µg/L	Two results at each location; one detect at SCA-2 and two at SCA-4; one higher result at each related to higher turbidity
Arsenic	Alluvial well SCA-4	13 µg/L to 19 µg/L, above EPA MCL screening level of 10 µg/L, below NM groundwater standard of 100 µg/L	Two measurements at location
Lead	Alluvial wells SCA-2 and SCA-4	Unfiltered concentrations of 19.8 µg/L to 38.1 µg/L, above EPA drinking water screening level of 15 µg/L, below NM groundwater standard of 100 µg/L	Two results at each location; one detect at SCA-2 and two at SCA-4; higher results related to higher turbidity

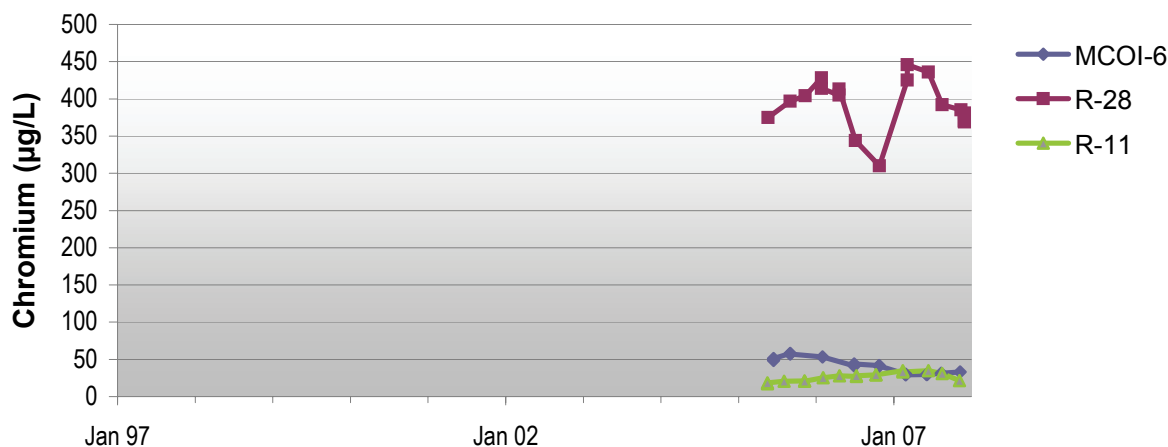


Figure 5-21. Filtered chromium in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.

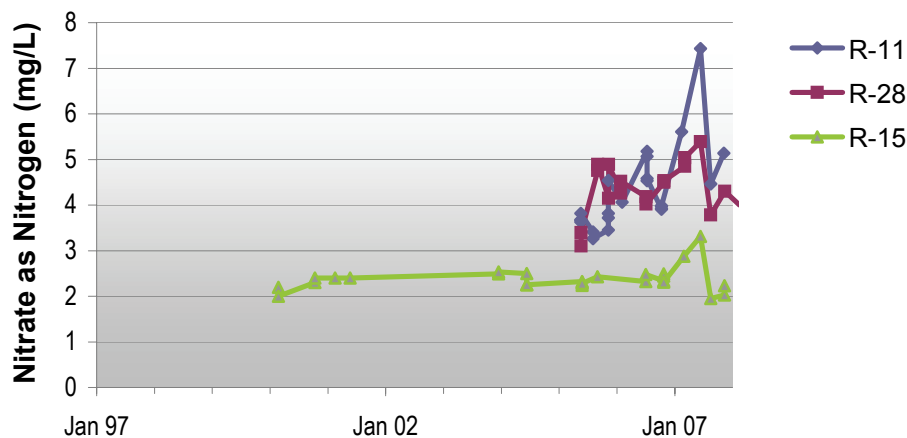


Figure 5-22. Filtered and unfiltered nitrate (as nitrogen) in Sandia and Mortandad Canyon regional aquifer groundwater. The NM groundwater standard is 10 mg/L.

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

Mortandad Canyon has a small drainage area that heads at TA-3. This drainage area receives inflow from natural precipitation and a number of National Pollutant Discharge Elimination System (NPDES) outfalls, including one from the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50. Past discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35 (Table 5-12). These discharges have affected groundwater quality in the canyons (Table 5-13).

**Table 5-12
Summary of Groundwater Contamination in Mortandad Canyon
(includes Ten Site Canyon and Cañada del Buey)**

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Mortandad and Ten Site Canyons	Multiple past and current effluent discharges	Chloride, fluoride, TDS, and mercury above NM ground water standards; strontium-90, arsenic, beryllium, chromium, and lead, above EPA MCL screening levels; gross beta and perchlorate above screening levels	Uranium, hexavalent chromium, and nitrate above fluoride at 88%, and TDS at 55% of ground water standards; bis(2-ethylhexyl)phthalate above and tritium at 65% of EPA MCL screening level, dioxane[1,4-] and perchlorate above screening level	Hexavalent chromium above and nitrate at 55% of NM ground water standards; trace perchlorate
Cañada del Buey	Major dry, minor liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

Table 5-13
Groundwater Quality in Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Chemical	Location	Result	Trends
Chromium	Regional aquifer monitoring well R-28	369 µg/L to 446 µg/L, above NM groundwater standard of 50 µg/L	Results in this range over three years of sampling
Nitrate (as N)	Regional aquifer monitoring wells R-28 and R-15	2.0 mg/L to 5.4 mg/L, below NM groundwater standard of 10 mg/L	Higher values in R-28 with results in this range for three years of sampling
Perchlorate	Regional aquifer monitoring well R-15	5.3 µg/L to 7.4 µg/L, below EPA DWEL of 24.5 µg/L	Results in this range for four years of sampling
Tritium	Intermediate wells MCOI-4, MCOI-5, MCOI-6	4,000 to 13,000 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values steady over three years of sampling; wells sample separate isolated perched zones
Nitrate (as N)	Intermediate wells MCOI-4, MCOI-5, MCOI-6	4.6 mg/L to 20 mg/L, above NM groundwater standard of 10 mg/L	Values steady over three years of sampling; wells sample separate isolated perched zones
Perchlorate	Intermediate wells MCOI-4, MCOI-5, MCOI-6	94 µg/L to 190 µg/L, above EPA DWEL of 24.5 µg/L	Results in this range for three years of sampling; slight decreases in MCOI-4, MCOI-6
Chromium	Intermediate well MCOI-6	29 µg/L to 33 µg/L, below NM groundwater standard of 50 µg/L	25% decrease over three years of samples
Bis(2-ethylhexyl) phthalate	Intermediate well MCOI-6	7.5 µg/L to 12.4 µg/L, above EPA MCL screening level of 6 µg/L	Compound found near this level in seven of eight sample events over three years
Dioxane[1,4-]	Intermediate wells MCOI-4 and MCOI-6	Volatile organic results are 37 µg/L to 64 µg/L, near or above EPA risk level of 61 µg/L; more precise semivolatile results are 5 µg/L to 38 µg/L	Semivolatile results at each location fairly steady over two years of samples
Uranium	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	29.6 µg/L, below NM groundwater standard of 30 µg/L	Steady over two years, may be leached from bedrock by percolation of sanitary effluent used to irrigate Overlook Park athletic fields
Nitrate (as N)	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	14.4 mg/L, above NM groundwater standard of 10 mg/L	Highest result; other values range from 3.6 mg/L to 8.9 mg/L over two years
Fluoride	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	0.89 mg/L to 1.4 mg/L, below NM groundwater standard of 1.6 mg/L	Highest result; values increasing over two years
TDS	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	531 mg/L to 572 mg/L, below NM groundwater standard of 1,000 mg/L	Values steady over two years
Strontium-90	Alluvial wells MCO-4B, MCO-5, MCO-6	41 pCi/L to 65 pCi/L, above EPA drinking water screening level of 50 pCi/L and 40 pCi/L 4-mrem DOE DCG screening level	Fairly stable for 10 years due to retention on sediments
Gross beta	Alluvial wells MCO-4B, MCO-5, MCO-6	105 pCi/L to 150 pCi/L, above EPA drinking water screening level of 50 pCi/L	Gross beta mainly due to presence of strontium-90

Table 5-13 (continued)

Chemical	Location	Result	Trends
Fluoride	Eight alluvial wells	0.83 mg/L to 1.7 mg/L, above NM groundwater standard of 1.6 mg/L	Results stable and generally below standard since 1999 treatment upgrades
Chloride	Alluvial well MCO-0.6	354 mg/L to 377 mg/L, above NM groundwater standard of 250 mg/L	Results up to 759 mg/L over three years of samples
TDS	Alluvial wells MCO-0.6, MCO-2, MCO-3	546 mg/L to 1,030 mg/L, above NM groundwater standard of 1,000 mg/L	Highest results in MCO-0.6; generally above standard for three years of samples
Nitrate (as N)	Alluvial wells MCO-4B, MCO-6, MCO-7	5.6 mg/L to 241 mg/L, above NM groundwater standard of 10 mg/L	Values not supported by duplicate analyses and reflect improper field preservation or possible analytical error; no corresponding changes in effluent quality
Perchlorate	Eight alluvial wells	11 µg/L to 31 µg/L, above EPA DWEL of 24.5 µg/L	Results generally decreasing since 2002 treatment upgrades
Total arsenic, beryllium, chromium, lead	Alluvial well MCO-2	Concentrations above respective EPA MCL screening levels	Results similar to total metals results in 2006, few sampling events due to little water
Chromium	Alluvial well MCO-2	41 µg/L, below NM groundwater standard of 50 µg/L	One prior measurement in 2000 was 13 µg/L
Total mercury	Alluvial well MCO-7	4.9 µg/L, above NM groundwater standard of 2 µg/L	One prior detection in 2002, eight sample events were nondetect
Benzo(a)pyrene and other PAH compounds	Alluvial well MCO-7	0.83 µg/L to 31 µg/L, above EPA MCL screening level of 0.2 µg/L	Analytes not detected in field duplicate or prior samples; likely result of analytical laboratory contamination

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow alluvial groundwater system of limited extent, and only two observation wells have ever contained water. Because treated effluent from the Laboratory's SWWS facility may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture-monitoring holes was installed during 1992 within the upper and middle reaches of the drainage. Past discharges included accidental releases from experimental reactors and laboratories at TA-46.

a. 2007 Radioactive Liquid Waste Treatment Facility Discharges

Data on the RLWTF's yearly radionuclide discharge into Mortandad Canyon from 2004 through 2007 appear in Supplemental Data Table S5-13. Table S5-13 shows mean annual levels in effluent for each radionuclide and the ratio of this to the 100-mrem DOE DCG for public dose. Figures 5-23 and 5-24 show the relationship of RLWTF average annual radionuclide activities and selected general inorganic chemical concentrations (fluoride, nitrate) in discharges to DOE DCGs or NM groundwater standards since 1996. The 2007 discharges from the RLWTF met all DOE, EPA, and NM requirements for permits and standards. Beginning in 1999, LANL made significant upgrades to the RLWTF treatment system. As a result, for the last eight years the RLWTF has met all DOE radiological discharge standards and all NPDES requirements, and for all but two weeks in 2003, the RLWTF has voluntarily met NM groundwater standards for fluoride, nitrate, and TDS. Two weekly composite samples exceeded the fluoride standard in 2003.

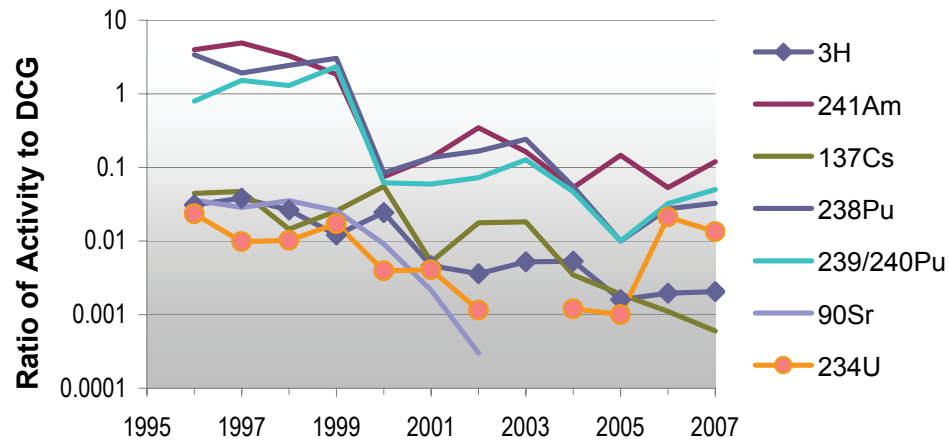


Figure 5-23. Ratio of 1996–2007 average annual radionuclide activity in RLWTF discharges to the 100-mrem public dose DOE DCGs, which are applicable to effluent releases.

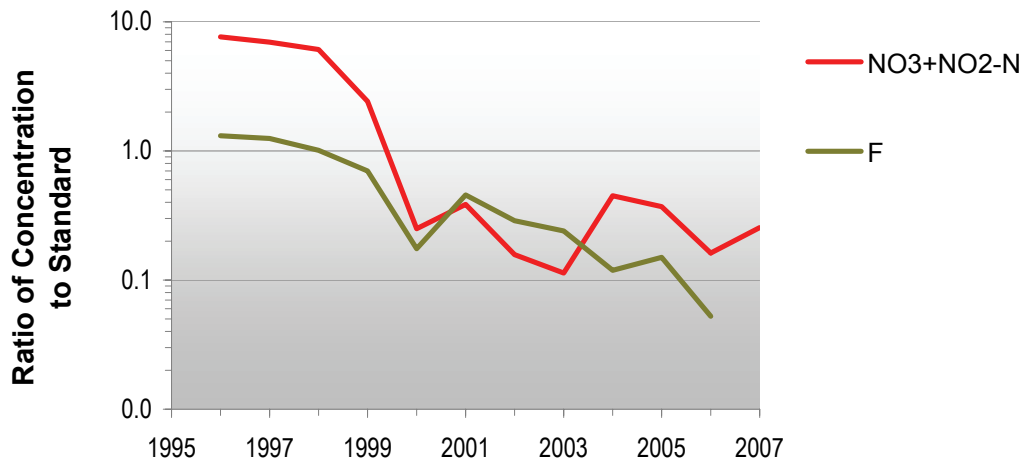


Figure 5-24. Ratio of 1996–2007 average annual nitrate plus nitrite (as nitrogen) and fluoride concentrations in RLWTF discharges to the NM groundwater standards.

During 2007, the nitrate + nitrite (as nitrogen) concentrations of all monthly analyses of effluent discharges from the RLWTF were less than the NM groundwater standard for nitrate (as nitrogen) of 10 mg/L, as has been the case since 2000 (Figure 5-25). The average 2007 effluent total nitrate + nitrite (as nitrogen) concentration was 2.55 mg/L. In 2007, the highest nitrate concentration in a Mortandad Canyon base flow grab sample collected below the outfall in Effluent Canyon was 6.4 mg/L.

The fluoride concentration in the discharge has also declined over the last few years (Figure 5-26). The 2007 effluent fluoride concentration (average value of 0.13 mg/L) was below the NM groundwater standard of 1.6 mg/L. In 2007, the fluoride concentration at the surface water station E-1E in Effluent Canyon just below the outfall was 0.36 mg/L.

A system for removing perchlorate from the RLWTF effluent became operational on March 26, 2002; no perchlorate has been detected in the effluent after this date. For 2007, no perchlorate was detected in effluent samples.

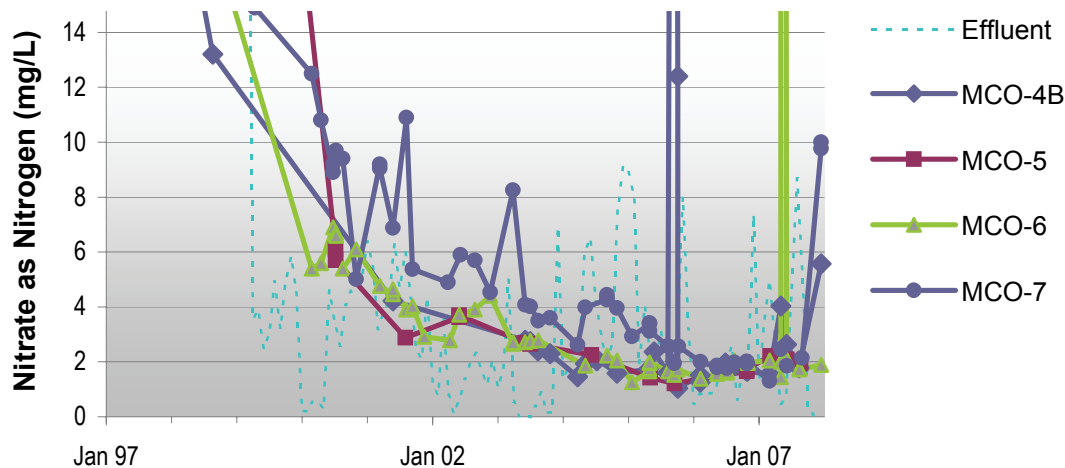


Figure 5-25. Filtered and unfiltered nitrate (as nitrogen) in RLWTF effluent and Mortandad Canyon alluvial groundwater; the NM groundwater standard is 10 mg/L. Groundwater results above about 3 mg/L taken after 2005 reflect field preservation errors.

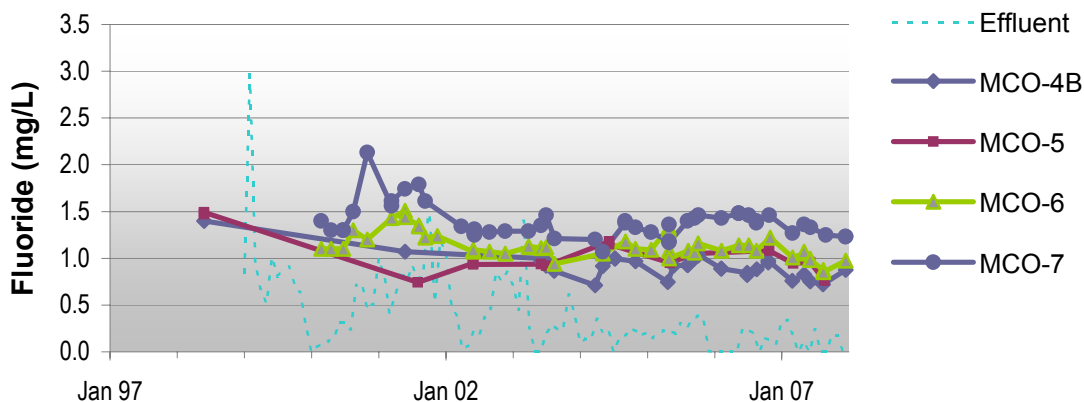


Figure 5-26. Fluoride in RLWTF effluent and Mortandad Canyon alluvial groundwater; the NM groundwater standard is 1.6 mg/L.

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer

The regional aquifer beneath Mortandad Canyon shows impacts from past LANL discharges; intermediate groundwater shows a generally larger effect. In 2007, sampling at regional aquifer monitoring well R-28 in Mortandad Canyon continued to show contamination by hexavalent chromium above the NM groundwater standard of 50 µg/L (which applies to any dissolved form of chromium) (Figure 5-20, Figure 5-21). The Laboratory began investigation of this issue in cooperation with NMED and identified past cooling tower discharges in Sandia Canyon as the likely source (ERSP 2006).

The nitrate concentration in R-28 is at about 55% of the NM groundwater standard (Figure 5-22). In regional aquifer monitoring well R-15, results for tritium, perchlorate, and nitrate are higher than in unaffected wells but are below standards or screening levels. Of these chemicals in R-15, nitrate shows the highest concentrations relative to a standard or screening level (Figure 5-22).

Contaminants found in Mortandad Canyon intermediate groundwater indicate an impact by LANL effluents, with some concentrations near or exceeding regulatory standards. MCOI-6, an intermediate groundwater well in Mortandad Canyon, consistently shows chromium in filtered samples at concentrations just below the NM groundwater standard (Figure 5-21). Nitrate (Figures 5-14, 5-27, 5-28), dioxane[1,4-] (Figure 5-29), bis(2-ethylhexyl) phthalate, and perchlorate (Figures 5-30 and 5-31) are consistently near or above standards or screening levels in some monitoring wells.

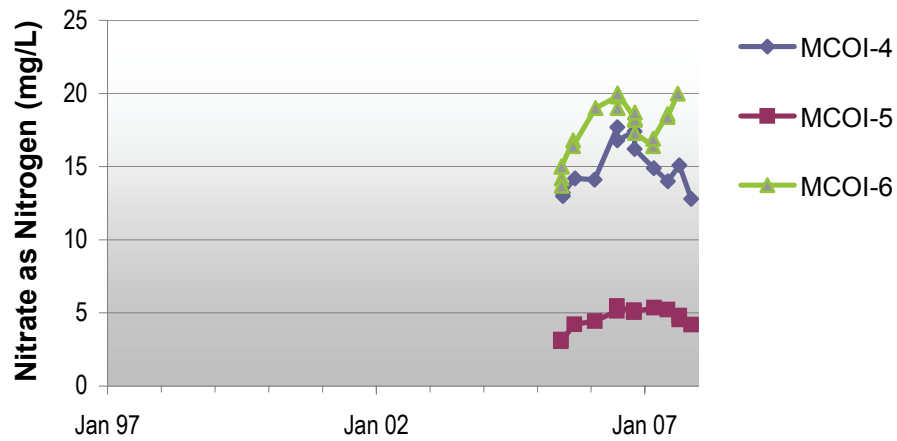


Figure 5-27. Filtered and unfiltered nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater; the NM groundwater standard is 10 mg/L.

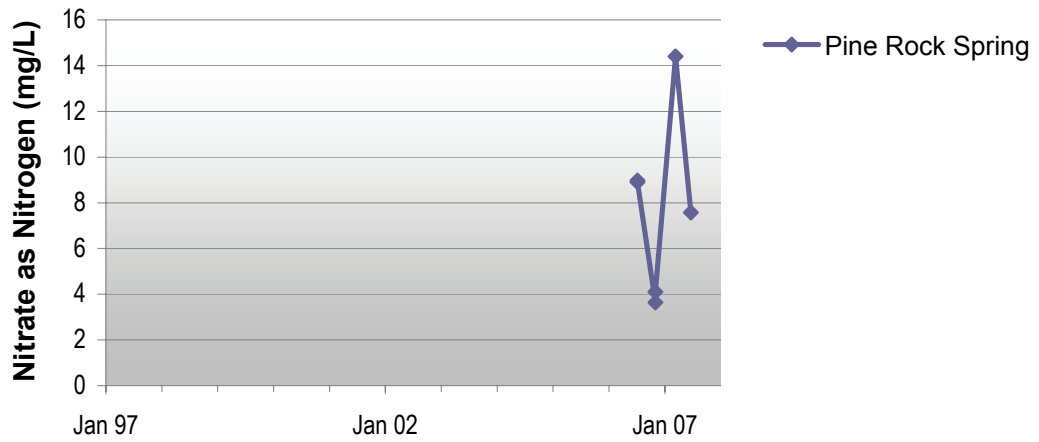


Figure 5-28. Filtered and unfiltered nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater at Pine Rock Spring on Pueblo de San Ildefonso land; the NM groundwater standard is 10 mg/L.

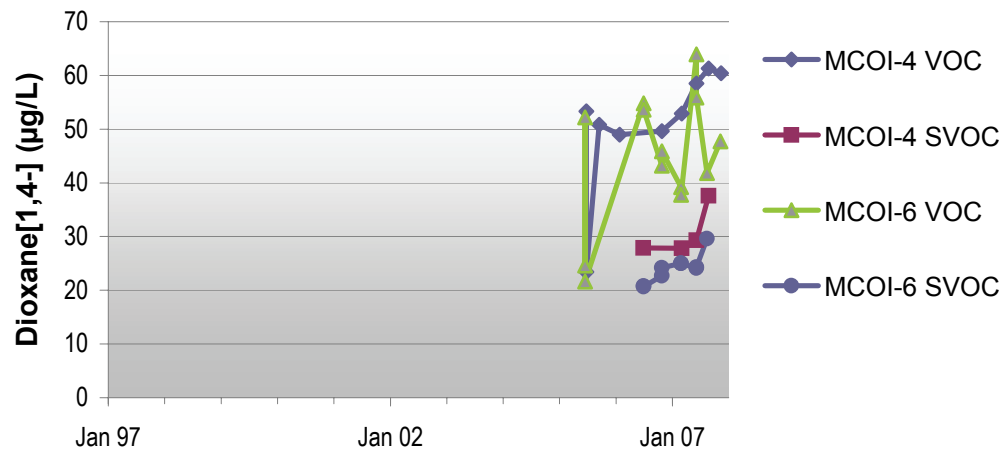


Figure 5-29. Dioxane[1,4-] in Mortandad Canyon intermediate groundwater; the EPA Region 6 10^{-5} risk value is 61.1 µg/L. The results using the Volatile Organic Compound (VOC) method are higher but have much less accuracy than lower results from the Semi-Volatile Organic Compound (SVOC) method.

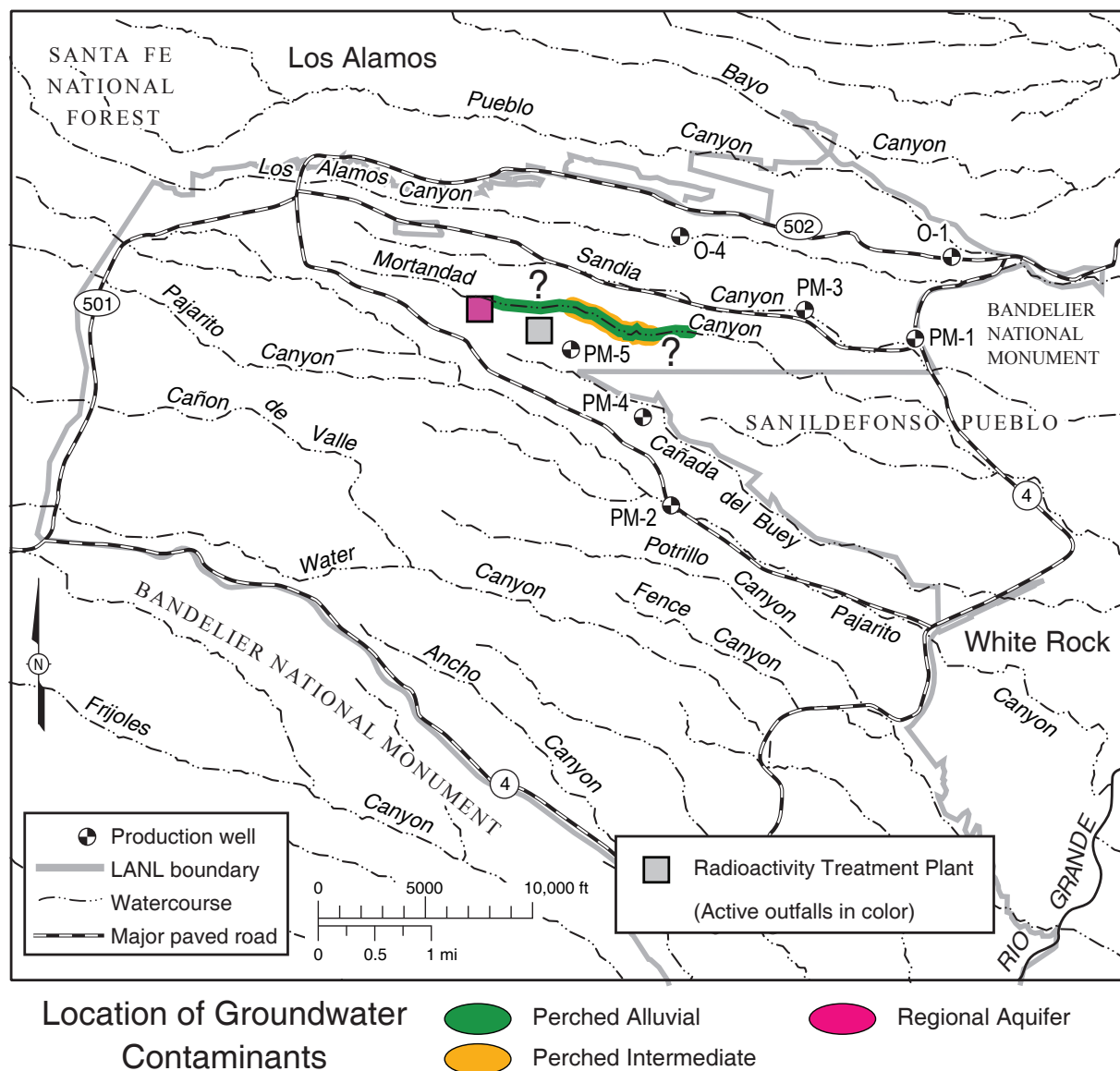


Figure 5-30. Location of groundwater contaminated by perchlorate; there is no applicable groundwater standard, but for comparison purposes, the concentrations in the areas indicated are above the 24.5 µg/L EPA Drinking Water Equivalent Level. Different colors indicate the affected groundwater zones.

Three intermediate wells in Mortandad Canyon (MCOI-4, MCOI-5, and MCOI-6) had tritium activities that ranged from 20% to 65% of the EPA MCL screening level of 20,000 pCi/L (Figure 5-32, 5-33). Tritium has a short half-life of about 12.3 years, so these values will decline rapidly because the tritium activity in effluent has decreased. Another intermediate well, MCOBT-4.4, had construction problems that affected sampling. As a result, we have not sampled the well for several years, and it will be plugged and abandoned. MCOI-4 was drilled nearby as a replacement.

Pine Rock Spring on Pueblo de San Ildefonso land had uranium concentrations near and nitrate concentrations (Figure 5-28) above the NM groundwater standards. Fluoride and TDS were also near the standards. These concentrations appear to be caused by the contribution of effluent to spring flow. The uranium values may be caused by dissolution of uranium from the bedrock by sanitary effluent used to water athletic fields at nearby Overlook Park (Teerlink 2007).

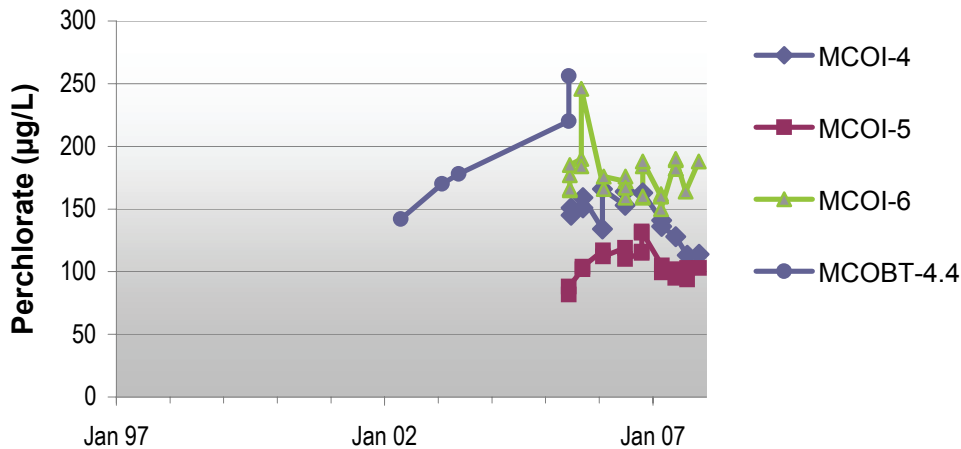


Figure 5-31. Perchlorate in Mortandad Canyon intermediate groundwater; while there is no applicable groundwater standard, for comparison purposes, the EPA DWEL is 24.5 µg/L.

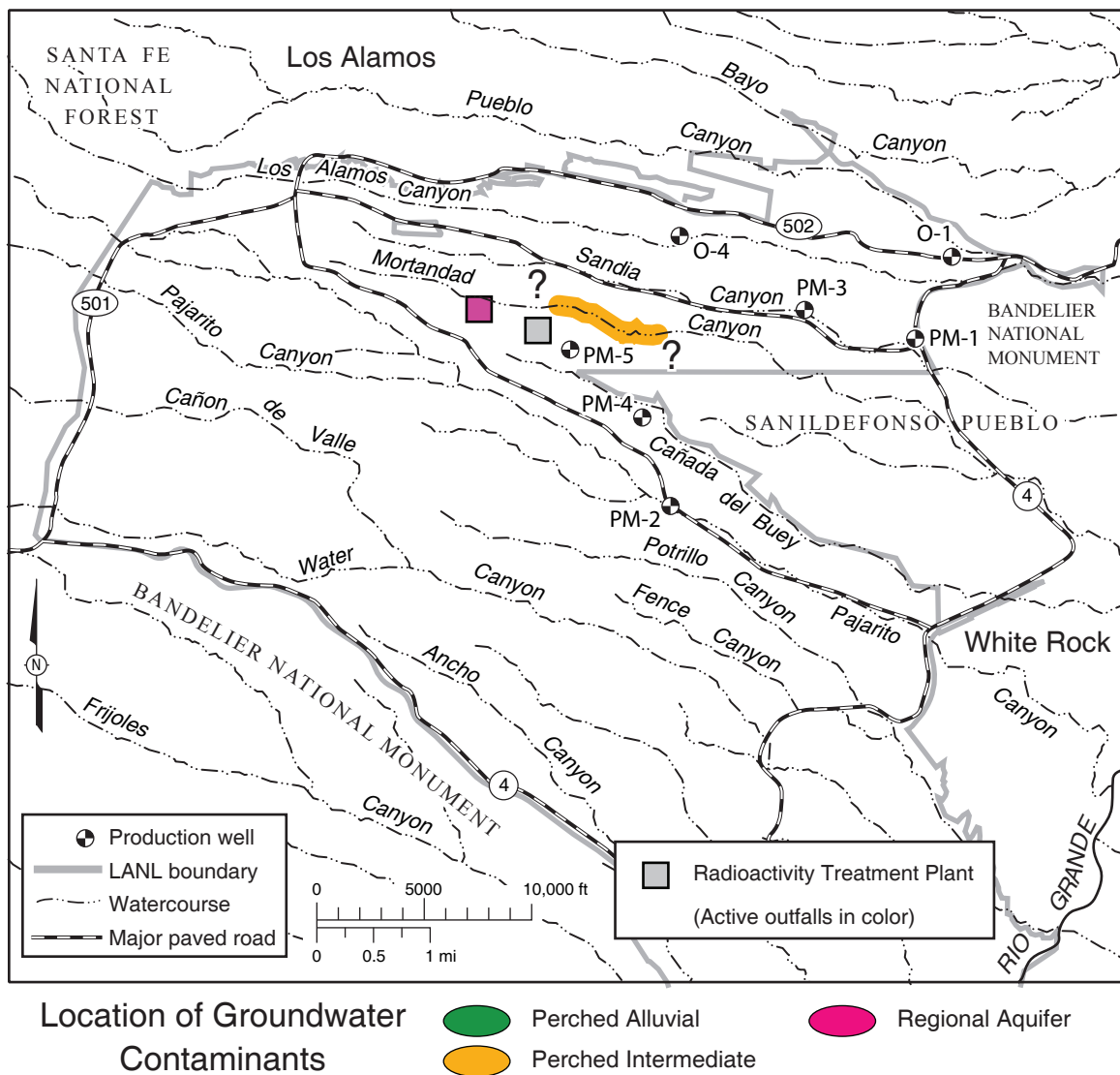


Figure 5-32. Location of groundwater contaminated by tritium. While there is no applicable groundwater standard, for comparison purposes, the area indicated has tritium activity above one-half of the 20,000 pCi/L EPA MCL screening level. Different colors indicate the affected groundwater zones.

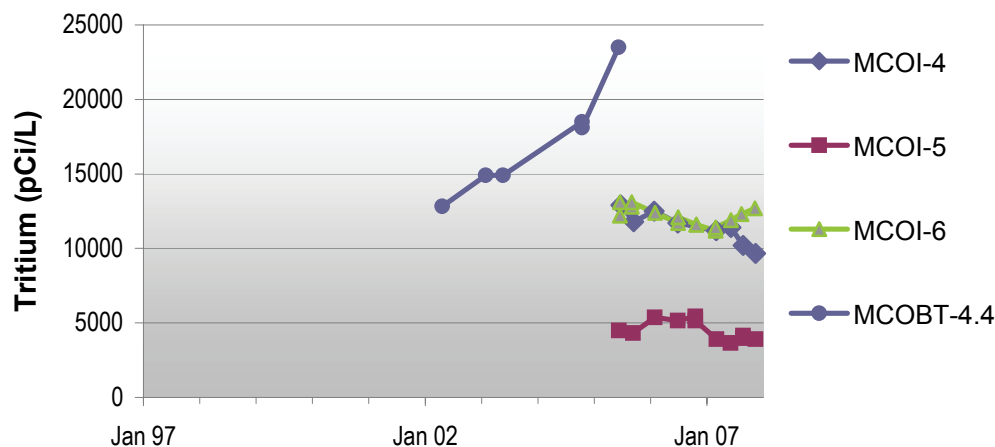


Figure 5-33. Tritium in Mortandad Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level (which does not apply to these samples) is 20,000 pCi/L.

In 2005, dioxane[1,4-] was measured and detected for the first time in two intermediate wells in Mortandad Canyon (Figure 5-29). There is no applicable groundwater standard for dioxane[1,4-]. However, for comparison purposes, the EPA Region 6 dioxane[1,4-] 10^{-5} risk value is 61 $\mu\text{g/L}$. This compound has been measured by two methods. The less-precise volatile organic compound method SW-846:8260B has a practical quantitation limit (PQL) of 50 $\mu\text{g/L}$ (the MDL is 20 $\mu\text{g/L}$). Many measured results by this method are above the EPA Region 6 risk value. A more sensitive semivolatile organic compound method SW-846:8270C has a PQL of 10 $\mu\text{g/L}$ (the MDL is 1 $\mu\text{g/L}$). Results measured by this method are below the EPA Region 6 risk value.

Bis(2-ethylhexyl)phthalate continues to be detected in samples from MCOI-6; there is no applicable groundwater standard for this compound, but for comparison purposes the concentrations were above the 6 $\mu\text{g/L}$ EPA MCL screening level. The source of this chemical at this well is not known; it has been found in seven of eight samples from MCOI-6.

c. Alluvial Groundwater

Radionuclide levels in Mortandad Canyon alluvial groundwater are, in general, highest just below the TA-50 RLWTF outfall at well MCA-5 and decrease down the canyon. Most radionuclides are adsorbed to sediment closer to the outfall and subsequently move with sediment rather than in groundwater. There are no applicable groundwater standards for these radionuclides; but for comparison purposes, since the early 1990s, radionuclide levels in groundwater samples have not exceeded the 100-mrem DOE DCGs for public dose (applicable to effluent discharges).

There are no applicable groundwater standards for most radioactivity in alluvial groundwater. However, for comparison purposes, in 2007, total LANL-derived radioactivity exceeded the 4-mrem DOE DCG screening level in Mortandad Canyon alluvial groundwater samples from wells MCO-4B, MCO-5, MCO-6 and MCO-7 (Figure 5-11). Strontium-90 was the main contributor to dose in these samples. For comparison purposes in absence of an applicable groundwater standard, for radioactivity from a DOE source, 2007 results for the strontium-90 exceeded the 4-mrem DOE DCG screening level in all four wells. Again for comparison purposes in absence of an applicable groundwater standard, the levels of strontium-90 also exceeded the EPA MCL screening level (Figure 5-10, Figure 5-34).

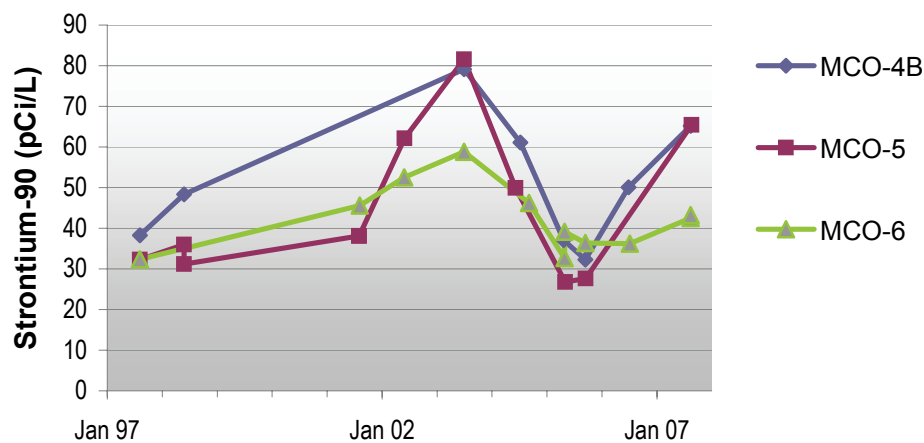


Figure 5-34. Strontium-90 in Mortandad Canyon alluvial groundwater. For comparison purposes, the EPA MCL screening level (which does not apply to these samples) is 8 pCi/L.

It appears that strontium-90 has been retained by cation exchange on sediment within the upstream portion of the alluvium. The level of strontium-90 has risen gradually at downstream alluvial wells MCO-5 and MCO-6 during the last 20 years, suggesting that the mass of the radionuclide is moving slowly downstream. However, the inventory of strontium-90 should be declining, since discharge amounts have decreased significantly and, as noted earlier, the half-life of strontium-90 is 28.8 years. Gross beta values (probably reflecting strontium-90 activity) in samples from most alluvial wells were high; there is no applicable groundwater standard, but for comparison purposes the results were near or exceeded the EPA 50 pCi/L drinking water screening level.

As shown in Figures 5-25 and 5-26, the nitrate (as nitrogen) and fluoride concentrations of effluent discharge from the RLWTF after March 1999 are below the NM groundwater standards. Under the groundwater discharge plan application for the RLWTF, the Laboratory collected additional quarterly samples for nitrate, fluoride, perchlorate, and TDS during 2007 from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCA-5 (or MCO-3), MCO-4B, MCO-6, and MCO-7.

With some exceptions, nitrate (as nitrogen) concentrations in these wells were below the NM groundwater standard of 10 mg/L (Figure 5-25), and fluoride concentrations were below the NM groundwater standard of 1.6 mg/L (Figure 5-26). In May 2007, a sample collected from MCO-6 had a nitrate (as nitrogen) result of 241 mg/L; the result of a field preservation error. A duplicate sample had 2 mg/L, and a reanalysis of the sample gave 1.5 mg/L. Though the reanalysis was done when the sample was out of holding time, it would have shown that such a high nitrate concentration was present in the sample. As well, the TDS for the sample was 308 mg/L, in line with usual measurements and indicating the nitrate result is not valid. Other nitrate measurements in December 2007 at MCO-4B of 5.7 mg/L and at MCO-7 of 10 mg/L are much higher than usual results and indicate a field or analytical error though the source of this could not be found. Variations in effluent quality do not appear to be large enough to account for these results (Figure 5-25).

All of the alluvial groundwater samples collected below the RLWTF outfall had fluoride concentrations above 50% of the NM groundwater standard, with some above the standard (Figures 5-13, 5-26). One downstream well (MCO-7.5) had a fluoride result exceeding the standard, a result of past effluent discharge.

Mortandad Canyon alluvial groundwater samples from wells downstream of the RLWTF outfall had high perchlorate concentrations (Figures 5-30 and 5-35). There is no applicable groundwater standard for perchlorate, but for comparison purposes, the 2007 concentrations at some wells were above the EPA's DWEL of 24.5 $\mu\text{g/L}$. Alluvial groundwater concentrations of perchlorate have dropped, especially near the outfall, following the removal of perchlorate from RLWTF effluent in March 2002.

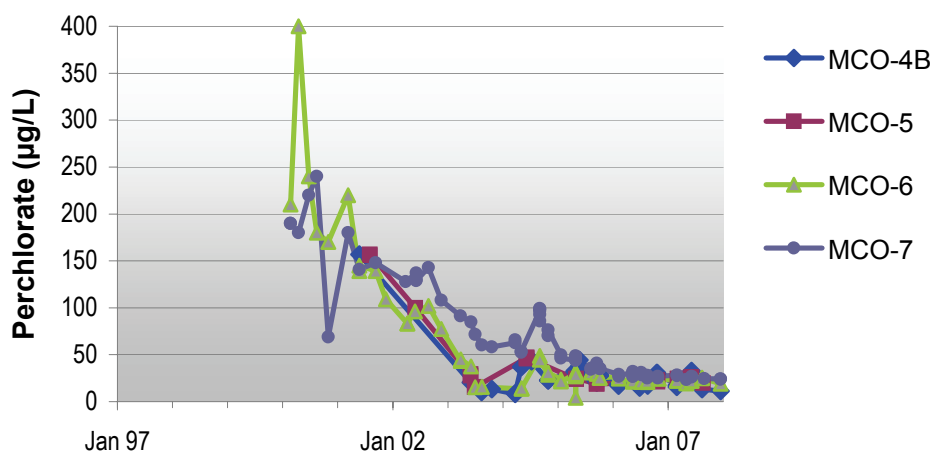


Figure 5-35. Perchlorate in Mortandad Canyon alluvial groundwater; while there is no applicable standard, for comparison purposes, the EPA DWEL is 24.5 µg/L.

e. Cañada del Buey

Water supply wells PM-4 and PM-5 are on the mesa top just south of Cañada del Buey. PM-4 operates as a backup well and in any year may have fewer sample events.

Alluvial well CDBO-6 in Cañada del Buey was sampled three times in 2007 with no chemicals near regulatory standards or screening levels.

5. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon has a drainage that extends into the Sierra de los Valles, west of the Laboratory. In lower Pajarito Canyon near the eastern Laboratory boundary, saturated alluvium occurs but does not extend beyond the boundary. In the past, the Laboratory released small amounts of wastewater into tributaries of Pajarito Canyon from several HE-processing sites at TA-9 (Table 5-14). Some firing sites border portions of tributaries Twomile and Threemile canyons. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at TA-18. Waste management areas at TA-54, used for disposal of organic solvents and low-level radioactive waste, occupy the mesa north of the lower part of the canyon. A small contaminated body of shallow intermediate groundwater occurs behind a former Laboratory warehouse location at TA-3, where the Laboratory disposed of waste materials. The main water quality impacts are from organic chemicals released at the TA-3 warehouse and from HE (Table 5-15).

Table 5-14
Summary of Groundwater Contamination in Pajarito Canyon
(includes Twomile and Threemile Canyons)

Canyon	Contaminant Sources	Groundwater contaminants		
		Alluvial	Intermediate	Regional
Pajarito, Twomile, and Threemile Canyons	Major dry sources, past major but minor present liquid sources	Mercury and chloride above and TDS at 86% of NM groundwater standards	Dichloroethene[1,1-], trichloroethane[1,1,1-], chloride and TDS above and mercury at 85% of NM groundwater standards; dioxane[1,4-] and RDX above EPA screening levels; lead at 84% of drinking water system screening level; trichloroethene, dichloroethane[1,1-] at trace levels	Trace RDX

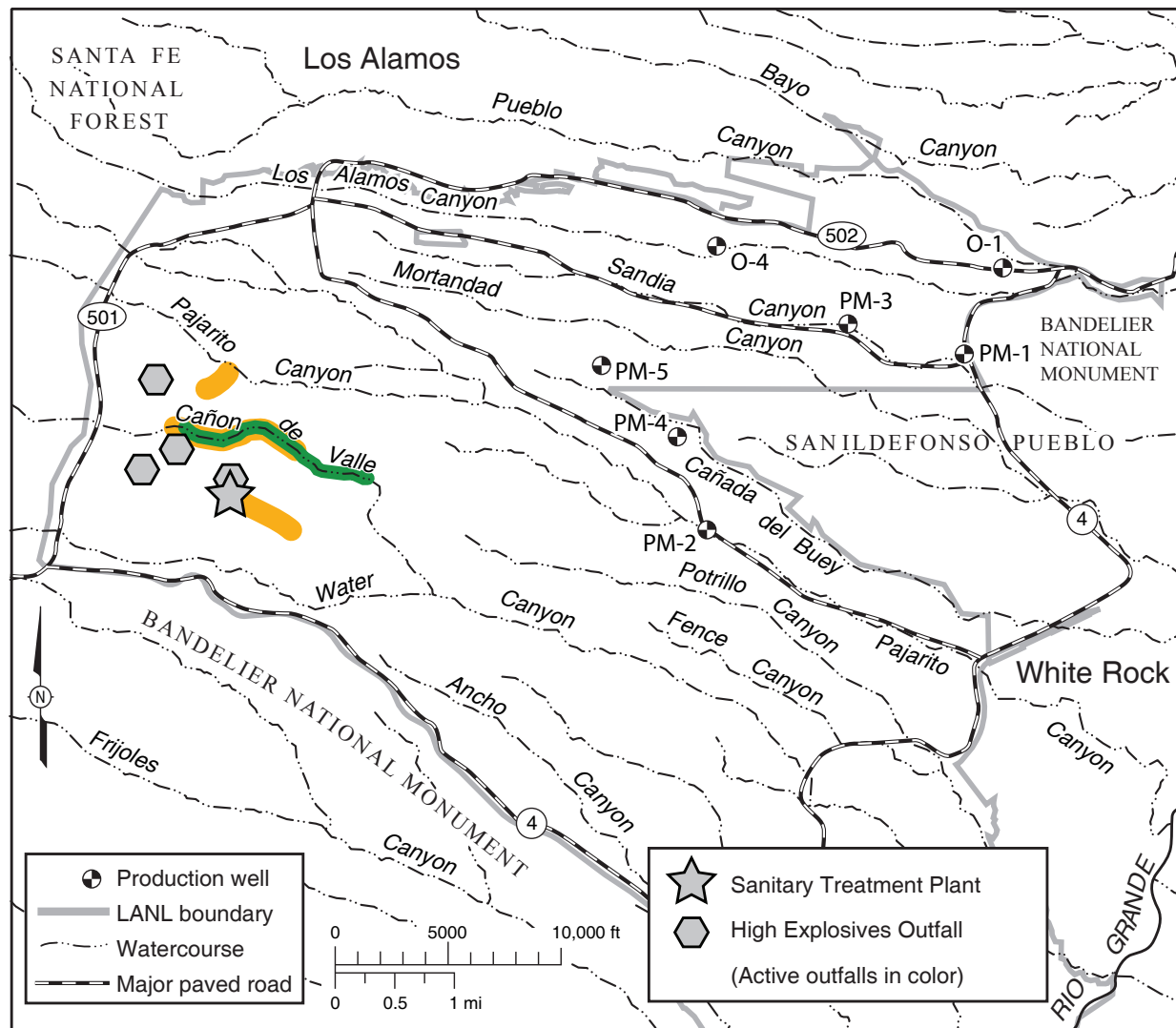
Table 5-15
Groundwater Quality in Pajarito Canyon (includes Twomile and Threemile Canyons)

Chemical	Location	Result	Trends
RDX	Regional aquifer well R-18	0.14 µg/L to 0.25 µg/L, below EPA risk level of 6.1 µg/L	Found in all 5 sample events since August 2006; not found in three prior sample events
Chloride	Intermediate wells 03-B-9, 03-B-10, 03-B-13	350 mg/L to 610 mg/L, above NM groundwater standard of 250 mg/L	Highest results over two years of sampling in March and December; usually 50 mg/L; perhaps from road salt
TDS	Intermediate wells 03-B-9, 03-B-10, 03-B-13	800 mg/L to 1230 mg/L, above NM groundwater standard of 1,000 mg/L	March and December 2007 results highest over two years of sampling ; usually 200 mg/L to 500 mg/L; perhaps from road salt
Mercury	Intermediate well 03-B-10	1.7 µg/L, below NM groundwater standard of 2 µg/L	Highest result by an order of magnitude out of five samples during two years of sampling
Lead	Intermediate wells 03-B-10, 03-B-13	8.8 µg/L to 12.6 µg/L, below EPA drinking water system screening level of 15 µg/L	In range of variable results over two years of sampling
Dichloroethene [1,1-]	Intermediate wells 03-B-9, 03-B-10, 03-B-13	2 µg/L to 11 µg/L, above NM groundwater standard of 5 µg/L	Detected in every sample at similar levels over two years; except that 03-B-9 only had water for two sampling events
Trichloroethane [1,1,1-]	Intermediate wells 03-B-9, 03-B-10, 03-B-13	41 µg/L to 206 µg/L, above NM groundwater standard of 60 µg/L	Detected in every sample at similar levels over two years; except that 03-B-9 only had water for two sampling events
Dioxane[1,4-]	Intermediate wells 03-B-9, 03-B-10, 03-B-13	Volatile organic results are 39 µg/L to 450 µg/L, above EPA Region 6 screening level of 61 µg/L; more precise semivolatile results are 20 µg/L to 146 µg/L	Results fluctuate over this range for two years of samples
Dichloroethane [1,1-]	Intermediate wells 03-B-9, 03-B-10, 03-B-13	1.2 µg/L to 5.9 µg/L, below NM groundwater standard of 25 µg/L	Detected in every sample at similar levels over two years; except that 03-B-9 only had water for two sampling events
Trichloroethene	Intermediate wells 03-B-9, 03-B-10, 03-B-13	0.8 µg/L to 2.0 µg/L, below EPA MCL screening level of 5 µg/L	Detected in all but two samples at similar levels over two years; except that 03-B-9 only had water for two sampling events
RDX	Intermediate Kieling and Bulldog Springs	0.14 µg/L to 6.4 µg/L, above EPA Region 6 screening level of 6.1 µg/L	Found in three of seven sample events at Kieling Spring, in all seven events at Bulldog Spring
Chloride	Alluvial wells 18-MW-18, PCO-2, PCO-3	130 mg/L to 320 mg/L, above NM groundwater standard of 250 mg/L	Highest results over two years of sampling in 18-MW-18 and over 20 years in PCO-2; similar to variable results in PCO-3 over 15 years
TDS	Alluvial wells 18-MW-18, PCO-3	515 mg/L to 859 mg/L, below NM groundwater standard of 1000 mg/L	Similar results for two years in 18-MW-18, for 20 years in PCO-3
Mercury	Alluvial wells 18-MW-8, PCO-3	1.8 µg/L to 6.7 µg/L, above NM groundwater standard of 2 µg/L	Fourth and highest detection over 20 years at PCO-3; second detection in five samples over two years at 18-MW-8 and found in both filtered and unfiltered samples

RDX was detected at Pajarito Canyon regional well R-18 near the detection limit and at 4% of the EPA 10^{-5} excess cancer risk tap water screening level. RDX is listed as a toxic pollutant in the New Mexico groundwater regulations (NMWQCC 2002).

5. Groundwater Monitoring

Samples from several of the intermediate groundwater springs in Upper Pajarito Canyon contained RDX, HMX, and other HE compounds as in prior years. One RDX result from Bulldog Spring was above the EPA 10^{-5} excess cancer risk tap water screening level (Figure 5-36).



Location of Groundwater Contaminants

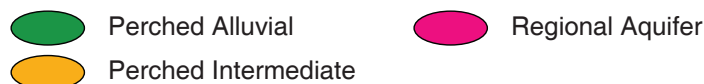


Figure 5-36. Location of groundwater containing RDX above one half of the EPA Region 6 10^{-5} excess cancer risk tap water screening level of $6.1 \mu\text{g/L}$. Different colors indicate the affected groundwater zones.

Samples from SWMU 03-010a intermediate groundwater wells 03-B-9, 03-B-10, and 03-B-13 had TDS and chloride results that were above groundwater standards. The TDS results from samples for these wells during the remainder of the year were about half the highest values. Samples from these wells also contained several organic chemicals including four chlorinated solvents (Table 5-15). Several organic chemicals were at concentrations exceeding NM groundwater standards. This SWMU is currently under investigation and the organic chemicals are some of the contaminants identified in the investigation (LANL 2005b). Compounds found in the wells included dichloroethane[1,1-], dichloroethene[1,1-], and trichloroethane[1,1,1-], and dioxane[1,4-].

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

Water Canyon and Cañon de Valle (a tributary) pass through the southern portion of LANL where the Laboratory conducts explosives development and testing. In the past, the Laboratory released wastewater into both canyons from several HE-processing sites in TA-16 and TA-9 (Table 5-16). In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall from the High Explosives Wastewater Treatment Facility. This outfall discharges a much smaller amount of water that generally meets NPDES permit requirements. Alluvial groundwater in Cañon de Valle shows barium above 1,000 µg/L, the NM groundwater standard (Table 5-17, Figure 5-37), and RDX above the EPA Region 6 screening level of 6.1 µg/L, corresponding to a 10^{-5} excess cancer risk (Figure 5-36). Intermediate perched groundwater in this area also shows RDX at concentrations above 6.1 µg/L. The Potrillo, Fence, and Indio canyon watersheds contain several open-burning/open-detonation and firing sites used for testing of weapons system components. These three small canyons have surface water only in response to precipitation events, and no known alluvial or intermediate groundwater.

Table 5-16
Summary of Groundwater Contamination in Water Canyon
(includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Canyon	Contaminant Sources	Groundwater contaminants		
		Alluvial	Intermediate	Regional
Cañon de Valle	Multiple dry and past effluent sources	Barium above NM groundwater standard, RDX above EPA excess cancer risk level	Boron above NM groundwater standard, lead above tap water screening level; RDX above EPA excess cancer risk level; tetrachloroethene at 33% and trichloroethene at 34% of EPA MCL screening level	None
Water Canyon	Multiple dry and past effluent sources	None, little alluvial groundwater	No intermediate groundwater	None
Potrillo, Fence, and Indio Canyons	Minor dry sources	No alluvial groundwater	No intermediate groundwater	None

Table 5-17
Groundwater Quality in Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Chemical	Location	Result	Trends
RDX	Regional aquifer well R-25	0.13 µg/L to 0.71 µg/L, below EPA risk level of 6.1 µg/L	Likely present due to well construction delays in 2000; levels have since decreased significantly
Boron	Intermediate Martin Spring	1250 µg/L to 1310 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Consistent with results collected over 17 year period
Lead	Intermediate Fish Ladder Spring, CdV-16-2(i)r	11 µg/L to 16 µg/L, above EPA drinking water system screening level of 15 µg/L	Highest value in CdV-16-2(i)r, spring value is consistent with 12 years of data
RDX	Five intermediate springs, five wells or well ports	Up to 137 µg/L, above EPA risk level of 6.1 µg/L	Present for 12 years in springs, during several years of sampling of wells
Tetrachloroethene	Three intermediate springs, three wells or well ports	0.4 µg/L to 1.7 µg/L, below EPA MCL screening level of 5 µg/L	Present for 12 years in springs, during several years of sampling of wells

Table 5-17 (continued)

Chemical	Location	Result	Trends
Trichloroethene	Four intermediate springs, two wells or well ports	0.26 µg/L to 1.7 µg/L, below EPA MCL screening level of 5 µg/L	Present for 12 years in springs, during several years of sampling of wells
Barium	One spring and five alluvial wells in Cañon de Valle	620 µg/L to 8700 µg/L, above NM groundwater standard of 1,000 µg/L	Present at these levels for 10 years in Cañon de Valle wells, only one sample taken at Fish Ladder Canyon well and WA-625 Spring
RDX	Four alluvial wells in Cañon de Valle, one in Water Canyon	0.38 µg/L to 36 µg/L, above EPA Region 6 screening level of 6.1 µg/L	Present at these levels for 10 years in Cañon de Valle wells, in both samples taken at WCO-2

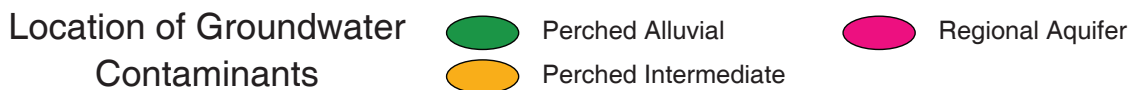
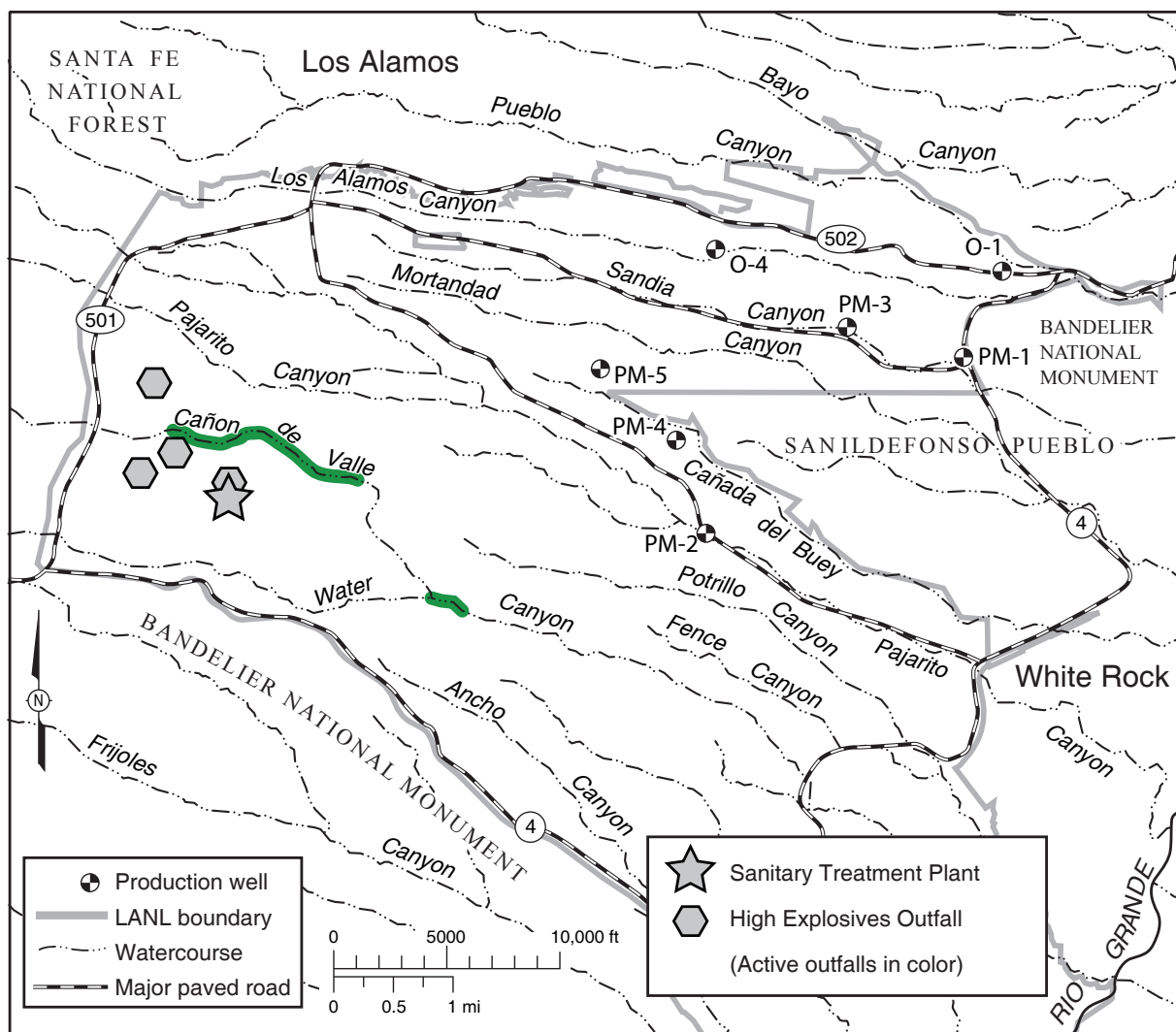


Figure 5-37. Location of groundwater containing barium above one half of the NM groundwater standard of 1,000 µg/L. Different colors indicate the affected groundwater zones.

Boron was found in samples from Martin Spring and other nearby springs at concentrations above the NM groundwater standard (for irrigation use), a reflection of past effluents (Figure 5-38).

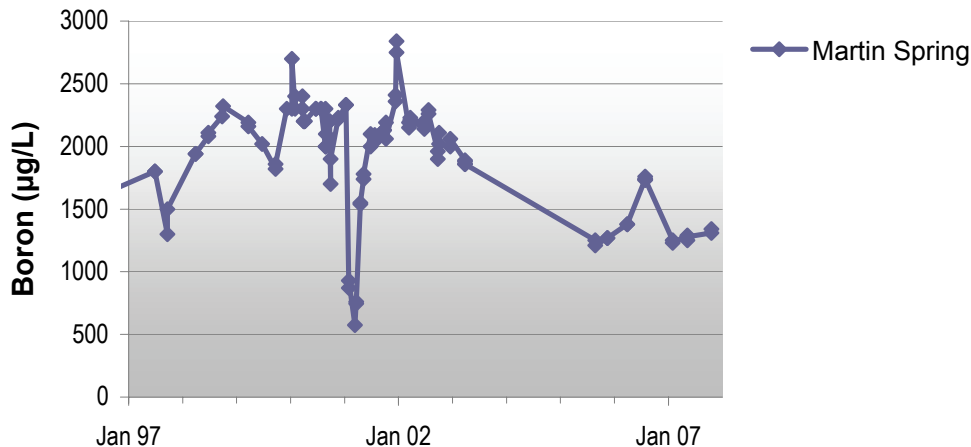


Figure 5-38. Boron in Cañon de Valle intermediate groundwater; the NM groundwater standard (for irrigation use) is 750 µg/L.

Intermediate perched zone well and spring samples contained several HE compounds. Of these compounds, RDX (Figures 5-36, 5-39, 5-40, 5-41) was present at the highest concentrations compared to risk levels, above the 6.1 µg/L EPA 10^{-5} excess cancer risk tap water screening level in springs and wells. The RDX levels have been fairly steady at most monitoring sites, though they show some seasonal fluctuation, for example, at Martin Spring (Figure 5-41). As seen in Figure 5-40, samples from two ports at regional aquifer well R-25 were apparently switched on February 7, 2007. The concentrations of RDX and several other organic chemicals at depths of 755 ft. and 892 ft. appear to be reversed in this sampling event and continue at usual values in later events.

The chlorinated solvents tetrachloroethene (also known as tetrachloroethylene, perchloroethylene [PERC]) and trichloroethene (or trichloroethylene [TCE]) continue to be found in several wells and springs (Table 5-17).

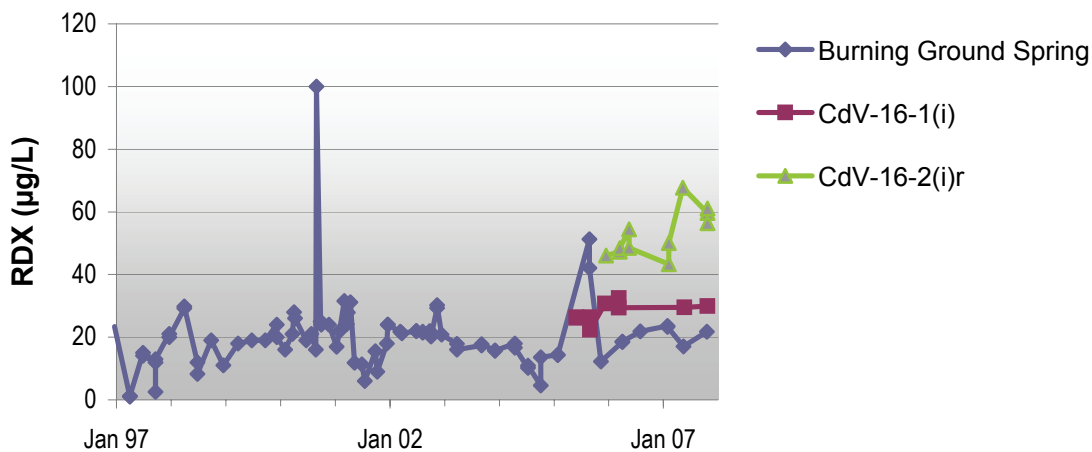


Figure 5-39. RDX in Cañon de Valle intermediate groundwater; the EPA Region 6 tap water screening level is 6.1 µg/L.

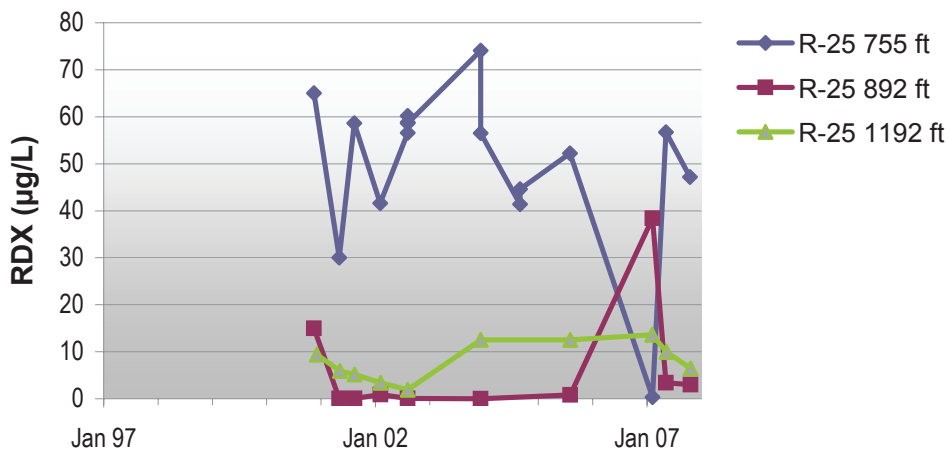


Figure 5-40. RDX in Cañon de Valle intermediate groundwater; the EPA Region 6 tap water screening level is 6.1 µg/L.

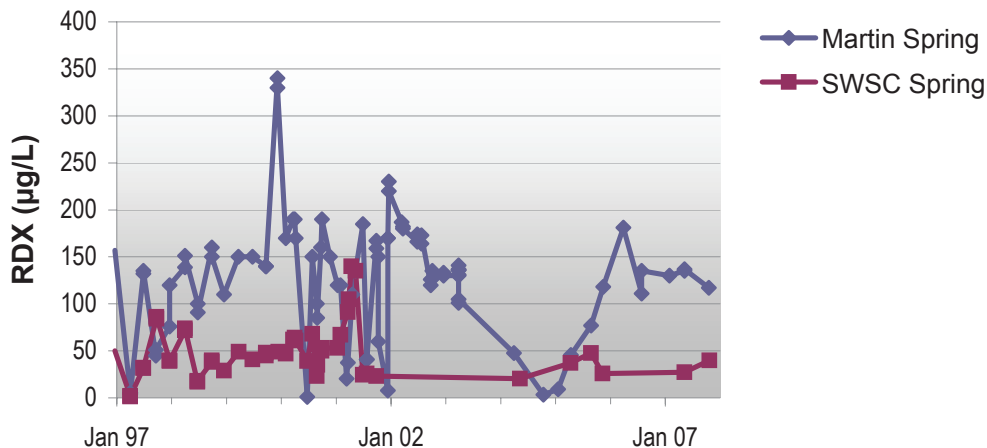


Figure 5-41. RDX in Cañon de Valle intermediate groundwater; the EPA Region 6 tap water screening level is 6.1 µg/L.

Barium, present due to past HE wastewater discharges, exceeded the NM groundwater standard in numerous alluvial wells in Cañon de Valle (Figures 5-37, 5-42). Alluvial well samples also contained several HE compounds. As with intermediate perched groundwater, RDX was the HE compound present at the highest concentrations compared to risk levels, some above the 6.1 µg/L EPA Region 6 10^{-5} screening level (Figures 5-36, 5-43).



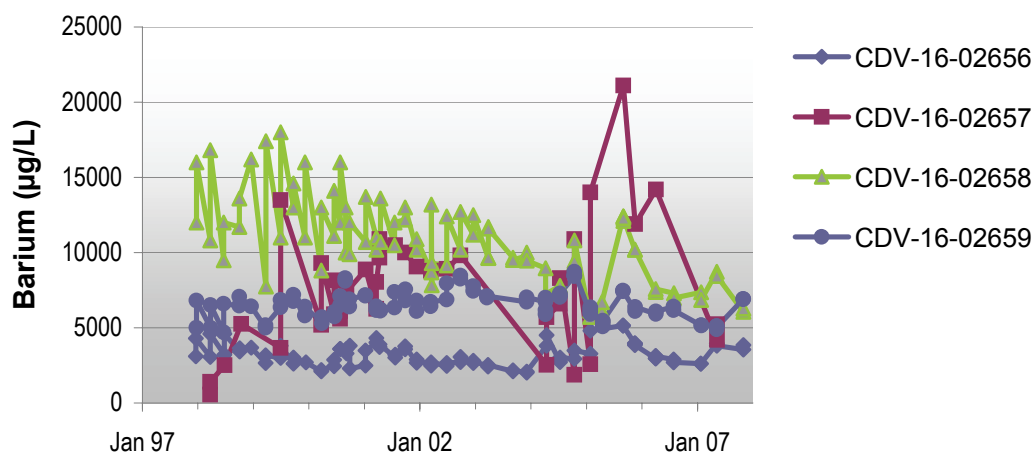


Figure 5-42. Barium in Cañon de Valle alluvial groundwater; the NM groundwater standard is 1,000 µg/L.

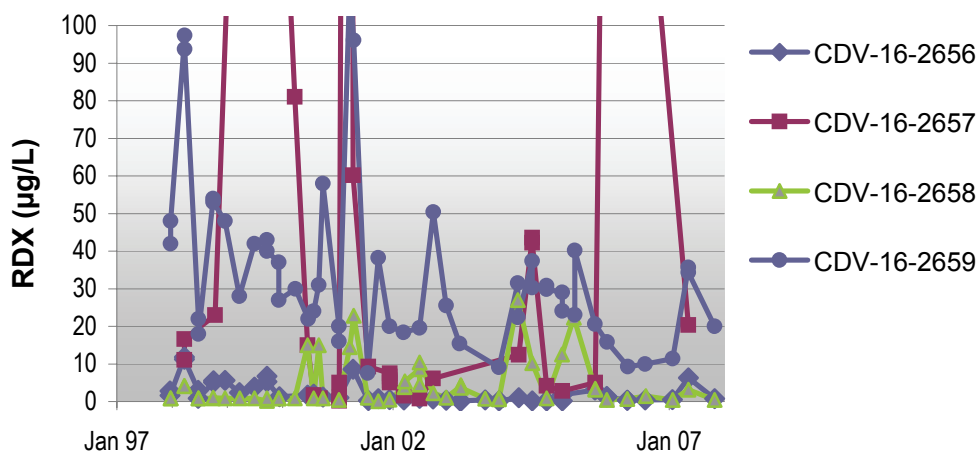


Figure 5-43. RDX in Cañon de Valle alluvial groundwater; the EPA Region 6 tap water screening level is 6.1 µg/L.

7. Ancho Canyon

Area AB at TA-49 was the site of underground nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). The tests involved insufficient HEs and fissionable material to produce a nuclear reaction. The canyons in the watershed are mainly dry with little alluvial and no known intermediate groundwater. In 1960, the US Geological Survey drilled three deep wells (Test Wells DT-5A, DT-9, and DT-10) to monitor regional aquifer water quality. Another regional aquifer well, R-31, lies downstream from firing sites at TA-39. No contaminants were found in these wells at concentrations near or above standards (Table 5-18).

Table 5-18
Summary of Groundwater Contamination in Ancho Canyon

Canyon	Contaminant Sources	Groundwater contaminants		
		Alluvial	Intermediate	Regional
Ancho Canyon	Minor dry sources and past effluent sources	Little or no alluvial groundwater	No intermediate groundwater	None

8. White Rock Canyon Springs

The springs that issue along the Rio Grande in White Rock Canyon represent the principal discharge of regional aquifer groundwater that flows underneath the Laboratory (Purtymun et al., 1980). The White Rock Canyon springs serve as boundary monitoring points for evaluating the Laboratory’s impact on the regional aquifer and the Rio Grande (Table 5-19). A few springs such as Spring 2B appear to represent discharge of intermediate perched groundwater; that spring is supplied by municipal sanitary effluent discharge or irrigation with effluent of athletic fields near White Rock.

Table 5-19
Summary of Groundwater Contamination in White Rock Canyon Springs

Canyon	Contaminant Sources	Groundwater contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: Springs	Sources in tributary canyons	No alluvial groundwater	Little intermediate groundwater	Natural fluoride, arsenic, uranium

Other than tritium, the only radionuclide detection of note in White Rock Canyon springs was natural uranium in La Mesita Spring (Table 5-20). Naturally occurring uranium is commonly detected in this spring and a few other nearby wells and springs. The tritium values in the White Rock Canyon springs are similar to results measured during the last decade. The highest results have been found at the Spring 4 group of springs. Activities there have decreased since 2002 and are now about 8 pCi/L at Spring 4 and Spring 4C and 32 pCi/L at Spring 4B. These springs discharge within a hundred yards of each other near the Rio Grande.

Table 5-20
Groundwater Quality in White Rock Canyon Springs

Chemical	Location	Result	Trends
Uranium	Regional aquifer La Mesita Spring, east of Rio Grande on San Ildefonso Pueblo lands	12.5 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Arsenic	Regional aquifer springs 2, 4, 4C, 6A, 6AAA	Up to 11.5 µg/L, above EPA MCL screening level of 10 µg/L; NM groundwater standard is 100 µg/L	Naturally occurring

Results for White Rock Spring perchlorate samples collected in 2007 are consistent with prior data; concentrations are below background levels observed in extensive sampling of NM groundwater by Plummer et al. (2006). The highest perchlorate value occurs east of the Rio Grande at La Mesita Spring on Pueblo de San Ildefonso land at a concentration of 0.85 µg/L. This spring has also had high nitrate and uranium values; it is not located near any apparent sources of contamination. Several of the springs in the Spring 4 series had perchlorate values of 0.5 to 0.6 µg/L, the highest concentrations for springs on the west side of the Rio Grande.

Spring 2 samples had fluoride concentrations at 0.6 mg/L, below the NM groundwater standard of 1.6 mg/L. The fluoride in this and nearby springs occurs naturally in groundwater near the Rio Grande and in the Española Basin.

9. Pueblo de San Ildefonso

This section covers results from Pueblo de San Ildefonso supply wells that lie near and east of the Rio Grande (Table 5-21). Other Pueblo de San Ildefonso wells and springs were covered in prior sections. The groundwater data for these wells and springs indicate the widespread presence of naturally occurring uranium at levels approaching the NM groundwater standard of 30 µg/L (Table 5-22). These measurements are consistent with previous samples. Naturally occurring uranium concentrations near or exceeding the NM groundwater standard are prevalent in well water throughout the Pojoaque area and Pueblo de San Ildefonso lands. The high gross alpha readings for these wells are related to naturally occurring uranium.

Table 5-21
Summary of Groundwater Contamination in White Rock Canyon Wells

Canyon	Contaminant Sources	Groundwater contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: San Ildefonso Pueblo and Buckman Well field	None	No alluvial groundwater	No intermediate groundwater	Natural TDS, fluoride, chloride, arsenic, boron, uranium

Table 5-22
Groundwater Quality in White Rock Canyon Wells

Chemical	Location	Result	Trends
Uranium	Regional aquifer Pueblo de San Ildefonso and Buckman supply wells	Up to 27 µg/L at Pueblo de San Ildefonso and 200 µg/L at Buckman No. 2, above NM groundwater standard of 30 µg/L	Naturally occurring
Gross alpha	Regional aquifer Pueblo de San Ildefonso and Buckman supply wells	Up to 12 µg/L at Pueblo de San Ildefonso and 102 µg/L at Buckman No. 2, above EPA drinking water system screening level of 15 µg/L (not applicable to gross alpha from uranium)	Naturally occurring, due to natural uranium
Fluoride	Westside and Eastside Artesian wells at Pueblo de San Ildefonso	Up to 4.8 mg/L, above NM groundwater standard of 1.6 mg/L	Naturally occurring
Chloride	Westside Artesian Well and Pajarito Well (Pump 1) at Pueblo de San Ildefonso	Up to 322 mg/L, above NM groundwater standard of 250 mg/L	Naturally occurring
TDS	Westside Artesian Well and Pajarito Well (Pump 1) at Pueblo de San Ildefonso, Buckman No. 2	600 mg/L to 1,150 mg/L, above NM groundwater standard of 1,000 mg/L	Naturally occurring
Arsenic	Regional aquifer Pueblo de San Ildefonso wells and Buckman No. 8	Up to 14.6 µg/L, above EPA MCL of 10 µg/L	Naturally occurring
Boron	Westside Artesian Well and Pajarito Well (Pump 1) at Pueblo de San Ildefonso	Up to 1,780 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Naturally occurring

Eastside Artesian and Westside Artesian wells have levels of sodium, chloride, fluoride, and TDS near or above NM groundwater standards or EPA health advisory levels. Westside Artesian well is not used as a drinking water source. Perchlorate concentrations in these wells ranged from nondetect to 0.57 µg/L.

The boron concentrations in the Eastside and Westside Artesian wells were above the NM groundwater standard of 750 µg/L (for irrigation use), similar to the values of past years. Several of the wells had arsenic concentrations that were near or above the 10 µg/L EPA MCL. These findings are also similar to results from past years and occur naturally.

10. Buckman Well Field

In 2007, we sampled three wells in the City of Santa Fe's Buckman Field (Table 5-21, 5-22). As in past samples, these wells, particularly Buckman well No. 2, contain high uranium relative to the NM groundwater standard of 30 µg/L. The gross alpha levels in these wells are attributable to the presence of uranium.

The water in some of these wells has high TDS, so concentrations of several chemicals including chloride are near or above NM groundwater standards or EPA health advisory levels. Naturally occurring metals such as arsenic and boron are also high in some wells.

G. QUALITY ASSURANCE OF GROUNDWATER, SURFACE WATER, AND SEDIMENT ANALYSES

1. Introduction

Environmental sampling incorporated QA in 2007 in accordance with DOE Order 414.1C, which prescribes a risk-based, graded approach to QA. To maximize effective resource use, this process promotes the selective application of QA and management controls based on the risk associated with each activity.

The LANL water quality database (<http://wqdbworld.lanl.gov/>) contains all the surface water and groundwater analytical data received from our contract analytical laboratories. None of the data are censored or removed. If analytical results were inconsistent with prior data, we investigated the laboratory records, and the sample may be reanalyzed or the location resampled. Both the initial sample and the follow-up sample analyses are kept in the database and are available to the public. In some cases, comments were appended to the records to indicate existence of recognized analytical issues. The primary documentation of analytical issues for data from a given year is provided in this report.

In 2007, the majority of the collected data were of high quality. The analytical laboratories qualified 8% of the data for potential data use issues; 40% (3% of the qualified data) of these qualifiers were because the results were between the quantitation and detection limits. The remaining approximately 5% of the results were qualified by the laboratory for potential data quality reasons. After data validation by the independent contractor AQA, 98% of all results were of sufficient quality for use. Overall, 22% of the accepted results were qualified for data quality reasons, including holding time violations, potential cross contamination, instrument calibration, and other reasons.

There are several interrelated components of the quality assurance efforts in the groundwater and surface water programs:

- Ensuring the quality and consistency of work processes at LANL used to collect and ship samples and to assess and validate data.
- Use of QC samples to measure the quality of sample collection processes and analytical results.
- Qualification and performance assessment of contract analytical laboratories.
- Validation of data packages.
- Review of analytical results.
- Audits and assessments of program and analytical laboratories.

2. Procedures for Work Processes

a. Methods

All sampling, data reviews, and data package validations were conducted using standard operating procedures that are part of a comprehensive QA program. The LANL quality program and procedures may be viewed at <http://www.lanl.gov/environment/all/qa.shtml>. Completed chain-of-custody forms serve as an analytical request form and include the requester or owner, sample number, program code, date and time of sample collection, total number of bottles, list of analytes to be measured, bottle sizes, and preservatives for each analysis required.

b. Results

Field quality assurance procedures and the quality plan documents were revised in 2006 and implemented for 2007 sampling for most of the affected documents. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that processes perform satisfactorily.

See Supplemental [Table S5-14](#), [Table S5-15](#), and [Table S5-16](#) for the analytes, analytical methods, and detection limits used for analysis of surface water, sediment, and groundwater samples, respectively, during 2007.

3. Quality Control for Samples and Analytical Results**a. Methods**

We submitted quality control samples along with environmental samples so that we can detect possible field or analytical laboratory contamination and track analytical laboratory performance. Differences in analytical results between field duplicate samples, for example, may indicate that the samples were not uniform or that there was significant variation in analyses. Detection of analytes in deionized water field blanks could indicate contamination of our deionized water source or sample bottles or contamination from the analytical laboratory. We evaluated the results from QC samples along with the environmental sample results to understand whether the results truly represent environmental measurements.

The required analytical laboratory batch QC is defined by the analytical method, the analytical statement of work (SOW), and generally accepted laboratory practices. The laboratory batch QC is used in the data-validation process to evaluate the quality of individual analytical results, to evaluate the appropriateness of the analytical methodologies, and to measure the routine performance of the analytical laboratory.

In addition to batch QC performed by laboratories, we submitted field QC samples to test the overall sampling and analytical laboratory process and to spot-check for analytical problems. These samples included equipment blanks, field blanks (deionized water), performance evaluation blanks (deionized water), and field trip blanks (described below). Duplicate analyses of selected samples were also conducted at the laboratory.

Equipment and Field Blanks: Equipment and field blanks were submitted for metals, organic chemicals, general inorganic, and radiochemistry analyses to monitor for contamination during sampling and decontamination of equipment. Contamination in the equipment and field blanks could be from either field contamination or contamination after sample collection. Any contamination in equipment or field blanks was reviewed to determine if a cause could be found.

Performance Evaluation Blanks: Performance evaluation blanks are deionized water blanks submitted as regular samples, without any indication that they are QC samples. These go through the same analytical process as the regular field samples. The deionized water blanks are measured with the same background contributions from reagents and biases as the regular samples, give an estimate of background and systematic analytical errors, and aid in the determination of false detections in associated environmental samples.

Field Trip Blanks: Trip blanks are a special case of performance evaluation blanks applicable to volatile organic compound measurements. They are kept with the samples from collection to analysis. Field trip blanks are used to help identify volatile organic compound cross contamination that may occur during sample handling, shipping, and storage, or at the analytical laboratory.

Field Duplicates: Field duplicates are split samples that provide information about field variation of sample results as well as analytical laboratory variation. Field duplicates can indicate sampling techniques with poor reproducibility.

b. Results

i. PCB and other organic chemical false positives results

In 2007, one recurring issue was the random detection of PCBs, pesticides, and polycyclicaromatic hydrocarbons (analyzed as part of the semivolatile organic suite) in many groundwater samples. These organic chemicals were often detected in just a field blank or in just one of a pair of field duplicates.

In nine groundwater samples, an Aroclor was detected resulting from analytical laboratory contamination (Aroclor in method blank) or laboratory cross-contamination. The samples are all from deep wells where the presence of PCBs is highly unlikely. Aroclors were also detected in 13 groundwater samples (including one field blank) in 2006, in four samples in 2005, and in four samples in 2004. These numbers suggest that analytical laboratory sample contamination by Aroclors is increasing.

Pesticides detected in one sample, but not in the duplicate, were rejected because the results were false positives caused by the presence of Aroclors. Aroclor-1242 was found in two other samples and in their analytical method blanks, indicating analytical contamination. Pesticide detections in another sample were rejected because the laboratory detected essentially the entire pesticide target analyte list which clearly indicates laboratory contamination.

An investigation of the source of the cross-contamination at GEL analytical laboratory determined that two non-LANL waste samples, containing extremely high concentrations of Aroclor-1242, -1254, and -1260, were extracted immediately before the LANL samples were processed. To correct the problems, GEL will not process LANL samples with those of other clients and has implemented more thorough glassware cleaning and segregation practices.

ii. Radionuclide false positive results

In late 2006 and early 2007, the number of apparent false positives for radioactivity analyses of groundwater samples using alpha spectroscopy seemed to have increased substantially. The alpha spectroscopy method is used to measure plutonium-238, plutonium-239/240, and americium-241. Other radionuclide analyses were not affected. A new MDA calculation process at GEL resulted in MDAs for plutonium-239/240 more than a factor of two lower than in 2005. This increased the number of detections in samples, making false positives more likely. The evident rate of false positives for plutonium-239/240 was 1% in 2005 and 2006 but is above 7% for the first part of 2007 (Table 5-23). False positives were identified as results from locations where plutonium is seldom detected. In many of these cases of apparent false positives, plutonium-239/240 was detected in only one of several samples collected on one date. As an example, at Sandia Canyon intermediate well SCI-1, plutonium-239/240 was detected in the equipment blank but not the original sample or duplicate. These inconsistencies indicate that the detection is a false positive or possibly from field contamination.

**Table 5-23
Plutonium-239/240 False Positive Rate**

Year	Number of Results	Number of False Positives	Percent of False Positives	Number of Detects	Percent of Detects
2005	332	3	0.9	17	5.1
2006	467	5	1.1	21	4.5
2007	104	8	7.7	8	7.7

Figure 5-44 shows the MDAs by year for all groundwater plutonium-239/240 results for 2005 through February of 2007. The plot shows the plutonium-239/240 MDA vs. 2 sigma (analytical uncertainty). The 1:1 line is for comparison purposes. Over the past three years, the MDAs have fallen significantly (with respect to analytical uncertainty) for results that are near the MDA. Figure 5-45 shows that for data collected between June 27, 2006, and February 26, 2007, the analytical laboratory reported results for plutonium-239/240 that

showed a systematic step decrease followed by a step increase in the lower limit (red line) for the reported MDA relative to the analytical uncertainty. Before and after these dates the analytical laboratory reported MDA values that were above the 3 sigma line, while many results between the dates fell closer to the 2 sigma line. A number of results always fall below these lines; these are cases with very large analytical results and small analytical uncertainties and are clearly detections.

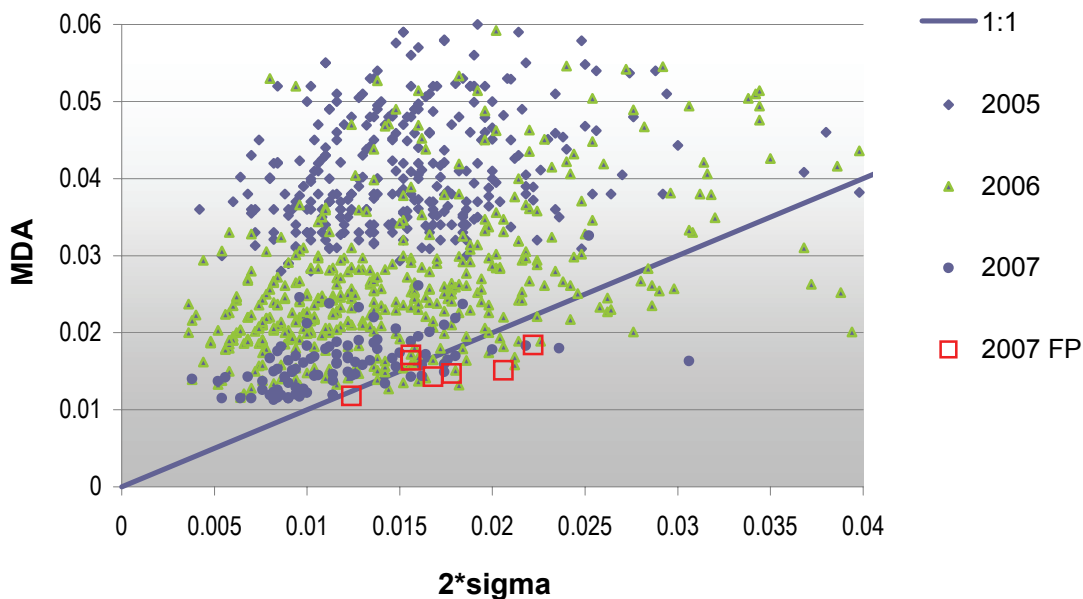


Figure 5-44. Minimum detectable activities (MDAs) for plutonium-239/240 for recent groundwater samples by year, showing a significant decrease in MDA relative to measurement uncertainty. The eight false positive results from 2007 (through February) are shown by square symbols.

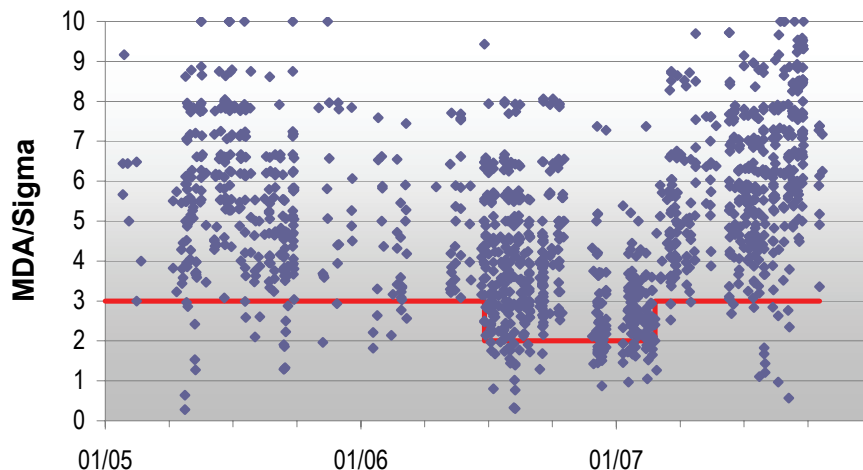


Figure 5-45. Ratio of MDA to the one-sigma analytical uncertainty for all groundwater plutonium-239/240 results from 2005 through October 29, 2007. For samples collected between June 27, 2006, and February 26, 2007, the analytical laboratory reported results that showed a systematic decrease in the lowest values for the ratio of reported MDA relative to the analytical uncertainty (red line).

This pattern of a lower MDA between June 27, 2006, and February 26, 2007, is also the case with results for plutonium-238 and americium-241. It appears that GEL changed its MDA calculation process between June 27, 2006, and February 26, 2007. The change on the latter date coincided with an inquiry from the Laboratory regarding this variation in alpha spectroscopy MDAs. The result of the variation in MDA calculation after June 27, 2006, was that many plutonium and americium measurements that were nondetects were inconsistently reported by the analytical laboratory as detections. One such sample was the plutonium-238 result of 0.0436 pCi/L (uncertainty 0.0193 pCi/L and MDA 0.035 pCi/L) collected on July 12, 2006, from Buckman Well No. 1. This result received widespread publicity as evidence of plutonium detection in the Santa Fe public water supply.

Though a root cause was not found for the change in MDA calculation process that resulted in increased false positives, GEL took actions to help prevent potential future false positives by improving their laboratory practices for glassware reuse and general laboratory cleanliness.

iii. Diesel range organics results

GEL did not correctly calculate the DRO MDL and many of the 2006/2007 results initially reported as detections were not detections. GEL had a false positive rate as indicated by method blank detections in excess of 50%. GEL will be increasing their DRO MDL from 16 µg/L to approximately 33 µg/L.

DRO detections in several 2006 and 2007 samples may be incorrect based on the very low signal level present on the chromatograms and because of the presence of DRO in the analytical laboratory method blanks.

The laboratory has agreed to use more standard reporting procedures for the DRO method for groundwater samples. As outlined in the analytical method, results will be reported to the PQL and more detailed information will be provided on blanks and detected results to help determine the reliability of the reported detections. These changes will make it less likely that false positive results will be reported and provide more defensible data for this method. GEL will also examine the method blank populations periodically to ensure that background levels are accurately reflected, use disposable pipettes instead of syringes, and perform more thorough cleaning of glassware and equipment.

4. Qualification and Performance Assessment of Analytical Laboratories

a. Methods

The Laboratory is responsible for acquiring analytical services that support monitoring activities. The Statement of Work (SOW) for analytical services follows the National Nuclear Security Administration Service Center's Analytical Management Program's Model SOW. The SOW provides to the contract analytical laboratories the general QA guidelines and includes specific requirements and guidelines for analyzing surface water, groundwater, and sediment samples.

Analytical laboratories undergo a pre-award assessment to evaluate their ability to perform the needed analyses.

LANL requires most analytical laboratories to participate in independent national performance evaluation programs. These programs measure each laboratory's performance when analyzing analytes in different media. The laboratories participate in the Mixed Analyte Performance Evaluation Program (MAPEP) and other pertinent programs as available for the analytical methods conducted under contract with LANL. For 2007, GEL, Paragon, and Severn-Trent Los Angeles (STLA) participated in both MAPEP and proficiency testing offered by Environmental Resource Associates, but STLA did not provide any water analyses for the covered analytes. STLA, Paradigm, and ALTA Analytical Laboratory did not participate in either of these programs.

b. Results

To provide access to additional laboratories and meet the requirements of the NMED Consent Order, analytical laboratory contracts were combined with the contracts within the LANL Environmental Programs Directorate under control of the Sample Management Office (SMO). Three additional laboratories were added to address specific needs created by the Consent Order and by the chromium issue.

- To address the need for polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), GEL subcontracted with Paradigm Analytical Laboratories. Due to performance problems with Paradigm Analytical Laboratories on the PCDDs and PCDFs analysis, the SMO transferred the work to ALTA Analytical Lab.
- To address the need for analysis of the biodegradation products of Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), Severn-Trent Laboratories was selected to do the analysis for mononitroso-RDX (MNX), dinitroso-RDX (DNX), and trinitroso-RDX (TNX) due to their previous experience with this method. The method development was conducted at the direction of the SMO for the Environmental Restoration Program and the first analyses conducted in 2001. The first analyses for the Water Stewardship Program were conducted in 2006 and were continued in 2007.

GEL participated in many different performance evaluation studies that addressed a majority of the parameters for which they conduct analysis. There are no performance evaluation programs for the specialty analyses conducted at STLA (hexavalent chromium-VI), ALTA (dioxins and furans), Paradigm (dioxins and furans), and Severn-Trent Saint Louis (STSL) (RDX breakdown products). Therefore, performance on groundwater samples at STLA, ALTA, Paradigm, and STSL was not assessed through performance evaluation programs.

Results for the applicable 2007 performance evaluation programs at GEL are given in Table 5-24 for water and soil samples. (Soil PE sample results are applicable to sediment samples.) Only results that were found deficient are discussed. The majority of results were found sufficient and these are not included.

Table 5-24
2007 Performance Evaluation Results at GEL Laboratories LLC

Evaluation	Analytes Affected	Results and Actions Taken
1st Quarter 2007 Performance Evaluations		
ERA WP-142	1,2-Dichloroethane by SW846 8260B and EPA Method 624	Reported value = < 1.00 µg/L; acceptance limits = 34.8 – 66.3 µg/L. False negative reported. No further corrective action was reported.
2nd Quarter 2007 Performance Evaluations		
ERA WS-126	Ortho-Phosphate by EPA 300.0	Reported value = 5.42 mg/L; acceptance limits = 4.20 – 5.33 mg/L. No corrective action reported. All batch quality control measures were acceptable. GEL determined that the error was introduced at either the initial dilution of the performance test sample or when the sample was diluted 10X during analysis.
ERA WS-126	Carbon tetrachloride by EPA 524.2	Reported value = 8.40 µg/L; acceptance limits = 8.64 – 13.0 µg/L. All quality control indicators were acceptable. No further corrective action was reported.
ERA WS-126	Methylene chloride by EPA 524.2	Reported value = 14.0 µg/L; acceptance limits = 14.9 – 22.3 µg/L. All quality control indicators were acceptable. No further corrective action was reported.

Table 5-24 (continued)

Evaluation	Analytes Affected	Results and Actions Taken
ERA WS-129	Ortho-Phosphate by EPA 365.2	Reported value = 1.91 mg/L; acceptance limits = 1.26 – 1.68 mg/L. No corrective actions were reported for the above PT failures.
ERA WS-129	1,1-Dichloroethylene by EPA 524.2	Reported value = 15.7 µg/L; acceptance limits = 10.4 – 15.6 µg/L. No corrective actions were reported for the above PT failures.
ERA WS-129	Methylene chloride by EPA 524.2	Reported value = 23.8 µg/L; acceptance limits = 15.8 – 23.6 µg/L. No corrective actions were reported for the above PT failures.
ERA WS-129	Ethylbenzene by EPA 524.2	Reported value = 18.2 µg/L; acceptance limits = 12.0 – 18.0 µg/L. No corrective actions were reported for the above PT failures.
NY300	Biochemical oxygen demand by EPA 405.1	Reported value = 263 mg/L; acceptance limits = 59.8 – 177 mg/L. The cause of the failure is reported as unknown by the laboratory.
NY300	Nitrate as N by EPA 353.2	Reported value = 18.4 mg/L; acceptance limits = 11.1 – 17.2 mg/L. All quality control indicators were acceptable. It was noted that the sample was analyzed at a 50X dilution. No further corrective action was reported.
NY300	Silver by EPA 200.8	Reported value = 312 µg/L; acceptance limits = 411 – 549 µg/L. All quality control indicators were acceptable. No further corrective action was reported.
NY300	Silver by EPA 6020	Reported value = 38.1 mg/kg; acceptance limits = 56.7 – 103 mg/kg. No corrective action was reported.
NY300	2-Nitrophenol by SW8270C	Reported value = < 10.0 µg/L; acceptance limits = 21.7 – 102 µg/L. The instrument quantitation software, Target, assigned this compound as a detection; however, the analyst mistakenly deleted the detection of this compound, determining that co-elution with 2,4-dimethylphenol had caused a false positive. Both 2-nitrophenol and 2,4-dimethylphenol were included in the PT sample.
NY300	2,4-Dinitrophenol by SW8270C	Reported value = < 667 µg/kg; acceptance limits = 644 – 790 µg/kg. The true value for this analyte is 398 µg/kg, which is less than the reported quantitation limit of 667 µg/kg.
NY300	Total cyanide by EPA 335.3	Reported value = 0.82 mg/L; acceptance limits = 0.30 – 0.723 mg/L. All quality control indicators were acceptable. It was noted that the sample was analyzed at a 10X dilution. No further corrective action was reported.
NY300	Hexavalent chromium by SW7196A	Reported value = 0.749 µg/L; acceptance limits = 407 – 589 µg/L. The laboratory reported the result as if the reporting units were mg/L rather than µg/L. The reported result should have been 749 µg/L, which is a high bias. All quality control indicators were acceptable. It was noted that the sample was analyzed at a 10X dilution. No further corrective action was reported.
NY300	Total sulfide by EPA 376.1	Reported value = 1.50 mg/L; acceptance limits = 2.47 – 8.28 mg/L. All quality control indicators were acceptable. It was noted that the reported result was low by a factor of two, indicating an improper dilution. No further corrective action was reported.
NY300	Aluminum and copper by EPA 200.8 and carbon tetrachloride by SW8260B	These results were acceptable but were reported outside the warning limits (i.e., check for error results).

Table 5-24 (continued)

Evaluation	Analytes Affected	Results and Actions Taken
MAPEP Study 17	Selenium in soil by SW6020	Selenium was reported as a false positive. No corrective action was reported.
MAPEP Study 17	Nickel-63 in soil, Uranium-234/233 in vegetation, and Zinc-65 in vegetation	These analytes were acceptable but were reported outside the warning limits. No corrective action was reported.
NY302	Fluoride by EPA 300.0	Reported value = 2.36 mg/L; acceptance limits = 2.48 – 3.03 mg/L. The laboratory reports that the batch quality control was acceptable and that no apparent cause for the error was found.
ERA WP-147	Titanium by EPA 200.8/SW6020	Reported value = 163 µg/L; acceptance limits = 172 – 227 µg/L. No corrective action was reported.
ERA SOIL-58	Silver Ag by SW6020	Reported value = 18.5 mg/kg; acceptance limits = 52.4 – 110 mg/kg. No corrective action was reported.
ERA SOIL-58	Tin by 6020	Reported value = 40.3 mg/kg; acceptance limits = 69.1 – 148 mg/kg. No corrective action was reported.
ERA SOIL-58	Methoxychlor by SW8081A	Reported value = 451 µg/kg; acceptance limits = 17.7 – 348 µg/kg. No corrective action was reported.
ERA SOIL-58	Diesel range organics by SW8015B	Reported value = 3,540 mg/kg; acceptance limits = 202 – 3,150 mg/kg. No corrective action was reported.
ERA SOIL-58	Total petroleum hydrocarbons by SW9071A and SM5520F	Reported value = 2,700 mg/kg; acceptance limits = 0.00 – 2,330 mg/kg. No corrective action was reported.
3rd Quarter 2007 Performance Evaluations		
ERA WS-132	Ortho-Phosphate by EPA 300.0	Reported value = 4.00 mg/L; acceptance limits = 3.03 – 3.88 mg/L. There were no apparent quality control failures observed in the associated analytical batch. No further corrective actions were stated.
ERA WS-132	Thallium by EPA 200.7	Reported value = 14.9 µg/L; acceptance limits = 6.36 – 11.8 µg/L. The true value of 9.09 µg/L is below GEL's reporting limit for this analyte.
ERA WS-132	Vanadium by EPA 200.8	Reported value = 276 µg/L; acceptance limits = 286 – 350 µg/L. A remedial PT sample was analyzed with acceptable results.
ERA WS-132	Zinc by EPA 200.8	Reported value = 1090 µg/L; acceptance limits = 871 – 1060 µg/L. A remedial PT sample was analyzed with acceptable results.
ERA WS-132	Uranium (Natural) by EPA 200.7	Reported value = 91.5 µg/L; acceptance limits = 59.6 – 84.6 µg/L. This analyte is commonly not analyzed using Method 200.7.
ERA WS-132	Tert-Butyl benzene by EPA 524.2	Reported value = 14.9 µg/L; acceptance limits = 36.0 – 54.0 µg/L. There were no apparent quality control failures observed in the associated analytical batch. Since >80% of the target analytes were acceptable, no further corrective actions are required.

Table 5-24 (continued)

Evaluation	Analytes Affected	Results and Actions Taken
ERA WS-132	Ethylene dibromide by EPA 504.1/EPA 8011	Reported value = 0.314 µg/L; acceptance limits = 0.343 – 0.801 µg/L. This PT sample was analyzed on an instrument not normally used for this method. Although a method detection limit study was analyzed and all quality control results were acceptable, use of this instrument may have contributed to the failed results. A remedial PT sample was analyzed with acceptable results.
ERA WS-132	Total residual chlorine by EPA 330.5/SM 4500 Cl G	Reported value = 0.853 mg/L; acceptance limits = 1.30 – 1.77 mg/L. There were no apparent quality control failures observed in the associated analytical batch. No further corrective actions were stated.
NY305	Acenaphthylene by EPA 8310	Reported value = 11.5 µg/L; acceptance limits = 13.9 – 46.3 µg/L. The failures for Method 8310 have been attributed to the extraction process. While the laboratory control sample (LCS) passed for the stated analytes, their recoveries were on the low end of the acceptance limits. The same is true for the LCS duplicate, with the exception of naphthalene, which did not meet acceptance limits at 60.4% (61-100%). The sample was not re-extracted due to the lack of sample volume available for re-extraction.
NY305	Naphthalene by EPA 8310	Reported value = 19.9 µg/L; acceptance limits = 20.4 – 88.1 µg/L. The failures for Method 8310 have been attributed to the extraction process. While the LCS passed for the stated analytes, their recoveries were on the low end of the acceptance limits. The same is true for the LCS duplicate, with the exception of naphthalene, which did not meet acceptance limits at 60.4% (61-100%). The sample was not re-extracted due to the lack of sample volume available for re-extraction.
NY305	Acenaphthylene by EPA 8270C	Reported value = 1.64 µg/L; acceptance limits = 1.80 – 4.73 µg/L. Each of the failed analytes for Method 8270C were under 10% Drift (%D) in the daily continuing calibration verification standard. The problem has been isolated to the instrument on which the samples were analyzed, MSD7, which is the oldest GC/MS and has exhibited sensitivity issues at the low end of the calibration range. Review of the initial calibration exhibited that the ratio between the 1 µg/mL standard and the 10 µg/mL standard for these compounds was not optimal. GEL is considering replacing this instrument during 2008.
NY305	Benzo(a)anthracene by EPA 8270C	Reported value = 1.11 µg/L; acceptance limits = 1.12 – 1.94 µg/L. Each of the failed analytes for Method 8270C were under 10%D in the daily continuing calibration verification standard. The problem has been isolated to the instrument on which the samples were analyzed, MSD7, which is the oldest GC/MS and has exhibited sensitivity issues at the low end of the calibration range. Review of the initial calibration exhibited that the ratio between the 1 µg/mL standard and the 10 µg/mL standard for these compounds was not optimal. GEL is considering replacing this instrument during 2008.
NY305	Benzo(b)fluoranthene by EPA 8270C	Reported value = 0.385 µg/L; acceptance limits = 0.398 – 1.14 µg/L. Each of the failed analytes for Method 8270C were under 10%D in the daily continuing calibration verification standard. The problem has been isolated to the instrument on which the samples were analyzed, MSD7, which is the oldest GC/MS and has exhibited sensitivity issues at the low end of the calibration range. Review of the initial calibration exhibited that the ratio between the 1 µg/mL standard and the 10 µg/mL standard for these compounds was not optimal. GEL is considering replacing this instrument during 2008.

Table 5-24 (continued)

Evaluation	Analytes Affected	Results and Actions Taken
NY305	Benzo(k)fluoranthene by EPA 8270C	Reported value = 0.814 µg/L; acceptance limits = 0.833 – 1.80 µg/L. Each of the failed analytes for Method 8270C were under 10%D in the daily continuing calibration verification standard. The problem has been isolated to the instrument on which the samples were analyzed, MSD7, which is the oldest GC/MS and has exhibited sensitivity issues at the low end of the calibration range. Review of the initial calibration exhibited that the ratio between the 1 µg/mL standard and the 10 µg/mL standard for these compounds was not optimal. GEL is considering replacing this instrument during 2008.
NY305	Dibenzo(a,h)anthracene by EPA 8270C	Reported value = 2.2 µg/L; acceptance limits = 0.521 – 2.17 µg/L. Each of the failed analytes for Method 8270C were under 10%D in the daily continuing calibration verification standard, with the exception of dibenzo(a,h)anthracene, which had a %D of -25%. The problem has been isolated to the instrument on which the samples were analyzed, MSD7, which is the oldest GC/MS and has exhibited sensitivity issues at the low end of the calibration range. Review of the initial calibration exhibited that the ratio between the 1 µg/mL standard and the 10 µg/mL standard for these compounds was not optimal. GEL is considering replacing this instrument during 2008.
NY305	Aroclor-1016 by EPA 8082	Reported value = false negative; acceptance limits = 2.51 – 12.8 µg/L. This Aroclor was misidentified by an inexperienced data peer reviewer. GEL has stated a more experienced reviewer will be used in the future. This is GEL's second Aroclor failure. Close scrutiny in the future is warranted.
NY305	Aroclor-1242 by EPA 8082	Reported value = false positive; acceptance limits = not applicable. This Aroclor was misidentified by an inexperienced data peer reviewer. GEL has stated a more experienced reviewer will be used in the future. This is GEL's third Aroclor failure. Close scrutiny in the future is warranted.
NY305	Acetone by EPA 8260B	Reported value = false negative; acceptance limits = 32.0 – 888 µg/L. There was no corrective action reported for this analyte.
NY305	Total Sulfide by EPA 376.1	Reported value = 13.0 mg/L; acceptance limits = 3.46 – 10.4 mg/L. The true value for this analyte is 6.95 mg/L. The unacceptable result has been attributed to a dilution error; the reported value is twice as high as the true value. Attention to detail was re-iterated to the analyst.
4th Quarter 2007 Performance Evaluations		
ERA WP-153	Turbidity by EPA 180.1/SM2130 B	Reported value = 7.80 NTU; acceptance limits = 3.14 – 4.60 NTU. This PT sample failure is currently under investigation by GEL.
ERA WP-153	Settleable Solids by EPA 160.5/SM2540 F	Reported value = 40 mL/L; acceptance limits = 23.6 – 38.4 mL/L. This PT sample failure is currently under investigation by GEL.
ERA WP-153	Titanium by EPA 200.8/SW6020	Reported value = 113 µg/L; acceptance limits = 130 – 172 µg/L. This PT sample failure is currently under investigation by GEL.
ERA WP-153	Sulfide by SW9030/9034	Reported value = 5.01 mg/L; acceptance limits = 0.635 – 4.25 mg/L. These PT sample failures are currently under investigation by GEL.
ERA WP-153	4-Methylphenol by EPA 625/ SW8270C	Reported value = < 10 µg/L [false negative]; acceptance limits = 17.4 – 223 µg/L. This PT sample failure is currently under investigation by GEL.

Table 5-24 (continued)

Evaluation	Analytes Affected	Results and Actions Taken
ERA WP-153	Surfactants (MBAS) by EPA 425.1/SM5540 C	Reported value = 0.526 mg/L; acceptance limits = 0.193 – 0.485 mg/L. This PT sample failure is currently under investigation by GEL.
NY307	Chloride by EPA 300.0	Reported value = 52.7 mg/L; acceptance limits = 54.7 – 66.3 mg/L. This PT sample failure is currently under investigation by GEL.
NY307	Sulfate by EPA 300.0	Reported value = 195 mg/L; acceptance limits = 197 – 247 mg/L. This PT sample failure is currently under investigation by GEL.
NY307	Isopropylbenzene by EPA 524.2	Reported value = 48.5 µg/L; acceptance limits = 31.0 – 46.4 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	1,1,1-Trichloroethane by EPA 524.2	Reported value = 15.8 µg/L; acceptance limits = 10.4 – 15.6 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	1,1-Dichloroethane by EPA 524.2	Reported value = 40.0 µg/L; acceptance limits = 25.8 – 38.6 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	1,1-Dichloropropene by EPA 524.2	Reported value = 40.0 µg/L; acceptance limits = 25.6 – 38.4 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	cis-1,2-Dichloroethene by EPA 524.2	Reported value = 27.5 µg/L; acceptance limits = 17.8 – 26.8 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	1,3-Dichloropropane by EPA 524.2	Reported value = 22.9 µg/L; acceptance limits = 15.1 – 22.7 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	2,2-Dichloropropane by EPA 524.2	Reported value = 27.4 µg/L; acceptance limits = 17.2 – 25.8 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	Bromochloromethane by EPA 524.2	Reported value = 53.0 µg/L; acceptance limits = 33.0 – 49.4 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	Carbon Tetrachloride by EPA 524.2	Reported value = 20.7 µg/L; acceptance limits = 13.1 – 19.7 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	Chloromethane by EPA 524.2	Reported value = 24.4 µg/L; acceptance limits = 9.72 – 22.7 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	Dibromomethane by EPA 524.2	Reported value = 27.2 µg/L; acceptance limits = 17.4 – 26.2 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	Dichlorodifluoromethane by EPA 524.2	Reported value = 44.0 µg/L; acceptance limits = 16.4 – 38.4 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	Methylene chloride by EPA 524.2	Reported value = 14.3 µg/L; acceptance limits = 9.44 – 14.2 µg/L. This PT sample failure is currently under investigation by GEL.
NY307	Trans-1,2-Dichloroethene by EPA 524.2	Reported value = 26.5 µg/L; acceptance limits = 16.9 – 25.3 µg/L. This PT sample failure is currently under investigation by GEL.

All other water and sediment analytes not shown in the table were acceptable



5. Validation of Data Packages

a. Methods

We verify that analytical data used to support monitoring activities are defensible and of known quality. Analytical data packages sent to us by the analytical laboratories undergo a rigorous review and validation process following the guidelines set in the DOE-AL Model standard operating procedure for data validation, which includes review of the data quality and the documentation's correctness and completeness. Table S5-5, Table S5-6, and Table S5-7 include the list of qualifiers and validation reason codes used to qualify the 2007 sediment and water data. When documentation or contract-compliance problems are identified during data validation, the analytical laboratory is contacted and attempts are made to resolve or clarify the problem.

b. Results

AQA validated all of the 2007 data packages. Individual validation memos were issued for each analytical fraction (method) for each data report. The average report had five data validation memos. AQA issued a number of nonconformance reports (NCRs) for Data Validation Memos that had to be reissued. Most of the NCRs were written in response to problems concerning minor documentation and typographical errors on individual memos. These reports were corrected and reissued. Associated sample results were generally not affected.

In 2007, documentation or contract-compliance problems required the largest analytical services provider, GEL, to issue package-specific NCRs. Most of the NCRs written in response to these problems concerned requests for clarification on data results and missing pages in the data packages. GEL reissued corrected documents for all of the reports containing missing documentation or erroneous data.

6. Review of Analytical Results

a. Methods

Radiological Data: Negative values are sometimes reported in radiological measurements. Negative numbers occur because radiochemistry counting instrument backgrounds are subtracted from sample readings to obtain net counts. Because of slight background fluctuations, individual values for samples containing little or no activity can be positive or negative numbers. Although negative values do not represent a physical reality, removing negative values would introduce a positive bias to a data set, so we report them as they are received from the analytical laboratory as required by the "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991). Also see Appendix B.

The precision of radiological analytical results is reported as one standard deviation (one sigma) of the total propagated uncertainty. For most radionuclide measurements, we report a detection as an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (indicating nondetect). University of Miami tritium data do not have laboratory qualifiers; in which case, a detected result is reported when analytical results are greater than three times the reported (one-sigma) uncertainty.

Nonradiological Data: For organic chemicals and some general inorganic chemistry parameters (that is, major anions, cations, and nutrients), the nondetections are reported at the PQL. For the metals and the rest of the general inorganic chemicals, nondetections are reported at the MDL. Data between the MDL and PQL are qualified as estimated (J) by the analytical laboratory. The analytical laboratory reports nonradiological results below the MDL as nondetections.

Detection-Limit Issues: The LANL analytic services SOW requires that analytical laboratories verify their calculated MDLs empirically. Federal regulations prescribe a process for determining analytical laboratory detection limits that uses standards based on deionized water. For analysis of environmental samples, these detection limits may not be achievable. The additional chemicals present in natural water samples may lead to

matrix interference in the analytical process, which decreases the method sensitivity. Comparing results from these analyses with a detection limit based on deionized water will lead to additional false positive results for environmental samples. Empirical determination of detection limits using natural sample matrices produces a detection limit that is achievable for these samples.

b. Results

In addition to data validation, results are reviewed to assess the need for actions. In some cases, the data review identifies issues with data quality that require action to determine the overall quality of the reported results. Issues with data quality identified either through validation or data review are addressed in this section.

Because of the sensitive nature of organic chemical sampling and analysis, a carefully designed field and analytical laboratory QC program is essential for evaluating the presence of organic chemicals in environmental samples. Organic chemicals may be detected in field QC samples such as field blanks or equipment blanks, indicating that they are not truly present in associated groundwater samples. These analytes may be present in the QC samples because of inadvertent contamination of sampling or analytical laboratory equipment by organic chemicals that come from other sources.

Most analytical methods require the analysis of laboratory-prepared method blanks or instrument blanks with each batch of samples. Target organic chemicals that are detected in these blanks indicate contamination from the sampling or analytical environments. Certain organic chemicals used in analytical laboratories are frequently detected in laboratory blanks, that is, contamination introduced by the analytical process is common for these compounds. These compounds include acetone, methylene chloride, toluene, 2-butanone, di-n-butyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl)phthalate (Fetter 1993). Numerous field, trip, and equipment blanks collected during this reporting period contained toluene, acetone, 2-butanone, and 2-hexanone, which indicates inadvertent sample contamination in either the field or analytical laboratory.

7. Department of Energy Contract Analytical Program Audits

a. Methods

The Office of Environmental Management at DOE Headquarters (HQ-EM) mandated participation in the DOE Contract Analytical Program (DOECAP; <https://doecap.oro.doe.gov/>). DOECAP is a consolidated, uniform audit program for conducting annual audits of commercial laboratories to eliminate audit redundancy by involving all DOE program line organizations and field elements, provide a pool of trained auditors sufficient to support consolidated audits, standardize terms and conditions of existing and proposed contracts to allow acceptance of consolidated audit results, and interface with state and federal regulatory agencies, as well as other industry standard-setting groups, such as the National Environmental Laboratory Accreditation Conference. LANL requires participation in DOECAP for all major analytical providers. Smaller or specialty providers are audited following the LANL Waste and Environmental Services Division QA Program.

Table 5-25 below shows the DOECAP audits conducted for 2007 for analytical laboratories used by LANL.

Table 5-25
DOECAP Audits Conducted in 2007 for Analytical Laboratories used by LANL

Laboratory	Audit Type	Audit Dates
Paragon Analytics, Fort Collins, Colorado	Annual Qualifications Audit	March 20–22, 2007
Severn Trent Laboratories, Inc., Earth City, Missouri	Annual Qualifications Audit	April 10–12, 2007
Severn Trent Laboratories, Inc., Earth City, Missouri	Surveillance of Corrective Actions	May 31–June 1, 2007
GEL, LLC, Charleston, South Carolina	Annual Qualifications Audit	April 24–26, 2007

DOECAP audits result in findings and observations when there are items of concern that need to be addressed in the audit report. The DOECAP Policies and Practices document defines the following findings and observations:

- A Priority I finding shall only be issued for a significant item of concern or significant deficiency regarding key management/programmatic control(s), which in and of itself represents a concern of sufficient magnitude to potentially render the audited facility unacceptable to provide services to the DOE if not resolved via immediate and/or expedited corrective action(s).
- A Priority II finding shall be issued to document a deficiency which in and of itself does not represent a concern of sufficient magnitude to render the audited facility unacceptable to provide services to the DOE.
- An observation provides the DOECAP a mechanism for identifying and tracking a deficiency of an isolated nature or lesser significance than that of warranting an issuance of a Priority II finding, as well as an opportunity for improvement identified during a DOECAP audit.

b. Results

The following DOECAP audits were conducted at facilities providing water and sediment data to the Water Stewardship Program:

- Paragon Analytics, Fort Collins, Colorado: This audit occurred on March 20–22, 2007. There were 16 new Priority II findings and 10 new observations. The corrective action plan has been approved and is available from the DOECAP web site.
- Severn Trent, Earth City Missouri: This audit occurred on April 10–12, 2007. There were three new Priority II findings and 1 new observation. The corrective action plan has been approved and is available from the DOECAP web site.
- GEL, LLC, Charleston, South Carolina: This audit occurred April 24–26, 2007. There were 13 new Priority II findings and 14 new observations. The corrective action plan has been approved and is available from the DOECAP web site.

8. Internal Audits

a. Methods

In 2007, the LANL QA organization performed three surveillance-type assessments and one independent assessment of sampling-related activities.

b. Results

Areas for improvement identified by these assessments were in the areas of procedure quality, sampling techniques, training of sampling personnel, and documentation of results. A comprehensive Improvement Plan has been developed to address all issues identified by QA and includes the following:

- Procedures are being upgraded to incorporate industry best practices and/or clarify requirements.
- Training for all sampling personnel is required for the procedure revisions and will include increased emphasis on improving sampling techniques and procedure adherence.
- Increased oversight of sampling activities will be performed by LANL's Water Stewardship Program.

All issues identified in the assessments have been formally documented in the LANL corrective action program and will be tracked to completion. In addition, the QA organization will verify completion of all actions prior to closure of the tracking documents.

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