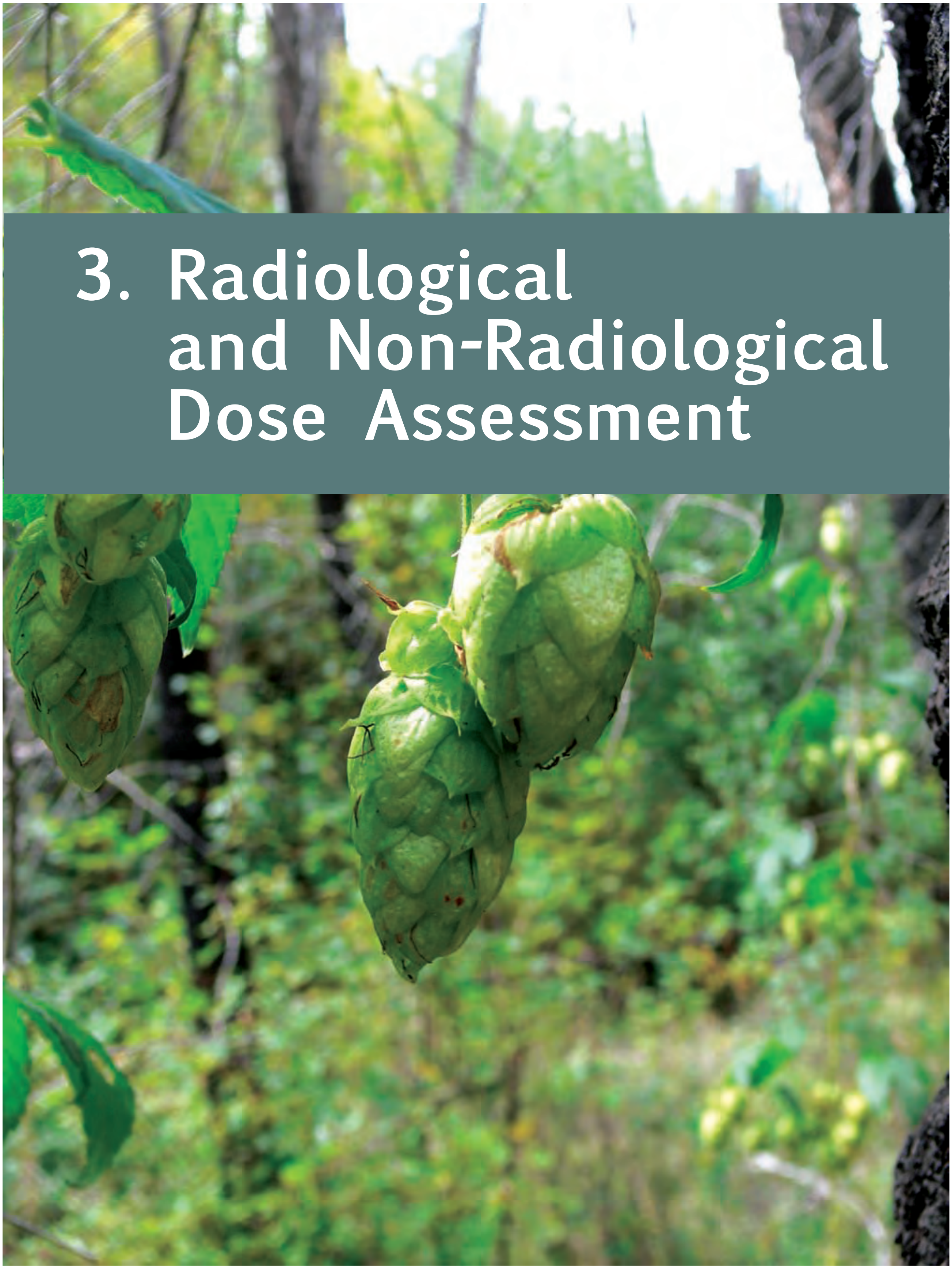

3. Radiological and Non-Radiological Dose Assessment

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 2006 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), usually at locations rarely visited by humans. In addition, the potential risks from nonradiological materials detected during 2006 and previous years' sampling activities are summarized.

As defined by DOE Standard 1153-2002 (DOE 2002), biota are divided into plants and animals. Plants receive the highest dose because they live their whole lives in one location. 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 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; 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 people 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 ALARA (as low as reasonably achievable) process and generally not exceeding a dose constraint of one-quarter of the primary dose limit, or 25 millirem in a year (DOE 1999). The dose received from airborne emissions of radionuclides is further restricted by the US Environmental Protection Agency's (EPA's) dose standard of 10 mrem/yr (EPA 1986), also known as the RAD-NESHAP (National Emission Standards for Hazardous Air Pollutants) dose limit. 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/DOE 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/DOE 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 begin 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 400 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 470 mrem/yr on average). It is extremely difficult to measure doses from LANL that are 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 not elsewhere.

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 km, 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.b.ii of this chapter).

To estimate the dose to the public, we combine 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 follow standard guidance and assume continuous occupancy for residences and places of business. For all other locations, we multiply 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 use 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 calculate the doses using the CAP88 model (EPA 2006), 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 2006).

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 (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 2006 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. Americium-241, plutonium-239,240, cesium-137, strontium-90, and tritium were measured in these samples at the following maximum concentrations: 0.288 pCi/L, 0.179 pCi/L, 8.32 pCi/L, 31.1 pCi/L, and 148.8 pCi/L, respectively. The maximum dose from ingesting one liter of water from this spring would be approximately 0.0065 mrem. The highest concentration of tritium detected in a Los Alamos County drinking water supply well was about 21 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 0.1 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 2006.

iv. Soil (Direct Exposure Pathway). We report 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.

Radionuclide concentrations above the RSRLs were detected in soil samples taken from perimeter locations at TA-8 (GT Site), West Airport, and Tsankawi/PM-1. At the TA-8 location, the following radionuclides were detected above RSRLs: 1) cesium-137 at 1.4 pCi/g compared to the RSRL of 0.83 pCi/g, 2) plutonium-238 at 0.0077 pCi/g compared to the RSRL of 0.0067 pCi/g, and 3) plutonium-239,240 at 0.039 pCi/g compared to the RSRL of 0.036 pCi/g. The elevated cesium-137 concentration on the perimeter of TA-8 is typical for samples taken at higher elevations, where increased rainfall results in higher concentrations of fallout radionuclides (Eisenbud et al., 1997, Whicker et al., 1982). The plutonium-238 and plutonium-239,240 concentrations are essentially indistinguishable from the RSRLs.

At the West Airport location, the plutonium-239,240 soil concentration was 0.091 pCi/g compared to the RSRL of 0.036 pCi/g. This elevated plutonium-239,240 soil concentration can be attributed to historical stack emissions from TA-21.

At the Tsankawi/PM-1 location, uranium-234 and uranium-238 soil concentrations were detected at 1.6 pCi/g compared to the RSRLs of 1.4 pCi/g. Although these concentrations are slightly elevated above the RSRLs, the ratio of the uranium-234 to uranium-238 concentrations is indicative of natural uranium and not attributed to past or present Laboratory operations.

Five on-site locations that are accessible to the public, specifically in the area of State Route 502 at TA-73, also have transuranic radionuclide concentrations above the RSRLs. The plutonium-239,240 concentrations at these locations ranged from 0.12 to 0.39 pCi/g compared to the RSRL of 0.036 pCi/g. The americium-241 concentrations at these locations ranged from 0.023 to 0.041 pCi/g compared to the RSRL of 0.019 pCi/g. The elevated transuranic radionuclide soil concentrations at these locations are also attributed to historical stack emissions from TA-21.

With the exception of the West Airport and TA-73 locations, the soil concentrations measured in 2006 are essentially indistinguishable from regional background and fallout concentrations, and the resulting dose from soil (external gamma exposure, dust inhalation, and soil ingestion) at the sample locations is less than 0.1 mrem/yr. In summary, we conclude that the LANL contribution to the dose from soil is less than 0.1 mrem/yr, and the majority of the radionuclides detected are primarily due to fallout and historical operations at the Laboratory.

v. Food (Ingestion Pathway). We report measurements of the radioactive content of foods in Chapter 8. During 2006, two wild edible plant species, common lambsquarter and amaranth, were collected on the perimeter of Pueblo de San Ildefonso within Mortandad Canyon. No other foodstuffs were collected during 2006.

The concentration of strontium-90 in the two samples of common lambsquarter and the two samples of amaranth were elevated compared with their respective RSRLs. Refer to Supplemental Data Table S8-3 for specific radionuclide concentration values. The total dose received from consuming a pound of these wild edible plants is much less than 0.1 mrem.

It should be noted that the strontium-90 levels in the common lambsquarter and amaranth samples are higher than in crops that are normally collected as part of the Laboratory's surveillance program. This specific ingestion scenario therefore serves as a worst-case example due to the elevated levels and the close proximity of the sample location to the Laboratory boundary.

We conclude that the LANL contribution to the dose from consuming wild foodstuffs (specifically common lambsquarter and amaranth from the perimeter of Pueblo de San Ildefonso land within Mortandad Canyon) is less than 0.1 mrem/yr, which is 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 are found in LANL 2006a and are the limits in Figure IV-1 of DOE 1993 and DOE 1995. In 2006, 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. In addition, the transfer of real property from DOE to the public is allowed if the modeled dose is no greater than 15 mrem/yr. The transfer of real property involving modeled doses greater than 15 mrem/yr requires the approval of DOE Headquarters. No real property was transferred in 2006. Refer to DOE 2000 for further information regarding this process.

3. Dose Calculations and Results

a. Population within 80 Kilometers. We used the local population distribution to calculate the dose from 2006 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 2006 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was 0.6 person-rem, which is significantly lower than the dose of 2.46 person-rem reported for 2005. Tritium contributed about 49% of the dose, and short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 from LANSCE contributed about 50% of the dose. The decrease in the 2006 collective population dose compared to 2005 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. Until 2005, collective population doses for the past 12 years had declined from a high of about four person-rem in 1994 to less than one person-rem in 2004 (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.

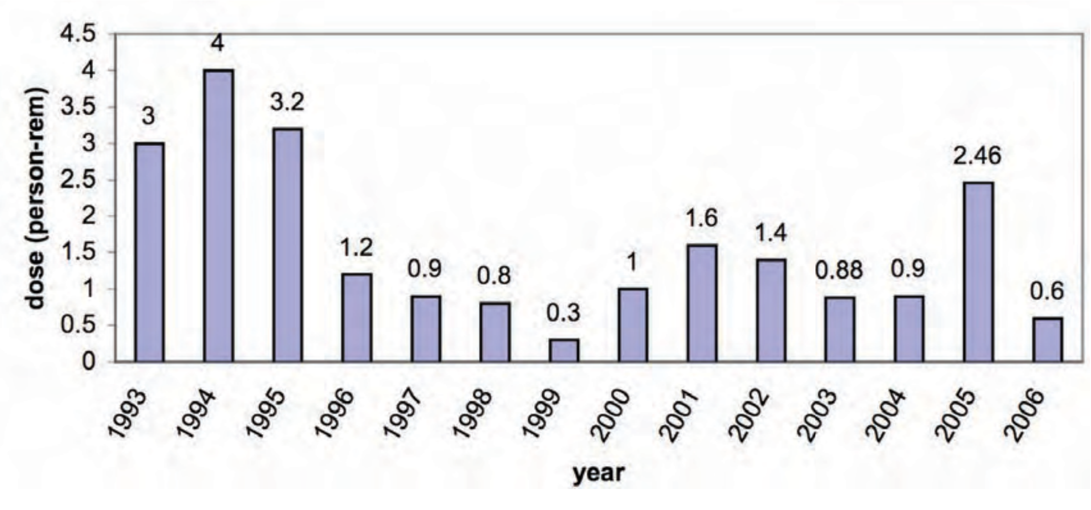

Figure 3-1. Annual collective dose (person-rem) to the population within 80 km of LANL.

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 the past six years, the airborne pathway (RAD-NESHAP) and all-pathways 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 0.176 mrem/yr from LANSCE and 0.20 mrem/yr from other LANL stacks. We added 0.047 mrem/yr from the radionuclides measured at the AIRNET station, though this dose is primarily from tritium, most of which was in the CAP88 modeled doses. Therefore, the total dose at East Gate was approximately 0.42 mrem/yr.

Because the LANSCE emissions for 2006 were reduced compared to an average of about two mrem/yr over the six years prior to 2006 (Figure 3-2), the location of the 2006 MEI was not as readily apparent as in the past and required more detailed calculations, as described below.

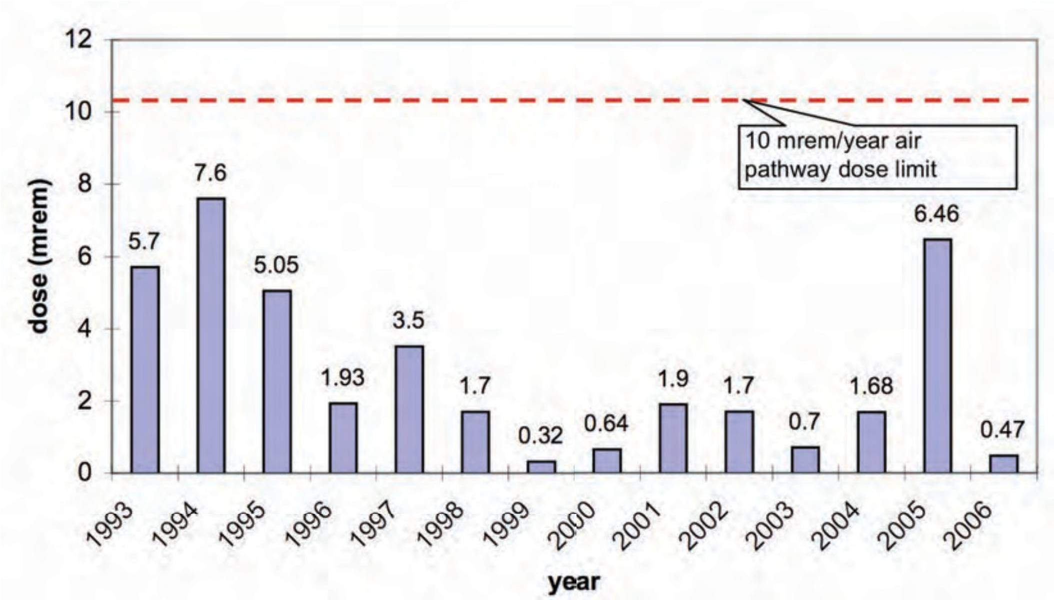

Figure 3-2. **Annual airborne pathway (RAD-NESHAP) dose (mrem) to the maximally exposed individual off-site over the past 14 years.**

To determine the RAD-NESHAP MEI location, we considered all compliance AIRNET station locations with an AIRNET dose greater than the AIRNET dose at East Gate (0.047 mrem/yr). The locations considered were TA-21 Area B (0.42 mrem/yr), Los Alamos Airport terminal (0.22 mrem/yr), Los Alamos County Landfill (0.10 mrem/yr), Los Alamos Inn South (0.09 mrem/yr), Crossroads Bible Church (0.05 mrem/yr), and Los Alamos Airport Road (0.05 mrem/yr).

The 0.42-mrem/yr dose measured near TA-21, Area B, was the result of remediation work at Area V, which is immediately adjacent to the TA-21 AIRNET station. The location of the maximum public dose from the Area V work is at Airport Road, where the dose is smaller than of the TA-21, Area B, dose (because the distance is greater).

The AIRNET dose at the Los Alamos County Airport terminal was larger than the dose at Airport Road. An ash pile adjacent to the terminal resulting from incinerator operations during the 1940s and 1950s was remediated, causing low levels of plutonium-239 in the ash to become airborne. The source of plutonium-239 in the ash was probably from the incineration of slightly contaminated trash. The AIRNET station at the terminal measured levels of airborne plutonium-239 from the ash pile that would result in a dose of 0.22 mrem/yr if an individual continuously breathed air at this location for a calendar year (24 hours/day and 365 days/year). Adding the dose at the terminal from all LANL stack emissions calculated by CAP88 (0.25 mrem) resulted in a total dose of 0.47 mrem/yr, which makes this the RAD-NESHAP MEI location for 2006.

ii. All-pathways MEI Dose. The location evaluated in 2006 as the potential all-pathways MEI is the boundary of the Pueblo de San Ildefonso Sacred Area north of Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant emits neutrons. The measured neutron dose at the boundary was 20 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 18/16 = 1.1 mrem/yr. A gamma photon dose was not calculated for this location because the low-energy photons emitted from the transuranic waste are absorbed in the intervening air layer between Area G and the Sacred Area. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the LANL stacks as 0.03 mrem/16 = 0.002 mrem/yr. We added the dose derived from measurements at the AIRNET station along the northern boundary of Area G (0.18 mrem/yr) closest to where the neutron dose was measured and applied the occupancy factor of 1/16 to obtain a dose of 0.011 mrem/yr. This results in a dose at this location of approximately 1.1 mrem/yr, which is greater than the airborne pathway MEI dose at East Gate and the Los Alamos County Airport terminal.

The airborne pathway MEI dose of 0.47 mrem/yr at the Los Alamos County Airport terminal 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 (HPS 1996, BEIR 1990). The all-pathways MEI dose of 1.1 mrem/yr at the 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 1993, DOE 1999), and, again, we conclude it causes no observable health effects.

In recent 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 2006 levels. The elevated levels in 2005 were caused by a broken valve at the inlet to the emissions controls system. An additional delay line was added in 2005 and contributed to the emissions reduction in 2006. Because stack emissions are expected to remain low, the major contributor to the air pathway MEI dose will most likely be from low levels of transuranic radionuclides in suspended wind-blown 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 2006, the Laboratory contributions to the dose at an average Los Alamos residence were 0.0078 mrem/yr from tritium and 0.0045 mrem/yr from LANSCE. Other radionuclides contributed about 0.0002 mrem/yr. This results in a total dose to an average Los Alamos resident of approximately 0.0125 mrem/yr.

ii. White Rock. During 2006, the Laboratory contributions to the dose at an average White Rock residence were 0.0091 mrem/yr from tritium and 0.0052 mrem/yr from LANSCE. Other radionuclides contributed about 0.0002 mrem/yr. This results in a total dose to an average White Rock resident of approximately 0.0145 mrem/yr.

The contributions from direct radiation, food, water, and soil are discussed in Section B.2 of this chapter; each contribution is essentially considered to be a zero dose. In summary, the total annual dose in 2006 to an average Los Alamos/White Rock resident from all pathways was about 0.01 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 (HPS 1996).

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. 988). Doses from terrestrial radiation range from about 50 to 150 mrem/yr, depending on the amounts of natural uranium, thorium, and potassium in the soil (McNaughton 2005).

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products, which contribute about 200 mrem/yr. 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.

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 470 mrem. Refer to Figure 3-3 for a comparison of the natural radiation background (and other sources) in Los Alamos County to the US average background. The estimated LANL-attributable 2006 all-pathways MEI dose, 1.1 mrem/yr, is about 0.2% of this dose.

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.

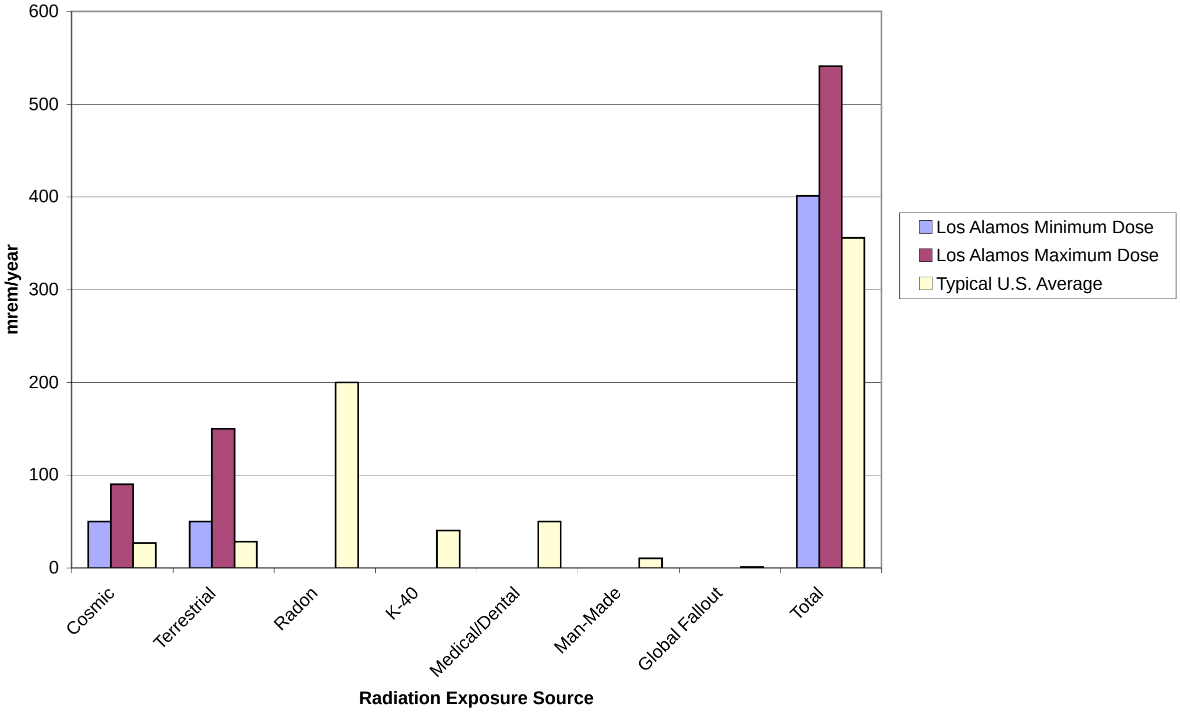

Figure 3-3 **Los Alamos County radiation background compared to average US background. Los Alamos County-specific background doses have not been determined for potassium-40, medical/dental exposures, man-made radiation, and global fallout, and are assumed to be the same as the US average in this figure.**

Table 3-1
LANL Radiological Dose for Calendar Year 2006

Pathway	Dose to Maximally Exposed Individual mrem/yr (mSv)	% of DOE 100 mrem/year Limit	Estimated Population Dose person-rem (person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose person-rem (person-Sv)
Air	0.47[a] (4.7×10^{-3})	0.47%	0.6 (6×10^{-3})	NA[b]	NA
Water	<0.1 ($<1.0\times10^{-3}$)	<0.1%	0	NA	NA
Other Pathways (foodstuffs, soils)	<0.1 ($<1.0\times10^{-3}$)	<0.1%	0	NA	NA
All Pathways	1.1[c] (1.1×10^{-2})	1%	0.6 (6×10^{-3})	~280,000	~131,600[d] (~1316)

[a] This is the RAD-NESHAP MEI dose measured at the Los Alamos County Airport terminal

[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 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 (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/all/qa.shtml), 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 2004a). Trees of the pine family (pinaceae) are representatives for terrestrial plants because they are radiosensitive (UNSCEAR 1996) and because their deep roots might tap into buried contamination (Foxx 1984a, b; Tierney 1987). Deer mice are representatives for 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 biota populations rather than to individual plants and animals 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 use the population area for deer mice of 3 ha (30,000 m^2) (Ryti et al. 2004; LANL 2004a). We also average 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 begin with an initial screening (DOE 2002) that compares 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 do not include external-radiation dose from experimental facilities such as the Dual Axis Radiographic HydroTest (DARHT) facility and LANSCE. To provide further refinement of the screening process, we screen on a radionuclide-by-radionuclide basis and compare each radionuclide concentration to the appropriate BCG. If the concentration exceeds 10% of the BCG (or biota dose limit) for any one radionuclide, a full-scale screening is performed using the sum-of-the-fractions approach.

2. Biota Dose Results

Soil, sediment, vegetation (overstory and/or understory), and small mammals were collected in 2005 and 2006 from several locations. Specifically, soil and understory vegetation were collected at regional, perimeter, and on-site locations. Overstory vegetation was collected at MDA B at TA-21. Understory vegetation was collected at MDA G at TA-54. Overstory and understory vegetation, birds, bees, and mice were collected around the DARHT facility at TA-15. Understory and overstory vegetation, sediment, and mice were collected upgradient and downgradient of the Los Alamos Canyon Weir. Understory vegetation, sediment, and mice were collected upgradient of the Pajarito Canyon Flood Retention Structure. Refer to supplemental tables for Chapters 7 and 8 for full details regarding analysis results.

All radionuclide concentrations in vegetation sampled were far below the terrestrial 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 (section B.2.iv.) of this chapter, 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. Refer to Chapter 7 for more information. A separate analysis of biota dose was performed for Mortandad Canyon, and the results are presented below.

a. Mortandad Canyon Biota Assessment Update. New data for Mortandad Canyon are presented in the *Mortandad Canyon Investigation Report* (LANL 2006b). The portion of Mortandad Canyon from the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) outfall to well MCO-8.2 in TA-5 fails the initial BCG screening, so a site-specific biota dose assessment is required. The methods are described in detail in McNaughton 2005.

Near the TA-50 RLWTF outfall, the concentrations of cesium-137 are higher than elsewhere in the canyon (187 pCi/g) and the canyon is narrower, while in the middle reaches (M3 and M4), the concentrations are lower (72 pCi/g) and the canyon is wider. If these concentrations of cesium-137 are averaged over the standard population area of 3 ha, the resulting population doses from cesium-137 amount to three mrad/day to both terrestrial plants and animals.

The americium-241, plutonium-239, and plutonium-238 concentrations in reach M3 are 21, 18, and 8 pCi/g, respectively. These concentrations result in a dose of about 3 mrad/day to plants and 1 mrad/day to animals.

The strontium-90 concentrations in reach E1E and further down canyon are less than 10% of the cesium-137 concentrations, so the strontium-90 biota dose is much less than 1 mrad/day to both plants and animals. The tritium concentration throughout the canyon is about 1 pCi/g, which is negligible. The uranium concentration throughout the canyon is also about 1 pCi/g, which is consistent with background. Both tritium and uranium contribute a negligible dose. Thus, the total dose from the RLWTF outfall to well MCO-8.2 in TA-5 is about 7 mrad/day to plants and 5 mrad/day to animals, which are below the DOE biota dose limits.

The previous dose estimates (LANL 2004b) of 9 mrad/day for terrestrial plants and seven mrad/day for terrestrial animals were slightly conservative. The 2004 and 2006 doses to terrestrial biota in the Mortandad Canyon watershed are similar and much less than the DOE biota-dose limits of 1,000 mrad/day to terrestrial plants and 100 mrad/day to terrestrial animals.

b. Surface Waters Biota Assessment. Unfiltered surface water samples were also collected in 2006 and analyzed for radionuclides. Specifically, samples were collected in Pueblo Canyon above Acid Canyon, lower Pueblo Canyon, DP Canyon above TA-21, DP Canyon below TA-21, Los Alamos Canyon between DP Canyon and SR-4, Los Alamos Canyon at the Rio Grande, and Mortandad Canyon below Effluent Canyon. The time-weighted sums of ratios for estimated annual average surface water concentrations of radionuclides in these major canyons were below the limiting aquatic animal and riparian animal BCGs (no greater than 43%). The primary contributor to the higher sum-of-the-ratios values was radium-226, which is probably of natural origin. Refer to Chapter 6, Table 6-2, for more information regarding specific radionuclide concentrations and associated BCG ratios.

D. NON-RADIOLOGICAL DOSE ASSESSMENT

1. Overview

We have concluded that dose to members of the public and biota from LANL radiological hazards is well understood and extensively documented. We wish to place equal emphasis on the risk to members of the public and biota 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 that have been released from LANL either during 2006 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 2007, 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, except for one sample at TA-54, Area G, which is not accessible to the public.

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. 2006 groundwater samples from this well have an average perchlorate concentration of 1.8 µg/L, which is less than 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 risk to human health.

In 2005 LANL found hexavalent chromium in Mortandad Canyon regional aquifer monitoring well samples at levels above the NM groundwater standard. Hexavalent chromium has also been found in a Sandia Canyon regional aquifer well. However, hexavalent chromium has not been found in drinking water supply wells, so at present there is no health risk from ingestion of water from these wells.

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

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 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. A few heavy metals were detected slightly above RSRLs at offsite and perimeter locations (Sportsman's Club and Two-Mile Mesa at TA-6), but were far below their soil screening levels and, therefore, do not pose a potential human health risk. One on-site location easily accessible from off site (TA-73/SR502 [west] near the Los Alamos Fire Department station) had detected semivolatile organic compounds resulting from asphalt scattered on the ground, but the concentrations detected were below residential 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, and the models to calculate future risks are being developed.

3. Conclusion

The environmental data collected in 2006 show that at present there is no potential public-health risk from non-radiological materials released from LANL. Further discussion of risk to the public from radiological and non-radiological materials released by the Laboratory to the environment is found in Chapter 10.

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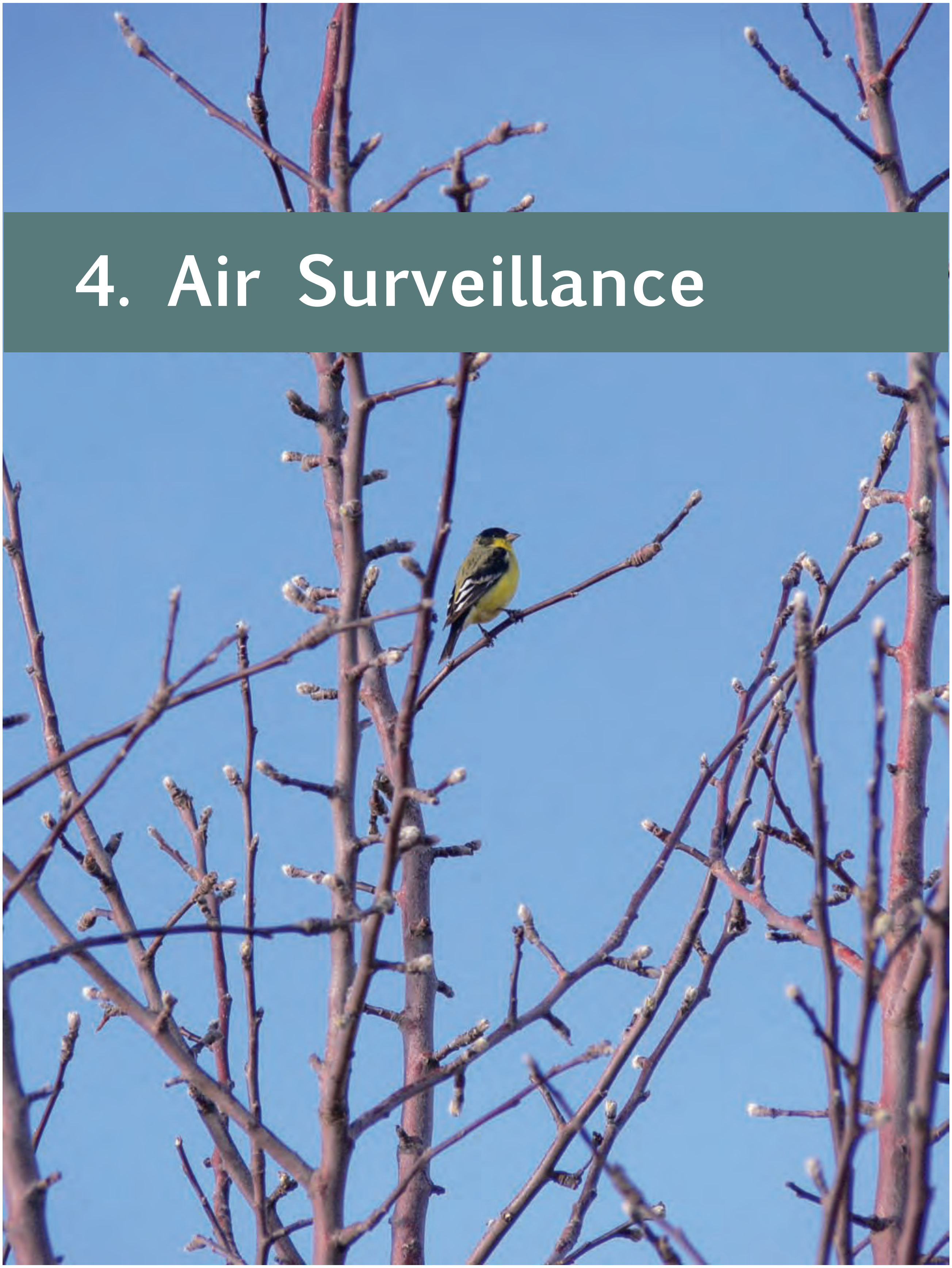
4. Air Surveillance



4. Air Surveillance

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A. AMBIENT AIR SAMPLING

1. Introduction

The radiological 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 fluctuate 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

			Annual Averages[c]				
Analyte	Units	EPA Concentration Limit[b]	2002	2003	2004	2005	2006
Alpha	fCi/m^3	NA[d]	0.8	0.8	1.1	0.9	1.0
Beta	fCi/m^3	NA	13.3	13.7	18.3	16.3	17.0
Tritium[e]	pCi/m^3	1500	-0.1	-0.1	0.1	0.1	-0.2
Pu-238	aCi/m^3	2100	0.0	-0.1	0.09	0.0	0.1
Pu-239	aCi/m^3	2000	0.3	-0.1	-0.07	0.1	0.2
Am-241	aCi/m^3	1900	0.3	-0.7	-0.47	0.1	-0.3
U-234	aCi/m^3	7700	21.7	20.9	17.4	12.4	16.6
U-235	aCi/m^3	7100	2.4	1.8	1.17	1.2	0.8
U-238	aCi/m^3	8300	21.8	20.1	17.0	13.2	16.1

[a] Data from regional air-sampling stations operated by LANL during the last 5 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] 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, such as rain or snow, can wash particulate matter out of the air. Consequently, changing 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.

Air quality group 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 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 2006, LANL operated about 50 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-3) are categorized as regional, pueblo, perimeter, waste site (Technical Area [TA] 54), 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 m^3 per minute. These filters are analyzed for various radionuclides.

Vertically mounted canisters that contain about 135 g of silica gel, with an airflow rate of about 0.0002 m^3 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 gel is a desiccant that removes moisture from the sampled air. After use in the field, the 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 recorded 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 transferred these data to an electronic table format 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 then 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.

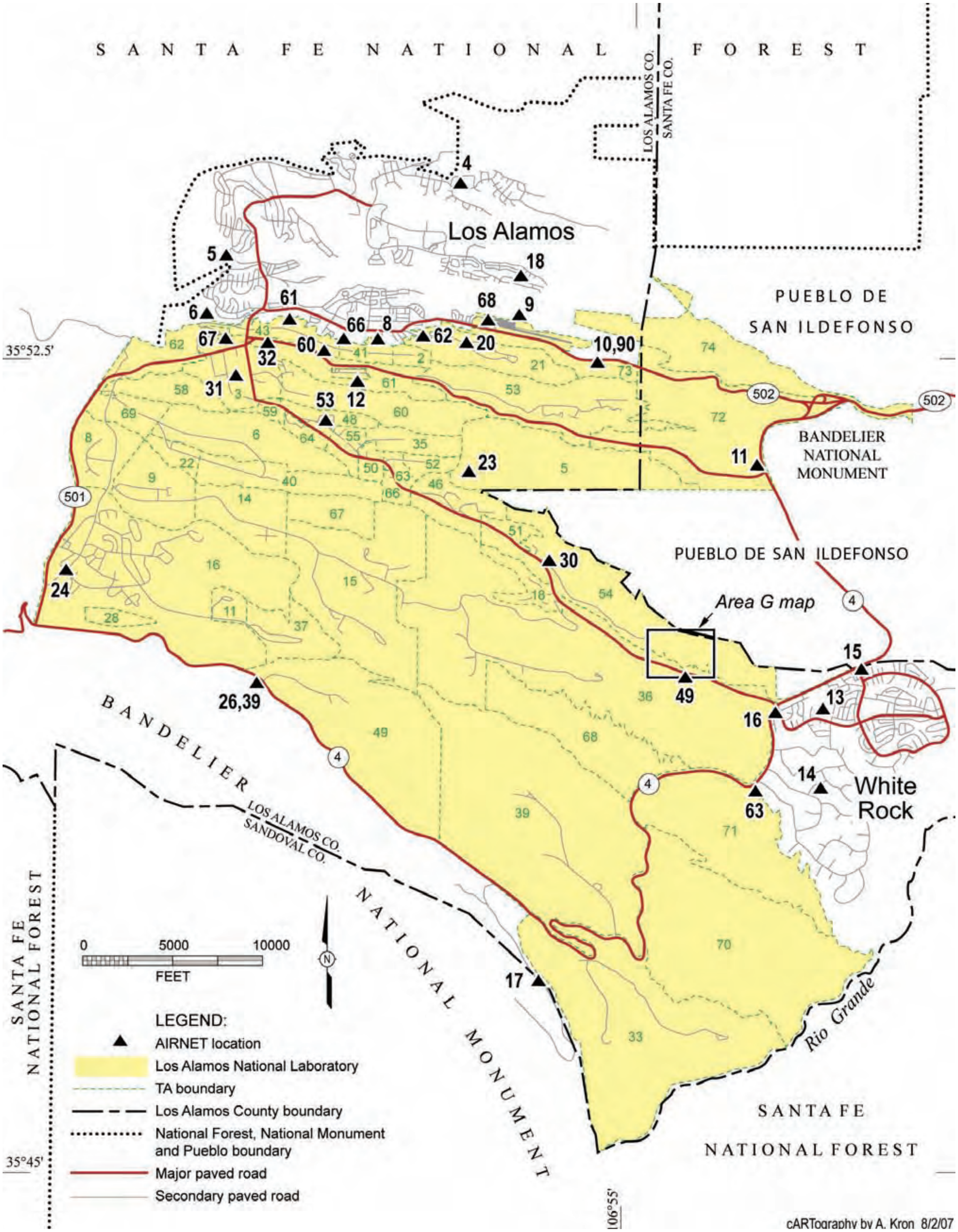

Figure 4-1. Off-site perimeter and on-site LANL AIRNET locations.

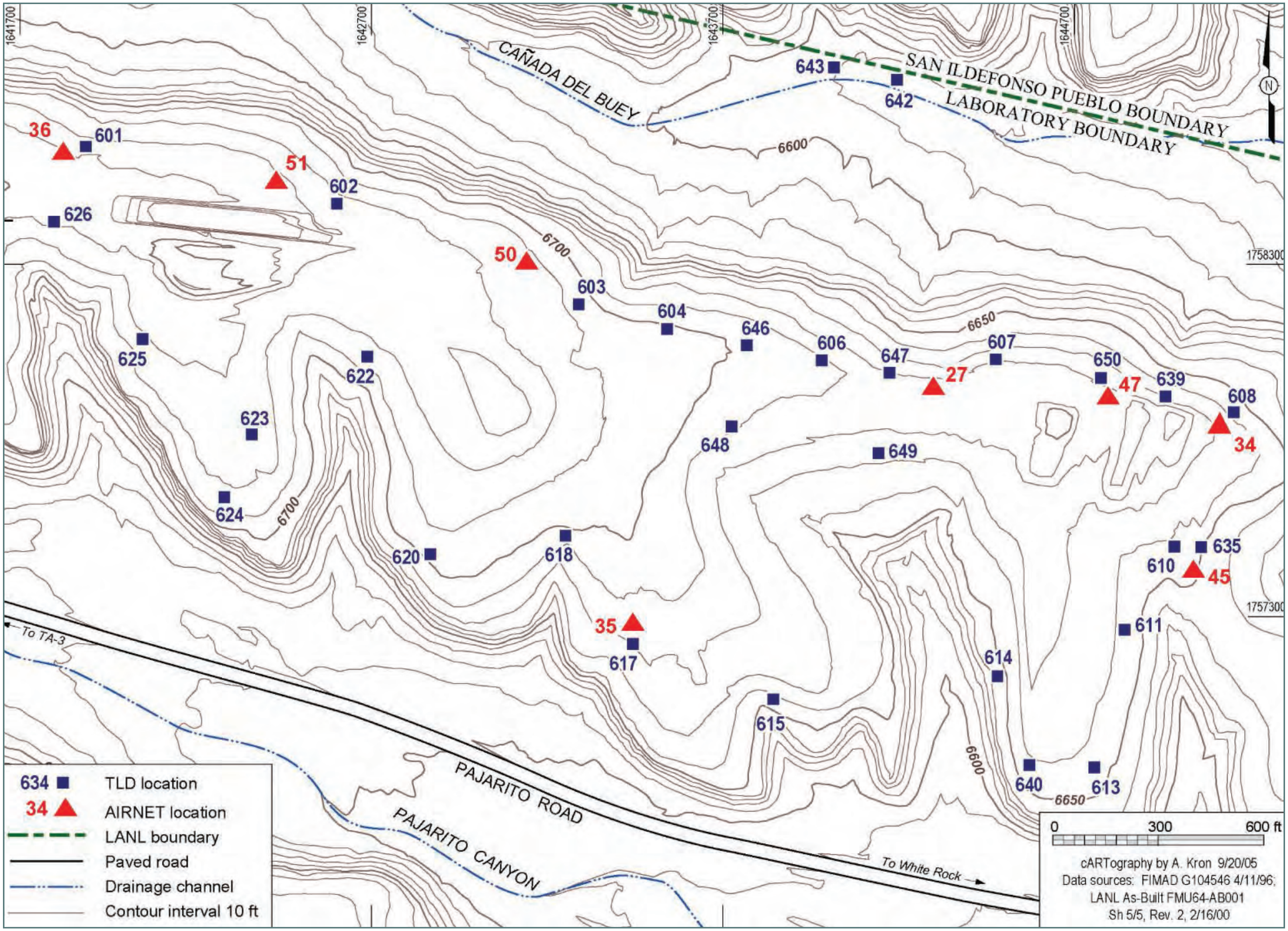

Figure 4-2. AIRNET and thermoluminescent dosimeter locations at TA-54, Area G.

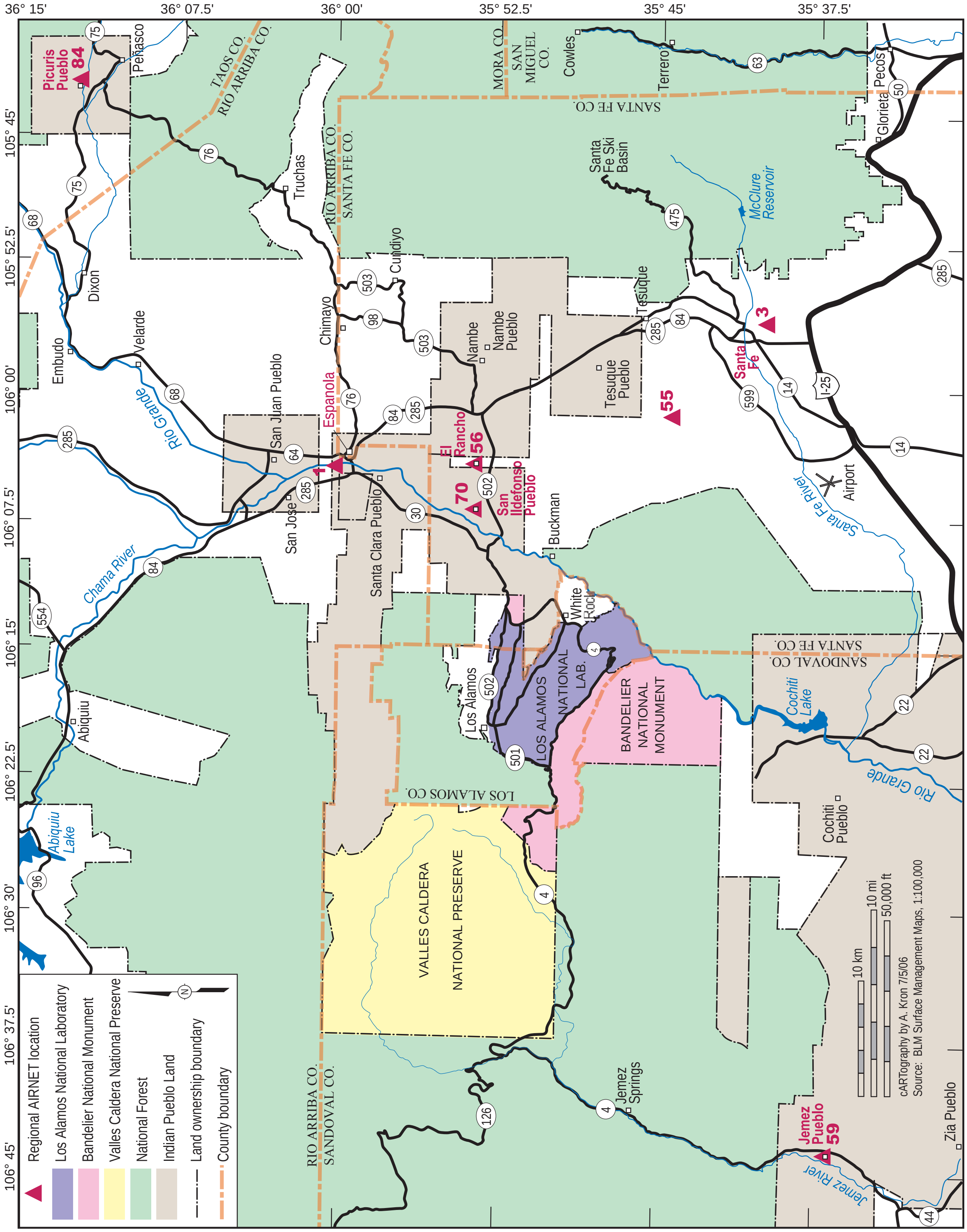

Figure 4-3. Regional and pueblo AIRNET locations.

d. Laboratory Quality Control Samples. The air sampling team and the analytical laboratories maintained a program of blank, spike, duplicate, and replicate analyses. This program provided information on the quality of the data received from analytical laboratories. These data were 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 4-12 summarize the 2006 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 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (fCi/m3)	Interval[a] (fCi/m3)	Station	(fCi/m3)
Regional	103	103	103	1.04	±0.10	01	1.16
Pueblo	78	78	78	0.94	±0.08	70	1.00
Perimeter	668	668	668	0.86	±0.02	18	1.34
Waste Site	206	205	205	0.91	±0.08	36	1.16
n-site	166	166	166	0.82	±0.04	30	0.93

[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 2006 — 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	103	103	103	17.0	±0.9	01	18.5
Pueblo	78	78	78	16.0	±0.9	70	16.8
Perimeter	668	668	668	15.5	±0.25	18	23.1
Waste Site	206	206	206	14.9	±0.5	36	15.4
On-site	166	166	166	15.0	±0.5	53	15.5

[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 2006 — Group Summaries

		Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
Station Grouping	Number of Biweekly Samples	>2s	>3s	Mean (pCi/m^3)	Interval[a] (pCi/m^3)	Station	(pCi/m^3)
Regional[b]	102	4	0	-0.2	±0.2	03	0.1
Pueblo[b]	78	3	0	-0.1	±0.3	59	0.0
Perimeter[b]	665	231	134	3.5	±0.8	26	9.0
Waste Site[c]	204	200	195	514	±239	51	3300
On-site[c]	165	89	66	6.3	±2.5	53	11.1

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

[b] EPA 40 CFR Concentration Limit is 1,500 pCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 pCi/m^3.

Table 4-5
Airborne Plutonium-238 Concentrations for 2006 — Group Summaries

		Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
Station Grouping	Number of Biweekly Samples	>2s	>3s	Mean (aCi/m^3)	Interval[a] (aCi/m^3)	Station	(aCi/m^3)
Regional[b]	15	0	0	0.1	±0.3	03	0.25
Pueblo[b]	12	0	0	-0.15	±0.2	84	0.01
Perimeter[b]	100	2	0	0.0	±0.1	44	0.6
Waste Site[c]	32	3	2	1.1	±1.3	36	3.8
On-site[c]	26	1	1	0.2	±0.3	52	0.9

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

[b] EPA 40 CFR Concentration Limit is 2,100 aCi/m^3.

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

Table 4-6
Airborne Plutonium-239,240 Concentrations for 2006 — Group Summaries

		Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
Station Grouping	Number of Biweekly Samples	>2s	>3s	Mean (aCi/m^3)	Interval[a] (aCi/m^3)	Station	(aCi/m^3)
Regional[b]	14	1	0	0.2	±0.5	03	0.9
Pueblo[b]	12	2	0	0.2	±0.4	59	0.4
Perimeter[b]	100	19	7	1.8	±2.4	09	30.2
Waste Site[c]	32	16	12	190	±265	36	760
On-site[c]	26	6	6	10	±14	20	64

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

[b] EPA 40 CFR Concentration Limit is 2,000 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3.

Table 4-7
Airborne Americium-241 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty >2s	Number of samples exceeding uncertainty >3s	95% Confidence Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (aCi/m^3)
Regional[b]	15	1	0	-0.30	±0.4	56	0.01
Pueblo[b]	12	4	0	0.4	±0.4	59	0.55
Perimeter[b]	100	25	0	0.1	±0.2	14	0.9
Waste Site[c]	32	16	8	4.7	±5.7	36	21
On-site[c]	26	8	3	1.4	±1.8	20	6.2

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

[b] EPA 40 CFR Concentration Limit is 1,900 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3.

Table 4-8
Airborne Uranium-234 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty >2s	Number of samples exceeding uncertainty >3s	95% Confidence Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (aCi/m^3)
Regional[b]	15	15	15	16.6	±5.1	56	21.4
Pueblo[b]	12	12	12	19.5	±9.2	59	35.3
Perimeter[b]	100	97	90	8.3	±1.7	32	29.2
Waste Site[c]	32	32	30	20.5	±10.1	51	47.7
On-site[c]	26	26	26	9.6	±3.8	20	18.7

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

[b] EPA 40 CFR Concentration Limit is 7,700 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3.

Table 4-9
Airborne Uranium-235 Concentrations for 2006 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty >2s	Number of samples exceeding uncertainty >3s	95% Confidence Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (aCi/m^3)
Regional[b]	15	5	0	0.8	±0.7	56	1.7
Pueblo[b]	12	4	1	1.5	±1.1	59	1.6
Perimeter[b]	100	16	2	0.5	±0.2	42	1.3
Waste Site[c]	32	8	3	1.3	±0.7	51	3.9
On-site[c]	26	3	0	0.4	±0.4	49	1.2

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

[b] EPA 40 CFR Concentration Limit is 7,100 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3.

Table 4-10
Airborne Uranium-238 Concentrations for 2006 — 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]	15	15	15	16.1	±5.0	03	19.7
Pueblo[b]	12	12	11	18.5	±7.8	59	32.0
Perimeter[b]	100	99	94	9.8	±1.6	32	31.4
Waste Site[c]	32	32	32	32.6	±30.8	51	154
On-site[c]	26	26	25	11.1	±2.6	20	15.0

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

[b] EPA 40 CFR Concentration Limit is 8,300 aCi/m^3.

[c] DOE Derived Air Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3.

Table 4-11
Airborne Gamma-emitting Radionuclides Potentially Released by LANL Operations

Nuclide	Number of Biweekly Samples	Number of samples > MDA[a]	Mean Concentration (fCi/m^3)	Measured MDA as % of required MDA[b]
As-73	186	0	1.3	0.2
As-74	186	0	-0.04	0
Cd-109	186	0	-0.3	0
Co-57	186	0	0.002	0.002
Co-60	186	0	-0.009	0
Cs-134	186	0	-0.05	0
Cs-137	186	0	-0.02	0
Mn-54	186	0	-0.01	0
Na-22	186	0	0.02	1.4
Rb-83	186	0	-0.02	0
Ru-103	186	0	-0.007	0
Se-75	186	0	0.002	0.03
Zn-65	186	0	-0.05	0

[a] Minimum detectable activity.

[b] Required MDA is set so 0.5 mrem annual dose can be measured.

Table 4-12
Airborne Concentrations of Gamma-emitting Radionuclides that Occur Naturally in Measurable Quantities

Nuclide	Number of Biweekly Samples	Number of samples > MDA[a]	Mean[b] Concentration (fCi/m^3)
Be-7	186	185	86
Pb-210	186	0	32

[a] Minimum detectable activity.

[b] Measurements less than the MDA are not included in the average.

All data in this AIRNET section, whether in the tables or the text, that are expressed as a value plus or minus (±) another value represent a 95% confidence interval. Because these confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurement 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 that approach 100%. All ambient concentrations are activity concentrations 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, then 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)/m^3. Polonium-210, a decay product of radon, and other naturally occurring radionuclides are the primary sources of alpha activity (NCRP 1975, NCRP 1987). The NCRP also estimated national average concentration levels of long-lived gross beta activity in air to be 20 fCi/m^3. 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 2006, we collected and analyzed approximately 1,200 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 4-4 and 4-5 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 beta count rates.

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).

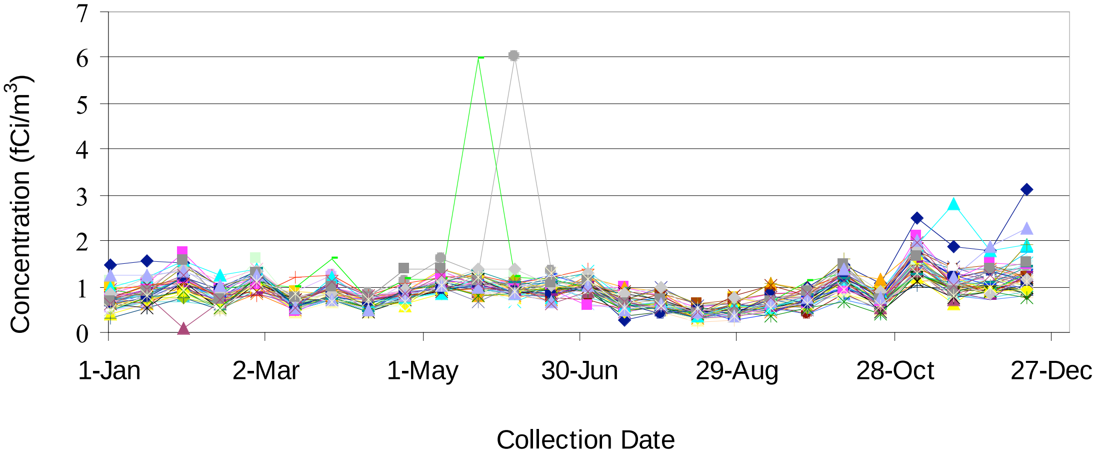

Figure 4-4. **Gross alpha measurements (fCi/m³) for all sampling sites by date collected in 2006.**

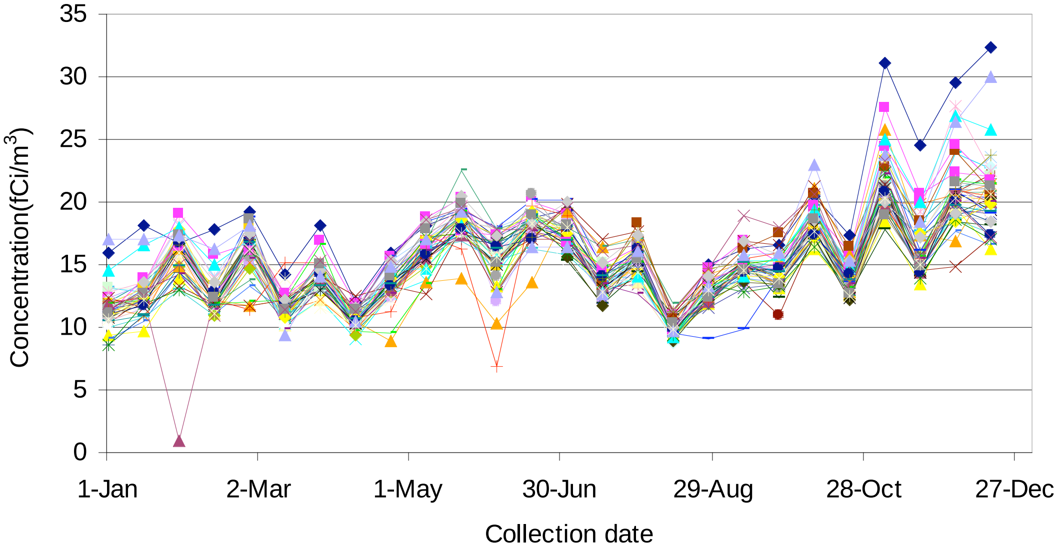

Figure 4-5. **Gross beta measurements (fCi/m³) for all sampling sites by date collected in 2006.**

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 2006 at the regional and pueblo stations were not significantly greater than zero (Table 4-4). The average concentration of tritium for the perimeter samplers was significantly greater than zero, as were the average concentrations for the on-site groups. The highest concentrations were measured at the TA-54 waste site in Area G. A source of elevated tritium levels at Area G was identified and moved to the tritium shafts at Area G. This waste came from decontamination and decommissioning work at TA-21. Concentrations at Area G during 2006 are not expected to continue at the same elevated levels. All annual mean concentrations at all sampling stations were well below the applicable EPA and DOE guidelines.

Figure 4-6 shows the measured stack emissions at TA-21 and also maximum and average off-site AIRNET measurements in nearby and generally downwind (east) Los Alamos. Emissions from stacks at TA-21 were stopped permanently in September 2006 as one of the TA-21 shutdown activities. The peak tritium concentrations were due to planned operational releases.

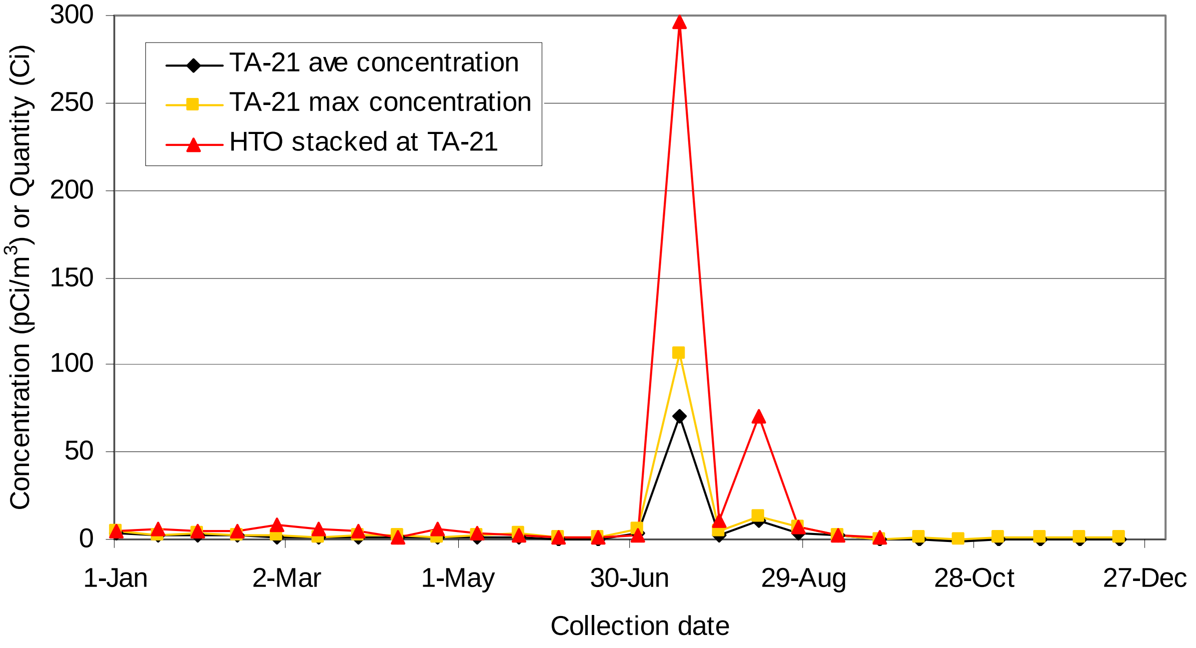

Figure 4-6. Tritium oxide stack emissions at TA-21 and ambient concentrations in east Los Alamos in 2006.

The highest off-site annual tritium concentration in 2006, 9 picocuries (pCi)/m^3 at station 26, is equivalent to about 0.6% of the EPA public dose limit of 1,500 pCi/m^3. Emissions from TA-16 seldom caused concentrations to exceed investigation levels as described in section A.5 of this chapter. (Investigation levels are set at values of five-year averages plus 3s.) We measured elevated tritium concentrations at a number of on-site stations, with the highest annual concentration (3300 pCi/m^3) at TA-54, Area G. This annual mean concentration is only about 0.016% of the DOE DAC for worker exposure of 20,000,000 pCi/m^3 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 2006. Three occurrences of plutonium-238 greater than 3s were measured. All were on site; the two highest were at Area G. The highest quarterly concentration was 15.5 aCi/m^3.

No detectable concentrations of plutonium-239,240 greater than 3s were found at any of the regional or pueblo samplers (Table 4-6). Seven perimeter quarterly concentrations were above their 3s uncertainties, four of which were collected at station 66 (Los Alamos Inn-South). The annual mean concentration at this location was 12 aCi/m^3, 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 below the Los Alamos Inn. Two other perimeter concentrations above 3s were measured, at stations 9 and 68 near the Los Alamos Airport, and are due to remediation work at TA-21 and TA-73. The annual mean concentrations for these two stations were 30 and 1.3 aCi/m^3, respectively.

The on-site station at TA-21 (station 20) exceeded 3s for its quarterly concentrations for three quarters—also due to the work at TA-21. Finally, 12 quarterly concentrations at Area G exceeded 3s. All on-site and waste site concentrations were below 0.2% of the DOE DAC for workplace exposure.

e. Americium-241. As with plutonium isotopes, americium is present in very low concentrations in the environment. No detected concentrations of americium-241 were measured off-site or at the perimeter. Table 4-7 summarizes the americium-241 data. Eleven on-site quarterly samples with a concentration of americium-241 greater than 3s were measured. Most were at Area G; two were at TA-21. The highest quarterly off-site and on-site concentrations were less than 0.2% 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 enriched (EU—enriched in uranium-234 and -235) or depleted (DU—depleted of uranium-234 and -235).

All annual mean concentrations of the three uranium isotopes were below 1% of the applicable EPA and DOE guidelines (Tables 4-8 through 4-10). The highest annual uranium concentrations were at locations with high dust levels from local soil disturbances, such as dirt roads at the Los Alamos County Landfill and LANL's TA-54, Area G. The regional and pueblo groupings had higher average concentrations of uranium isotopes than the perimeter group because of increased particulate matter concentrations associated with unpaved roads, unpaved parking lots, and other soil disturbances, such as construction activities and grazing, but not any known man-made sources of uranium.

During 2006, there were two detections of DU (stations 51 and 60), as shown in Figure 4-7. Firing sites use DU in tests and so there is DU dust at the Laboratory in places. Excess 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). We measured one instance of EU during 2006 (station 9) near the remediation work at TA-21. EU remaining from Manhattan era work is expected in this area.

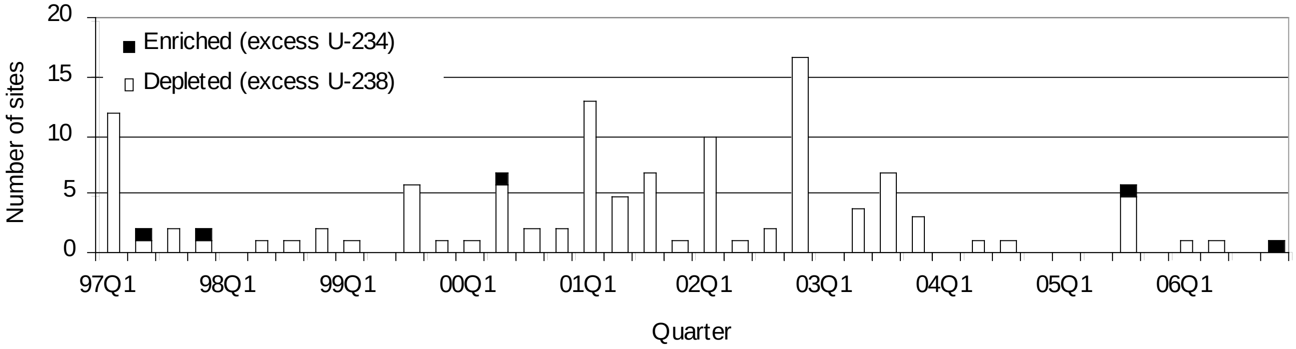

Figure 4-7. Number of sites where enriched or depleted uranium has been detected from 1997 through 2006.

g. Gamma Spectroscopy Measurements. In 2006, the air sampling team requested gamma spectroscopy measurements (Tables 4-11 and 4-12) on biweekly filters grouped across sites for a single sampling period, which are identified as “clumps.” Our practice is to investigate the measurement of any analyte concentration (listed in Table 4-11) above its MDA. We do not investigate detected quantities of beryllium-7, potassium-40, and lead-210, which are natural radionuclides normally present in measurable concentrations. In 2006, beryllium-7 was routinely detected.

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, immediate follow-up.

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

In 2006, air sampling values exceeded alert action levels on-site only. In the second quarter, the alert action levels were exceeded for plutonium-239 at two stations at Area G due to unexpected airborne releases during routine operations involving the receipt of waste from TA-21 cleanup.

Tritium alert levels were also exceeded at Area G near a pit which contained tritium-contaminated waste. Starting in May, tritium concentrations increased and peaked in the hottest months then decreased steadily towards the end of the year. This waste was subsequently moved to a shaft containing other tritium-contaminated waste.

An unexpected plutonium-239 concentration was attributed to the El Rancho station in the fourth quarter of 2006. We initiated a further investigation: a re-analysis of samples from the same time periods at the same location, as well as a suite of swipes taken on the AIRNET housing. All negative results confirm that there was no plutonium contamination at this site. The original values were rejected.

6. Long-Term Trends

a. Uranium. Even though the annual and quarterly concentrations of uranium isotopes vary, peak concentrations for all three isotopes occur during the windier second quarter of each year (Figure 4-8). For years, the uranium-238 concentrations have been consistently higher than the uranium-234 concentrations.

The samples with DU or EU were all collected on Laboratory property or within Los Alamos County. This year, one EU and two DU detections were made. Off-site concentrations of DU are comparable to, or less than, historical natural uranium concentrations. A notable increase was observed in the three years following the 2000 Cerro Grande fire when compared to the three years before (Figure 4-8). It seems the lower levels of the years prior to the fire are again the norm.

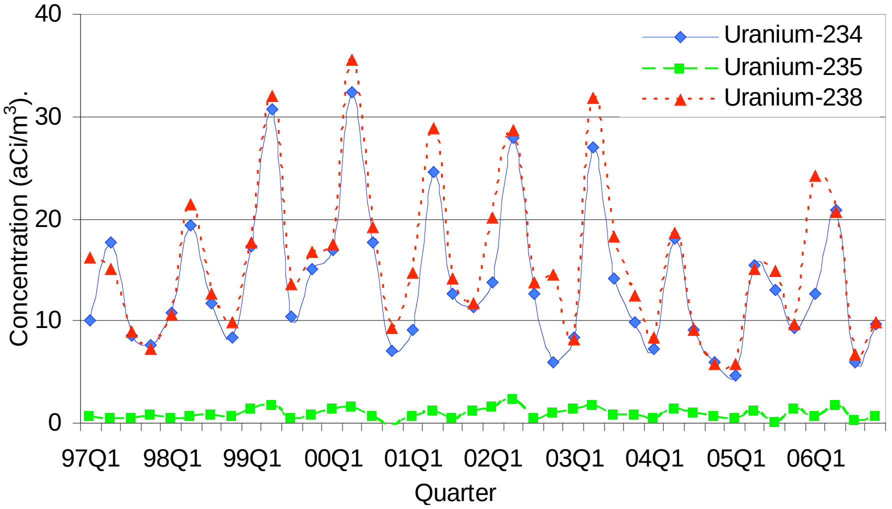

Figure 4-8. **AIRNET quarterly uranium concentrations (network-wide excluding site at TA-36).**

b. Plutonium and Americium. Only two 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 sampling stations at TA-21 and TA-54, where about one-quarter of the measurements are detected concentrations of these radionuclides. 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 waste site (TA-54) this year is due to resuspension during operations involving the transfer of cleanup waste from TA-21 to Area G during the second quarter. The remediation activities at TA-21 are the cause for the increase in the on-site americium-241 and plutonium-239 annual averages.

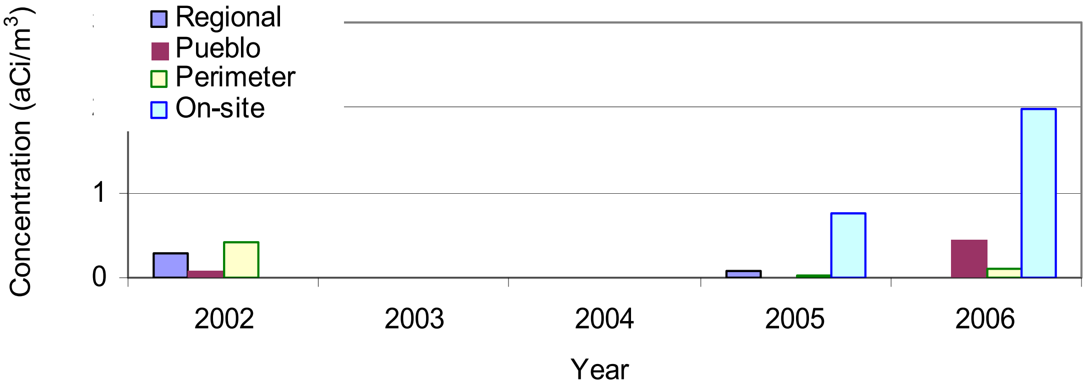

Figure 4-9. Am-241 concentration trends.

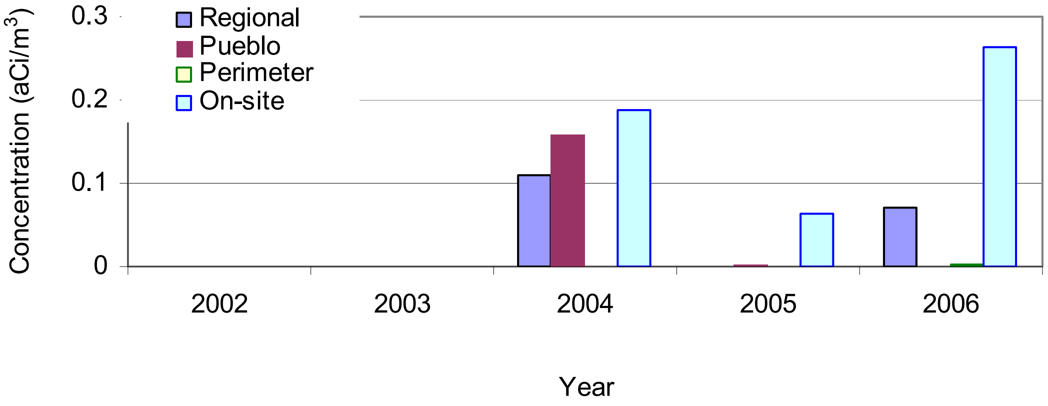

Figure 4-10. Pu-238 concentration trends.

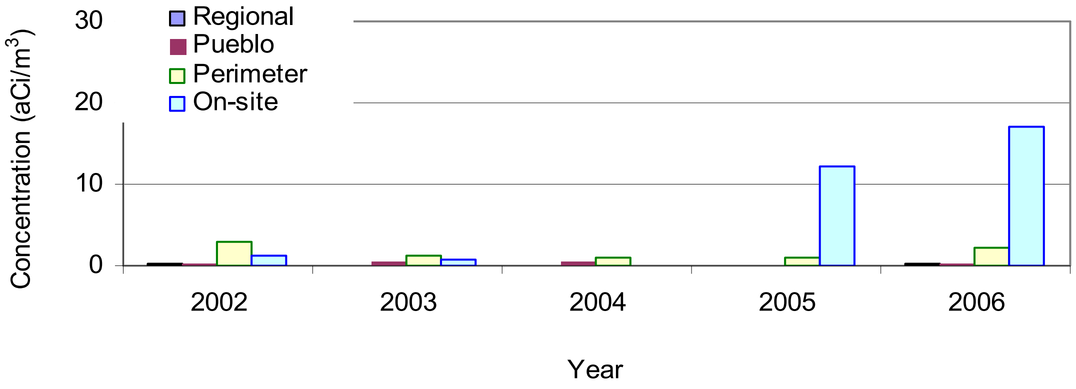

Figure 4-11. Pu-239,240 concentration trends.

Annual average concentrations of plutonium-239 and americium-241 are above zero for the TA-54, Area G, sampling stations. Concentrations at the TA-54 samplers have been low for several years, except for the soil-screening operation in 2002 (Figure 4-12) (ESP 2002) and this year's elevated plutonium-239 values. The average concentrations for the other sample location groupings vary but remain near zero, with occasional samples and/or locations having detected concentrations.

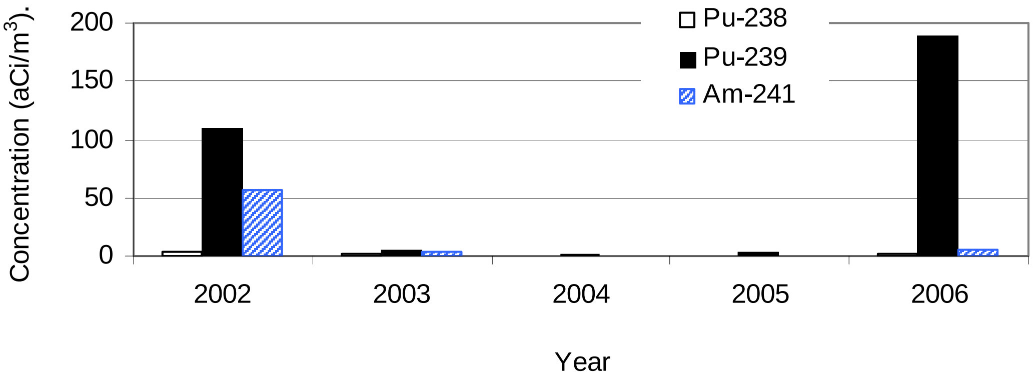

Figure 4-12. Americium and plutonium concentration trends for TA-54, Area G.

c. Tritium. Unlike other radionuclides, tritium concentrations are strongly influenced by current operations so emissions show no distinctive trends. The trend in concentrations at Area G has been down over the last five years (Figure 4-13). However, in 2006 tritiated waste near a few samplers raised the annual average. This waste has subsequently been relocated elsewhere at Area G: lower releases and doses are anticipated in the future. With the closure of two stacks at TA-21 this year, we see lower ambient tritium values nearby.

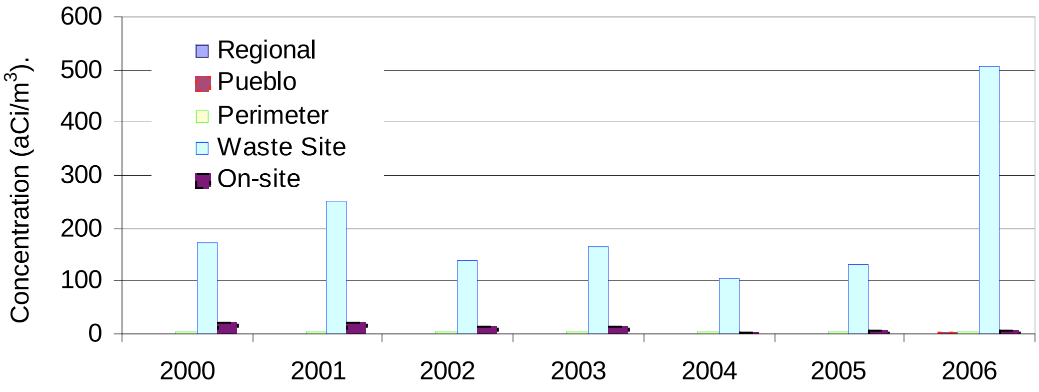

Figure 4-13. Tritium concentration trends.

B. STACK SAMPLING FOR RADIONUCLIDES

1. Introduction

Radioactive materials are an integral part of many activities at LANL. Some operations involving these materials may vent 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 impacts on the public and the environment. 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 Title 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 2006, we identified 28 stacks meeting this criterion. Where sampling is not required, emissions are estimated using engineering calculations and radionuclide materials usage information.

2. Sampling Methodology

In 2006, we continuously sampled 28 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 analysis laboratory. This 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. These isotopic data are then used to calculate emissions from each 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 elemental tritium. The air is then passed through a palladium catalyst that converts the elemental tritium to HTO. The sample is then pulled through three additional vials containing ethylene glycol, which collect the newly formed HTO. Liquid scintillation counting determines the amount of HTO and HT by analyzing the ethylene glycol for the presence of tritium.

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 2006 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). See Section F in this chapter for the results of analytical quality assurance measurements. General discussions on the sampling and analysis methods for each of LANL's emissions follow.

b. Particulate Matter Emissions. We removed and replaced the glass-fiber filters that sample facilities with significant potential for radioactive particulate emissions weekly and shipped them to an off-site analytical laboratory. Prior to shipping, each sample was screened with a hand-held instrument to determine if there were any unusually high levels of alpha or beta radioactivity. The laboratory performed analyses for the presence of alpha and beta radioactivity after the sample had 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 performed gamma spectroscopy analysis to identify specific isotopes in the sample.

The glass-fiber filters were composited every six months for radiochemical analysis because gross alpha/beta counting cannot identify specific radionuclides. We used the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. The Rad-NESHAP team compared 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.) identified 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 is performed the day of change-out prior to shipment to the off-site analytical laboratory.

c. Vaporous Activation Products Emissions. We removed and replaced the charcoal canisters installed at facilities with the potential for significant vaporous activation products emissions weekly, and then shipped the samples to the off-site analytical laboratory, where gamma spectroscopy identified and quantified 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, were collected and transported to LANL's Health Physics Analytical Laboratory on a weekly basis. The Health Physics Analytical Laboratory added an aliquot of each sample to a liquid scintillation cocktail and determined the amount of tritium in each vial by liquid scintillation counting.

e. Gaseous Mixed Activation Products (GMAP) Emissions. Continuous monitoring was used, rather than off-line analysis, to record and report GMAP emissions 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 were measured with the ionization chamber. The real-time current this ionization chamber measured was recorded on a strip chart, and the total amount of charge collected in the chamber over the entire beam operating cycle was integrated on a daily basis. The gamma spectroscopy system analyzed the composition of these GMAP emissions. Using decay curves and energy spectra to identify the various radionuclides, we determined the relative composition of the emissions. Decay curves were typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes were made at LANSCE, new decay curves and energy spectra were recorded.

4. Analytical Results

Measurements of LANL stack emissions during 2006 totaled approximately 1,290 Ci. Of this total, tritium emissions comprised approximately 893 Ci, and air activation products from LANSCE stacks contributed nearly 398 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium, were less than 0.00002 Ci. Emissions of particulate matter plus vaporous activation products (P/VAP) were about 2.3 Ci, which is about a 100-fold increase from 2005. Increased hot cell activities at TA-48 accounted for the increase, though this amount has a very small dose impact.

Table 4-13
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2006 (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		1.44E-07	1.21E-06	1.70E-05	1.20E-06	1.31E-04		2.91E-08
TA-03-102			3.01E-10	1.76E-09				
TA-16-205	3.40E+02							
TA-21-155	5.68E+01							
TA-21-209	4.48E+02							
TA-48-001						2.31E+00		
TA-50-069		2.61E-10	2.37E-09					
TA-53-003	2.74E+00						8.02E+00	
TA-53-007	5.93E+00					9.91E-03	5.47E+02	
TA-55-004	4.02E+01			2.61E-08	9.33E-09			8.88E-09
Total[h]	8.93E+02	1.44E-07	1.21E-06	1.70E-05	1.21E-06	2.32E+00	5.55E+02[I]	3.80E-08

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 314 curies released from diffuse sources at TA-53.

Table 4-13 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-14 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP.

Table 4-15 presents the half-lives of the radionuclides typically emitted by LANL operations. During 2006, the LANSCE facility (TA-53) non-point source emissions of activated air comprised approximately 530 Ci of carbon-11 and 22 Ci of argon-41.

Table 4-14
Detailed Listing of Activation Products Released from Sampled LANL Stacks in 2006 (Ci)

TA-Building	Nuclide	Emission
TA-48-0001	As-73	7.86E-07
TA-48-0001	Br-76	4.79E-04
TA-48-0001	Br-77	1.44E-04
TA-48-0001	Br-82	4.43E-06
TA-48-0001	Ga-68	3.75E-03
TA-48-0001	Ge-68	3.75E-03
TA-48-0001	Kr-79	2.3E+00
TA-48-0001	Se-75	1.2E-05
TA-48-0001	V-48	1.17E-08
TA-53-0003	C-11	8.02E+00
TA-53-0007	Ar-41	1.42E+01
TA-53-0007	As-73	4.07E-05
TA-53-0007	Be-7	9.19E-07
TA-53-0007	Br-76	2.32E-03
TA-53-0007	Br-77	2.99E-04
TA-53-0007	Br-82	2.81E-03
TA-53-0007	C-10	1.72E-01
TA-53-0007	C-11	1.84E+02
TA-53-0007	Hg-197	4.36E-03
TA-53-0007	Hg-197m	4.36E-03
TA-53-0007	N-13	1.37E+01
TA-53-0007	Na-24	1.14E-06
TA-53-0007	O-14	3.53E+01
TA-53-0007	O-15	2.01E+01
TA-53-0007	Os-191	5.29E-05
TA-53-0007	Se-75	2.49E-05

Table 4-15
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

5. Long-Term Trends

Figures 4-14 through 4-17 present radioactive emissions from sampled LANL stacks. These figures illustrate trends in measured emissions for plutonium, uranium, tritium, and GMAP emissions. As the figures demonstrate, emissions from plutonium and uranium isotopes stayed relatively steady since 2000, varying slightly each year but staying in the low-microcurie range. Tritium emissions showed a slight increase in 2006 due to ongoing source removal activities at two tritium facilities at TA-21. In 2006, emissions of GMAP returned to a low level, following a one-year elevation in 2005 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 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, future emissions from these stacks will be reported as part of LANL's non-monitored source program. These future emissions will be calculated based on emissions rates measured in the summer and early fall of 2006.

In 2006, LANSCE operated in the same configuration as 2002–2005, 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 April through December.

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 greatly elevated emissions in 2005, relative 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 in 2006. In all years, emissions were below all regulatory limits. Figure 4-18 shows the individual contribution of each of these emission types to total LANL emissions. It clearly shows that GMAP emissions and tritium emissions make up the vast majority of radioactive stack emissions. Bear in mind that 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 site boundary.

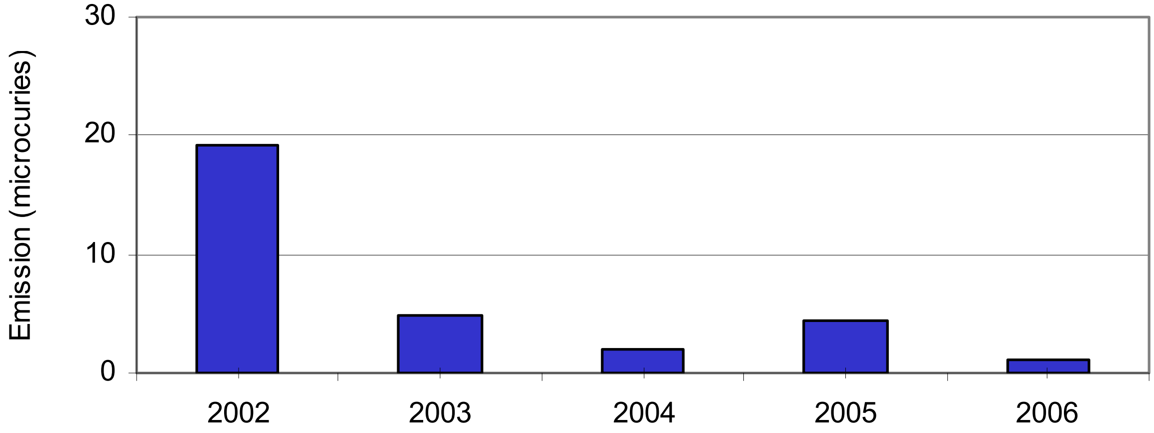

Figure 4-14. **Plutonium emissions from sampled LANL stacks.**

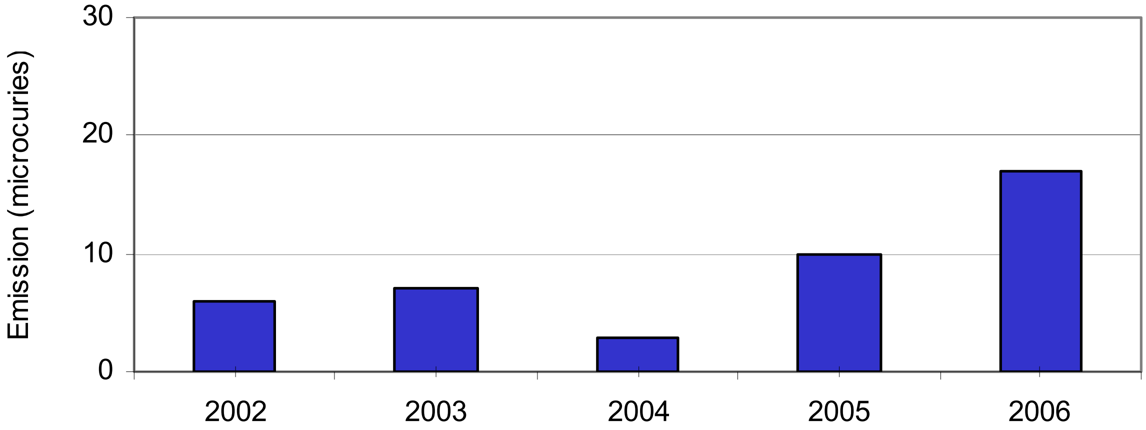

Figure 4-15. Uranium emissions from sampled LANL stacks.

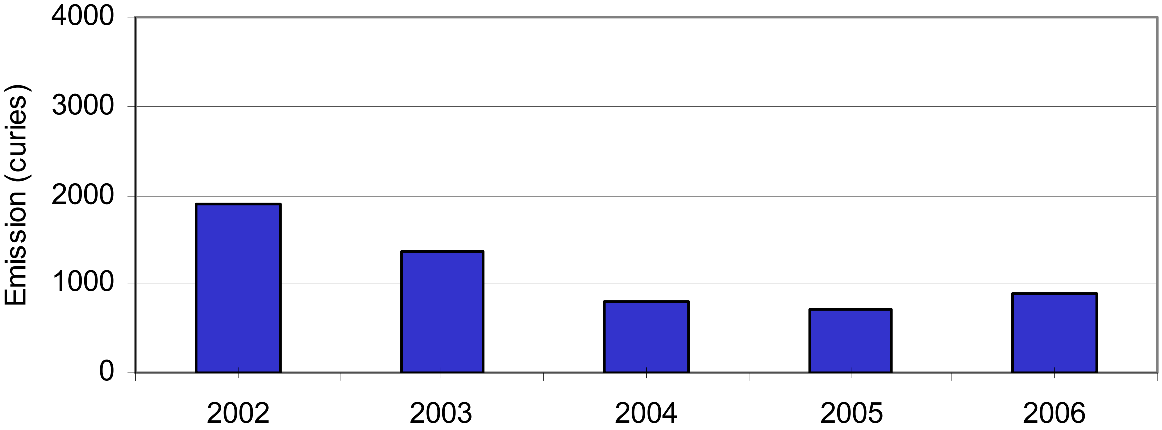

Figure 4-16. Tritium emissions from sampled LANL stacks.

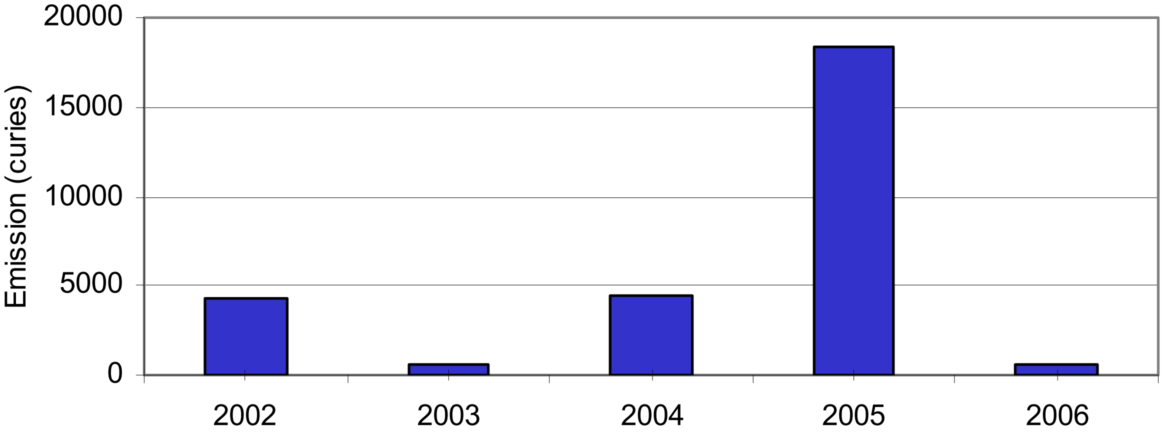

Figure 4-17. GMAP emissions from sampled LANL stacks.

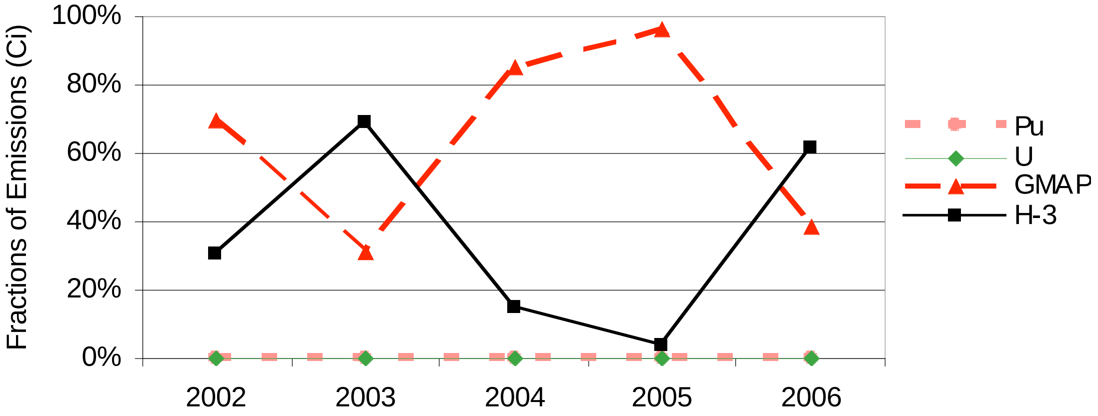

Figure 4-18. **Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP.**

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). 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 90 thermoluminescent dosimeter (TLD) stations around LANL and in the surrounding communities (Figures 4-2 and 4-19).

b. Neutron Dosimeters. We monitor potential neutron doses with 50 albedo TLD stations near known or suspected sources of neutrons (mostly at or near TA-54). Albedo dosimeters are sensitive to neutrons and use a hydrogenous material that causes neutron backscatter to simulate the human body.

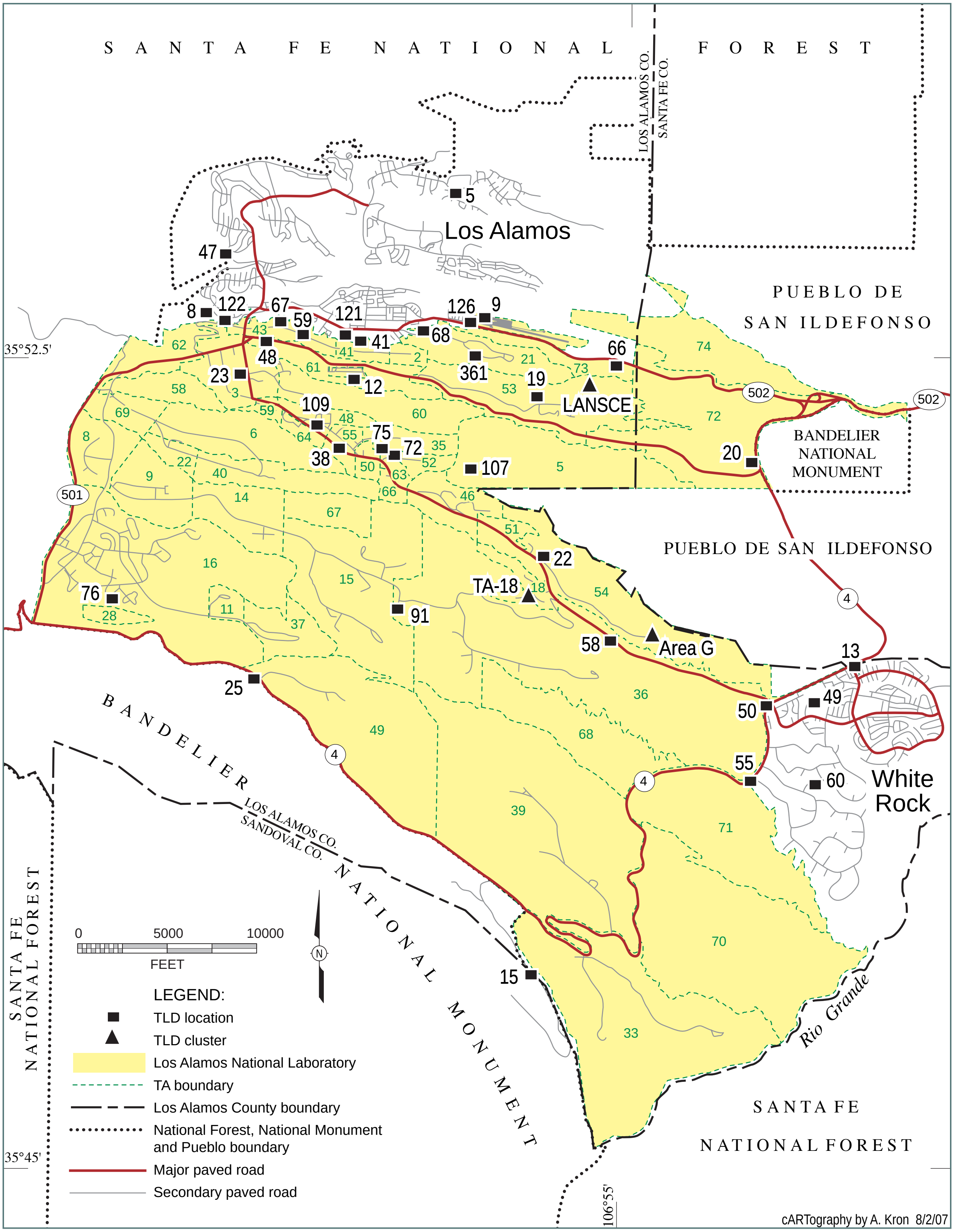

Figure 4-19. Off-site perimeter and on-site LANL TLD locations.

c. Neutron Background. Natural cosmic rays result in a neutron background dose of approximately 10 mrem/yr. However the neutron dosimeters record a dose of approximately 2 mrem/yr because the environmental dosimeters are calibrated with a D_2O-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 quailty assurance 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 8%.

4. Results

The annual dose equivalents at all stations except those at 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 4-2 shows the locations of the stations at TA-54, Area G, which is a temporary storage area for transuranic waste awaiting shipment to the Waste Isolation Pilot Plant.

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, TLD #134 is 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 18 mrem, 14 mrem, and 14 mrem, respectively. The dose measured by TLD #134 is higher than the others because TLDs #642 and #643 are in Canada 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, the public dose near TLD #134 is calculated as 18/16 = 1.1 mrem.

TLD #133 is located several hundred meters further from Area G and measures nothing above the cosmic-ray background. This is expected because of the distance and the shielding provided by the air.

Annual doses of 18 mrem and 10 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 limiting public access.

D. NONRADIOACTIVE AMBIENT AIR MONITORING

1. Introduction

During 2006, we continued a reduced version of the Non-Radiological Air Sampling Network (NonRadNet) implemented in 2001. Currently, the objectives of NonRadNet are to conduct monitoring to develop a database of typical background levels of selected nonradiological species in the communities nearest LANL and to measure 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 2006, 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 station is at the Los Alamos Medical Center (at AIRNET station 61) and the other is near 48th Street (AIRNET station 6). Both of these latter 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 PM-10 or PM-2.5 sample inlets, measures continuously 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. 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

a. Particulate matter. We achieved an overall data collection efficiency exceeding 90% for 2006. Annual averages and 24-hour maxima for both particle sizes at the three locations are shown in Table 4-16. The annual average for PM-10 is about 13 µg/m^3 at all locations; the annual average for PM-2.5 is about 7 µg/m^3. These annual averages are well below EPA standards (see Table 4-16). The 24-hour maxima for both PM-2.5 and PM-10 at all three locations are also much less than EPA standards.

Table 4-16

PM-2.5 and PM-10 Concentration Data Summary for 2006 (µg/m^3)

Station Location	Constituent	Maximum 24 hour (g/m^3)	Annual Average (g/m^3)
48th Street, Los Alamos	PM-10	42	12
	PM-2.5	15	6
Los Alamos Medical Center	PM-10	54	14
	PM-2.5	17	7
White Rock Fire Station	PM-10	64	15
	PM-2.5	16	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. Table S4-11 (in the Data Supplement) 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 2006, LANL burned roughly 6,100 pounds of high explosives.

An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicates no adverse air quality impacts. The quantities of materials detonated during 2006 were less than the amounts for which impacts are analyzed in the DOE (1999) report.

6. Beryllium Sampling

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). Beryllium air concentrations for 2006 are very similar to those measured in recent years.

During 2006, we analyzed quarterly composite samples from 23 sites for beryllium, aluminum, and calcium (see Table S4-12 in the Data Supplement). These sites are located near potential beryllium sources at LANL or in nearby communities. Beryllium and aluminum concentrations in soil occur in a fairly constant ratio: note the linear dependence in Figure 4-20 (correlation coefficient = 0.92). Non-natural occurrences of beryllium would appear far to the right of the straight line. The red triangle with a beryllium concentration of 0.14 ng/m^3 (from Area G station 36) seems to have a slightly elevated beryllium concentration. However, this and all other values are less than 2% of the NESHAP standard and are therefore considered of no health concern. We believe all the other measured beryllium concentrations are of a natural origin and represent resuspended soil and dust.

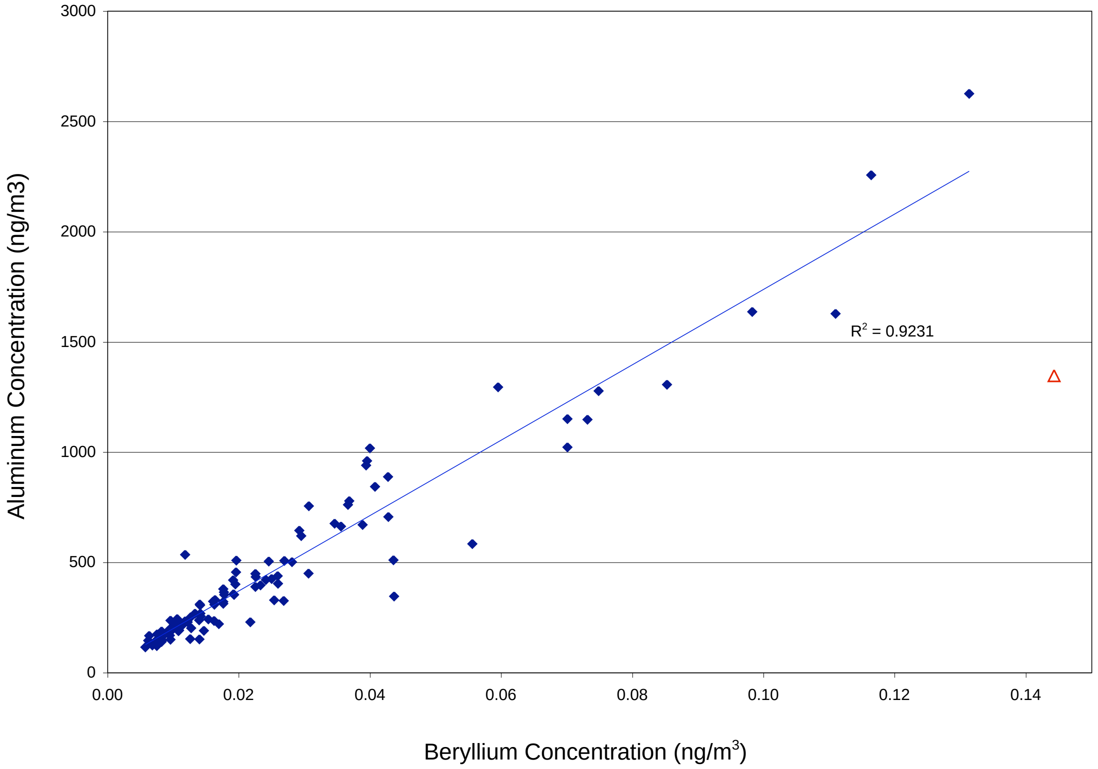

Figure 4-20. Correlation between aluminum and beryllium concentrations in AIRNET samples.

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/.

2. Monitoring Network

A network of seven towers gathers meteorological data at the Laboratory (Figure 4-21). 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.

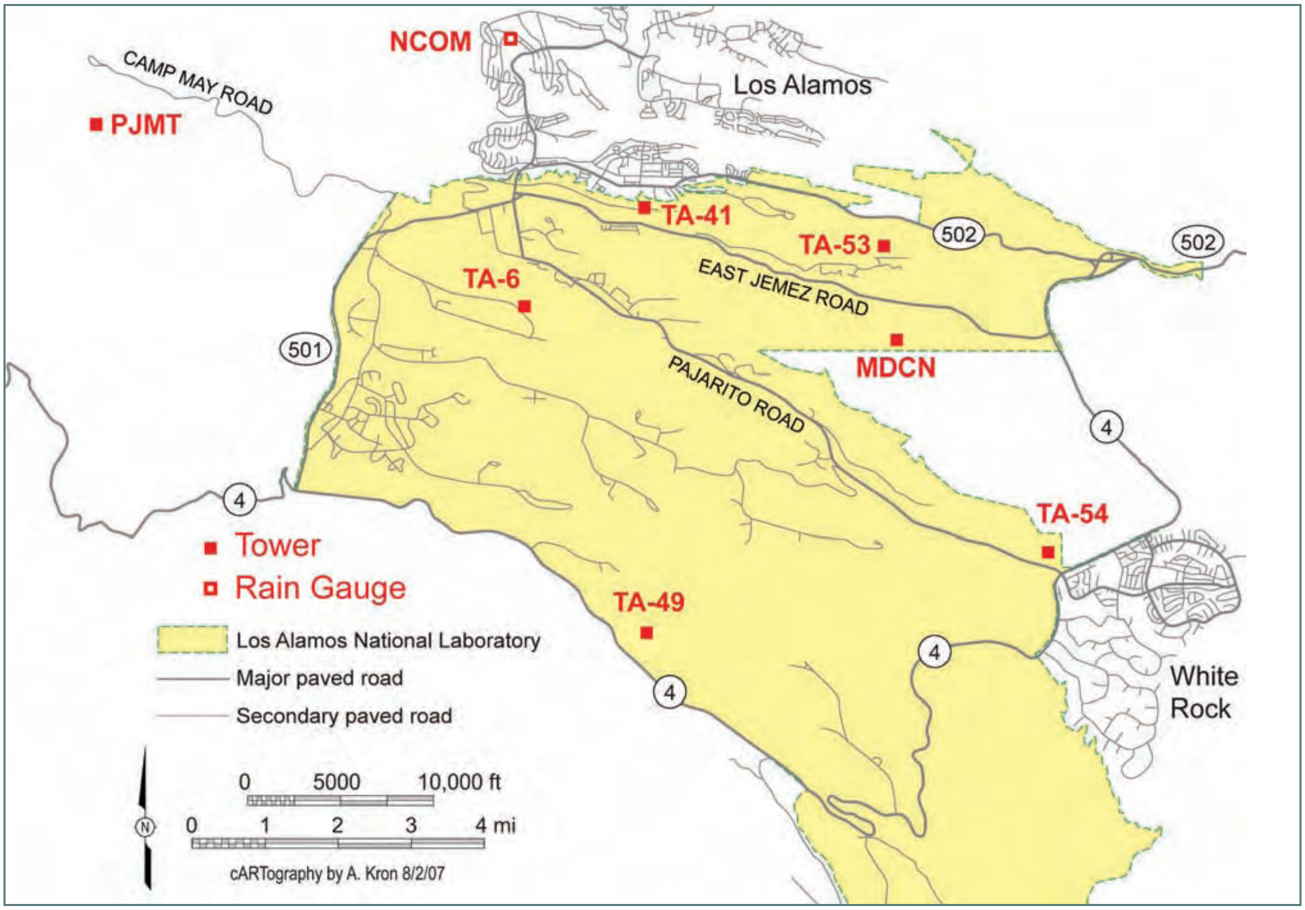

Figure 4-21. Location of meteorological monitoring towers and rain gauges.

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 annually refurbished and calibrated during an internal audit/inspection. Field instruments are replaced with backup instruments, and the replaced instruments are checked to verify that they remained in calibration while in service. All instrument calibrations are traceable to the National Institute of Standards and Technology. 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 of 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. 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 13, 1963. The Sangre de Cristo Mountains to the east of the Rio Grande valley act as a barrier to wintertime arctic air masses that descend into the central US, making the occurrence of local subzero temperatures rare. Winds during the winter are relatively light, so extreme wind chills are uncommon.

Temperatures are highest from June through August. 90% of minimum temperatures during these months range from 45˚F to 61˚F. 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 Los Alamos 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 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. 2006 in Perspective

Figure 4-22 presents a graphical summary of Los Alamos weather for 2006. 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 2006 was warmer and dryer than normal. The average annual temperature in 2006 of 49.6˚F exceeded the normal annual average of 47.9˚F by 1.7˚F. The total precipitation in 2006 of 16.62 in. was 12% below normal (18.95 in.). January, February, April, May, and June were particularly warm months, while September was clearly cooler than normal. The year began very dry as drought conditions that returned in late 2005 continued through May 2006. The late June monsoon start was early, but the rains ebbed in mid July. The monsoon returned in force during August with double the average rainfall amount for the month, as was the case the previous year. Autumn recorded average rainfall amounts but 2006 ended on a high note as December saw twice as much snow as usual with a massive two-day storm during the final week. The strong year-end surge in precipitation was not enough to cover the debt from the first half of the year, however, and 2006 ended with below average precipitation, albeit with hope for a snowy winter.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-23 shows the historical record of temperatures in Los Alamos from 1926 through 2006. 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 4-23. Every year since 1998 has been warmer than the 1971–2000 normal. 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.

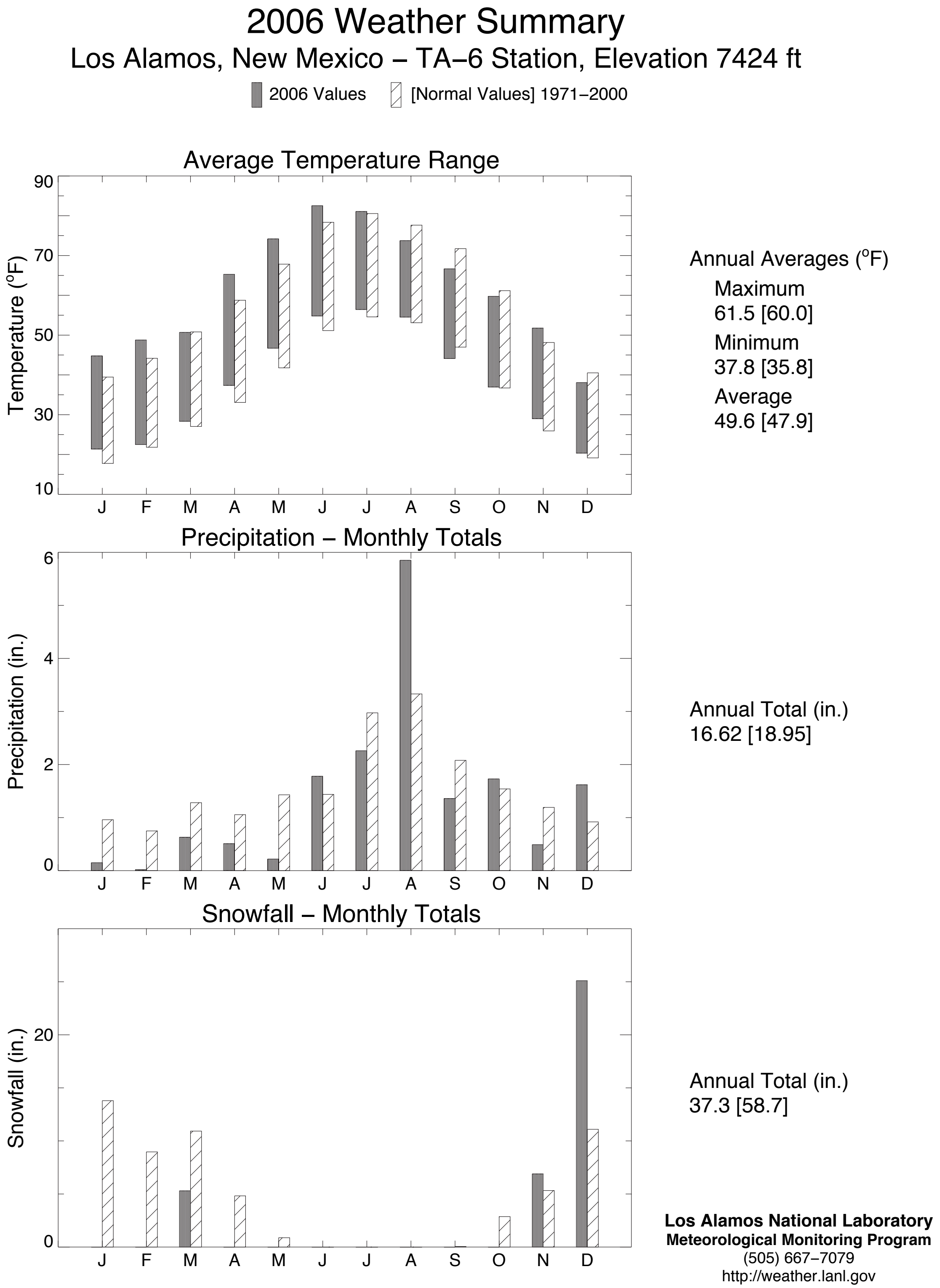

Figure 4-22. **Weather summary for Los Alamos in 2006 at TA-6 station, elevation 7,424 ft. Numbers in brackets are 30-year averages, and non-bracketed numbers are 2006 figures.**

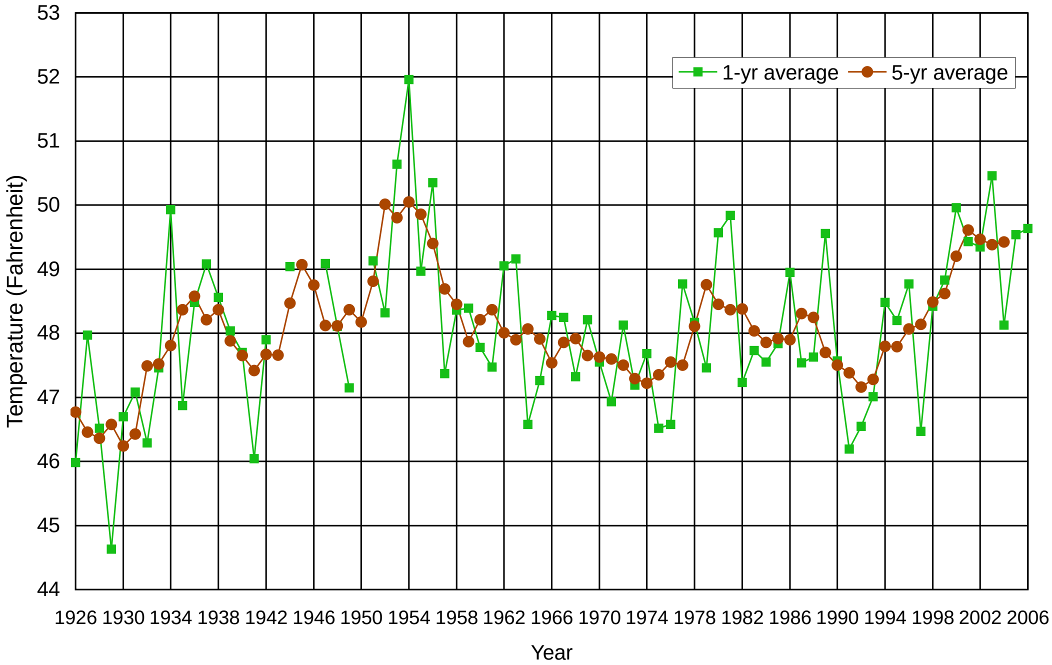

Figure 4-23. **Temperature history for Los Alamos.**

Figure 4-24 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 the nearly 17 inches are clearly not far off the normal of about 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 record in Los Alamos.

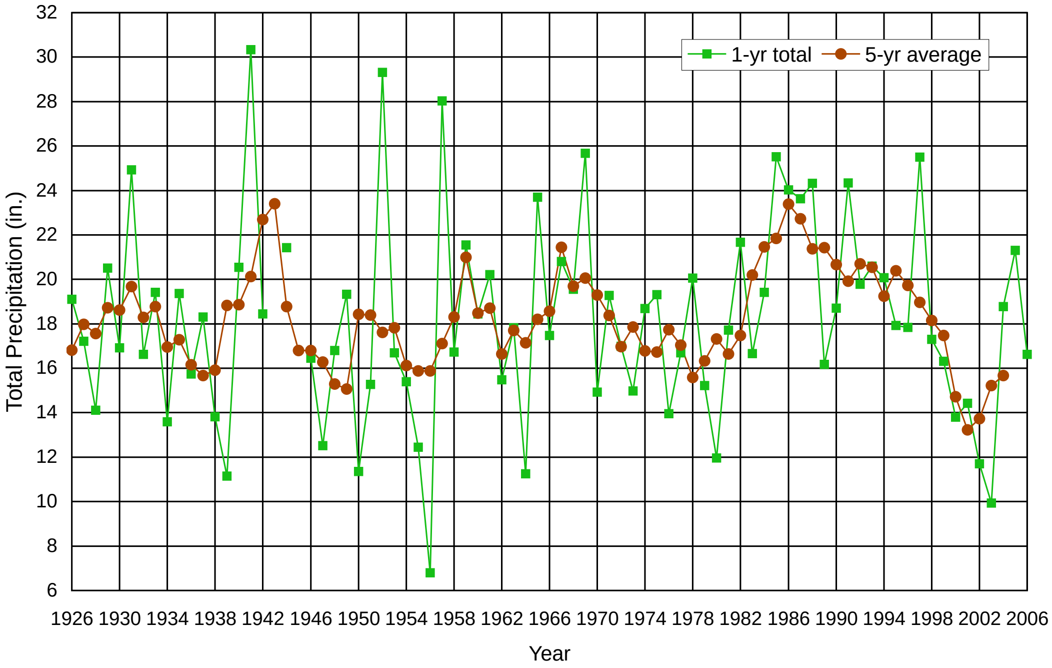

Figure 4-24. **Total precipitation history for Los Alamos.**

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-25. Wind roses depict the percentage of time that wind blows from each of 16 direction bins. For example, winds are from the south at TA-6 almost 14% of the time during days in 2006. Winds are from the north slightly more than 2% 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 about 6 to 11 mph. Winds from the south at TA-6 exceed 17 mph only a fraction of 1% of the time.

The wind roses are based on 15-minute-averaged wind observations for 2006 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 from the west, resulting from a combination of prevailing winds from the west 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 westerly winds. 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. Curiously, however, winds on the Pajarito Plateau are faster during the day than at night. This is due to vertical mixing that is driven by sunshine. During the day, the mixing is strong and brings momentum down to the surface, resulting in slower wind aloft and faster wind at the surface. At night, there is little mixing so wind aloft remains fast and wind at the surface receives little boosting from aloft.

F. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

During 2006, the air quality organization revised approximately 12 procedures to reflect the constant improvements in the processes; no plans required revisions. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate 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 then 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.

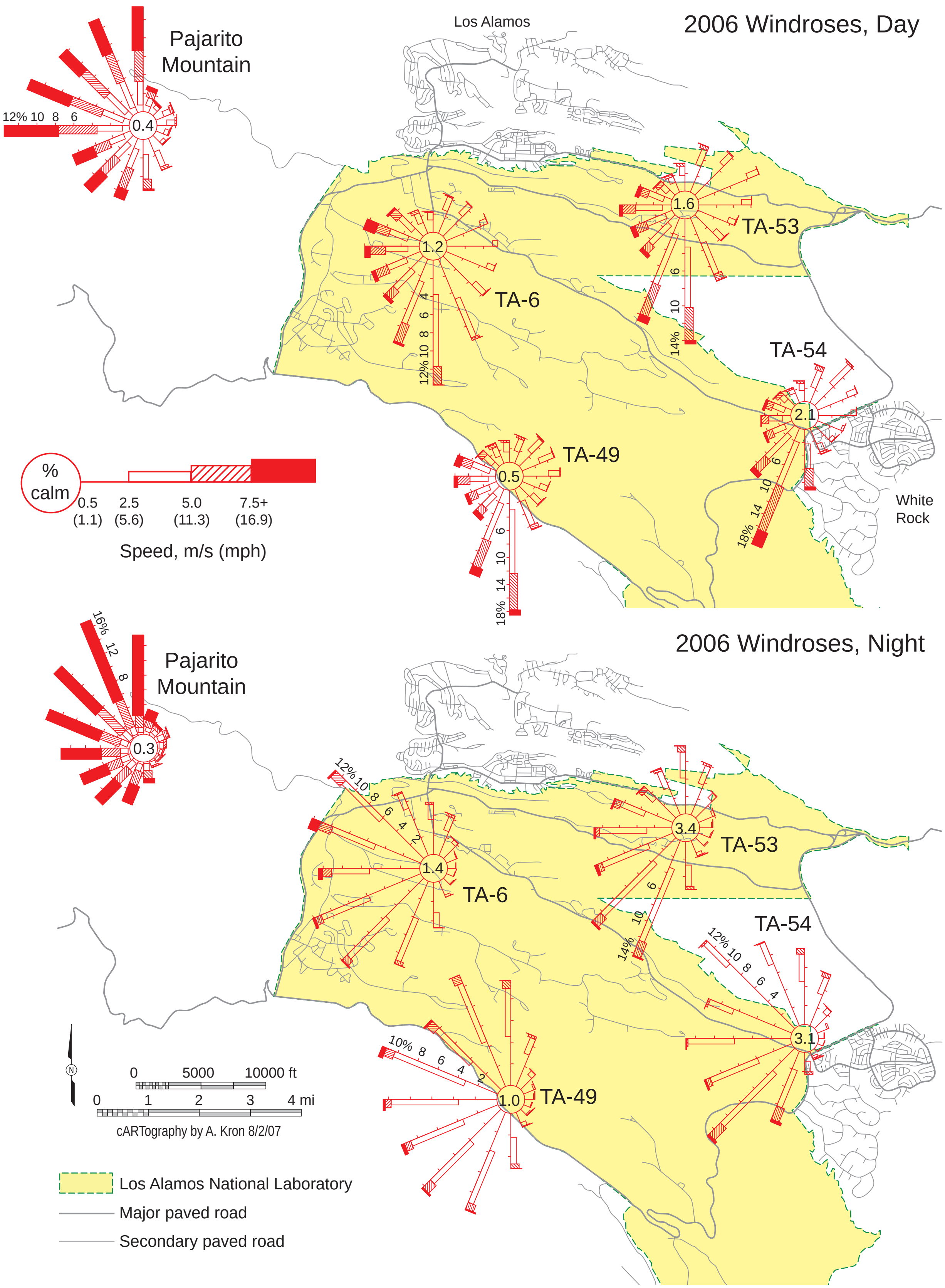

Figure 4-25. **Daytime and nighttime wind roses, 2006.**

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 that is prepared by stack monitoring staff to evaluate every data group received from a supplier.

b. Results Field data completeness for AIRNET and stacks was 100%. Sample run time was greater than 98.6% for AIRNET and 99.7% 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 chemical 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 are 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 99.61% for AIRNET filters, 99.02% for AIRNET silica gel, and 99.9% for stacks. The overall results of the quality monitoring in 2006 indicate that all analytical laboratories maintained the same high level of control that has been observed in the past several years.

4. Analytical Laboratory Assessments

During 2006, one internal and one external laboratory performed all chemical analyses reported for AIRNET and RADAIR 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 participated in national performance-evaluation studies during 2005 and the study sponsors judged the analytical laboratory to have acceptable performance for all analytes attempted in all air sample matrices.

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5. Groundwater Monitoring

5. Groundwater Monitoring

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David B. Rogers and Bart J. Vanden Plas

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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor water quality on the Pajarito Plateau and in 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 Project 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 ft. 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 (1) the regional aquifer underlying the area and include (2) the shallow perched groundwater found within canyon alluvium and (3) the perched groundwater at intermediate depths above the regional aquifer.

To comply with the requirements of the NMED Compliance Order on Consent (Consent Order), LANL significantly expanded the number of monitored groundwater locations during 2005. Groundwater monitoring conducted during 2006 was carried out according to the first Interim Sitewide Monitoring Plan approved by NMED under the Consent Order (LANL 2006). LANL's Water Stewardship Project 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 (2005), which summarizes results of investigations conducted under the Hydrogeologic Workplan from 1998 through 2004.

1. Geologic Setting

Los Alamos National 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).

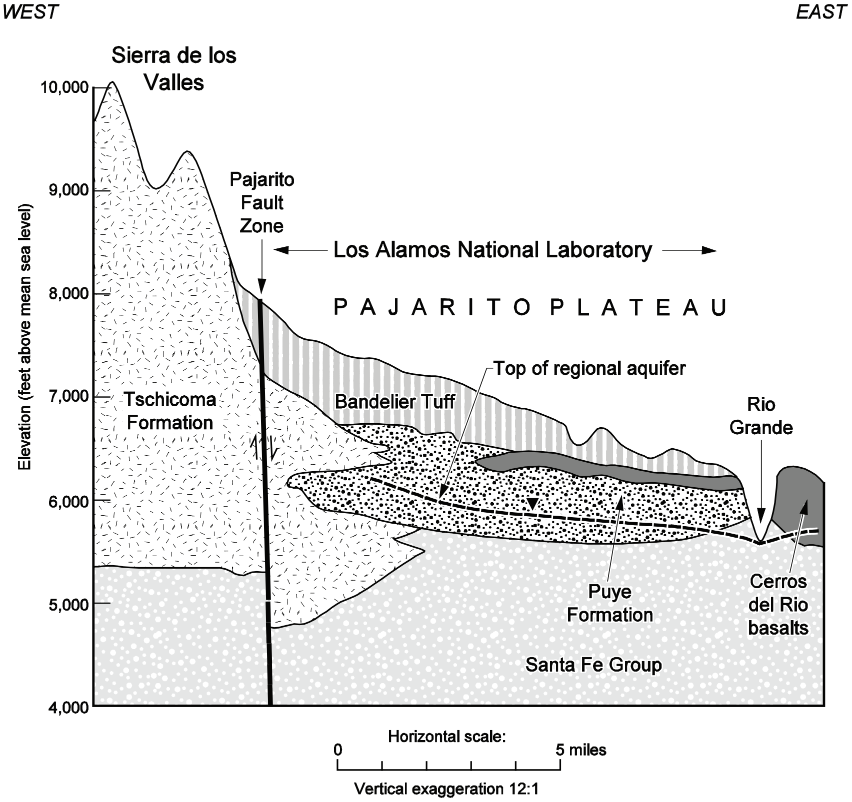


Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau.

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.

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 lies atop a thick zone of mainly unsaturated rock, with the principal 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.

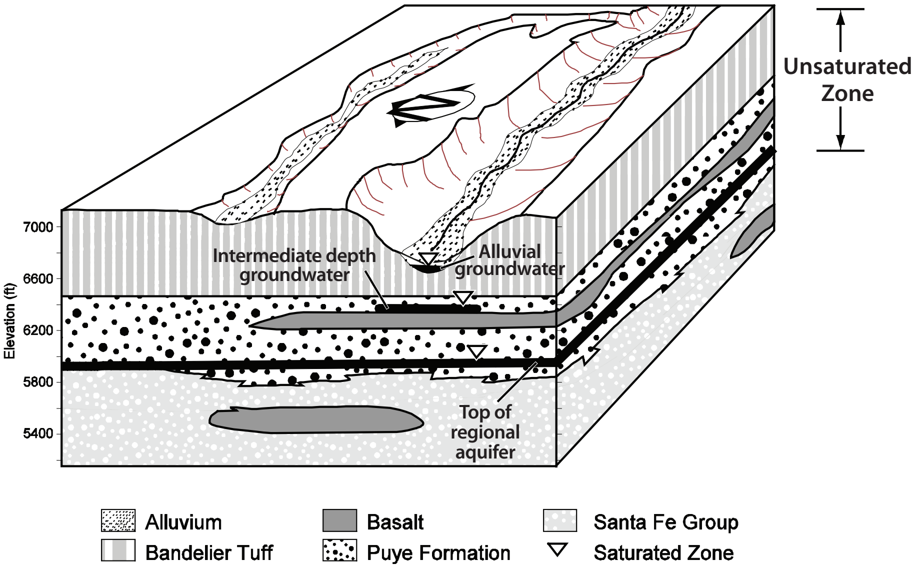


Figure 5-2. **Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.**

The three modes of groundwater occurrence are (1) perched alluvial groundwater in canyon bottoms, (2) 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. Evapotranspiration and infiltration into underlying rocks deplete the alluvial groundwater as it moves down the canyon.

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. Intermediate groundwater 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 water occurs in volcanics on the flanks of the Sierra de los Valles to the west of the Laboratory. This water discharges at several springs (Armstead and American) and yields a significant flow from a gallery in Water Canyon. Intermediate perched water 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 water may be infiltration from streams that discharge from canyons along the mountain front, or underflow of recharge from the Sierra de los Valles.

The regional aquifer of the Los Alamos area 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 flows generally 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 2005). Groundwater velocities vary spatially but are typically 30 ft/yr.

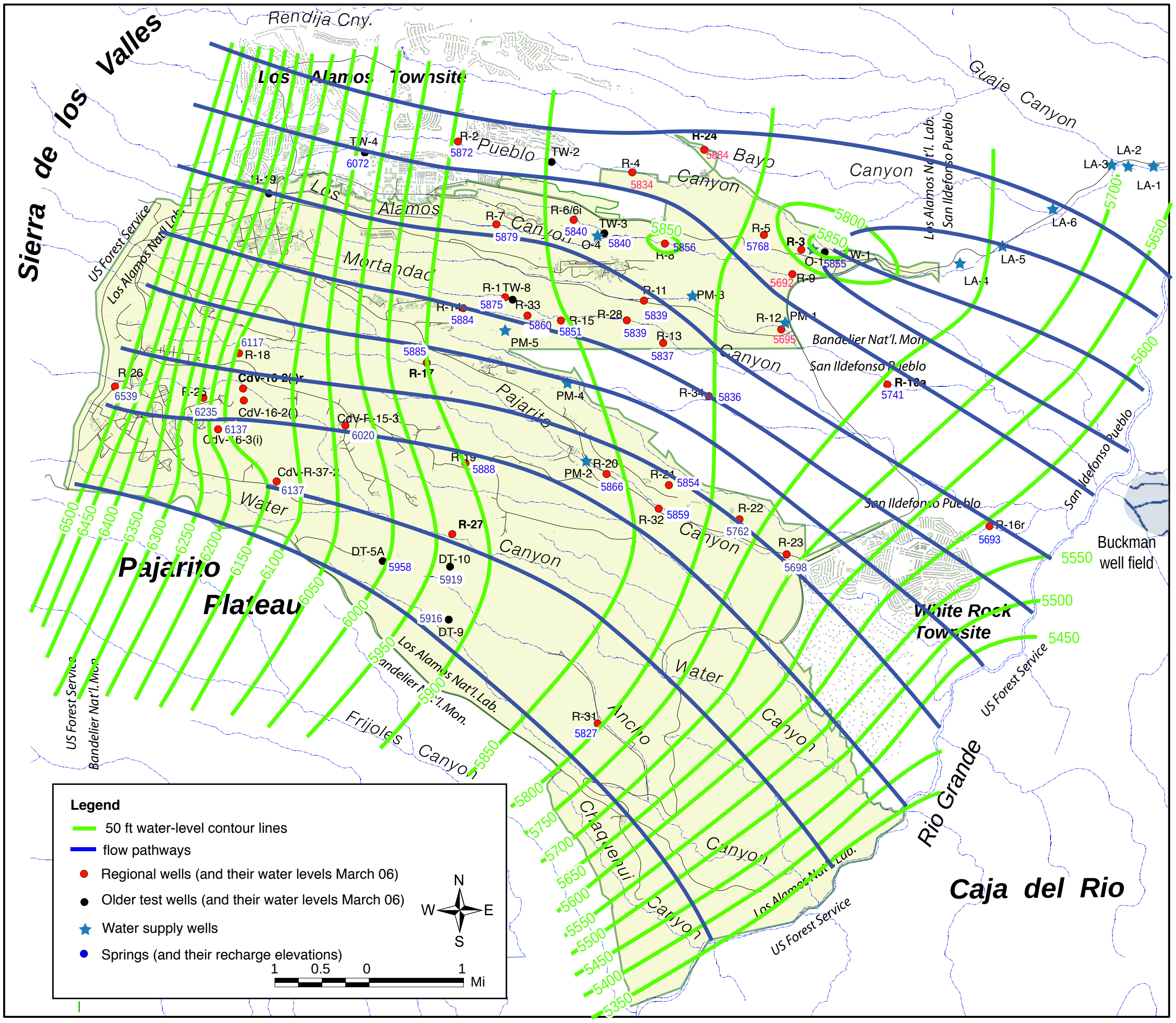


Figure 5-3. Contour map of average water table elevations in March 2006 for the regional aquifer (LANL 2007a).

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, limits their volumetric contribution to recharge reaching the regional aquifer.

3. Overview of Groundwater Quality

Since the 1940s, liquid effluent disposal by the Laboratory has affected water quality in the shallow perched groundwater that lies beneath the floor of a few canyons. Liquid effluent disposal is also the primary means by which Laboratory contaminants have affected the quality of deep groundwater, including intermediate perched zones and the regional aquifer. Where Laboratory 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 significant amounts of 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 the shallow perched groundwater bodies, and impacts on the regional aquifer are reduced.

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.

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 three sanitary treatment plants in Pueblo Canyon (ESP 1981). Only the Bayo sanitary treatment plant is currently operating. The Laboratory has also operated numerous sanitary treatment plants, three of which are shown in Figure 5-4.

Liquid effluent disposal at the Laboratory has impacted the quality of alluvial groundwater in several canyons. 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.

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

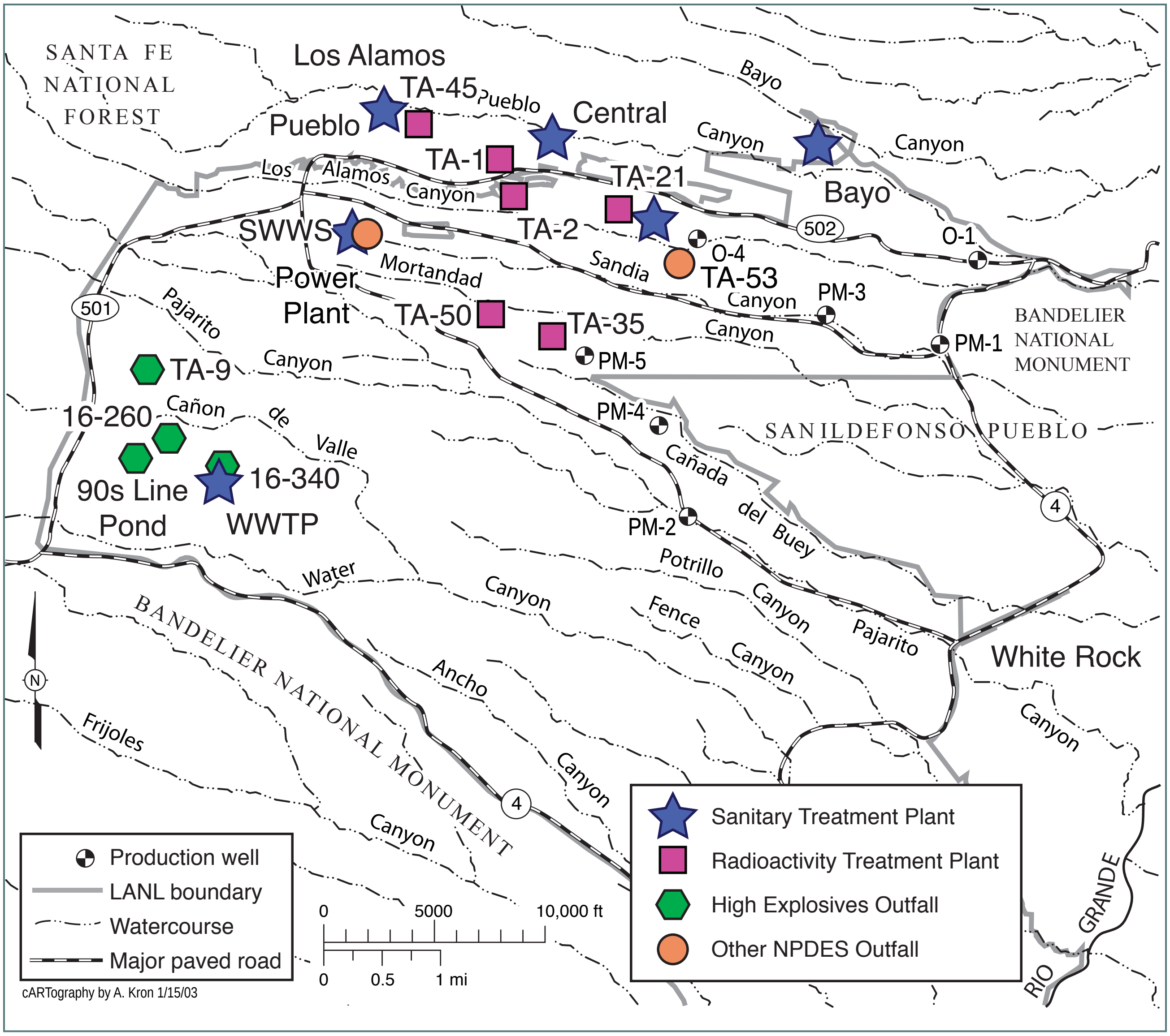


Figure 5-4. **Major liquid release sources (effluent discharge) potentially affecting groundwater. Most outfalls shown are inactive.**

Figure 5-5 summarizes regional groundwater quality issues at the Laboratory. In 2006, the high explosives compound Royal Demolition Explosive (RDX) was detected in the regional aquifer for the first time at Pajarito Canyon well R-18. RDX is listed as a toxic pollutant in the New Mexico groundwater regulations (NMWQCC 2002). The concentration was near the detection limit and at 2% of the EPA 10^{-5} excess cancer risk tap water screening level. RDX was not found in samples taken during 2005 from this well. Earlier detection of RDX in the regional aquifer at 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 the New Mexico Environment Department (NMED).

Hexavalent chromium and nitrate have been found in several regional monitoring wells. Hexavalent chromium is above the NM groundwater standard in one regional aquifer well and at 60% of that standard

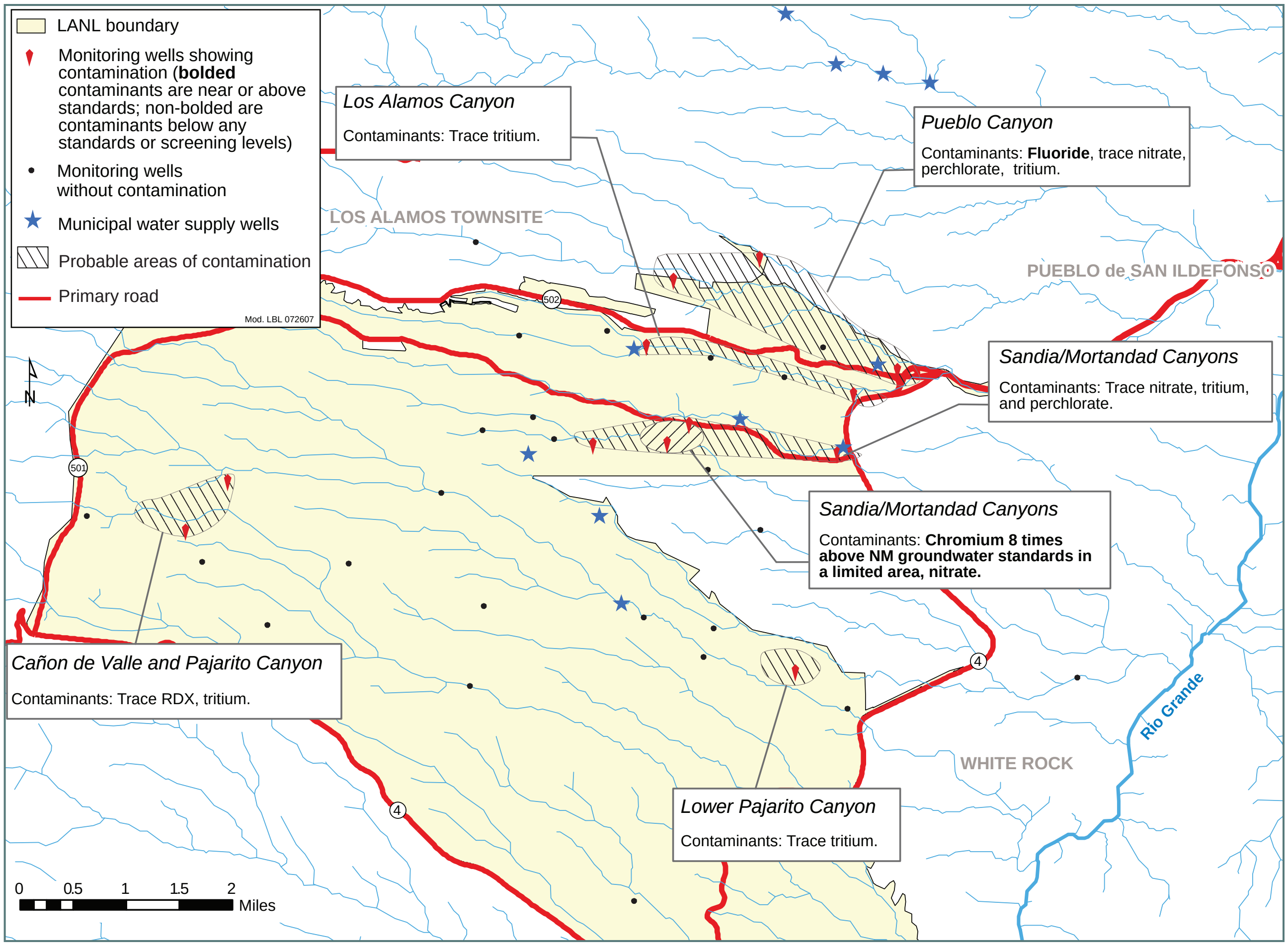


Figure 5-5. **Summary of regional aquifer groundwater quality issues at Los Alamos National Laboratory.**

in another. Nitrate (as nitrogen) reaches 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, drinking water wells in the Los Alamos area have not been adversely 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 of 24.5 µg/L. 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 requirements.

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

C. GROUNDWATER STANDARDS

We apply regulatory standards and risk levels in evaluating groundwater samples as described in Table 5-1. For water supply wells, which draw water from the regional aquifer, we compare 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 drinking water, 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 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 screen results for these compounds at a risk level of 10^{-5} for cancer-causing substances or a hazard index of one (HI = 1) for non-cancer-causing substances. A HI of one or less indicates that no (noncancer) adverse human health effects are expected to occur. 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 Region 6 tap water screening levels are at a risk level of 10^{-6}, so we use 10 times these 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. The standards for groundwater or NMWQCC's surface water standards (NMWQCC 2000), including the wildlife habitat standards, also apply to this water (see Chapter 6).

D. MONITORING NETWORK

In 2005, the Laboratory and the NMED signed the Consent Order, which specifies the process for conducting groundwater monitoring at the Laboratory. The Consent Order requires that the Laboratory annually submit an Interim Facility Groundwater Monitoring Plan (Interim Plan) to the department for its approval. The first Interim Plan was approved in June 2006 (LANL 2006). Groundwater monitoring in 2006 was conducted by the Laboratory according to the Interim Plan.

Groundwater sampling locations are divided into three principal groups related to the three modes of groundwater occurrence: the regional aquifer, perched alluvial groundwater in the bottom of some canyons, and localized intermediate-depth perched groundwater systems (Figures 5-6, 5-7, 5-8, 5-9, and 5-10). The springs and wells are described by Purtymun (1995), LANL (2005), and (for new wells) individual well completion reports.

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 5-10 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 5-10 also shows the location of three City of Santa Fe wells monitored by the Laboratory.

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 Derived Concentration Guides, 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 apply to drinking water systems
Radionuclides	Effluent samples	DOE 100-mrem Derived Concentration Guides		DOE Order 5400.5	On site	DOE public dose limit is 100 mrem/yr, applies to effluent discharges
Radionuclides	Other groundwater samples		4-mrem Derived Concentration Guides, 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 because they apply only to drinking water systems
Non-radionuclides	Water supply wells	EPA MCLs, NM groundwater standards, EPA 10^{-5}, and HI = 1 risk levels for NM toxic pollutants with no standard		40 CFR 141-143, 20.6.2 NM Administrative Code	On site and off site	EPA MCLs apply to drinking water systems. Use EPA Region 6 table for 10^{-5} and HI = 1 risk values
Non-radionuclides	Other groundwater samples	NM groundwater standards, EPA 10^{-5} and HI = 1 risk levels for NM toxic pollutants with no standard	EPA MCLs	40 CFR 141-143, 20.6.2 NM Administrative Code	On site and off site	NMED regulations protect all groundwater. EPA MCLs are for comparison because they apply only to drinking water systems. Use EPA Region 6 table for 10^{-5} and HI = 1 risk values

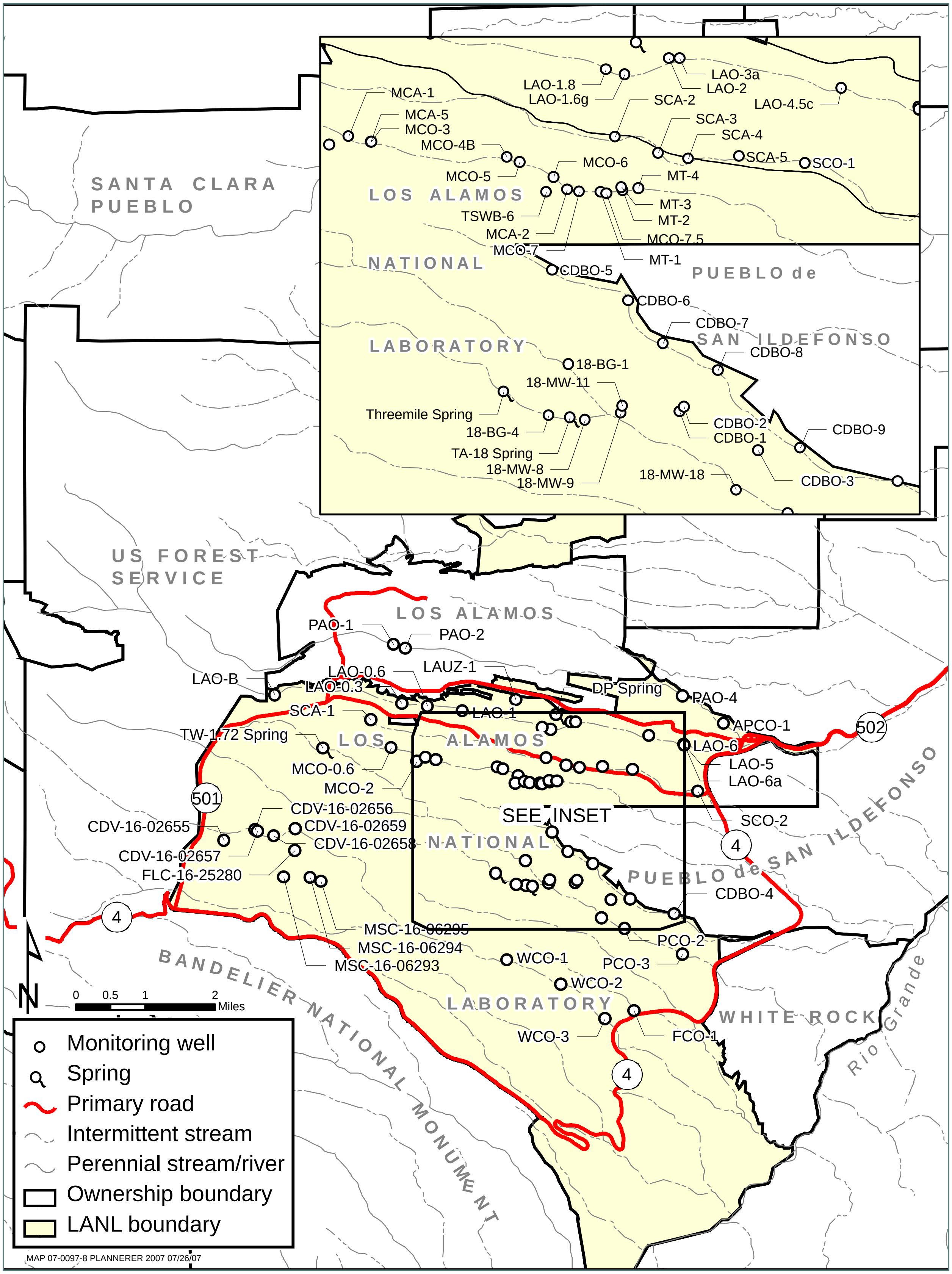


Figure 5-6. Springs and wells used for alluvial groundwater monitoring.

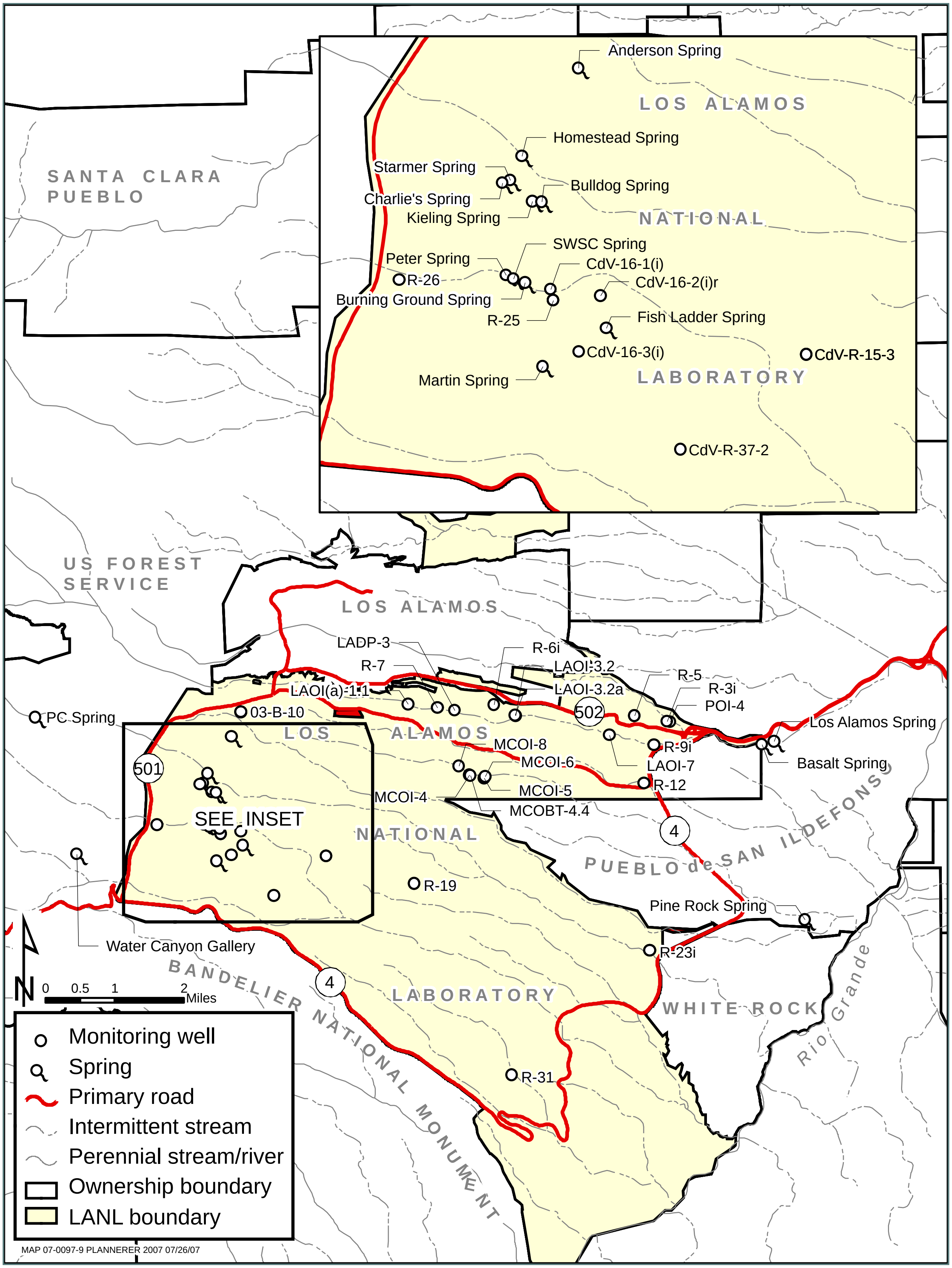


Figure 5-7. Springs and wells used for intermediate perched zone monitoring.

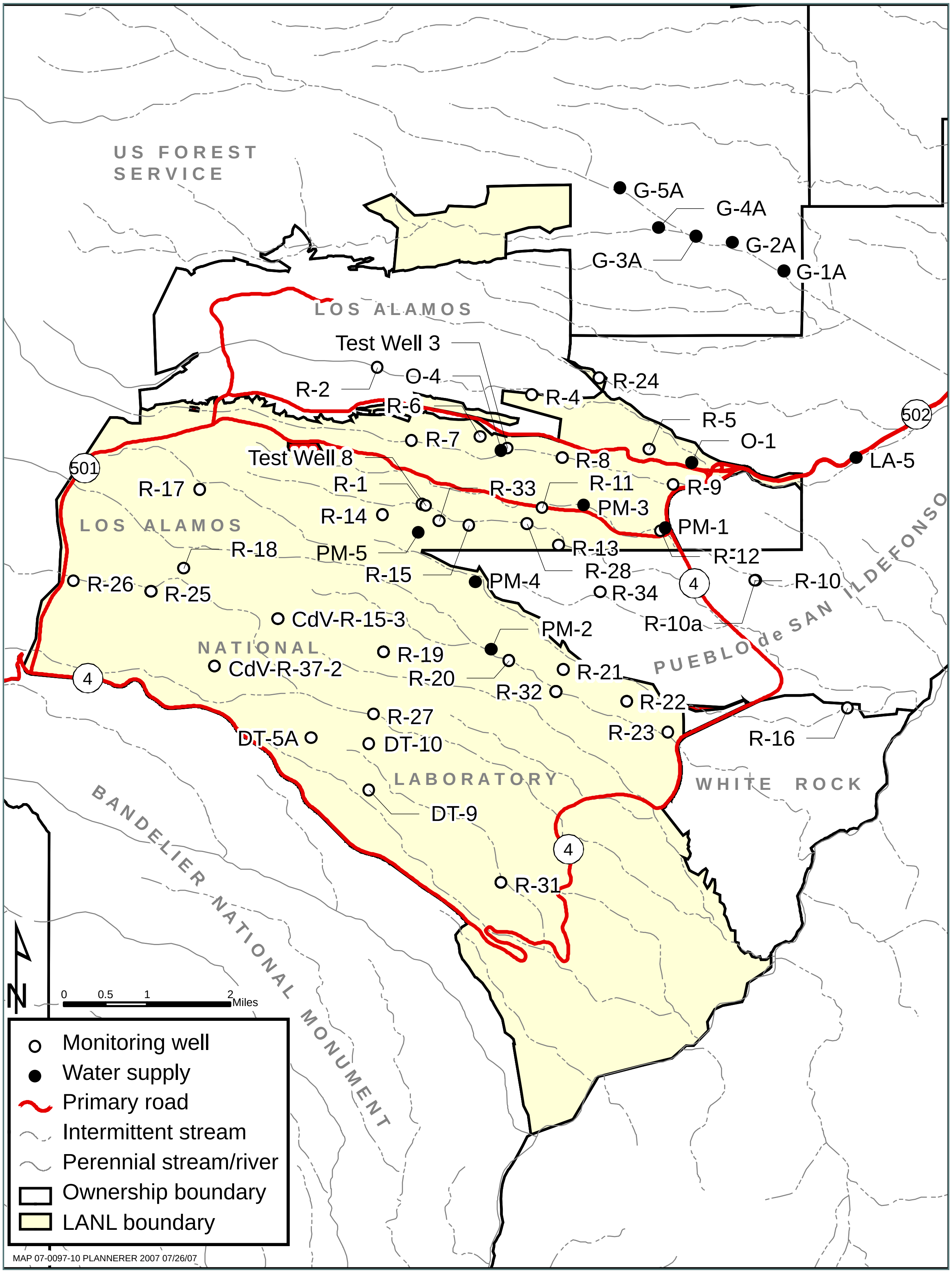


Figure 5-8. **Wells used for regional aquifer monitoring.**

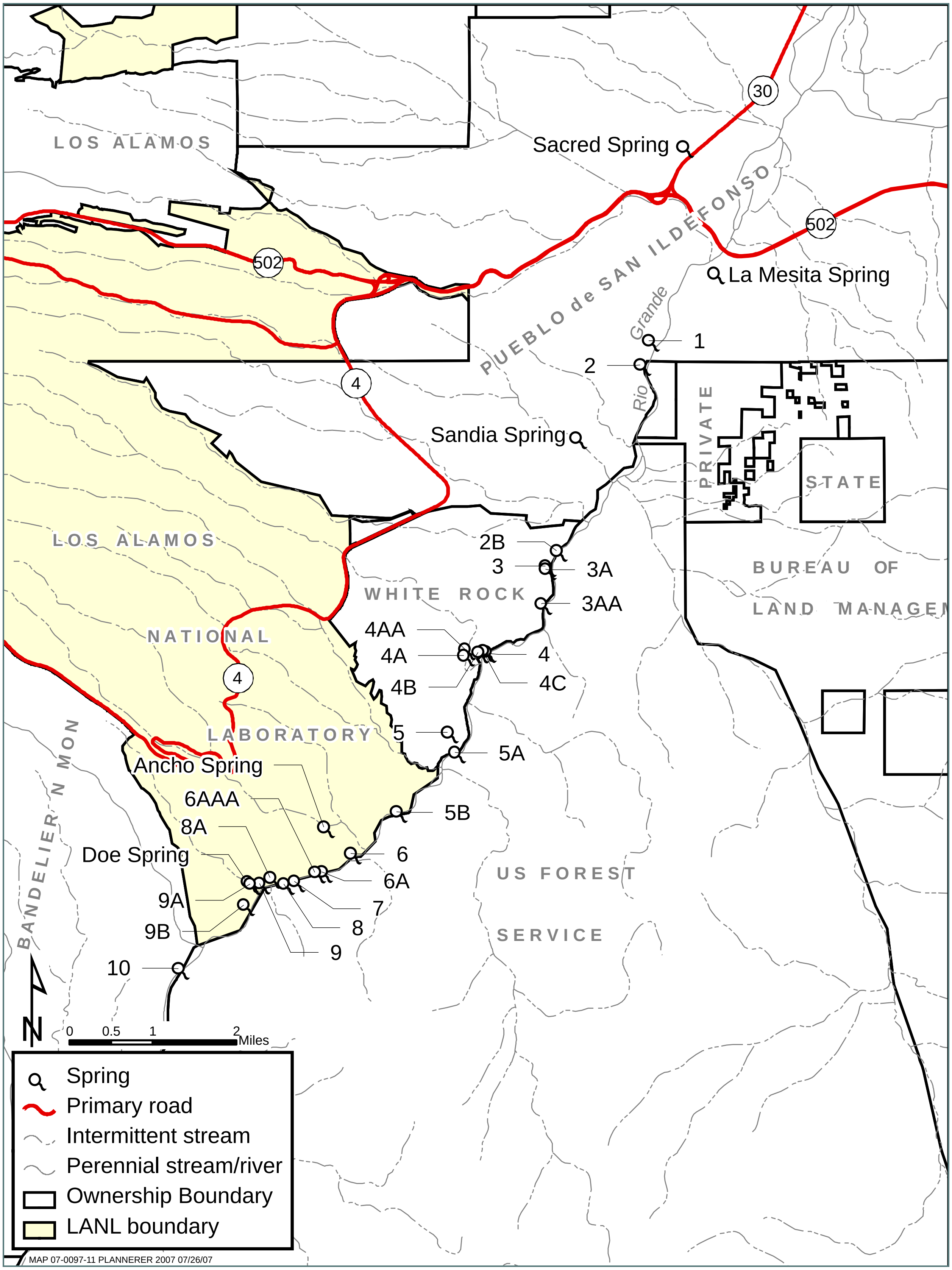


Figure 5-9. **Springs used for regional aquifer monitoring.**

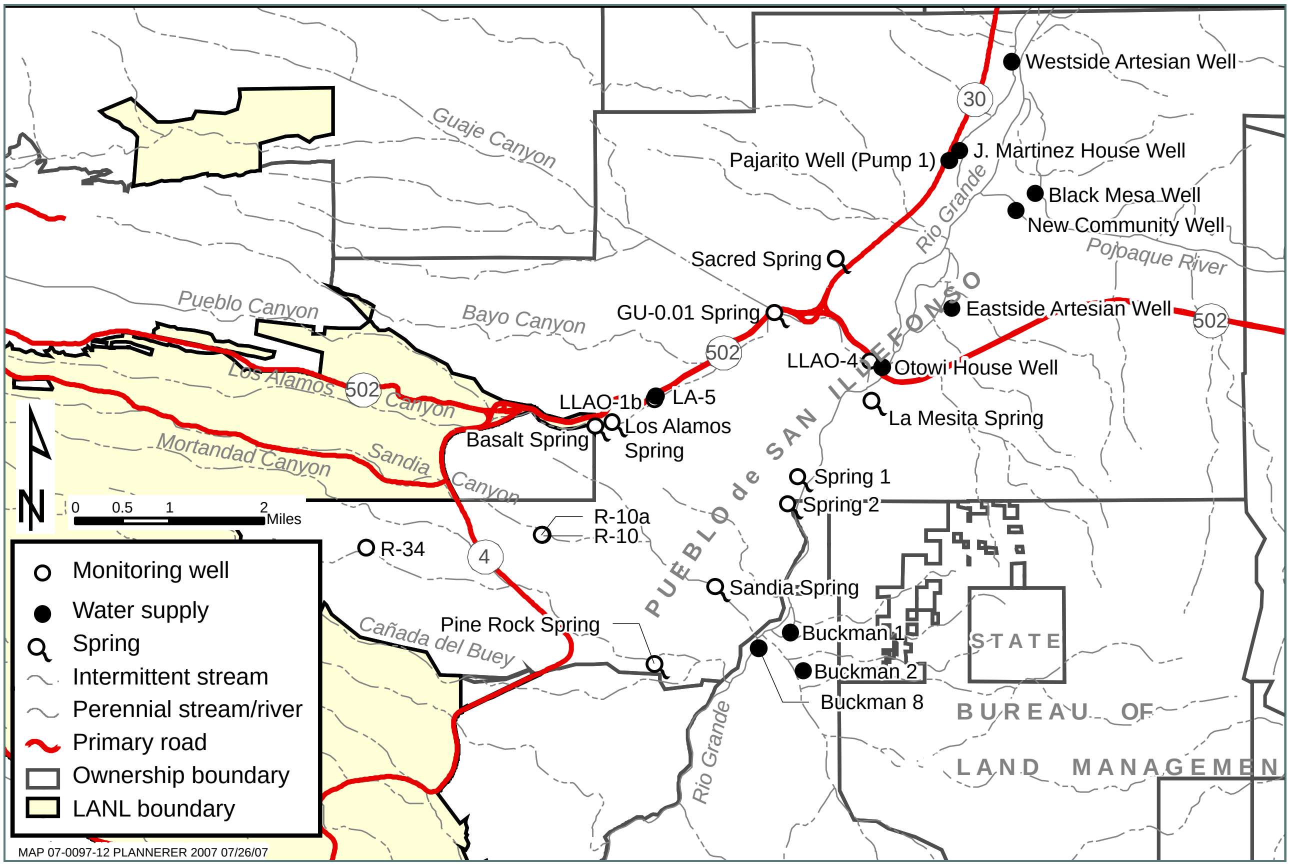


Figure 5-10. **Springs and wells used for groundwater monitoring at the City of Santa Fe Buckman well field and on Pueblo de San Ildefonso.**

Water quality monitoring results are given in accompanying supplemental data tables (on included compact disk), 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 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 2006 is given in Allen et al. (2007).

1. Regional Aquifer and Intermediate Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring wells, supply wells, and springs. Wells recently constructed under the Hydrogeologic Workplan (LANL 1998) 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 2006 are described in Chapter 2, section B.9.b.

In the 1950s and 1960s, the Laboratory located the first eight regional aquifer monitoring wells where they might detect contaminants infiltrating from areas of effluent disposal or underground weapons-testing operations. Newer characterization wells have been installed beginning in 1998. Some of these newer wells penetrate down to 600 ft or more into the regional aquifer, and several have multiple sampling ports within intermediate perched zones and the regional aquifer. A column on the supplemental data tables identifies the groundwater zones sampled by different ports of these wells and gives the depth of the port or top of the well screen.

The Laboratory collects samples from 12 Los Alamos County water supply wells in three well fields that produce 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 come from wells located on Pueblo de San Ildefonso 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 use 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, over 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 the new 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 undergo extensive well development to reduce the turbidity of water samples and to remove drilling fluids from the rock formations. Effects of drilling fluid on water quality appear to linger longer in multiple completion wells than in single completion wells because the latter can be developed more vigorously. Well screens installed in lower permeability zones are also difficult to develop. The quality of water samples from single screen wells may also be better because they can be purged when sampled.

Most Pajarito Plateau groundwater is under chemically oxidizing conditions, meaning that free oxygen is dissolved in the water. Addition of organic matter in drilling fluids into the aquifer near a well stimulates bacterial activity, which reduces available oxygen and changes the chemical behavior of several constituents found in groundwater and adjacent aquifer material. With reducing conditions (absence of oxygen), the solubility of metals such as manganese and iron increases, and they are dissolved from the surface of minerals that make up the aquifer's rock framework or possibly from well fittings. Several other chemical constituents may also increase or decrease in concentration as a result of the mainly temporary effect of the drilling fluids on the region near the well (Bitner 2004, ERSP 2005).

The Well Screen Analysis Report (LANL 2007b) provided a geochemical evaluation of 80 screens in 42 wells that had been completed and sampled as of December 2006. The report concluded the following:

- The most common drilling artifact is the presence of reducing conditions.
- Single-screen wells show the least impact from residual drilling fluids.
- The majority of the screens in multiple-screen wells are impacted by residual drilling fluids.
- However, nearly all multiple-screen wells have at least one screen interval rated as good or very good for measuring water quality.
- A vast majority of the screens were able to detect strontium, barium, and zinc. Fewer were able to detect uranium.
- 46% of the screens detected the presence of residual organics from drilling fluids. Organics with a high organic-carbon partition coefficient would not be detected reliably in the presence of residual organic drilling fluids.
- 45% of the screens detected the presence of various stages of reducing conditions.
- Tritium and RDX can be detected reliably in all screens. Strontium-90 can be detected in 91% of the wells. Percentages of detection range from 46% to 76% for other potential contaminants, with the exception of TNT, which could only be detected 31% of the time. The capability of detecting potential contaminants was higher for single-screen wells.

As a result of the first well screen assessment conducted in 2005 (ERSP 2005), LANL began a pilot study to rehabilitate wells R-12, R-16, and R-20. During late summer-autumn of 2006, the sampling systems were removed from these wells and they were purged extensively and jetted. A more aggressive hydropulse system was used in R-20. Preliminary results of the pilot rehabilitation produced were reported in the Pilot Well Rehabilitation Study Summary Report (LANL 2007c).

E. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables present groundwater monitoring data for 2006. 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 2006. The table also gives the total propagated one-sigma (one standard deviation) analytical uncertainty and the analysis-specific minimum detectable activity (MDA), where available. 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 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 (which indicates that the result is a nondetect). The analytical laboratory reports as detected a result that is greater than the measurement-specific MDA. University of Miami 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 issues. The table shows two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7). After we receive the analytical laboratory data packages, the packages receive secondary validation by an independent contractor, Analytical Quality Associates (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 to the standards shown on the table.

Table S5-8 lists the results of general chemical analyses of groundwater samples for 2006. 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. We use both methods because LC/MS/MS by SW-846 6850 (or EPA 6850 Modified) for perchlorate has not yet been officially promulgated by the EPA. The results of trace metal analyses appear in Table S5-10.

As part of the rehabilitation pilot study, three wells (R-12, R-20, and R-16) underwent redevelopment and testing during 2006 to improve sample quality. Results for those tests and accompanying sampling are covered in a separate report (LANL 2007c) 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 groundwater contaminants. The maps provide a spatial context for distribution of groundwater contamination. Rather than showing data for 2006 alone, the maps represent a synthesis of the last several years of groundwater data collected for 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 2006, we analyzed samples from selected springs and monitoring wells for organic constituents. Table S5-11 summarizes 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 (DROs), and HEs. The Quality Assurance (QA) Section of this chapter (Section H) covers analytes and analytical methods. Many of the possible organic 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 contamination acquired during sampling. Trip blanks accompany samples during sample preparation, transportation, and shipment to determine if organic contamination occurs. Table S5-12 shows organic compounds detected in 2006 and results from field QC samples.

A large number of groundwater samples were analyzed for dioxins and furans in 2006. Only two of these compounds have screening levels or regulatory standards. These values are about the same magnitude as the detection limits. The method is quite sensitive and these compounds were found near the detection limit in a large number of samples. See the QA Section for more discussion on this topic.

a. Organic 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 constituents 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 constituents 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

In 2006, other than for naturally occurring radionuclides (for example, radium-226 and uranium-234), no water supply radioactivity analyte activity or concentration value exceeded the 4-mrem DOE DCGs applicable to drinking water. One regional aquifer result exceeded a 4-mrem DOE DCG, but that standard is mentioned for comparison purposes as it is not applicable to the sample: this was the result for neptunium-237 in monitoring well R-27, located in Water Canyon. The preponderance of nondetections for neptunium-237 in samples collected on that date indicates that the detected result is a false positive. No other regional aquifer radioactivity results were greater than regulatory standards.

Otherwise, the main radioactive element detected in the regional aquifer is naturally occurring uranium, found 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.

For well and spring samples from intermediate perched groundwater, other than for naturally occurring radionuclides, no results exceeded the 4-mrem DOE DCG screening levels (Table 5-1). Three wells in Mortandad Canyon (MCOI-4, MCOI-5, and MCOI-6) had tritium activities that ranged from 25% to 60% of the EPA MCL (screening level) of 20,000 pCi/L. Pine Rock Spring on Pueblo de San Ildefonso had a uranium concentration of 32 µg/L (above the NM groundwater standard of 30 µg/L) and related gross alpha of 29 pCi/L. 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). This is because the effluent represents additional water passing through the rock and sanitary effluent dissolves uranium from the bedrock.

Pajarito Canyon intermediate monitoring well R-23i at 534 ft had one gross alpha value of 17 pCi/L in an unfiltered sample; while there is no applicable groundwater standard, for comparison purposes, the MCL is 15 pCi/L. This sample had an extraordinarily high turbidity of 785 NTU (nephelometric turbidity units); the higher than usual gross alpha, gross beta, and uranium values for this sample probably reflect natural radioactivity of aquifer material incorporated in the sample.

There are no applicable groundwater standards for radioactivity from a DOE (LANL) source in perched alluvial groundwater, however, for comparison purposes, results for the following constituents were near or exceeded the 4-mrem DOE DCGs: plutonium-239,240 in Pueblo Canyon; and strontium-90 from alluvial groundwater in Mortandad and DP/Los Alamos Canyons. Again, for comparison purposes in the absence of applicable groundwater standards, the maximum strontium-90 values in alluvial groundwater from Mortandad and DP/Los Alamos Canyon were above the EPA MCL of 8 pCi/L (Figure 5-11).

While there are no applicable groundwater standards, for comparison purposes, total LANL-derived radioactivity exceeded the 4 mrem DOE DCG in alluvial groundwater samples from Pueblo Canyon (plutonium-239,240 and americium-241 in PAO-2 and APCO-1), Los Alamos Canyon (plutonium-239,240, americium-241, and strontium-90 in DP Spring and well LAUZ-1), and Mortandad Canyon (tritium, plutonium-238, plutonium-239,240 americium-241, and strontium-90 in wells MCO-4B and MCO-6) (Figure 5-12). While there are no applicable groundwater standards, for comparison purposes, the highest total radioactivity in 2006 was found in MCO-4B, above the 4 mrem DCG. These high radioactivity values are not directly related to turbidity, which, in these wells is both relatively high and also variable with time. While there are no applicable groundwater standards, for comparison purposes, gross beta values in some samples from alluvial wells in Mortandad and DP/Los Alamos Canyon exceeded the EPA 50 pCi/L drinking water screening level. The gross beta activity in these wells likely is due to presence of strontium-90.

3. Perchlorate in Groundwater

During the last decade, the EPA recognized the potential for perchlorate toxicity at concentrations in the µg/L range. Based on a new toxicity assessment by the National Academy of Sciences, the EPA set a Drinking Water Equivalent Level of 24.5 µg/L for perchlorate in 2006. The March 2005 NMED Order on Consent for LANL mandates a 4 µg/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 µg/L to 1.8 µg/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 much above background as a result of past effluent discharges. Otherwise perchlorate concentrations are near the values found by Plummer et al. (2006).

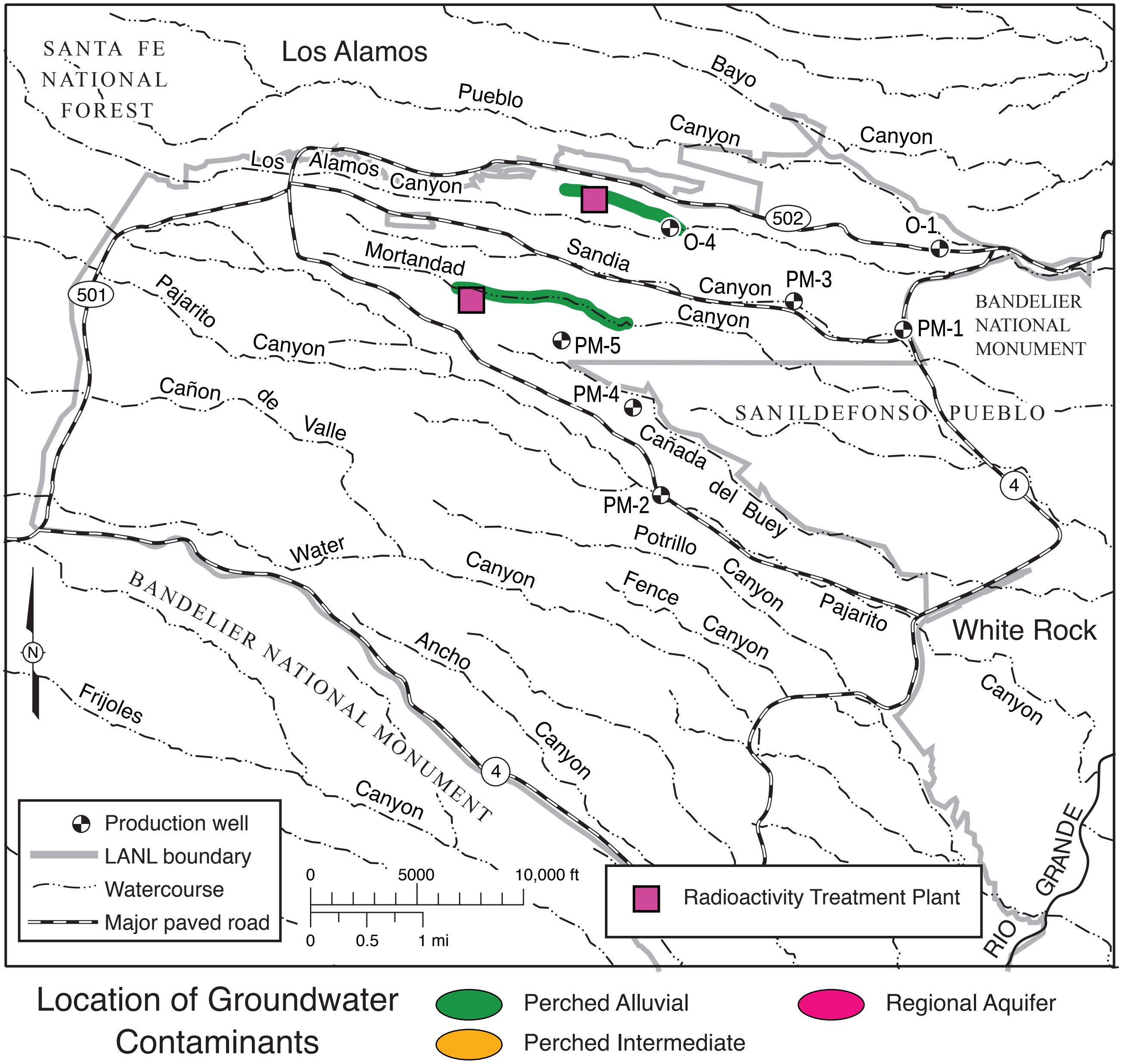


Figure 5-11. Location of groundwater contaminated by Sr-90: while there is no applicable groundwater standard, for comparison purposes, the area indicated has Sr-90 activity above the 8 pCi/L EPA MCL. Different colors indicate the affected groundwater zones. Along canyons, the extent of alluvial groundwater 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.

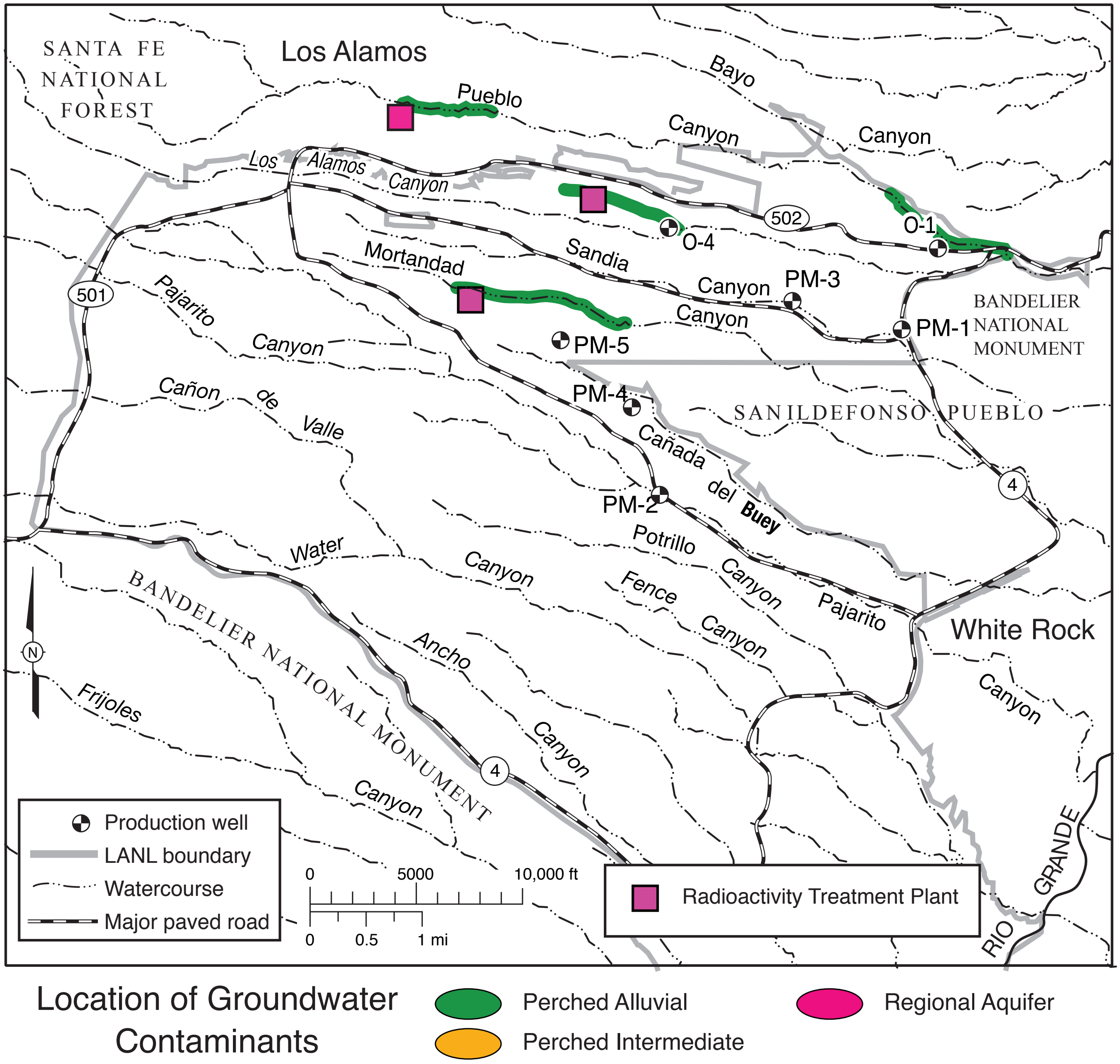


Figure 5-12. **Location of groundwater contaminated by radioactivity: while there is no applicable groundwater standard, for comparison purposes, samples from the area indicated have the sum of Sr-90, Pu-238, Pu-239,240, and Am-241 above the 4-mrem DOE DCG. Different colors indicate the affected groundwater zones.**

4. 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 a Sandia Canyon regional aquifer well 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 over 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 in water samples of residual aquifer or soil material 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. These 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 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.

In 2005, a number of groundwater samples had selenium results that exceed the NM Livestock Watering Standard of 5 µg/L. All but one of these results were analyzed using SW-846:6010B, which has a nominal detection limit of 6 µg/L. In 2006, selenium samples were analyzed with SW-846:6020, which has a detection limit of 2.5 µg/L; selenium was not detected in any groundwater sample in 2006.

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 5-2). The Guaje well field, located northeast of the Laboratory, contains five water supply wells. No tritium was detected in low-detection-limit (1 pCi/L) analysis of samples from these wells (Table S5-3). Groundwater with such 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). Rendija and Barrancas Canyons have seen little past Laboratory activity, have only ephemeral surface water, and have no known alluvial or intermediate groundwater.

Table 5-2
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 MCL

Perchlorate was found in each of the five wells in the Guaje well field at concentrations ranging from 0.31 to 0.41 µg/L, which is consistent with background levels and prior findings. G-1A and G-2A both had arsenic at about 83% of to above the EPA MCL of 10 µg/L. This naturally-occurring arsenic has been found in this well field at such levels during its entire history.

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 5-3).

Table 5-3
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	Plutonium-239,240, arsenic	Nitrate at 50% of NM GW Std., fluoride at 70% of NM GW Std.	Fluoride at 50% of NM GW Std., trace perchlorate and nitrate
Los Alamos and DP Canyons	Multiple past effluent discharges	Strontium-90, fluoride at 65% of NM GW Std.	None	None
Lower Los Alamos Canyon	Multiple past effluent discharges	Nitrate above NM GW Std.	Nitrate above NM GW Std.	None

Pueblo Canyon receives effluent from Los Alamos County's Bayo Sewage Treatment Plant. Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Little radioactivity is found in current groundwater samples. Tritium 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. High nitrate concentrations found in alluvial and intermediate groundwater may be due to sanitary effluent from the 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. Low-detection-limit tritium results for supply well O-1 in 2006 were about 21 pCi/L; values have fallen by a factor of two since the end of 2004. The tritium level indicates the diluted presence of past tritium-bearing surface water recharge in the regional aquifer. Four O-1 samples showed perchlorate at an average of 1.8 µg/L; perchlorate concentrations have also fallen, from an average of 2.7 µg/L in 2004. O-1 had an above-background nitrate as nitrogen concentration of 0.9 mg/L in 2006 (compared to an MCL of 10 mg/L); the nitrate concentration in 2005 was 1.4 mg/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 58 pCi/L. Tritium was not detected in samples from R-2, located between the outfall site and R-4, or farther downstream in R-5.

Regional aquifer nitrate and perchlorate values are also near background at R-2. R-4 and R-5 showed nitrate (as nitrogen) at up to 20% of the 10-mg/L NM groundwater standard. R-4 samples contained fluoride at 50% of the 1.6 mg/L NM groundwater standard (Figure 5-13); fluoride values in samples from this well have been steady since 2005. Perchlorate was at background in R-2, and at the highest concentration for these wells, of 4 μg/L, in R-4. Father downstream, R-5 had a perchlorate concentration of 1.2 μg/L.

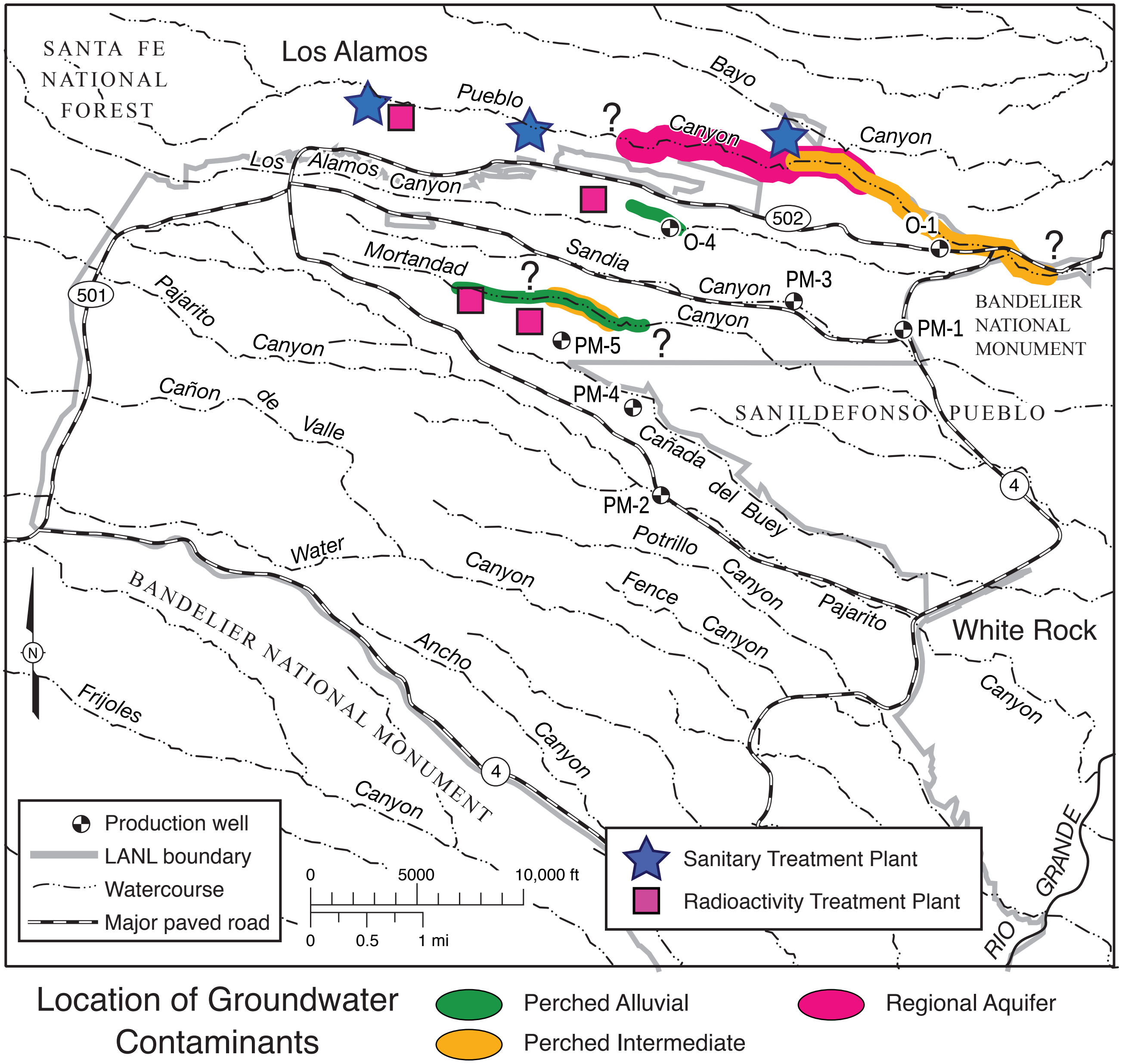


Figure 5-13. **Location of groundwater containing fluoride above one half of the 1.6 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.**

A sample from Pueblo Canyon intermediate well R-3i had a uranium concentration of 7.8 µg/L, above levels in background wells. The higher uranium may result from dissolution of uranium from surrounding bedrock by sanitary or other effluent (Teerlink 2007). Low-detection-limit tritium values in intermediate wells ranged from nondetection in R-5 to 21 pCi/L in POI-4 and 74 pCi/L in R-3i. R-5 showed 1.1 mg/L of fluoride in the intermediate zone at 66% of the NM groundwater standard, which is similar to prior data (Figure 5-13). POI-4 had 5 mg/L of nitrate (as nitrogen) or 50% of the 10 mg/L NM groundwater standard (Figure 5-14). This is the highest nitrate value measured to date in this well; prior values have ranged from 3 mg/L to 4 mg/L; nearby intermediate-depth wells have also shown values in this range. Perchlorate values from the intermediate zone were nondetection or near background values, except for a result of 1.65 µg/L from R-5. A sample from R-3i had diesel range organics just above the detection limit; however, the analytical laboratory found that it had incorrectly determined the MDL for this analyte.

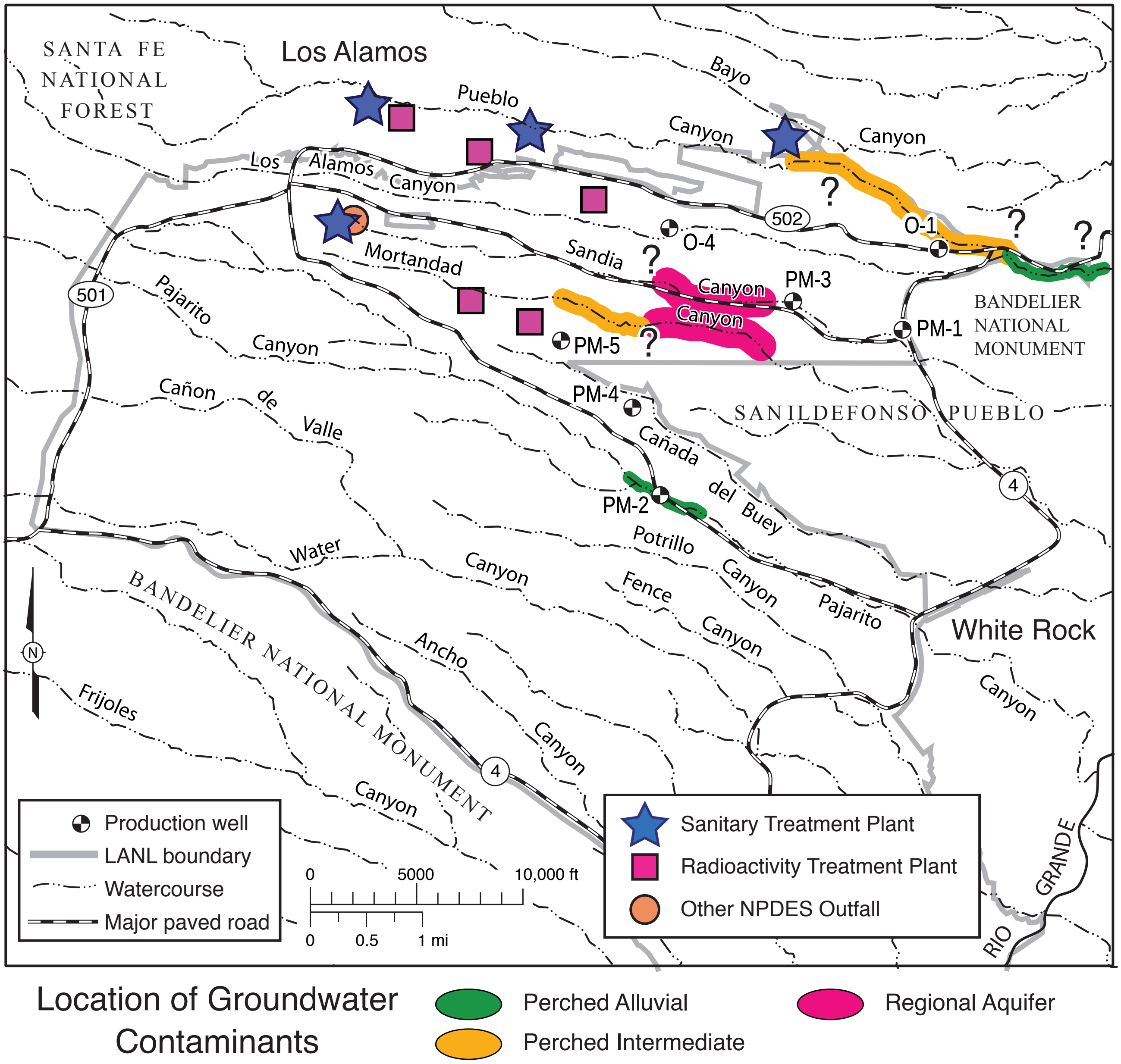


Figure 5-14. Location of groundwater containing nitrate (as nitrogen) above one half of the 10 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones.

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). The sample quality indicates that the wells were impacted by being submerged; apparently surface sediment was forced down along the well casing. This sediment could have carried radioactive and other chemical constituents into the well screens. The filtered and unfiltered aluminum values in APCO-1 are the highest (by a factor of 10) observed in that well to date. The turbidity value for this sampling event was high– 85 NTU, higher than the prior high of 19 NTU and the more usual 5 NTU. Aluminum values in PAO-1, sampled two days later than APCO-1, are also much higher than most prior values (except for those measured in 2005). Turbidity in PAO-1 was 10 NTU, similar to one prior value; therefore, the elevated aluminum in PAO-1 is apparently not related to turbidity in this instance. Alternatively, turbidity may have varied considerably during purging and sampling.

All four sampled alluvial wells in Pueblo Canyon had strontium-90 at values ranging from 6% to 19% of the 8-pCi/L EPA MCL screening level. Three wells had detectable plutonium-239,240 as in prior years. The unfiltered plutonium-239,240 result for APCO-1 (1.5 pCi/L) exceeds the prior highest result by a factor of 10; there is no applicable groundwater standard for this sample, however, for comparison purposes, the 4 mrem DOE DCG is 1.2 pCi/L. Again, for comparison purposes in absence of an applicable groundwater standard, an unfiltered plutonium-239,240 result in PAO-2 (1.17 pCi/L) is just below the 4 mrem DOE DCG (Figure 5-12). The filtered results for plutonium-239,240 in these groundwater samples are much lower (0.0691 pCi/L and 0.271 pCi/L, respectively). The elevated results for unfiltered plutonium-239,240 may also be attributed to elevated turbidity and entry of surface sediment into the well screen, resulting from the August 2006 flooding.

b. Los Alamos Canyon. Low values of tritium were found in a few regional aquifer wells in Los Alamos Canyon, indicating a small contribution from recent recharge. Values in Test Well 3 and R-9 were 15 pCi/L and 11 pCi/L, respectively, while results from other wells were nondetections. The perchlorate concentration in R-9 was 0.98 µg/L, while other regional aquifer and supply wells in Los Alamos Canyon were at background, that is, below 0.6 µg/L. Several of the newer regional aquifer wells had high levels in samples of aluminum, iron, and manganese due to drilling fluid or turbidity effects.

Isopropyl benzene was found for the first time just above the detection limit in R-9. This compound has been found in several other wells and apparently is derived from decomposition of residual drilling materials. Because of a leaking fuel tank found at TA-21 during 2002, supply well O-4 was sampled four times during 2005 for diesel range organics; none were detected.

Samples from intermediate wells LAOI(a)-1.1 and LAOI-7 had detections of americium-241 and plutonium-238, respectively. However, these detections were near the MDA and not repeated in other samples, indicating that the results are false positives. Basalt Spring, which is fed by intermediate groundwater, is in lower Los Alamos Canyon on Pueblo de San Ildefonso land. A filtered sample contained strontium-90 just above the detection limit, as in some prior years. No strontium-90 was detected in the unfiltered sample. The latter result would be expected to be higher, so the filtered result may be a false positive or strontium-90 could be present near the detection limit.

Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained 4,300 pCi/L, 1,000 pCi/L, 3,180 pCi/L and 1,200 pCi/L of tritium, respectively. These moderate values indicate a residual impact of past effluent; the wells lie downstream from the former radioactive liquid waste discharge in DP Canyon. Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 also had 10 µg/L, 3 µg/L, 5 µg/L, and 0.9 µg/L of perchlorate, respectively.

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 (Figure 5-11). Also for comparison purposes in absence of an applicable groundwater standard, the strontium-90 values in DP Spring and well LAUZ-1 were respectively 78% of and above the 4-mrem DOE DCG (Figure 5-12). As in past years, several other LANL-derived radionuclides (plutonium, americium) were found in alluvial groundwater but at values well below the 4-mrem DCG screening levels. Tritium levels in alluvial groundwater in these two canyons have fallen sharply since the cessation of discharges. Tritium was present in 2006 samples at values between 31 pCi/L to 160 pCi/L.

In lower Los Alamos Canyon on Pueblo de San Ildefonso land, an unfiltered sample in LLAO-1b showed plutonium-239,240 well above the detection limit but at 15% of the 4-mrem DCG screening level. This was the first detection of plutonium-239,240 in the well. The sample was collected on August 9 after the first day of flooding that month. As described above, the flooding apparently forced surface sediments carrying radionuclides into the well screens.

Samples from DP Spring and LAO-2 in DP Canyon had fluoride concentrations at up to 65% of the NM groundwater standard (Figure 5-13). The fluoride is likely a residual of past effluent discharges into the canyon. The filtered and unfiltered nitrate (as nitrogen) results from samples at LLAO-1b were respectively 6.1 mg/L and 9.7 mg/L (Figure 5-14). The latter value is the highest measured in the well and is 97% of the NM groundwater standard. The source of nitrate may be releases into Pueblo Canyon from the Los Alamos County sanitary treatment plant. The nitrate (as nitrogen) concentration at nearby Basalt Spring was 91% of the standard.

Metals concentrations in alluvial wells in Los Alamos Canyon showed the effect of turbidity, with relatively high values of aluminum and iron. 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 (Figure 5-15). 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.

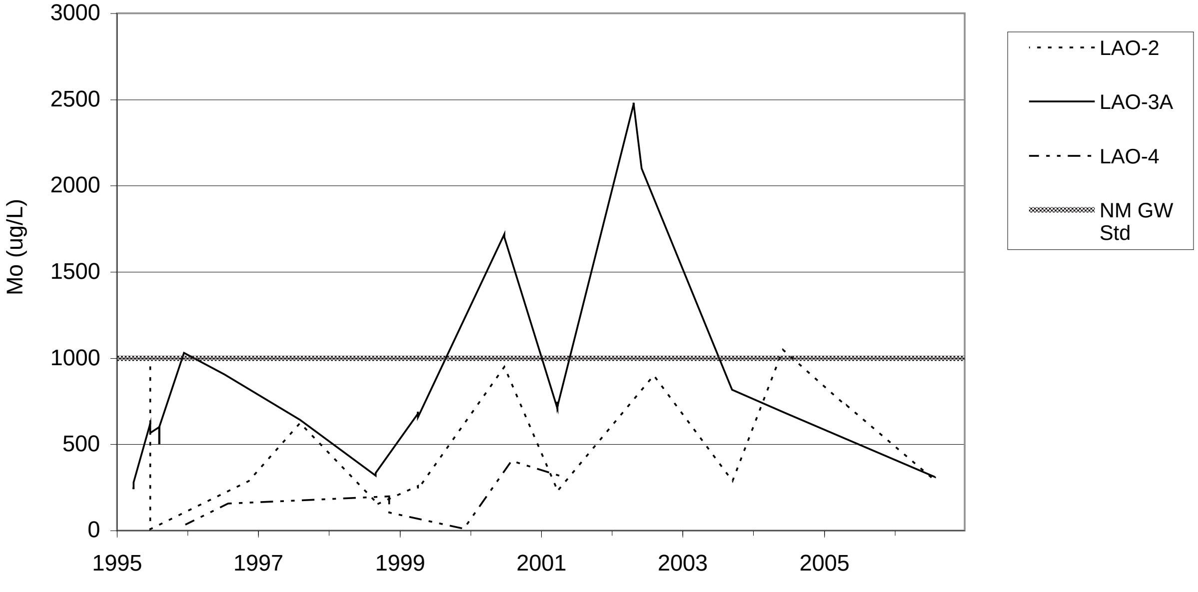


Figure 5-15. **Molybdenum concentration histories in Los Alamos Canyon alluvial groundwater compared with the NM groundwater standard.**

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 5-4). 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 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 5-16). Sandia and Mortandad Canyons lie close together, and water infiltrating beneath Sandia Canyon may have been diverted to the south by southwesterly dipping basalts prior to reaching the regional aquifer (ERSP 2006). In October 2006, chromium concentrations in samples from regional aquifer well R-11 in Sandia Canyon were 29 µg/L or 59% of the groundwater standard; other analyses show the chromium is in the hexavalent form.

Table 5-4
Summary of Groundwater Contamination in Sandia Canyon

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Sandia Canyon	Multiple liquid discharges	Arsenic	None	Hexavalent chromium at 59% of NM GW std., nitrate at 50% of NM GW std.

Samples from supply wells PM-1 and PM-3 showed no tritium using the method with a 1 pCi/L detection limit. Tritium activities in regional wells R-11 and R-12 were 11 pCi/L and 38 pCi/L respectively. Nitrate (as nitrogen) in R-11 was 51% of the NM groundwater standard, apparently due to past Laboratory sanitary effluent releases (Figure 5-14).

In Sandia Canyon, perchlorate values at supply wells PM-1 and PM-3 ranged from 0.40 to 0.45 µg/L, similar to prior results and within background. Perchlorate results were 0.1 µg/L in R-12 and averaged 0.73 µg/L in samples from R-11. The R-11 values are slightly above background. Organic compounds detected in well samples appear to result from inadvertent low-level contamination during analysis or sampling.

Tritium activities in intermediate groundwater samples from two screens at R-12 were 121 pCi/L and 14 pCi/L, decreasing with depth. Perchlorate was not detected in these samples.

Two new alluvial wells (SCA-1 and SCA-5) were sampled in Sandia Canyon. A set of samples from SCA-1 produced a nitrate result of 6 mg/L in one sample (60% of the NM groundwater standard), but nitrate was not detected in the other (Figure 5-14). It appears that a field preservation error caused the higher value.

A PCB, aroclor-1260, was found in the first sample from Sandia Canyon alluvial well SCA-1 at 6% of the NM groundwater standard. PCBs are present in sediment and runoff samples in this canyon. The turbidity in the sample from this 1.5-ft-deep well was 93 NTU.

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 5-5).

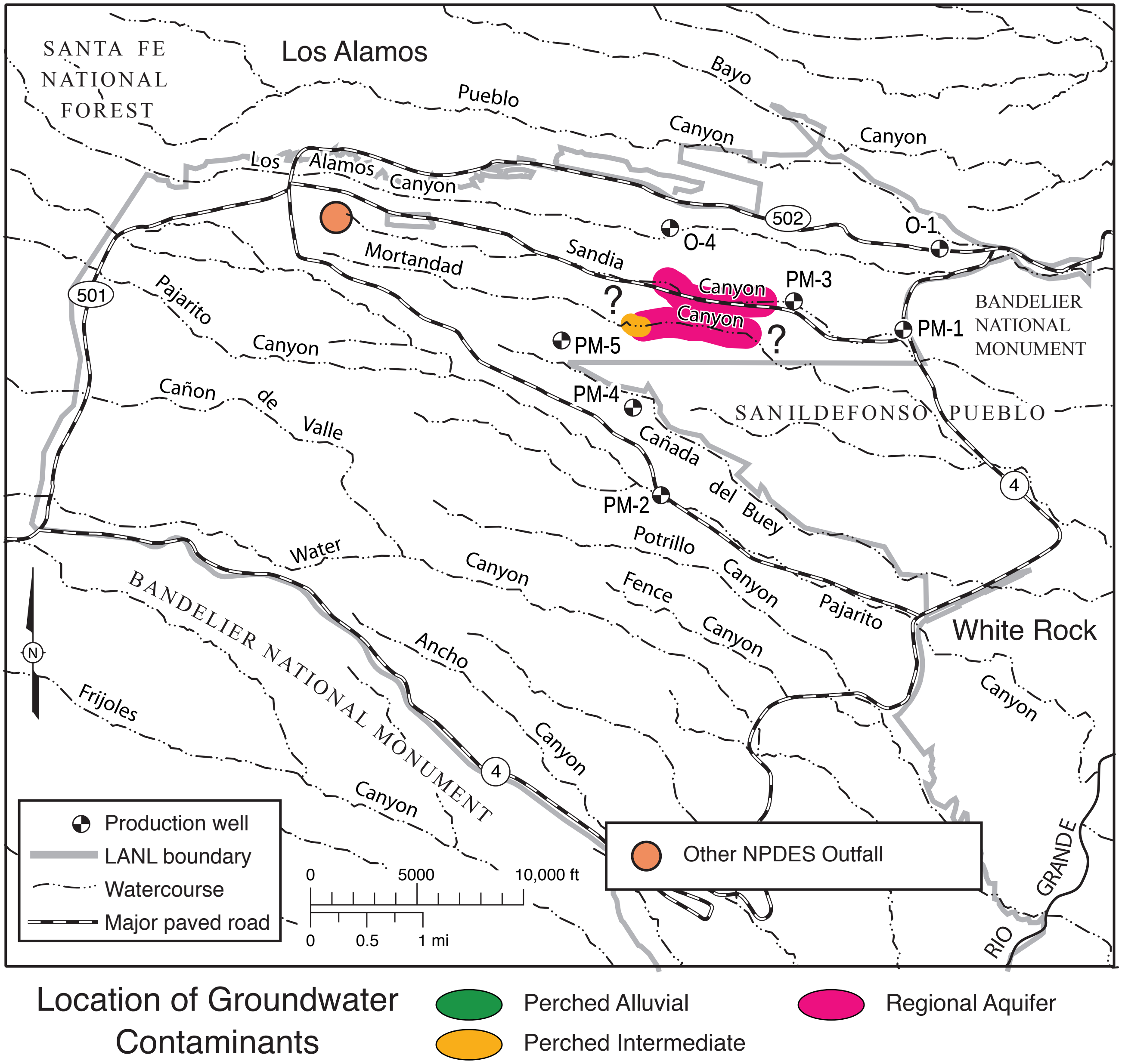


Figure 5-16. **Location of groundwater containing dissolved or hexavalent chromium above one half of the 50 µg/L NM groundwater standard. Different colors indicate the affected groundwater zones.**

Table 5-5
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 and fluoride above NM GW stds., strontium-90, perchlorate	Uranium, hexavalent chromium, nitrate, and fluoride above NM GW stds., tritium, perchlorate, bis(2-ethylhexyl)phthalate, dioxane[1,4-]	Hexavalent chromium above and nitrate at 45% of NM GW stds., trace perchlorate
Cañada del Buey	Major dry, minor liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow perched alluvial groundwater system of limited extent, and only two observation wells have ever contained water. Because treated effluent from the Laboratory's SWWS facility at TA-46 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. 2006 Radioactive Liquid Waste Treatment Facility Discharges. Data on the RLWTF's yearly radionuclide discharge into Mortandad Canyon from 2004 through 2006 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 5-17 and 5-18 show the relationship of RLWTF average annual radionuclide activities and selected general inorganic concentrations (fluoride, nitrate, perchlorate) in discharges to DOE DCGs or NM groundwater standards since 1996. The 2006 discharges from the RLWTF met all DOE, EPA, and NM requirements. Beginning in 1999, LANL made significant upgrades to the RLWTF treatment system. As a result, for the last seven 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 total dissolved solids (TDS). Two weekly composite samples exceeded the fluoride standard in 2003.

During 2006, the nitrate + nitrite (as nitrogen) concentrations of all 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 5-19). The average 2006 effluent total nitrate + nitrite (as nitrogen) concentration was 1.62 mg/L. In 2006, the highest nitrate concentration in a Mortandad Canyon base flow grab sample taken below the outfall in Effluent Canyon was 3.5 mg/L.

The fluoride concentration in the discharge has also declined over the last few years (Figure 5-20). The 2006 effluent fluoride concentration (average value of 0.08 mg/L) was below the NM groundwater standard of 1.6 mg/L. In 2006, the fluoride concentration in Mortandad Canyon at the surface water station Mortandad below Effluent Canyon was 0.38 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 (Figure 5-21). For 2006, no perchlorate was detected in effluent samples.

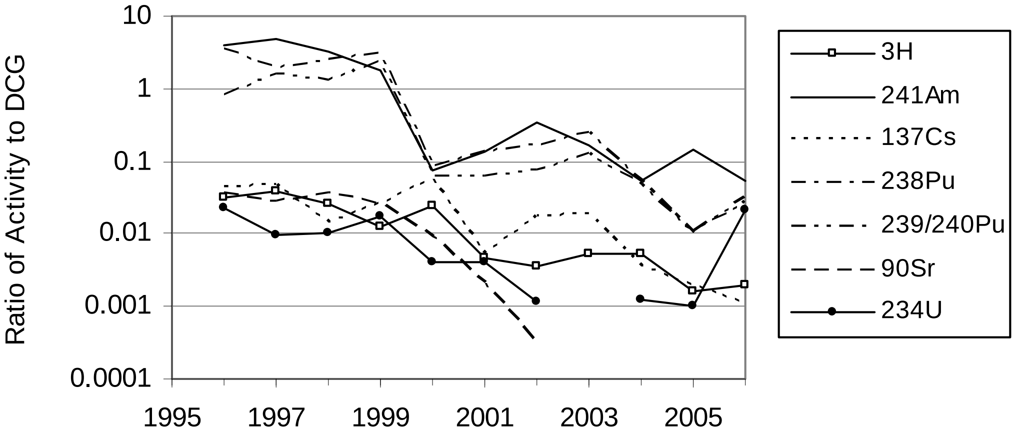


Figure 5-17. Ratio of 1996–2006 average annual radionuclide activity in RLWTF discharges to the 100-mrem public dose DOE DCGs.

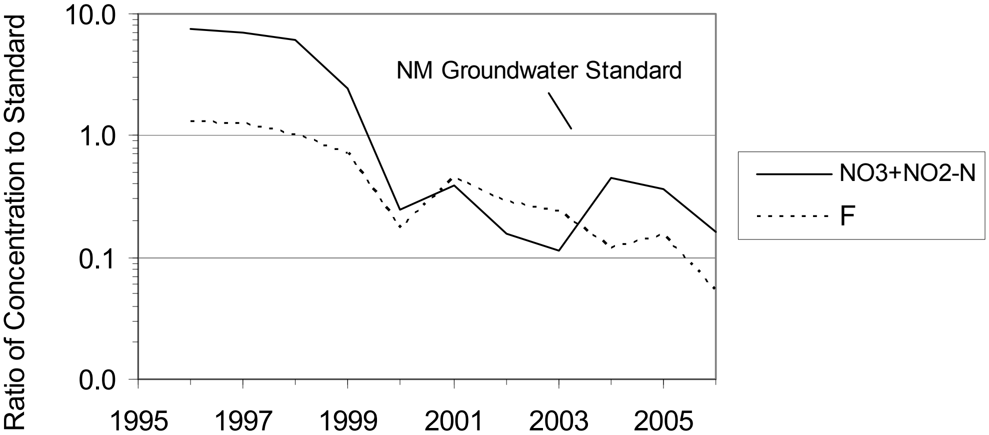


Figure 5-18. Ratio of 1996–2006 average annual mineral concentration in RLWTF discharges to the NM groundwater standards.

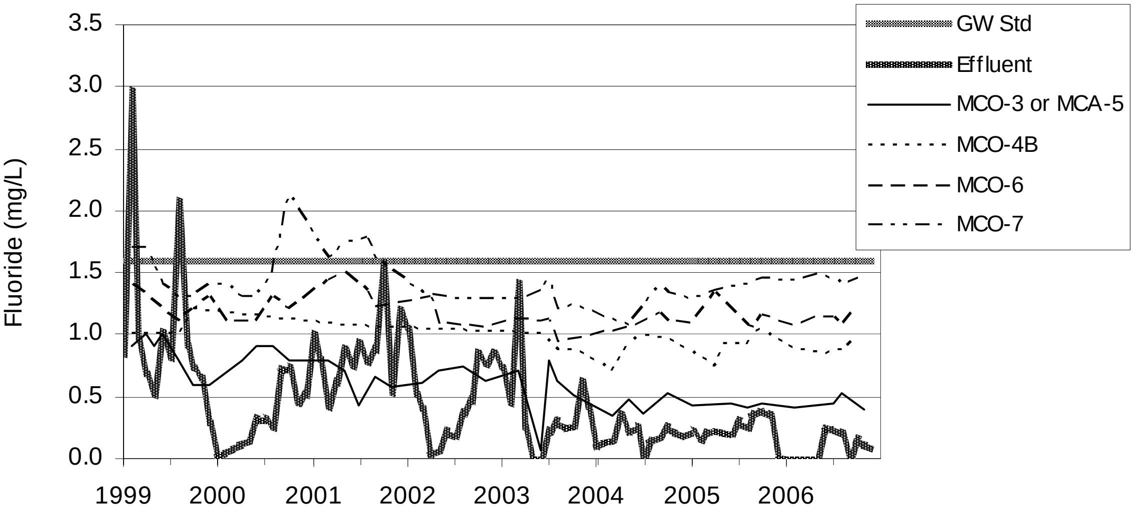


Figure 5-19. Nitrate in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2006, compared to the NM groundwater standard.

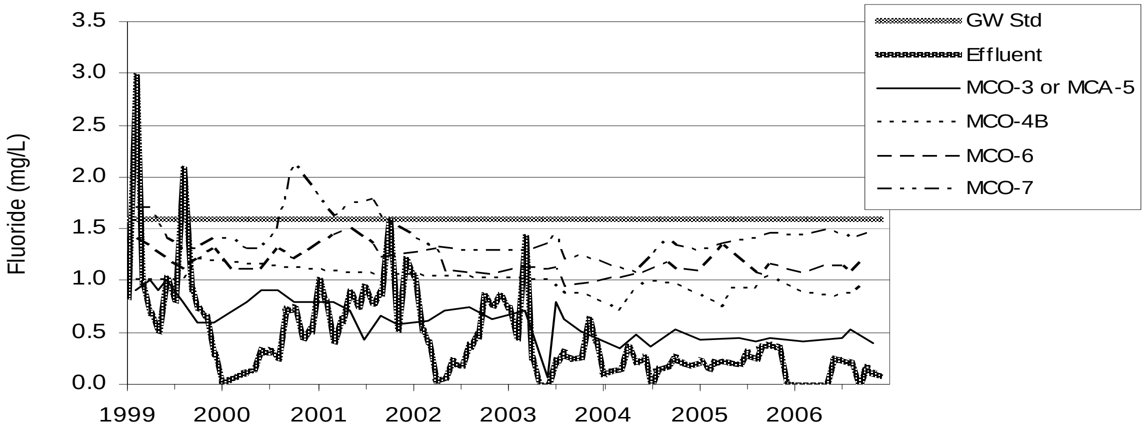


Figure 5-20. **Fluoride in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2006, compared to the NM groundwater standard.**

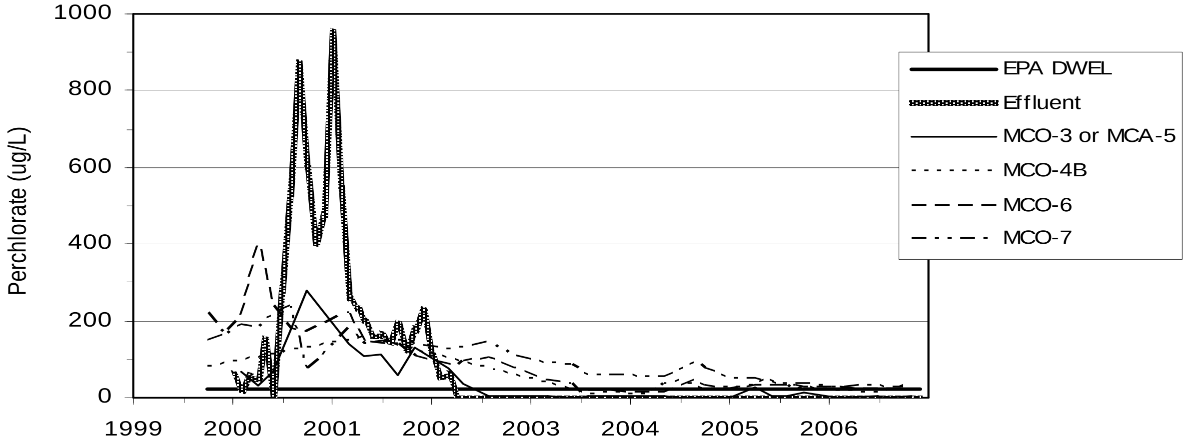


Figure 5-21. **Perchlorate in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2006; there is no applicable groundwater standard so for comparison purposes results are shown relative to EPA's Drinking Water Equivalent Level of 24.5 µg/L.**

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer. The regional aquifer beneath Mortandad Canyon shows impact from past LANL discharges; intermediate groundwater shows a generally larger effect. In 2006, 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 (Figure 5-16). 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). MCOI-6, an intermediate groundwater well in Mortandad Canyon, consistently showed filtered chromium just below the NM groundwater standard.

Between 2000 and 2005, R-15 tritium showed an increase from 2 pCi/L to 29.6 pCi/L (Figure 5-22). Since May 2005 the tritium activity of well samples has been relatively stable at about 29.7 pCi/L. The recent higher values indicate some contribution of recent recharge to the regional aquifer at R-15. However, these values are below the EPA MCL screening level of 20,000 pCi/L. A corresponding increase occurred for perchlorate (from less than 5 µg/L to 7 µg/L) but not nitrate (Figure 5-23). As with tritium, perchlorate concentrations have been fairly stable since June 2004, at about 6.4 µg/L. The earlier perchlorate data have a MDL of 4 µg/L giving lower precision for that period.

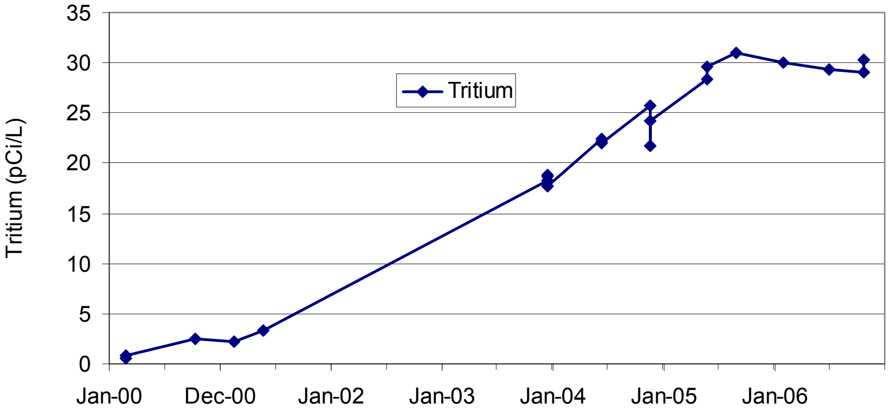


Figure 5-22. **Tritium history in Mortandad Canyon regional aquifer well R-15.**

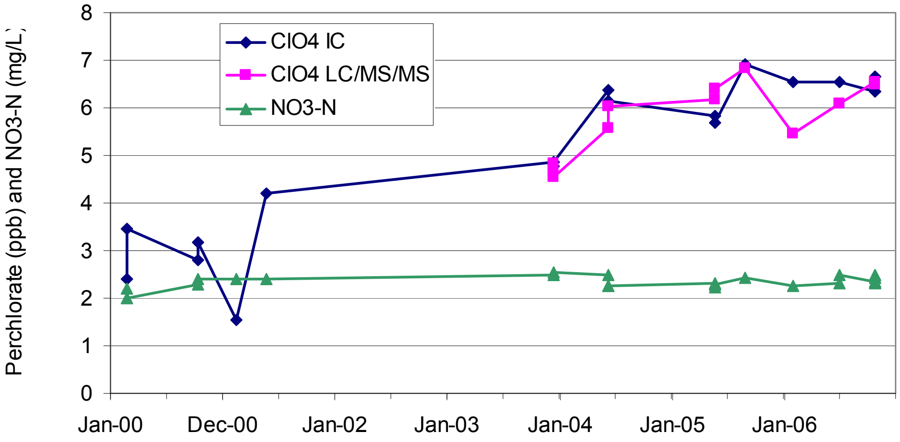


Figure 5-23. **Perchlorate and nitrate histories in Mortandad Canyon regional aquifer well R-15.**

R-28 has tritium values averaging 184 pCi/L and perchlorate concentrations in the range of 1 µg/L; these results along with the chromium levels indicate impact of LANL effluents. Nitrate (as nitrogen) concentrations in samples from R-28 were 45% of the NM groundwater standard of 10 mg/L in 2006 (Figure 5-14). Test Well 8 had tritium values of 3.0 pCi/L and 15.7 pCi/L and perchlorate concentrations averaging 0.26 µg/L. No other regional aquifer well in Mortandad Canyon had repeatable low-detection limit tritium detections, and other perchlorate values were below 0.5 µg/L. Filtered and total chromium results in R-28 have been above 400 µg/L and have been confirmed as hexavalent chromium by separate analysis.

Contaminants found in Mortandad Canyon intermediate groundwater indicate an impact by LANL effluents, with some compounds near or exceeding regulatory standards. Three wells in Mortandad Canyon (MCOI-4, MCOI-5, and MCOI-6) had tritium activities that ranged from 25% to 60% of the EPA MCL screening level of 20,000 pCi/L (Figure 5-24). Tritium has a short half life of about 12.4 years, so these values will decline rapidly because the tritium activity in effluent has decreased. Pine Rock Spring on Pueblo de San Ildefonso had a uranium concentration of 32 µg/L (above the NM groundwater standard of 30 µg/L) and related gross alpha of 29 pCi/L. These 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). The tritium activity in this spring was 30 pCi/L.

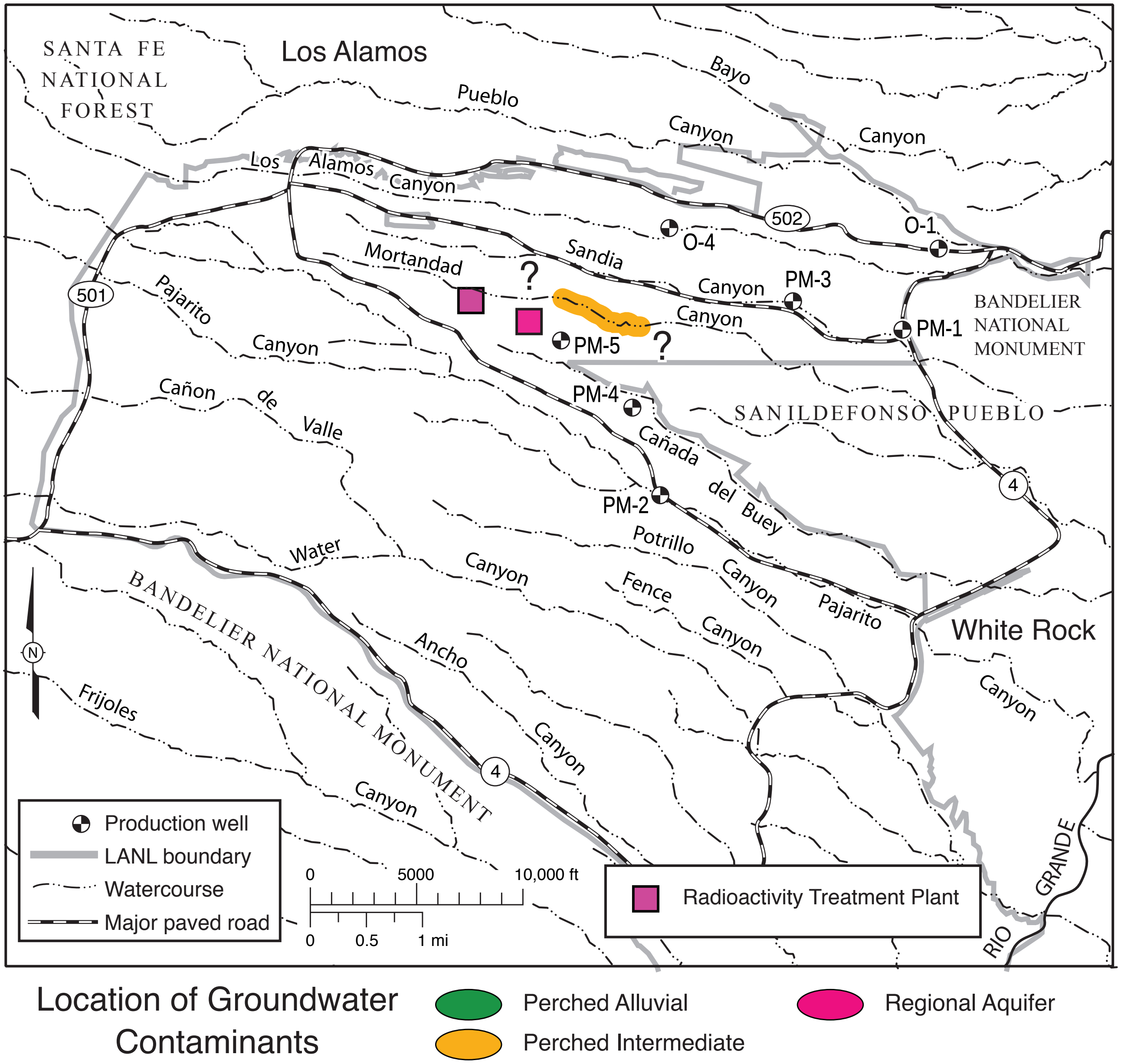


Figure 5-24. **Location of groundwater contaminated by tritium: while there is no applicable groundwater standard, for comparison purposes, the area indicated has tritium activity above one-half of the 20,000 pCi/L EPA MCL. Different colors indicate the affected groundwater zones.**

Nitrate (as nitrogen) concentrations in two of the intermediate wells (MCOI-4 and MCOI-6) ranged from 14 mg/L to 20 mg/L, above the NM groundwater standard of 10 mg/L (Figure 5-14). The nitrate (as nitrogen) concentration in MCOI-5 was 5.5 mg/L. Perchlorate was not detected in the well farthest upstream (MCOI-8) but in three other wells ranged from 110 µg/L to 190 µg/L (Figure 5-25); while there is no applicable groundwater standard, for comparison purposes, the EPA's Drinking Water Equivalent Level is 24.5 µg/L. The fluoride concentration in MCOI-8, however, was above the 1.6 mg/L NM groundwater standard (Figure 5-13). At Pine Rock Spring, the fluoride, nitrate (as nitrogen), and total dissolved solids were respectively 56%, 90%, and 58% of the NM groundwater standards.

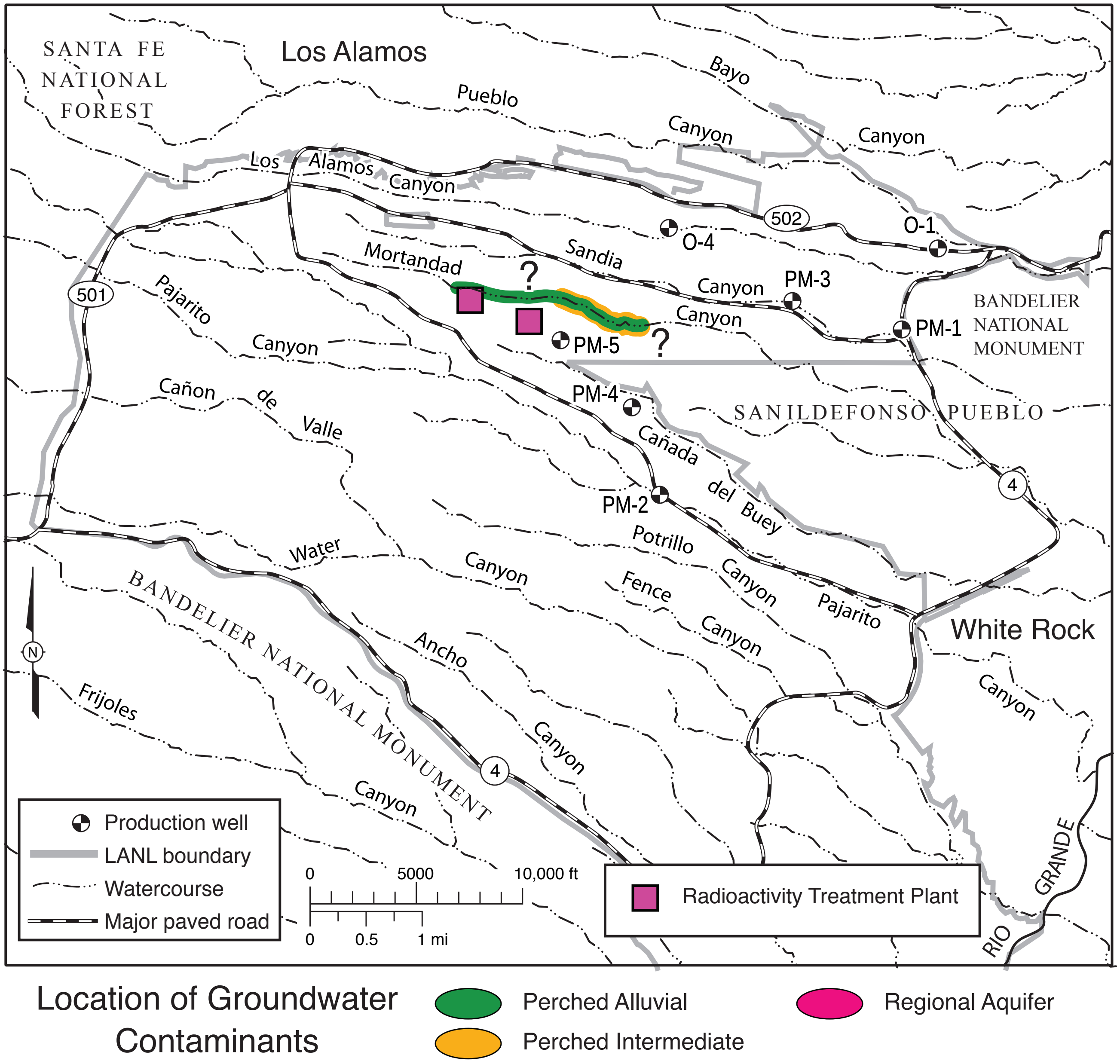


Figure 5-25. **Location of groundwater contaminated by perchlorate; there is no applicable groundwater standard, but for comparison purposes, the concentrations in the areas indicated are above the 24.5 µg/L EPA Drinking Water Equivalent Level. Different colors indicate the affected groundwater zones.**

Chromium was detected in three of the newest intermediate-depth wells: MCOI-8, MCOI-5, and MCOI-6. In MCOI-8 and MCOI-5 the filtered values are much lower than the unfiltered values, leading to the conclusion that the chromium comes from aquifer or well materials, rather than the groundwater. Elevated total nickel concentrations in MCOI-5 and MCOI-8 support a conclusion that metal corrosion or aquifer material are the chromium source in this well. Because these wells have little water, they must be sampled with a bailer, which produces very turbid samples (turbidities of 31 NTU for MCOI-8 and 1 NTU to 17 NTU for MCOI-5). On the other hand, MCOI-6 has sufficient water to allow use of a pump and produces lower turbidity samples (1.3 NTU to 4.9 NTU). Both filtered and unfiltered chromium values in MCOI-6 are near or slightly above

50 µg/L (the NM groundwater standard). Analysis in 2006 confirms that this chromium is predominantly in the form of hexavalent chromium. MCOI-5 also had filtered nickel at 28% of the NM groundwater standard (for irrigation use) of 200 µg/L.

In 2005 the organic compound dioxane[1,4-] was detected in two intermediate wells in Mortandad Canyon. 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 µg/L. All 2005 detected analytical results were below or slightly above the practical quantitation limit (PQL) of 50 µg/L (the MDL is 20 µg/L) for the volatile organic method SW-846:8260B. In 2006, samples were analyzed using a more sensitive semivolatile organic method SW-846:8270C which has a practical quantitation limit (PQL) of 10 µg/L (the MDL is 1 µg/L). In 2006, dioxane was detected in MCOI-4, MCOI-5, and MCOI-6 at concentrations of 28 µg/L, 9 µg/L, and 24 µg/L, respectively. The highest result, in MCOI-4, was 45% of the EPA Region 6 tap water screening level.

Bis(2-ethylhexyl)phthalate was detected in duplicate samples taken in June and October from MCOI-6; there is no applicable groundwater standard for this compound, but for comparison purposes the concentrations were above the 6 µg/L EPA MCL. The source of this compound at this well is not known. Bis(2-ethylhexyl)phthalate is a plasticizer and common field or analytical laboratory contaminant. However, the compound has been found in four of five samples from MCOI-6 at concentrations ranging from 2 µg /L to 12 µg/L. This compound was also found in a June sample from MCOI-4 at 16 µg/L.

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 have not exceeded the 100-mrem DOE DCGs for public dose (applicable to effluent discharges). The levels of strontium-90 (which is not as strongly adsorbed) and gross beta in these wells are high; these constituents have no applicable groundwater standard, but for comparison purposes, usually exceed their respective EPA MCL or screening level in many of the wells. In past years, the levels of strontium-90, plutonium-238, plutonium-239,240, and americium-241 in alluvial groundwater exceeded the 4-mrem DOE DCG screening levels; also given for comparison purposes as there are no applicable groundwater standards for these radionuclides.

There are no applicable groundwater standards for most radioactivity in alluvial groundwater, however, for comparison purposes, in 2006, total LANL-derived radioactivity exceeded the 4 mrem DOE DCG in Mortandad Canyon alluvial groundwater samples from wells MCO-4B and MCO-6 (Figure 5-12). For comparison purposes in absence of an applicable groundwater standard, for radioactivity from a DOE source, results for the strontium-90 were near or exceeded the 4-mrem DOE DCG in MCO-4B. Again for comparison purposes in absence of an applicable groundwater standard, the levels of strontium-90 also exceeded the EPA MCL (Figure 5-11). 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 5-19 and 5-20, 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 total dissolved solids during 2006 from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCA-5 (or MCO-3), MCO-4B, MCO-6, and MCO-7. Nitrate (as nitrogen) concentrations in these wells were below the NM groundwater standard of 10 mg/L (Figure 5-19), and fluoride concentrations were below the NM groundwater standard of 1.6 mg/L (Figure 5-20). MCO-3 had a maximum nitrate (as nitrogen) at about 39% of the NM groundwater standard. All of the alluvial groundwater samples taken below the RLWTF outfall had fluoride concentrations above 60% of the NM groundwater standard, with some above the standard (Figure 5-13). Two downstream wells (MT-3 and MCO-7.5) had fluoride values exceeding the standard, a result of past effluent discharge.

Chloride and TDS concentrations in MCO-0.6 were above the NM groundwater standards (which are intended for domestic water supply). This alluvial well is located upstream from the RLWTF outfall, rarely has water, can seldom be sampled, and represents a small saturated thickness. TDS was also 84% of the NM groundwater standard (intended for domestic water supply) at MCO-2 in Effluent Canyon. This well is also shallow with little saturated thickness.

RLWTF outfall had high perchlorate concentrations (Figures 5-21 and 5-25). There is no applicable groundwater standard for high perchlorate, but for comparison purposes, the 2006 concentrations at some wells were above the EPA's Drinking Water Equivalent Level of 24.5 µg/L. Alluvial groundwater concentrations of perchlorate have dropped, especially near the outfall, following the removal of perchlorate from RLWTF effluent in March 2002. Nonetheless, the perchlorate concentrations generally increase downstream, with maximum 2006 concentrations at various wells of 3.8 µg/L at MCO-3 (nearest the outfall), 30.6 µg/L at MCO-4B, 27 µg/L at MCO-6, and 32 µg/L at MCO-7. This shows that effluent quality improvement has had the largest effect on groundwater quality near the outfall, and affects groundwater quality farther downstream more slowly.

The July barium results in MCO-0.6 are 70% of the NM groundwater standard and are twice the highest prior value (though data are sparse). In October sampling, the filtered cobalt result was 25.4 µg/L (which was 51% of the NM groundwater standard intended for irrigation use). This was nearly twice the previous high, out of three total samples. This well is shallow with little (and stagnant) water and samples have high turbidity.

d. Long-Term Radioactivity Trends. Figures 5-26 through 5-30 depict long-term trends of radionuclide concentrations in surface water and shallow perched alluvial groundwater in Mortandad Canyon downstream from the RLWTF outfall at TA-50. The surface water samples are from the monitoring station "Mortandad below Effluent Canyon", a short distance downstream from the outfall. Radioactivity levels at this station vary daily depending how soon individual samples are collected after a release from the RLWTF and on the composition of a release. These samples also vary in response to changing amounts of runoff from other sources in the drainage.

The alluvial groundwater samples shown in figures 5-26 through 5-30 are from observation well MCO-6 in the middle reach of the canyon. Groundwater radioactivity at MCO-6 is more stable than surface water sampled at station Mortandad below Effluent Canyon because it is farther from the outfall and because groundwater responds more slowly to variations in runoff water quality. Because of its strong adsorption to sediments, cesium-137 is not usually detected in groundwater samples, though it was detected in 2005 at alluvial well MCA-5, nearest the outfall.

Chemical reactions such as adsorption do not delay tritium transport, so tritium activity is relatively uniform throughout the alluvial groundwater. Average annual tritium activity in the RLWTF effluent dropped below the EPA MCL screening level (20,000 pCi/L) in 2001, and tritium activity has dropped in surface water and alluvial groundwater since then. Tritium activities in Mortandad Canyon alluvial groundwater have been below the MCL screening level since 2001 (Figure 5-26).

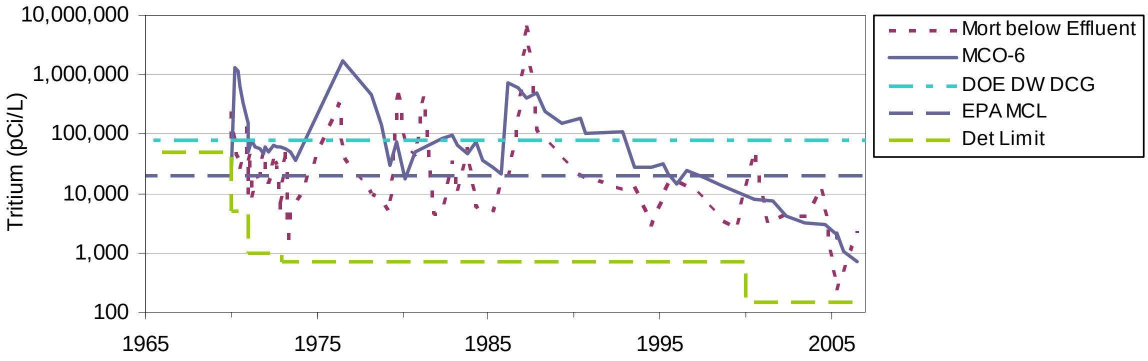


Figure 5-26. Tritium activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for tritium so the DOE DCG and EPA MCL are shown for comparison purposes.

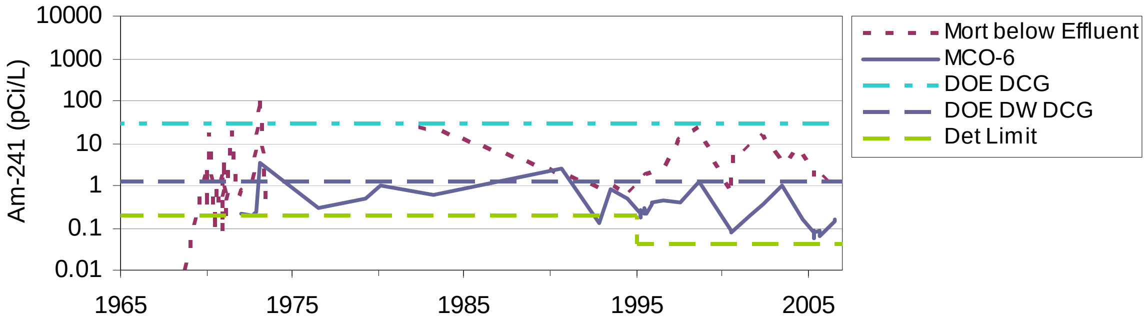


Figure 5-27. Americium-241 activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for americium-241 so the DOE DCG is shown for comparison purposes.

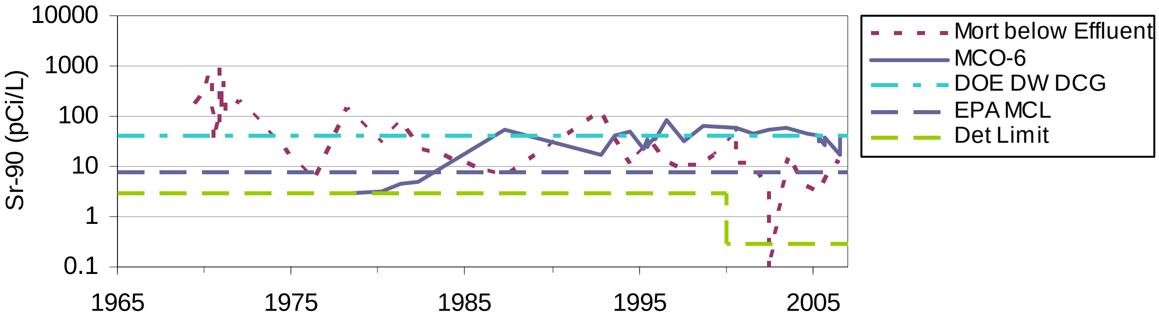


Figure 5-28. Strontium-90 activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for strontium-90 so the DOE DCG and EPA MCL are shown for comparison purposes.

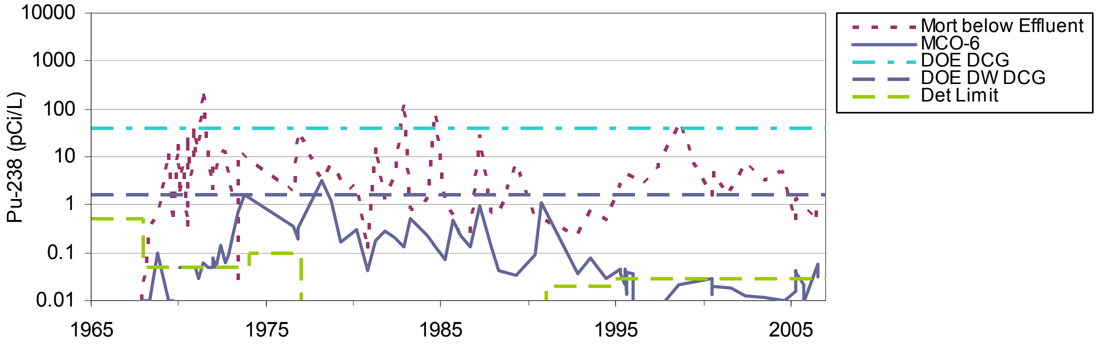


Figure 5-29. **Plutonium-238 activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for plutonium-238 so the DOE DCG is shown for comparison purposes.**

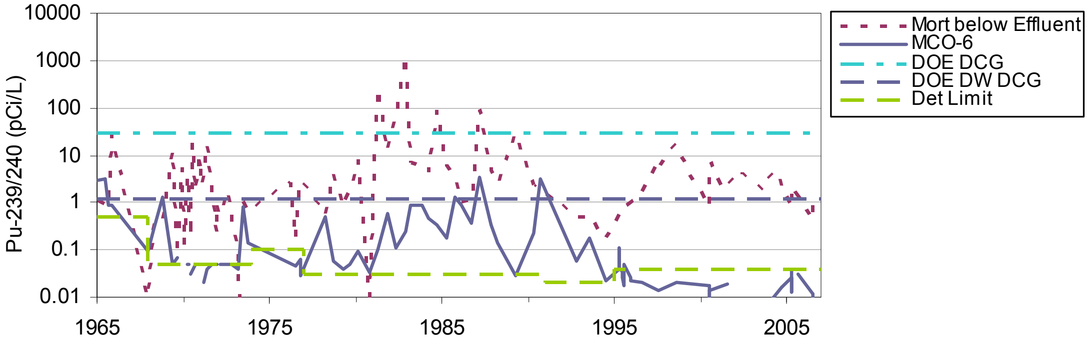


Figure 5-30. **Plutonium-239,240 activity history at Mortandad Canyon surface water station Mortandad below Effluent Canyon and alluvial groundwater well MCO-6; there is no applicable groundwater standard for plutonium-239,240 so the DOE DCG is shown for comparison purposes.**

Before 1990, americium-241 activity was not measured regularly at monitoring stations in Mortandad Canyon. For most years prior to 1999, the americium-241 activity of RLWTF discharges exceeded the 100-mrem DOE DCG for public dose of 30 pCi/L (Figure 5-27). There are no applicable groundwater or surface water standards for americium-241; for comparison purposes, over the last few years, americium-241 in surface water nearest the outfall has been just below the 100-mrem DOE DCG, whereas in the groundwater nearest the outfall it is closer to the 4-mrem DCG screening level. Americium-241 in alluvial groundwater downstream at MCO-6 has been below the 4-mrem DOE DCG screening level since the early 1970s. This is true for alluvial wells closer to the outfall than MCO-6 only since the early 1990s.

In 2006, strontium-90 was detected in surface water at Mortandad below Effluent Canyon and in all alluvial groundwater observation wells down to MCO-7 (Figure 5-28). There are no applicable groundwater or surface water standards for strontium-90; for comparison purposes, the strontium-90 activities in the upstream wells remain at values in the range of the 4-mrem DOE DCG screening level (40 pCi/L) and the EPA MCL screening level (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 wells MCO-5 and MCO-6 during the last 20 years, suggesting that the mass of the radionuclide is moving slowly downstream.

Both plutonium isotopes were detected in surface water at Mortandad below Effluent Canyon and at some alluvial wells in 2006 (Figures 5-29 and 5-30). There are no applicable groundwater or surface water standards for plutonium isotopes; however, for comparison purposes, both isotopes have been historically detected at Mortandad below Effluent Canyon and at MCO-3 (now MCA-5) at levels near the 100-mrem DOE public dose DCGs (30 pCi/L for plutonium-239,240 and 40 pCi/L for plutonium-238), but the levels have decreased during the past few years. Values at other alluvial observation wells, except for MCO-4 and MCO-7.5, were near the detection limit in the 1990s. Plutonium has, in general, been detected in all alluvial observation wells in Mortandad Canyon but appears to be decreasing in activity at downstream locations.

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. No tritium was detected in samples from these two wells. Analyses for perchlorate in samples from PM-4 and PM-5 had an average concentration of 0.34 µg/L, similar to earlier results. No HE compounds were detected in samples from these wells.

Alluvial well CDBO-6 in Cañada del Buey was sampled twice in 2006 with no constituents 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 that 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 5-6). 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, 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.

Table 5-6
Summary of Groundwater Contamination in Pajarito Canyon
(Includes Twomile and Threemile Canyons)

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Pajarito, Twomile, and Threemile Canyons	Major dry sources, past major but minor present liquid sources	Chloride above and nitrate at 50% of NM GW stds.	Dichloroethene[1,1-] and trichloroethane[1,1,1-] above NM GW stds., RDX above EPA excess cancer risk level, trichloroethene, dichloroethane[1,1-], dioxane[1,4-]	Trace RDX

In 2006, tritium was not detected by the low-detection-limit method (MDA about 1 pCi/L) in the one sample from supply well PM-2. Four perchlorate analyses had an average concentration of 0.30 µg/L, similar to prior data.

In regional aquifer well R-18, strontium-90 was found in a filtered sample but not in the paired unfiltered sample or in the filtered or unfiltered field duplicate. As well, there are no strontium-90 detects in prior samples. The lack of consistency for this apparent detection between paired samples and prior samples indicates that this result is an analytical artifact.

Regional aquifer well R-22 lies just east of MDA G, the low-level radioactive waste management facility. In 2006, R-22 showed tritium at 2–3 pCi/L in the uppermost of five regional aquifer ports. This result is consistent with previous sampling observations. Tritium was also found at 9 pCi/L in the deepest port, consistent with earlier results. Over the past year, R-18 tritium values have jumped around from nondetect to 7 pCi/L; results for the last three samples have been mainly nondetect. In R-23, perchlorate was found at 0.47 µg/L, which is near background. Otherwise, in regional aquifer samples from Pajarito Canyon, tritium was not detected or was at about 1 pCi/L, and perchlorate was at background values.

RDX was detected at Pajarito Canyon regional well R-18 near the detection limit and at 2% 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). RDX was detected in samples taken in August and December 2006, but not in two samples taken in 2005. The compound 2,6-Diamino-4-nitrotoluene (a breakdown product of RDX) was also detected in the December sample from R-18, but it was not found in August 2006, the only other time it was analyzed.

One-time organic compound detections occurred in several wells in this watershed. Total xylenes were found in a number of groundwater samples collected around the Laboratory in 2006, particularly during two periods of late August and October. Of the 13 detections, one was rejected in validation and six occurred in equipment, field, or trip blanks. In October, two samples from R-17 found total xylene near the detection limit. During this period, xylene[1,3-]+xylene[1,4-] was found in equipment and trip blanks and samples at R-23i, samples from two depths at R-17, a sample at R-1 (Mortandad Canyon), and a field blank at R-20.

One R-22 sample contained two pesticides, also near the detection limit. For a set of samples collected during late August, three locations (18-BG-1, 18-MW-11, and R-22 at 1,273 ft in the regional aquifer) had samples that contained one or more of the pesticides DDD[4,4’-], DDE[4,4’-], and DDT[4,4’-]. None of the locations have prior detections of pesticides, and the results are likely due to analytical laboratory contamination.

Seven springs were sampled in the Upper Pajarito Canyon drainage. The springs are fed by intermediate-depth groundwater from within adjacent mesas. PC Spring lies west of LANL in the Sierra de los Valles, so likely reflects background conditions. These intermediate springs mainly issue along canyon sides above adjacent streams. Plutonium-239,240 was detected in two of five samples from Homestead Spring in Pajarito Canyon—a field blank and unfiltered field duplicate—but was not detected in the filtered field duplicate and the other unfiltered and filtered samples. Thus, the results appear to be false positives.

Tritium and strontium-90 were found at low levels in two shallow intermediate wells (03-B-10 and 03-B-13) that monitor SWMU 03-010a behind a former warehouse at TA-3. Several intermediate springs in Upper Pajarito Canyon and intermediate well R-23i in Lower Pajarito Canyon had low-detection-limit tritium activities in the range of 30 pCi/L to 90 pCi/L.

August samples from 03-B-10 and 03-B-13 had TDS results of about 550 mg/L, about 60% of the groundwater standard (intended for domestic water supply). The TDS results from samples for these wells during the remainder of the year were about half these values.

Most of the intermediate wells and springs in Pajarito Canyon had perchlorate concentrations below 0.55 µg/L. The highest values of 0.8 µg/L were found at Bulldog Spring. Filtered iron in samples from six of the springs ranged from 60% of to above the NM groundwater standard (for domestic water supply) of 1,000 µg/L. The iron may be present in colloidal form that passes through the filter.

Samples from several of the intermediate groundwater springs in Upper Pajarito Canyon contained RDX, HMX, and other HE compounds as in prior years. As in earlier samples, RDX was detected at Bulldog Spring at 75% of the EPA 10^{-5} excess cancer risk tap water screening level (Figure 5-31).

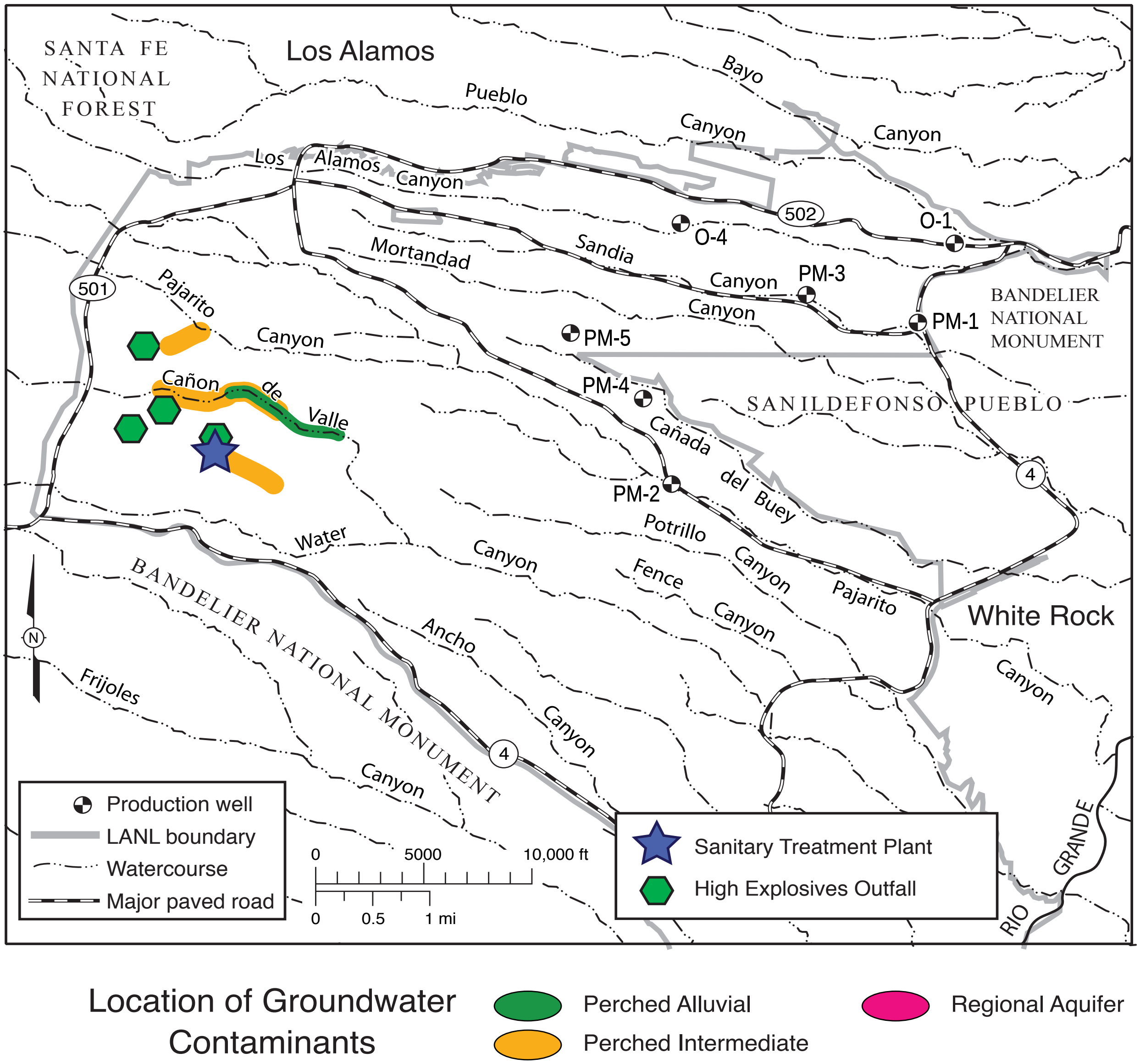


Figure 5-31. **Location of groundwater containing RDX above one half of the EPA Region 6 10^{-5} excess cancer risk tap water screening level of 6.1 µg/L. Different colors indicate the affected groundwater zones.**

Samples in 2006 from SWMU 03-010a intermediate groundwater wells 03-B-10 and 03-B-13 contained several organic compounds including four chlorinated solvents. Several compounds were at concentrations exceeding NM groundwater standards. This SWMU is under investigation according to a plan approved by NMED and these compounds are some of the contaminants of concern identified in the investigation. In 2006, samples were analyzed for the first time for dioxane[1,4-] and it was found at up to 142 µg/L, above the EPA 10^{-5} excess cancer tap water screening level. Other compounds found in the wells were chloroform, trichloroethene, dichloroethane[1,1-], dichloroethene[1,1-], and trichloroethane[1,1,1-]. The concentrations of the latter two of these compounds were above NM groundwater standards in some of the samples.

Strontium-90 was detected in PCO-3 (0.65 pCi/L or 8% of the MCL screening level). Strontium-90 has been detected in this well at such values three times since 2001. However, strontium-90 has not been detected in all samples taken, even at a given sampling event and this inconsistency casts some doubt on the presence of strontium-90 in the groundwater. Alluvial well samples in lower Pajarito Canyon also contained 60 pCi/L to 80 pCi/L of tritium.

August samples showed nitrate (as nitrogen) at 60% of the NM groundwater standard in alluvial well 18-MW-9 (Figure 5-14). Prior data are not available for this location. In December samples, the nitrate level was 20% of the standard.

Chloride and TDS values from alluvial well PCO-3 in lower Pajarito Canyon are, respectively, just above or just below the NM groundwater standard (intended for domestic water supply). The values in this well have fluctuated widely, with current results in the middle of the range. The well has little water and has not been sampled often. Alluvial groundwater perchlorate concentrations had a maximum value of 0.57 µg/L at 18-MW-9.

As described in the previous section, pesticides were detected in samples from 18-BG-1 and 18-MW-11. None of the locations where pesticides were found during the August sampling event have prior pesticide detections, and the results are likely due to analytical laboratory contamination.

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 5-7). In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall from the High Explosives Wastewater Treatment Facility. Alluvial groundwater in Cañon de Valle shows barium above 1 mg/L, the NM groundwater standard (Figure 5-32), and RDX above 6.1 µg/L, an EPA risk-based tap water screening level that corresponds to a 10^{-5} excess cancer risk (Figure 5-31). 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.

In 2006, neptunium-237 was detected in one sample from regional aquifer monitoring well R-27. There is no applicable groundwater standard for neptunium-237, but for comparison purposes, the activity exceeded the 4-mrem DOE DCG. On July 1, 2006 four samples collected from this well were analyzed for radioactivity, a filtered and unfiltered sample and field duplicate. In the filtered field duplicate, the analytical laboratory reported detection of neptunium-237 at a level slightly above the detection limit. This is the only detection of neptunium-237 in the six samples collected from this well in 2006 and early 2007. The preponderance of nondetections indicates that the detected result was a false positive.

No tritium was detected in any of three regional aquifer monitoring wells sampled within this watershed. Perchlorate was either not detected or values were below 0.31 µg/L and thus within the background range.

The main metals found in well samples at high values relative to standards were iron and manganese. The occurrence of these high metals concentrations results from reducing conditions caused by drilling fluid impact (ERSP 2005).

Table 5-7
Summary of Groundwater Contamination in Water Canyon
(Includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Cañon de Valle	Multiple dry and past effluent sources	Barium above NM GW std, RDX above EPA excess cancer risk level, tetrachloroethene, trichloroethene	Boron above and barium at 65% of NM GW stds., RDX above EPA excess cancer risk level, trace tetrachloroethene, trichloroethene	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

Isopropylbenzene was again detected in CdV-R-37-2 at 1,200 ft. This compound may be a temporary result of drilling fluids used. Trichloro-1,2,2-trifluoroethane[1,1,2-] was also found at this port but in only one of several samples. This compound is also known as freon 113. It may show up as a false positive when running a mass spectrometer. In 2005 trichloro-1,2,2-trifluoroethane[1,1,2-] was found in most field trip blanks and samples from this and a nearby well, suggesting some source of sample contamination or analyte misidentification.

For intermediate groundwater samples from upper Cañon de Valle, tritium activities ranged from 7 pCi/L to 66 pCi/L for wells and 60 pCi/L to 130 pCi/L for springs and are consistent with earlier sampling results. Perchlorate in intermediate-depth wells was either not detected or close to background, with the highest value of 0.49 µg/L. For springs flowing from intermediate perched zones, perchlorate values ranged up to 0.74 µg/L, slightly above background.

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. Barium was found in a sample from Peter Spring at 66% of the NM groundwater standard (Figure 5-32).

Intermediate perched zone well and spring samples contained several HE compounds. Of these compounds, RDX (Figure 5-31) was present at the highest levels 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 chlorinated solvents tetrachloroethene (also known as tetrachloroethylene, perchloroethylene, or PERC) and trichloroethene (or trichloroethylene or TCE) continue to be found in Burning Ground and Martin Springs. The highest values were in Burning Ground Spring at 8% and 2% of the respective NM groundwater standards which are 20 µg/L and 100 µg/L. Tetrachloroethene was also found in two wells, with the highest values at 624 ft in CdV-16-1(i) at about 5% of the NM groundwater standard.

Cañon de Valle alluvial well CDV-16-02657 had uranium at up to 34% of the 30 µg/L NM groundwater standard, consistent with levels previously seen in that well. Tritium was found in many alluvial wells in Cañon de Valle and Martin Spring Canyon at activities ranging from 70 pCi/L to 155 pCi/L. Alluvial

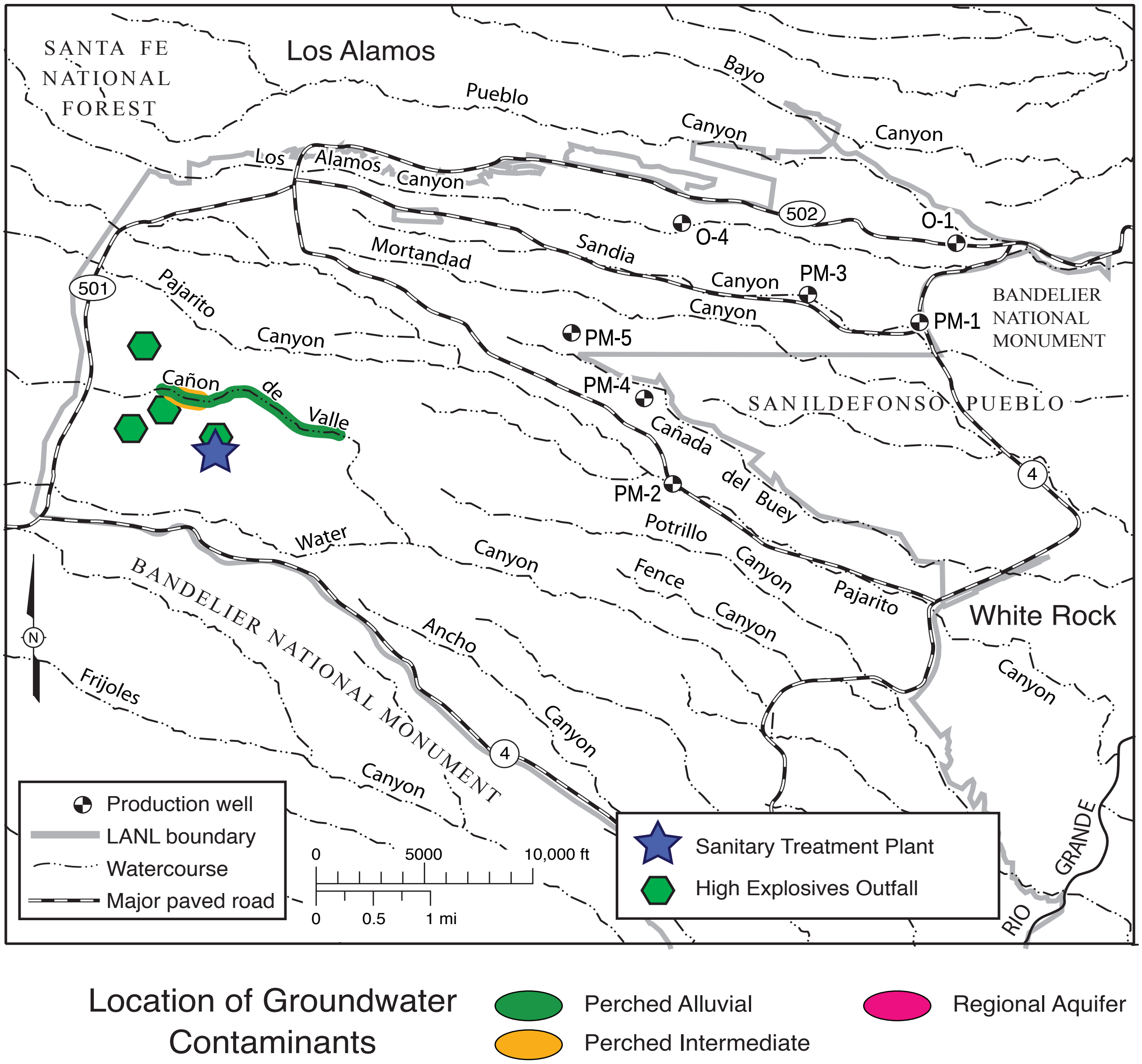


Figure 5-32. **Location of groundwater containing barium above one half of the NM groundwater standard of 1 mg/L. Different colors indicate the affected groundwater zones.**

wells CDV-16-02656 and CDV-16-02659 showed the highest perchlorate values for this area, just above background at 0.88 µg/L. Perchlorate results for these wells were variable and results for two other alluvial wells were nondetections.

Barium, present due to past high explosives wastewater discharges, exceeded the NM groundwater standard in numerous alluvial wells in Cañon de Valle (Figure 5-32). Aluminum, iron, and manganese related to sample turbidity also exceeded NM groundwater standards (for domestic water supply or irrigation use) in alluvial groundwater samples in Cañon de Valle.

Alluvial well samples contained several HE compounds. As with intermediate perched groundwater, RDX was present at the highest levels compared to risk levels, some above the 6.1 µg/L EPA 10^{-5} excess cancer risk level (Figure 5-31). Some RDX values in 2005 were also above the risk level.

Tetrachloroethene and trichloroethene were found in alluvial well CDV-2658 at 13% and 3% of the respective NM groundwater standards which are 20 µg/L and 100 µg/L. These compounds are commonly found in groundwater in Cañon de Valle.

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 (Table 5-8). 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 well, R-31, lies downstream from firing sites at TA-39. Tritium was detected only in the shallowest regional aquifer port of R-31 at 0.6 pCi/L. Perchlorate values were either in the range for background or were nondetections. Iron and manganese concentrations are high in the upper two ports of R-31 due to persistent effects of drilling fluids.

Table 5-8
Summary of Groundwater Contamination in Ancho Canyon

		Groundwater contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Ancho Canyon	Minor dry sources and past effluent sources	None, little 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 5-9). A few springs such as Spring 2B appear to represent discharge of perched groundwater; that spring is supplied by municipal sanitary effluent discharge or irrigation with effluent of athletic fields near White Rock.

Table 5-9
Summary of Groundwater Contamination in White Rock Canyon Springs

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

Other than tritium, the only radionuclide detection of note in White Rock Canyon springs was natural uranium in La Mesita Spring. As in past years, the concentration was nearly 10 µg/L, or 32% of the NM groundwater standard. Naturally occurring uranium is commonly detected in this and a few other nearby wells and springs. White Rock Spring tritium values are similar to prior results. The new result at 31 pCi/L for Spring 4B is slightly lower than earlier results of 45 pCi/L. The result of 11 pCi/L in Sacred Spring is the first value above 1 pCi/L in that location.

Results for White Rock Spring perchlorate samples collected in 2006 are consistent with prior data; concentrations are below background results observed in extensive sampling of NM groundwater by Plummer et al. (2006). The highest value occurs east of the Rio Grande at La Mesita Spring on Pueblo de San Ildefonso at a concentration of 0.71 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 73% of the NM groundwater standard of 1.6 mg/L. The fluoride occurs naturally in groundwater near the Rio Grande and in the Española Basin.

A PCB compound (aroclor-1254) was detected in Spring 3, with no evidence of analytical laboratory contamination, though the analytical laboratory cannot rule out preparation lab contamination. The concentration is 7% of the NM groundwater standard and is an estimated value (J qualified). At this location there are no prior PCB detections. As well, there are only three aroclor detections in prior spring samples, with two in the past seven years, so sampling or analytical laboratory contamination is a likely explanation for the Spring 3 result. In 2005, a detection of the PCB compound aroclor-1262 occurred in the Spring 1 sample.

Nearly every White Rock spring sample contained acetone (all below 4 µg/L) and toluene (all below 1 µg/L). Methylene chloride, acetone, butanone[2-], and hexanone[2-] were found in the field blanks and some of these compounds were found in field trip blanks. Acetone was found in the field blanks at 30 µg/L and 40 µg/L but either not detected in associated spring samples or found at much lower levels. No toluene was found in the trip blanks. These results suggest possible field sample contamination.

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. 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. 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. The high gross alpha readings for these wells are related to naturally occurring uranium.

Eastside Artesian and Westside Artesian wells have levels of sodium, chloride, fluoride, and total dissolved solids 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 0.5 µg/L.

The boron value in the Westside Artesian well was 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 60% to 85% of the 10 µg/L EPA MCL. These findings are also similar to results from past years.

A large number of PAH (polycyclic aromatic hydrocarbon) compounds (semivolatile organic compounds including benzo(a)pyrene, for example) were found in a sample from LA-5. The compounds were only found in the field duplicate but not the companion sample, indicating an analytical laboratory contamination source. Also, the presence of the compound chloronapthalene suggests contamination from the analytical laboratory spike sample.

10. Buckman Well Field

In 2006, we sampled three wells in the City of Santa Fe's Buckman Field (Table 5-10). The detection of plutonium-238 in Buckman well No. 1 is likely an artifact of analysis. From 2001 through 2006, plutonium-238 was analyzed in 19 samples from wells in the Buckman Field. The 2006 result is the only detection and the result is close to the MDA supporting the conclusion that it is an analytical outlier. 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.

Table 5-10
Summary of Groundwater Contamination in White Rock Canyon Wells

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

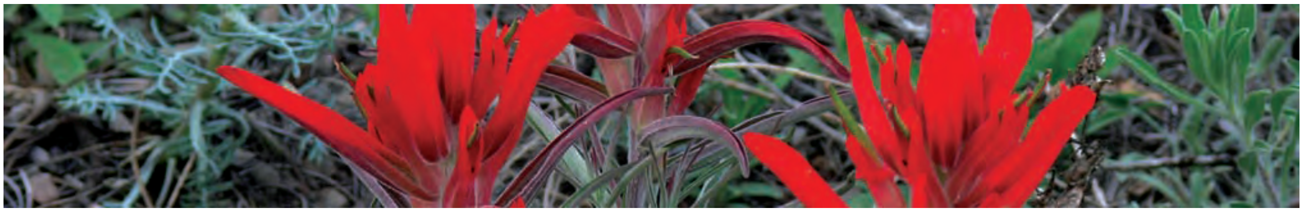
Generally, no tritium is detected in these wells at a detection limit of about 1 pCi/L, and this was the case with the 2006 samples. Perchlorate concentrations in the Buckman wells ranged from 0.24 µg/L to 0.33 µg/L, within the range of naturally occurring values. Two of the wells had arsenic concentrations near the 10 µg/L EPA MCL.

G. QUALITY ASSURANCE OF GROUNDWATER, SURFACE WATER, AND SOIL SAMPLE ANALYSES

1. Introduction

Environmental sampling personnel conducted QA activities in 2006 in accordance with DOE Order 414.1A, 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 water quality database (http://wqdbworld.lanl.gov/) contains all the surface water, groundwater, and sediment analytical data received from our analytical laboratories. None of the data are censored or removed. If analytical results are inconsistent with prior data, we investigate 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 are 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 2006, the majority of the collected data were of high quality. The analytical laboratories flagged 7% of the data for potential data use issues; two thirds of these flags were because the results were between the quantitation and detection limits. The remaining approximately 2% of the results were flagged by the laboratory for potential data quality reasons. After data validation by AQA, 97% were of sufficient quality for use. Overall, 21% 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 quality control (QC) samples to measure the quality of sample collection processes and analytical results.
- Qualification and performance assessment of analytical laboratories.
- Validation of data packages
- Review of analytical results
- Audits and assessments of program and analytical laboratories

The methods and results for each of these components of the quality program are discussed in the following subsections.

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 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, and bottle sizes and preservatives for each analysis required.

b. Results. Field quality assurance procedures and the quality plan documents were revised in 2006, but the revisions were not implemented until after the end of the 2006 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 Tables S5-14, S5-15, and S5-16 for the analytes, analytical methods, and detection limits used for analysis of surface water, sediment, and groundwater samples during 2006.

3. Quality Control for Samples and Analytical Results

a. Methods. We submit 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 evaluate the results from QC samples along with the environmental sample results in order 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 select samples were also conducted at the laboratory.

Equipment and Field Blanks: Equipment and field blanks were submitted for metals, organic, 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 (DI) blanks submitted as regular samples, without any indication that they are QC samples. They go through the same analytical process as the regular field samples. The DI 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. The nitrate results for five samples at four groundwater and surface water locations (Sandia below Wetlands, R-23i, Sandia below Wetlands, and South Fork of Sandia Canyon at E122) sampled between July 28, 2006, and September 18, 2006, were reported at levels over 500 mg/L. Review of these samples found that the nitrate values were not supported by the total dissolved solids determination or the historical data for the sites, where these data were available. Additional testing at the laboratory on containers still available indicated that the high levels of nitrate were not found in unpreserved samples. The high nitrate values in these samples therefore, were likely from the incorrect use of nitric acid preservative in the field in place of the method-specified sulfuric acid preservative. In those cases where it appeared that an error was made, the data were marked rejected during data validation due to the possibility of a field sampling error. This issue also occurred in 2005.

In some cases, sample results for filtered and unfiltered sample results are compared to see if the results for each are consistent with historical results, as well as with each other. There were several instances where the filtered and unfiltered results indicated that there might have been a problem with how the sample containers were labeled in the field. In these cases, results for inorganic analytes were higher in the filtered sample when compared to the unfiltered sample collected at the same time from the same location. In each case, the samples were examined at the laboratory to determine if it was possible to tell if the samples were filtered or unfiltered. In those cases where it appeared that an error was made, the data were marked rejected during data validation due to the possibility of a field sampling error.

4. Qualification and Performance Assessment of Analytical Laboratories

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

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 2006, General Engineering Laboratories (GEL) and Severn-Trent Los Angeles (STSL) participated in both MAPEP and proficiency testing offered by Environmental Resource Associates, but STSL 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 Order and by the chromium issue.

- To address the need for polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDDs and 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.
- To address concerns about hexavalent chromium first reported in 2006, STLA was selected to conduct the hexavalent chromium analysis by EPA Method SW-846:7191.

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 (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 performance evaluation programs at GEL are given in Table 5-11 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 was found sufficient; these results are not included.

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. Tables S5-5, S5-6, and S5-7 in the Data Supplement list qualifier and validation flag codes that accompany 2006 sediment and water data. When documentation or contract-compliance problems are identified during data validation, the analytical services laboratory is contacted and attempts are made to resolve or clarify the problem.

Table 5-11
Results of Performance Evaluations at GEL Laboratories

Evaluation	Analytes Affected	Results and Actions Taken
ERA Rad-63	Gross beta by EPA 900.0 and SW9310	Result was less than the acceptable range (Reported value 29.5 pCi/L; acceptance limits, 30.4–47.8 pCi/L).
ERA WS-112	Vanadium by EPA 200.8 and SW6020	Result was less than the acceptable range (Reported value 782 µg/L; acceptance limits, 891–1,090 µg/L).
ERA WS-114	Copper by EPA 200.8	Result was less than the acceptable range (Reported value 590 µg/L; acceptance limits, 614–750 µg/L).
	Vanadium by EPA 200.8	Result was less than acceptable range (Reported value 329 µg/L; acceptance limits, 401–490 µg/L).
	Zinc by EPA 200.8	Result was less than the acceptable range (Reported value 424 µg/L; acceptance limits, 425–519 µg/L).
		The serial dilution had a high recover for Cu, V, and Zn, indicating a matrix effect. If the laboratory had reported the 5X dilution, each of these results would have been acceptable. GEL reported acceptable results for these analytes in the following PT study, WS-117.
ERA WS-120	Mercury by EPA 245.1/245.2 and SW846 7470A	Result was greater than the acceptable range (Reported value 26.7 µg/L; acceptance limits, 1.91–3.55 µg/L). A dilution error occurred causing a 10X bias to the reported value.
	Nitrite + Nitrate as N by EPA 353.1	Result was less than the acceptable range (Reported value 6.09 mg/L; acceptance limits, 7.16–8.76 mg/L). Although the batch QC results were all acceptable, causing the performance sample results to be reported, instrument instability problems have resulted in the purchase of a new analytical nstrument to resolve instability issues.
	Uranium by EPA 200.7 and SW846 6010B	Uranium is not typically reported by inductively coupled plasma (ICP) analyses. The U results by ICP-mass spectrometry (MS) for this PT study were acceptable. No further corrective action is required.
	Vanadium by EPA 200.8 and SW846 6020	Result was greater than the acceptable range (Reported value 800 µg/L; acceptance limits, 609–745 µg/L). This analyte is not typically reported by ICP-MS. The vanadium results by ICP for this PT were acceptable. No further corrective action is required.

Table 5-11 (continued)

Evaluation	Analytes Affected	Results and Actions Taken
ERA WP-138	2,3,4,6-Tetrachlorophenol by SW846 8270C and EPA 625	Result was less than the reporting limit of 10 µg/L (Reported value <10 µg/L; acceptance limits, 4.52–61.5 µg/L). A database problem caused upload of an incorrect target list. If the proper list had been used, an acceptable value of 34.4 µg/L would have been reported. No further corrective action was reported by the laboratory.
	Nitrite + Nitrate as N by EPA 353.1	Result was less than the acceptable range (Reported value 16.9 mg/L; acceptance limits, 18.2 – 25.9 mg/L). Although the batch QC results were all acceptable, causing the PT sample results to be reported, instrument instability problems have resulted in the purchase of a new RFA instrument to resolve instability issues.
	Titanium by EPA 200.8 and SW846 6020	Result was less than the acceptable range (Reported value 199 µg/L; acceptance limits, 214–280 µg/L). This analyte is not typically reported by ICP-MS. No further corrective action is required.
ERA WS-122	Turbidity by EPA 180.1/SM 2130 B	Result was greater than the acceptable range (Reported value 3.96 NTU; acceptance limits, 3.98 – 5.42 NTU).
MAPEP-16	Endosulfan II by SW846 8081A	Laboratory reported a false positive. The sample chromatogram revealed possible contamination in the retention time area for Endosulfan II.
MAPEP-15	Strontium-90 (mixed analyte soil standard)	Result was greater than the acceptable range (Reported value 209.7 Bq/kg; acceptance limits, 220.0–408.7 Bq/kg). GEL did not report a corrective action for this failure.

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

b. Results. Analytical Quality Associates, Inc. (AQA) validated all of the 2006 data packages. Individual validation memos were issued for each analytical fraction 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 2006, 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 data packages. GEL reissued corrected documents for all of the reports containing missing documentation or erroneous data. All NCRs were successfully closed except as noted in the following section.

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 that case, a detected result is reported when analytical results are greater than three times the reported (one-sigma) uncertainty.

Nonradiological Data: For organic compounds and some general inorganic chemistry (that is, major anions, cations, and nutrients) parameters, the nondetections are reported at the Practical Quantitation Limit (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 by the analytical laboratory. The analytical laboratory reports nonradiological results below the MDL as nondetections.

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

For example, there was an RDX interference found by GEL in the HE analyses by EPA SW-846 Method 8330, conducted during 2006. GEL investigated the interference and was not able to find a definitive cause. All affected data were identified during the corrective action process and appropriately qualified during data validation. As a result, most of the groundwater data for the last quarter of 2006 were analyzed following EPA SW-846 Method 8321 to avoid the problems with Method 8330.

GEL experienced difficulty with the calibration for the compound 1,4-dioxane by the volatile organic EPA SW-846 Method 8260 (MDL 20 μg/L). This resulted in the majority of the 1,4-dioxane results being rejected in validation. There were problems with blank contamination as well. To provide better results, 1,4-dioxane was added to the analyte list for EPA SW-846 Method 8270 (MDL 1 μg/L).

Diesel range organics (DRO) were analyzed more extensively to address waste characterization criteria. GEL reported a significant number of detections for DRO in areas where DRO was not expected or likely to be present. Investigation into this issue revealed that GEL was not using an appropriate detection limit for this analysis. The detection limit issue is still under investigation and will be resolved in 2007.

GEL subcontracted with Paradigm Analytical Laboratory to provide PCDD and PCDF analysis by EPA Method SW-846: 8290, as required by the Consent Order. The Paradigm results indicated very low-level detections at a majority of the groundwater locations sampled (detections reported at 34 of 36 groundwater locations). To correct the problem of false positive detections, LANL changed to ALTA Analytical Laboratory. ALTA showed a lower rate of detection (detections reported at four of 13 locations) but still at a higher rate than expected for PCDDs and PCDFs in groundwater. These detections of PCDDs and PCDFs in groundwater have occurred inconsistently in individual samples and their related duplicate samples. In addition, these compounds have been detected inconsistently between sample rounds for the same locations. Paradigm has also reported contamination in some of the method blanks associated with these samples, but the detection of

PCDDs and PCDFs in the method blanks and samples has not been consistent. This pattern of inconsistent detections of PCDDs and PCDFs in groundwater has continued into 2007, and LANL is investigating this issue.

There were 21 detections of Xylene[1,3-]+Xylene[1,4-] in 2006 evenly split between groundwater samples and blanks. All of the detections were below PQL. GEL was asked to investigate possible low-level contamination by Xylene[1,3-]+Xylene[1,4-]. GEL reported that there was no evidence of pervasive contamination in the laboratory. The data were qualified following the data validation procedure requirements. There were seven results with associated blank contamination that were qualified as non-detects, 13 results were reported as detections less than the PQL, and one result was rejected because of carryover contamination in the laboratory.

There were detections of 4,4'-DDT and or its breakdown products in three wells in 2006. These were the first samples collected for pesticides at these three locations. All detects were below the PQL and were not confirmed in subsequent samples collected from these locations. The analytical laboratory and data validation subcontractor indicated that the data were acceptable as reported for both the detections and the subsequent non-detections reported. Therefore, both sets of results are reported in the database.

There were four detections of PCBs reported in 2006 groundwater samples. Three of these detections were below the PQL and were marked as estimated (with the J qualifier) by the laboratory. This simply means that the results are valid detections but are near the MDL. Reanalyses of these samples were not conducted because the holding time had expired and reanalysis of samples at this level would not have produced useful data to determine detect status for these low levels. There was also a detection of Aroclor-1242 at a concentration of 4.5 µg/L in a sample from R-12 at 810.8 ft. This sample was re-extracted and reanalyzed after the 7-day extraction holding time had expired, but within two months of sampling, and was found to have non-detectable levels of Aroclor-1242 in the sample (result reported as less than 0.143 ug/L). While this result was rejected due to the holding time violation based on National Functional Guidelines (EPA 2001), other guidance in the Clean Water Act (40 CFR Parts 122 and 136) provides for a one-year holding time for PCBs in water. Therefore, it is unlikely that the high levels of Aroclor-1242 reported in the first analysis would have been lost in the sample over the time interval in question due to the stability of PCBs.

There were a series of volatile organic compounds detected in well R-20 at various depths including toluene, naphthalene, isopropylbenzene, acetone, and tetrachloroethene. Investigation into the detections of toluene indicated that there were problems with the well involving the packer system used and that this system might have contributed to the contamination detected at the well. Review of the data by AQA and GEL did not indicate any data quality problems with the analyses provided by GEL. Sampling conducted after addressing some of the possible problems with the field equipment were inconclusive, with detections of acetone in both samples and associated equipment and field trip blanks. The naphthalene, isopropylbenzene, and tetrachloroethene were not detected in the samples or blanks during the subsequent sampling rounds.

There were several detections of plutonium-239/240 that may be false positives. The results are greater than the minimum detectable activity (MDA) and less than three times the sample-specific uncertainty. A thorough review of the data reported by the laboratory was conducted by GEL, AQA, and LANL and no specific cause has been identified. However, a review of plutonium-239,240 data for the past few years shows that the analytical laboratory is reporting much lower MDAs with their results in 2006. Additional investigations into this issue are ongoing.

7. Audits and Assessments of Program and Analytical Laboratories

a. Methods. In addition to routine review of data packages, analytical laboratory oversight includes audits, site visits, and conference calls to review general laboratory quality practices. Problems identified during these processes normally require the laboratory to take a formal corrective action. Audits are conducted at least every three years for laboratories contracted by the SMO for environmental sample analysis.

b. Results. GEL and Severn-Trent St. Louis receive an audit on an annual basis due to the large amount of work they perform for the programs at LANL.

In December 2006, AQA conducted a Data Package Assessment (DPA) at GEL. This assessment included data package completeness, documentation of the analytical work, instrument calibration and calibration checks, method quality control, secondary reviews and QA oversight, sample receiving and custody, holding times, use of appropriate methods, calculation review, and sample preparation. Ancillary records reviewed in support of the assessment include analyst proficiency training, standards preparation and traceability, calibrations not included in the data package, holding blanks, electronic files, laboratory performance evaluation samples, and any non-conformances and corrective actions associated with the report. Additionally, contractual compliance with the DOE-AL Model SOW and LANL SOW was reviewed.

This data package assessment included data packages for organic, radiochemical, and general inorganic analyses. All the files were retrieved quickly and contained all the required documentation except as noted in the audit report. There were 12 items submitted for corrective action listed in the data package audit report. One of these items relates to the corrective action for the RDX interference discussed in Section 6b. Of the remaining issues, two did not relate to LANL groundwater data and the other 9 issues were for contractual or documentation issues that did not adversely impact the data reported by GEL during 2006.

Data package assessments were not conducted at STSL, STLA, ALTA, or Paradigm in 2006.

There were no internal program audits or assessments performed in 2006 for the Water Stewardship Program.

8. Department of Energy Contract Analytical Program Audits

a. Methods. The Office of Environmental Management at DOE Headquarters (HQ-EM) mandated participation in the Department of Energy 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 Environmental Characterization & Remediation (ECR) QA Program.

DOECAP audits result 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 mechanism for identifying and tracking a deficiency of an isolated nature or lesser significance than that warranting issuance of a Priority II finding, as well 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:

- STSL DOECAP: This audit occurred on April 5–7, 2006. Four Priority II (PII) findings from 2005 remain open. There were 14 new PII findings and 22 new observations, of which 10 findings and 14 observations were for operations unrelated to LANL samples. The corrective action plan has been approved and is available on the DOECAP website.
- GEL DOECAP: This audit occurred on May 9–12, 2006. All Priority II (PII) findings from 2005 were closed. There were seven new PII findings and 10 new observations. All findings and all but one observation directly affect data processes for LANL data. The final audit report is available on the DOECAP website.

DOECAP did not conduct audits of STLA, ALTA, or Paradigm in 2006.

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